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

May 8, 2012

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

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

Dear Mr. Dollhopf:

In a letter dated April 24, 2012, Enbridge Energy, Limited Partnership (Enbridge) received comments from the United States Environmental Protection Agency (U.S. EPA) regarding the Kalamazoo River Hydrodynamic and Sediment Transport Model Report (HDM Report) submitted on April 20, 2012. The U.S. EPA requested that a HDM Report Addendum be submitted on May 4, 2012 to address these comments.

Enbridge proposed a revised submittal date of May 8, 2012 which was verbally granted on May 3, 2012. Enbridge has since addressed the comments. This letter together with five hard copies of the Kalamazoo Hydrodynamic and Sediment Transport Model Report Addendum dated May 8, 2012 has been delivered to the U.S. EPA Documentation Unit located in Trailer 9. In addition, an electronic version has been uploaded to the Enbridge FTP site. Site information is provided below.

URL:	https://ftp.enbridgeus.com
Account:	enbline6bagencies
Password:	marshall12

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

Sincerely,

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

Richard Adams
Vice President, U.S. Operations

CC: John Sobojinski, Enbridge
Bob Steede, Enbridge
Christopher Haux, Enbridge
Jim Snider, Enbridge
Michelle DeLong, MDEQ
Mark DuCharme, MDEQ

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RESPONSE TO COMMENTS LOG

The United States Environmental Protection Agency (U.S. EPA) has received the following documents submitted by Enbridge Energy, Limited Partnership, Enbridge Pipelines (Lakehead) L.L.C., Enbridge Pipelines (Wisconsin), and Enbridge Energy Partners, L.P. (herein collectively referred to as "Enbridge") on April 13, 2012 and April 20, 2012:

Enbridge Energy, Limited Partnership letter to the US. EPA requesting an extension for submittal of a report documenting hydrodynamic modeling performed by Enbridge, submitted on April 13, 2012

Enbridge Energy, Limited Partnership Kalamazoo River Hydrodynamic and Sediment Transport Model Report (HDM Report), submitted on April 20, 2012.

On April13, 2012, Enbridge requested a deadline extension for the HDM Report until April20, 2012. U.S. EPA granted Enbridge's request verbally on April 13, 2012. As stated above, U.S. EPA has received Enbridge's HDM Report and is currently reviewing it. U.S. EPA will approve, disapprove and require modifications, or modify Enbridge's HDM Report in a subsequent letter after U.S.EPA's review is complete.

In the meantime, Enbridge shall submit to the U.S. EPA an HDM Report Addendum on May 8, 2012. The HDM Report Addendum shall include the items described below.

1. Please provide a table of proposed model calibration acceptability criteria for:

   a. Water surface elevation (WSE);

      Response: Proposed water surface elevation calibration acceptability criteria are provided in *Attachment 1*.

   b. Discharge and velocity model parameters (e.g., similar to the example provided by USGS);

      Response: Proposed discharge and velocity calibration acceptability criteria are provided in *Attachment 1*.

   c. A comparison of simulated versus observed parameter values relative to those criteria for the model calibration runs completed to date. (Comparisons should be made for each of the site stage recorder stations, unless specific rationale for a different approach is given.)

      Response: Comparisons of simulated versus observed parameter values are provided in *Attachment 1*.

If the proposed acceptability criteria are different than those suggested by USGS, Enbridge shall provide justification for the proposed values.

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2. Please provide a narrative interpreting the HDM calibration results obtained to date. The interpretation shall also include recommendations for additional data collection and/or revisions to the calibrated HDM if the simulated values do not meet acceptability criteria for individual stations.

   Response: Please refer to *Section 1.0* in the Kalamazoo River Hydrodynamic and Sediment Transport Model Report Addendum.

3. Please provide additional compilations and graphical presentations of data from the sensitivity analysis model runs to support a more detailed evaluation of the HDM response to variations in specific parameter values. The additional data compilation shall include tables and graphs presenting changes in various parameter values at discrete cross-section/transect locations (e.g., rather than zonal summaries). Parameters for which the additional compilation shall: WSE, discharge, velocity, sediment load, sediment texture, and erodibility. The locations for the additional data compilation shall consist of the stage recorder locations, plus other representative locations specified by the USGS.

   Response: Additional compilations and graphical presentations of data from the sensitivity analysis model runs are provided in *Attachment 3*.

4. In coordination with the U.S. EPA and USGS personnel, please provide a schedule for performing additional model refinements (e.g., 3D model of select areas, addition of submerged oil transport), and for additional model scenarios to be evaluated using the calibrated HDM.

   Response: A proposed schedule to perform additional model refinements is provided in *Attachment 4*.

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Enbridge Line 6B MP 608
Marshall, MI Pipeline Release

Kalamazoo River Hydrodynamic and Sediment Transport Model Report Addendum

Prepared for United States Environmental Protection Agency

Enbridge Energy, Limited Partnership

Submitted: May 8, 2012

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ATTACHMENTS

Attachment 1 **Tables and Figures in Response to Comment 1**

Attachment 2 **Figures in Response to Comment 2**

Attachment 3 **Tables and Figures in Response to Comment 3**

Attachment 4 **Figures Not Included in Original Document**

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LIST OF ACRONYMS

USGS	United States Geological Survey

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1.0 Calibration Interpretation

1.1 Interpretation of Calibration Results

- The similarity in riverine and floodplain simulated flows at the Kalamazoo River United States Geological Survey (USGS) Battle Creek Station can be explained since the simulated flows were calibrated to the USGS Station recorded flow. Differences between them are attributable to differences in grid design and resolution. The riverine grid is a curvilinear grid fitted to the river channel. The river portion of the floodplain grid is part of a Cartesian grid not matched to the river channel. The Cartesian grid has cells that can be partially in the river and partially on the floodplain.
- Differences in measured vs. simulated velocities is attributable several factors:
    - Velocity is sensitive to bathymetry values at the cross-sections. Cross sections with inadequate bathymetry data affect the simulated velocity values.
- The sediment mass flux calibration results support the geomorphic surface interpretations (*Figures 4-10* and *4-12* of the *Kalamazoo River Hydrodynamic and Sediment Transport Model* (Enbridge, 2012) submitted to the United States Environmental Protection Agency on April 20, 2012).
    - Sediment deposition upstream of Ceresco Dam, the Kalamazoo River Dam, and in the ponded area upstream of Morrow Lake is characterized by soft sediments (i.e. low energy, depositional environments) during both the riverine and floodplain calibration flow events. The sediment deposition in these areas is silt and clay with little to no sand.
    - The exception to this deposition pattern upstream of the dams occurs at the 35th Street Bridge. Sand deposition increases at the 35th Street Bridge, probably because overall sediment loads increase (i.e. increased erosion) during the peak flow (July 25th) and falling limb (July 27th) of July 2010 flood event.
    - Sand is the predominant particle size at the Kalamazoo River at Battle Creek USGS gaging station during the first four days of the October/November 2011 and the first 2 days of the July 2010 calibration model runs. The gaging station is located downstream of the confluence of the Kalamazoo River (concrete channel) and the Battle Creek River. The predominance of sand is created by the sediment input at the Battle Creek River. As the model run continues, the sand mass flux decreases quickly as it becomes more representative of actual

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conditions for this flow event. Unlike the other cross-section locations, the sand is still a component of the sediment profile for the remainder of the model run which is indicative of the higher velocity and discharge in this part of the river.

- At the Morrow Lake Dam, the dominant sediment class size is clay. Silt and sand are deposited within Morrow Lake and only the clay particles reach the dam even during flood events.
- The comparison of the October/November 2011 model run velocities and the 2011 Spring focus areas indicate that the majority of submerged oil deposition areas are present where the velocities are less than 1.0 foot per second. A total of 259 focus areas contained moderate and/or heavy submerged oil in the Spring 2011 Reassessment. Of these focus areas, 77% had velocities less than 1.0 foot per second; 21% had velocities between 1.0 and 1.5 feet per second; and 2% had deposition occurring with velocities between 1.5 and 2.0 feet per second.
- The comparison of the July 2010 model run velocities and the 2011 Spring focus areas indicate that the majority of submerged oil deposition areas are present where the velocities are less than 1.0 foot per second. A total of 259 focus areas contained moderate and/or heavy submerged oil in the Spring 2011 Reassessment. Of these focus areas, 69% had velocities less than 1.0 foot per second; 27% had velocities between 1.0 and 1.5 feet per second; and 4% had deposition occurring with velocities greater than 1.5 but less than 2.53 feet per second.
- The areas with velocities less than 1 foot/second are the primary deposition areas such as upstream of the dams, oxbows, cutoff channels, backwater areas, the delta, and the sediment fan.
- The 2011 Reassessment focus areas with velocities greater than 1.0 foot per second are located in similar geomorphic settings that do not include the primary deposition areas.
    - A majority of the areas are located adjacent to the channel banks.
    - A number of areas are located on the outside of meander bends where the water depth fosters deposition despite the higher water velocities.
    - A number of areas are located where the channel width narrows. The narrow channel increases water velocity yet deposition is occurring along the channel banks. This phenomenon also occurs on the

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upstream side of islands where the channel splits but deposition is occurring along the channel banks.

- Some areas are associated with widening of the channel especially immediately downstream of a narrow stretch where the velocities are dissipating across the wider channel cross-section. This has also occurred where backwater areas are adjacent to the channel banks.
- The October/November 2011 riverine calibration model does not show greater than 1 foot/second velocities in depositional areas downstream of the 35th Street Bridge. This is consistent with the effect of the Morrow Lake Dam.
- The July 2010 floodplain calibration model has two areas downstream of the 35th Street Bridge with velocities greater than 1 foot per second in depositional areas. The first is 36.80 South which is located along the south channel bank of the main Kalamazoo channel before the channel widens into the Morrow Lake Delta. The second is Delta I which is a depositional area at the upstream end of an island adjacent to the primary distributary channel into the Delta.

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2.0 References

Enbridge, 2012. Enbridge Line 6B MP 608 Pipeline Release; Marshall, Michigan*; Kalamazoo River Hydrodynamic and Sediment Transport Model.* April 20, 2012.

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Attachment 1

Tables and Figures in Response to Comment 1

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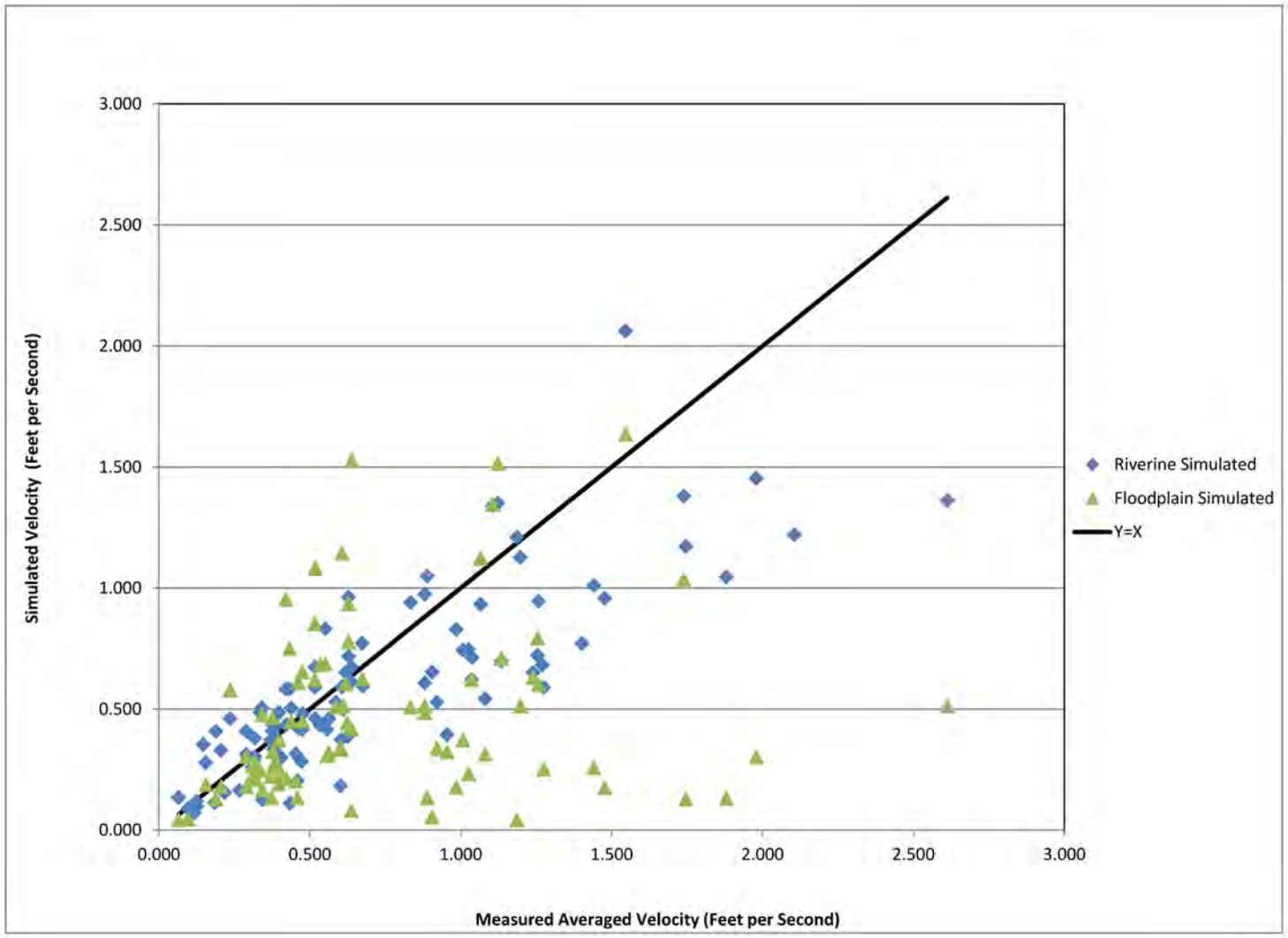

ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

POINT VELOCITY COMPARSIONS:
RIVERINE GRID VS.
FLOODPLAIN GRID

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

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Table 1-1. May 2011 Riverine Water Surface Elevation Calibration Statistical Summary
Enbridge Line 6B MP 608 Marshall, MI Pipeline Release
Enbridge Energy, Limited Partnership

Water Surface Elevation

Date	Number of Data Points	Average (Feet)	Mean Absolute Error (Feet)	Normalized Mean Absolute Error* (Percent)	Root Mean Square Error (Feet)	Normalized Root Mean Square Error* (Percent)
5/13/2011	8	823.08	0.31	7.0	0.44	10.2
5/14/2011	4	807.67	0.39	9.8	0.50	13.7
5/15/2011	6	795.03	0.36	6.4	0.46	8.5
5/16/2011	9	815.92	0.50	8.8	0.61	11.0
5/17/2011	9	815.92	0.50	8.8	0.61	11.0
5/18/2011	6	831.11	0.50	9.7	0.64	13.1
5/19/2011	9	815.71	0.43	7.7	0.56	10.5
5/20/2011	7	817.68	0.36	6.7	0.55	10.6
5/23/2011	9	815.86	0.47	8.2	0.59	10.8

Flow

Location	Number of Data Points	Average (Cubic Feet per Second)	Mean Absolute Error (Cubic Feet per Second)	Normalized Mean Absolute Error (Percent)	Root Mean Square Error (Cubic Feet per Second)	Normalized Root Mean Square Error (Percent)	Index of Agreement
Morrow Lake Dam Outlet	13	1785.38	67.08	3.8	76.37	4.5	0.94
Kalamazoo River Gage	12	1299.17	18.34	1.4	25.05	2.0	0.99

Footnotes:
* Normalized to measured water depth factors

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Table 1-2. October/November Riverine Calibration Statistical Summary
Enbridge Line 6B MP 608 Marshall, MI Pipeline Release
Enbridge Energy, Limited Partnership

Water Surface Elevation

Date	Number of Data Points	Average of data points (Feet)	Mean Absolute Error (Feet)	Normalized Mean Absolute Error (Percent)*	Root Mean Square Error (Feet)	Normalized Root Mean Square Error (Percent)*
10/28/2011	10	817.89	0.28	6.3	0.36	8.3
10/29/2011	10	818.04	0.47	10.1	0.57	12.6
10/31/2011	10	818.12	0.67	14.1	0.80	17.3
11/1/2011	10	817.97	0.59	12.7	0.72	16.2
11/2/2011	10	817.91	0.58	12.8	0.72	16.4
11/3/2011	10	817.84	0.57	12.7	0.71	16.4
11/4/2011	10	817.82	0.54	12.0	0.68	15.8
11/5/2011	10	817.71	0.48	11.0	0.61	14.5
11/7/2011	10	815.26	0.45	9.8	0.60	13.3
11/8/2011	10	817.61	0.48	11.2	0.59	14.3

Flow

Location	Number of Data Points	Average (Cubic Feet per Second)	Mean Absolute Error (Cubic Feet per Second)	Normalized Mean Absolute Error (Percent)	Root Mean Square Error (Cubic Feet per Second)	Normalized Root Mean Square Error (Percent)	Index of Agreement
Morrow Lake Dam Outlet	12	1010.00	10.66	1.1	14.20	1.5	1.00
Kalamazoo River Gage	13	672.08	18.98	2.8	21.67	3.3	0.98

Velocity

Location	Number of Data Points	Average (Feet per Second)	Mean Absolute Error (Feet per Second)	Normalized Mean Absolute Error (Percent)	Root Mean Square Error (Feet per Second)	Normalized Root Mean Square Error (Percent)	Index of Agreement
All Stations	100	0.72	0.21	29.0	0.31	35.0	0.87

Footnotes:
* Normalized to measured water depth factors

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Table 1-3. May 2011 Floodplain Calibration Statistical Summary
Enbridge Line 6B MP 608 Marshall, MI Pipeline Release
Enbridge Energy, Limited Partnership

Water Surface Elevation

Date	Number of Data Points	Average (Feet)	Mean Absolute Error (Feet)	Normalized Mean Absolute Error (Percent)*	Root Mean Square Error (Feet)	Normalized Root Mean Square Error (Percent)*
5/26/2011	8	821.44	0.36	5.5	0.45	7.1
5/27/2011	6	811.37	0.82	11.6	0.99	15.0
5/30/2011	9	824.19	0.47	6.8	0.60	9.1
6/1/2011	9	818.95	0.45	6.5	0.58	8.6
6/2/2011	8	821.99	0.29	4.5	0.41	6.5
6/3/2011	8	821.73	0.31	5.0	0.41	6.7
6/4/2011	5	836.05	0.31	5.7	0.37	7.3
6/5/2011	7	813.13	0.27	4.9	0.35	6.7
6/6/2011	6	812.41	0.58	11.0	0.76	15.0

Flow

Location	Number of Data Points	Average (Cubic Feet per Second)	Mean Absolute Error (Cubic Feet per Second)	Normalized Mean Absolute Error (Percent)	Root Mean Square Error (Cubic Feet per Second)	Normalized Root Mean Square Error (Percent)	Index of Agreement
Morrow Lake Dam Outlet	14	2710.71	130.11	4.8	153.00	5.4	0.99
Kalamazoo River Gage	14	2080.86	75.19	3.6	91.49	4.0	1.00

Footnotes:
* Normalized to measured water depth factors

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Table 1-4. October/November Floodplain Calibration Statistical Summary
Enbridge Line 6B MP 608 Marshall, MI Pipeline Release
Enbridge Energy, Limited Partnership

Water Surface Elevation

Date	Number of Data Points	Average (Feet)	Mean Absolute Error (Feet)	Normalized Mean Absolute Error (Percent)*	Root Mean Square Error (Feet)	Normalized Root Mean Square Error (Percent)*
10/28/2011	10	817.89	0.47	10.5	0.68	15.6
10/29/2011	10	818.04	0.70	15.2	0.84	18.7
10/31/2011	10	818.12	0.73	15.4	0.84	18.3
11/1/2011	10	817.97	0.82	17.8	0.91	20.5
11/2/2011	10	817.91	0.80	17.6	0.88	20.0
11/3/2011	10	817.84	0.79	17.7	0.86	20.0
11/4/2011	10	817.82	0.74	16.7	0.84	19.6
11/5/2011	10	817.71	0.81	18.7	0.94	22.3
11/7/2011	10	815.26	0.65	13.9	0.75	16.6
11/8/2011	10	817.61	0.85	19.8	0.95	23.1

Flow

Location	Number of Data Points	Average (Cubic Feet per Second)	Mean Absolute Error (Cubic Feet per Second)	Normalized Mean Absolute Error (Percent)	Root Mean Square Error (Cubic Feet per Second)	Normalized Root Mean Square Error (Percent)	Index of Agreement
Morrow Lake Dam Outlet	10	974.44	11.31	1.2	13.00	1.4	0.99
Kalamazoo River Gage	11	642.10	14.47	2.3	15.78	2.6	0.98

Velocity

Location	Number of Data Points	Average (Feet per Second)	Mean Absolute Error (Feet per Second)	Normalized Mean Absolute Error (Percent)	Root Mean Square Error (Feet per Second)	Normalized Root Mean Square Error (Percent)	Index of Agreement
All Stations	86	0.75	0.41	54.6	0.60	67.5	0.53

Footnotes:
* Normalized to measured water depth factors

Table 1-5. July 2010 Floodplain Calibration Statistical Summary
Enbridge Line 6B MP 608 Marshall, MI Pipeline Release
Enbridge Energy, Limited Partnership

Comparison of Oil Marks vs. Simulated Water Surface Elevations

Date	Number of Data Points	Average (Feet)	Mean Absolute Error (Feet)	Root Mean Square Error (Feet)
7/25/2011	283	840.85	1.86	2.20
7/26/2011	283	840.85	1.68	2.05
7/27/2011	283	840.85	1.40	1.76

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Attachment 2

Figures in Response to Comment 2

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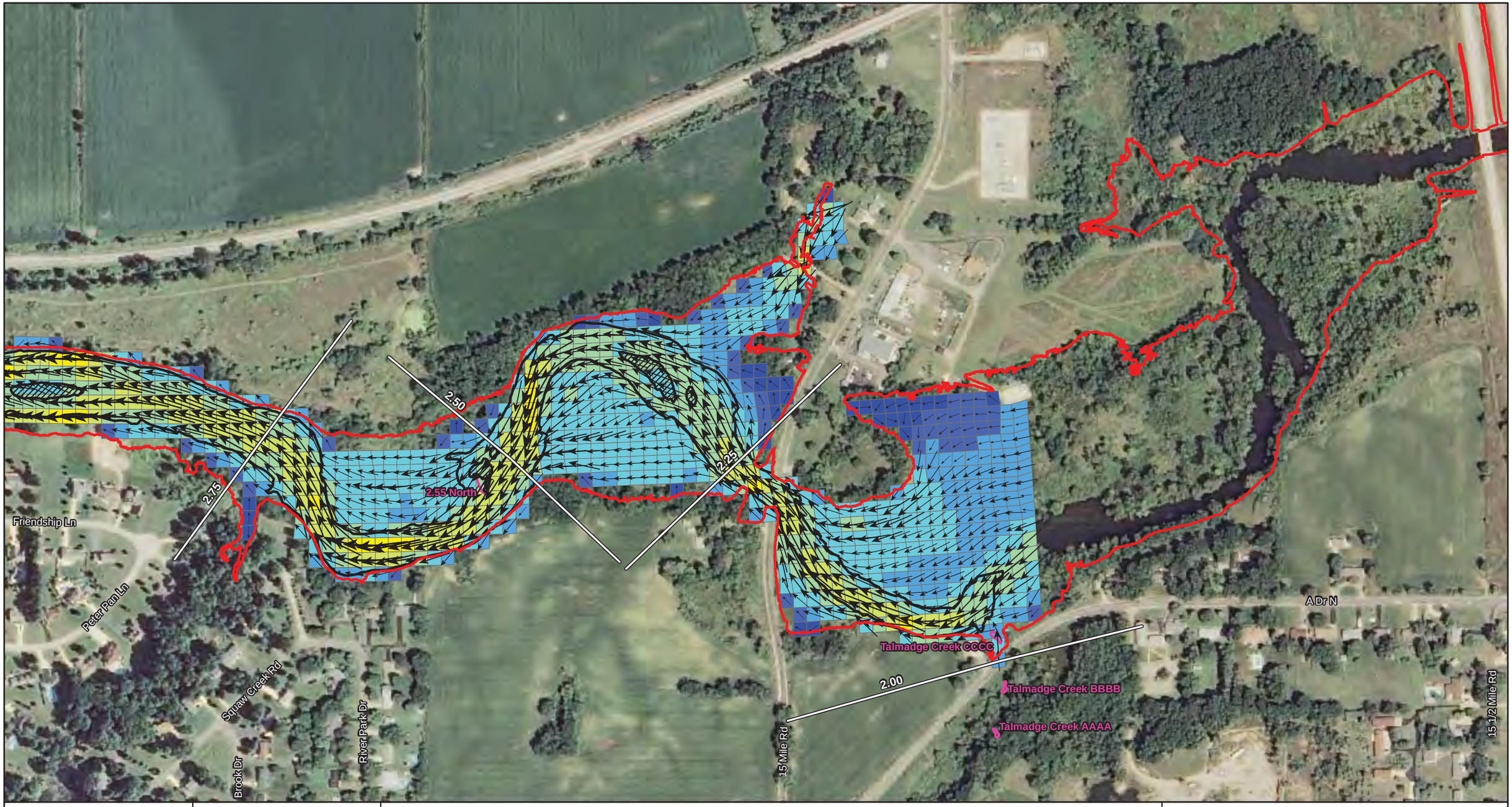
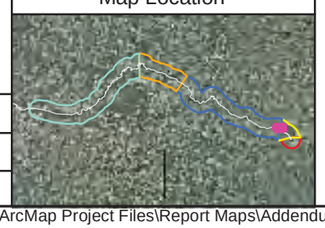


ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 01.88 - MP 02.91

SHEET 1 OF 45

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

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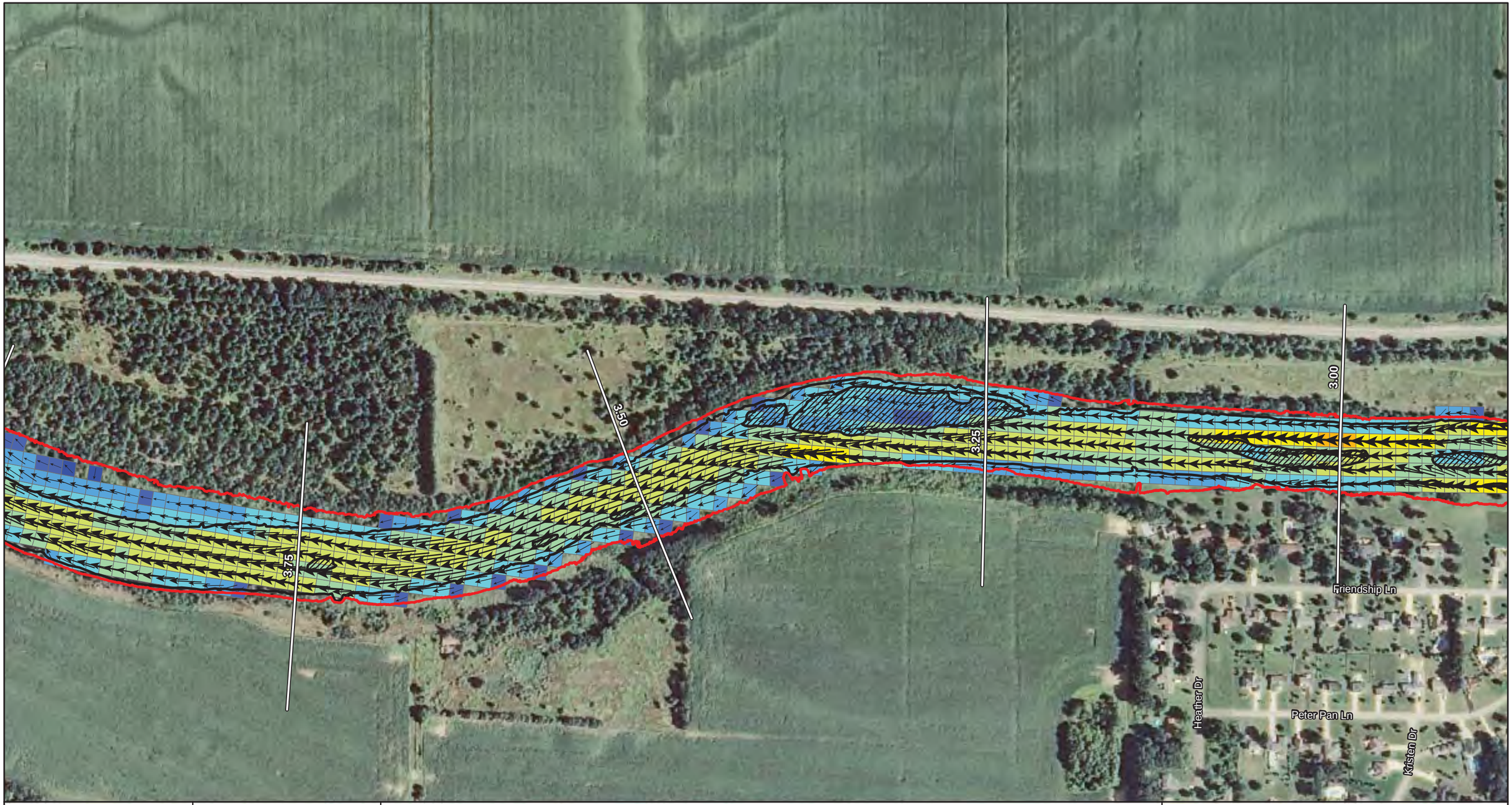
Aerial Photography Date: July & August 2009



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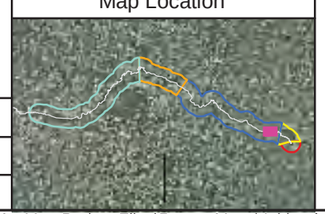

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FLOODPLAIN GRID: VELOCITY WITH
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MP 01.88 - MP 02.91

SHEET 2 OF 45

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

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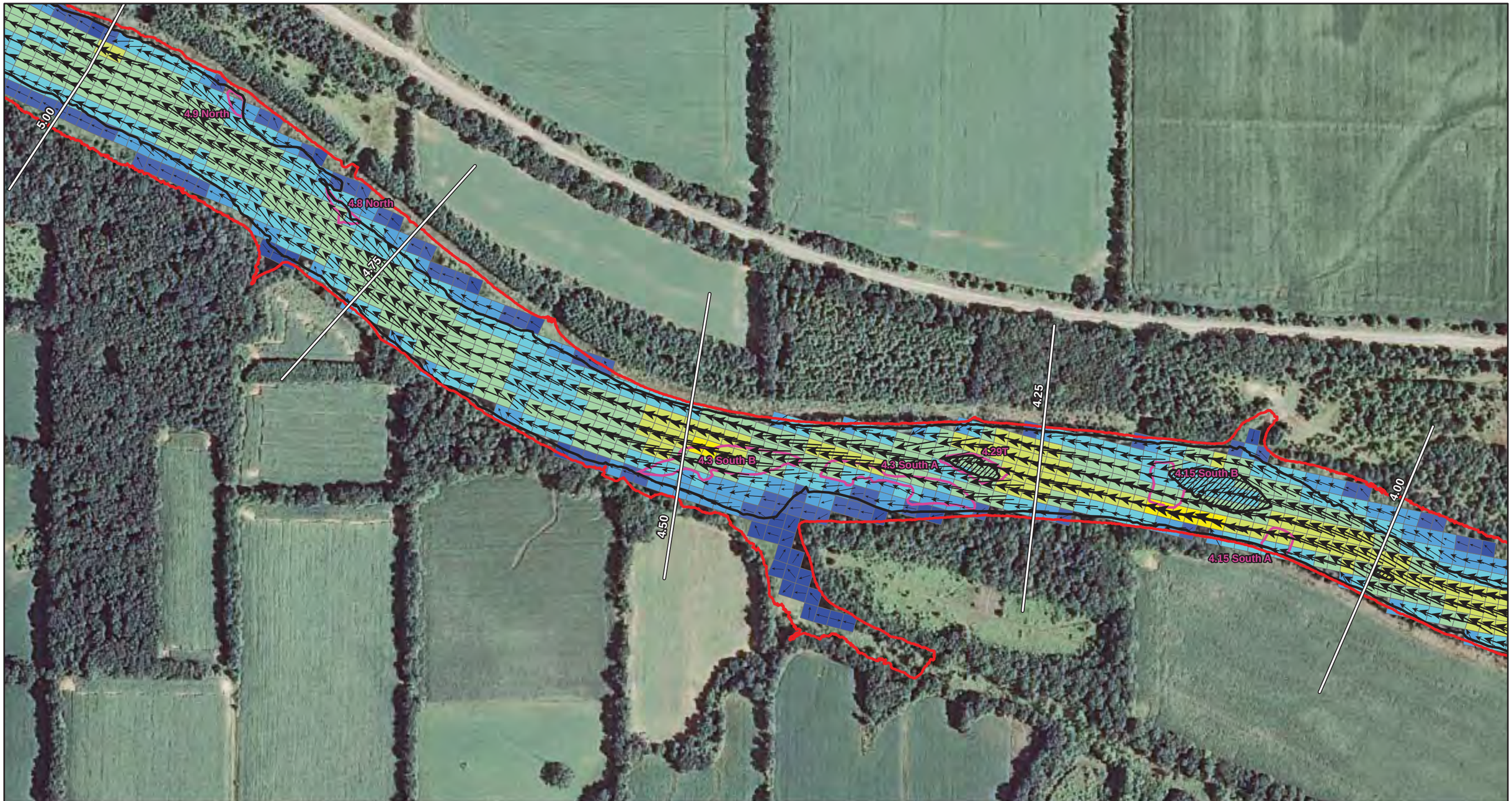
Aerial Photography Date: July & August 2009



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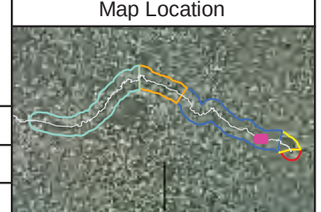

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FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
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MP 03.93 - MP 04.98

SHEET 3 OF 45

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

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Aerial Photography Date: July & August 2009

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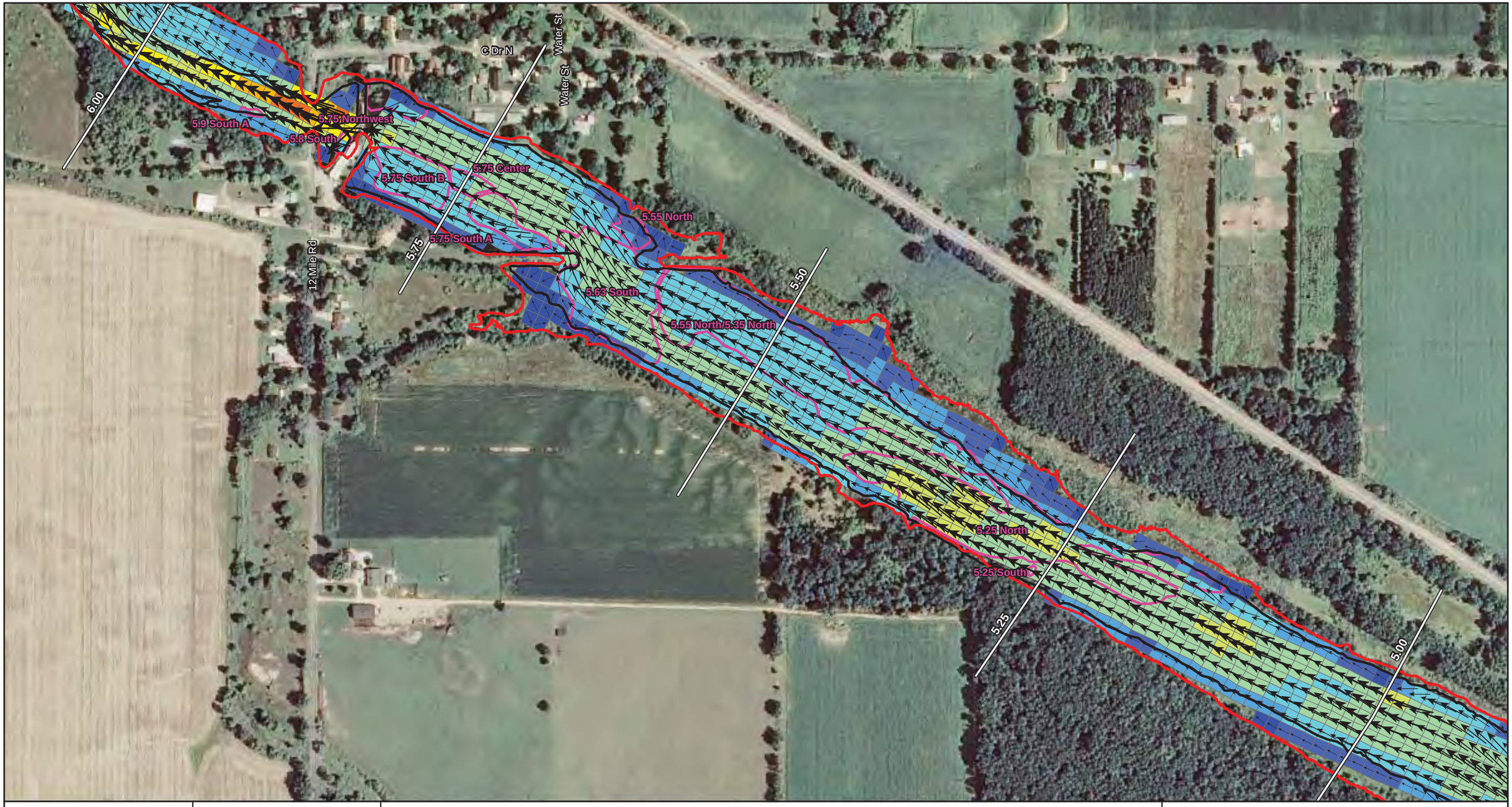

ENBRIDGE

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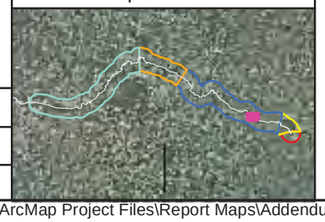

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Velocity (ft/sec)

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- 0.25 - 0.5 ft/sec
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- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

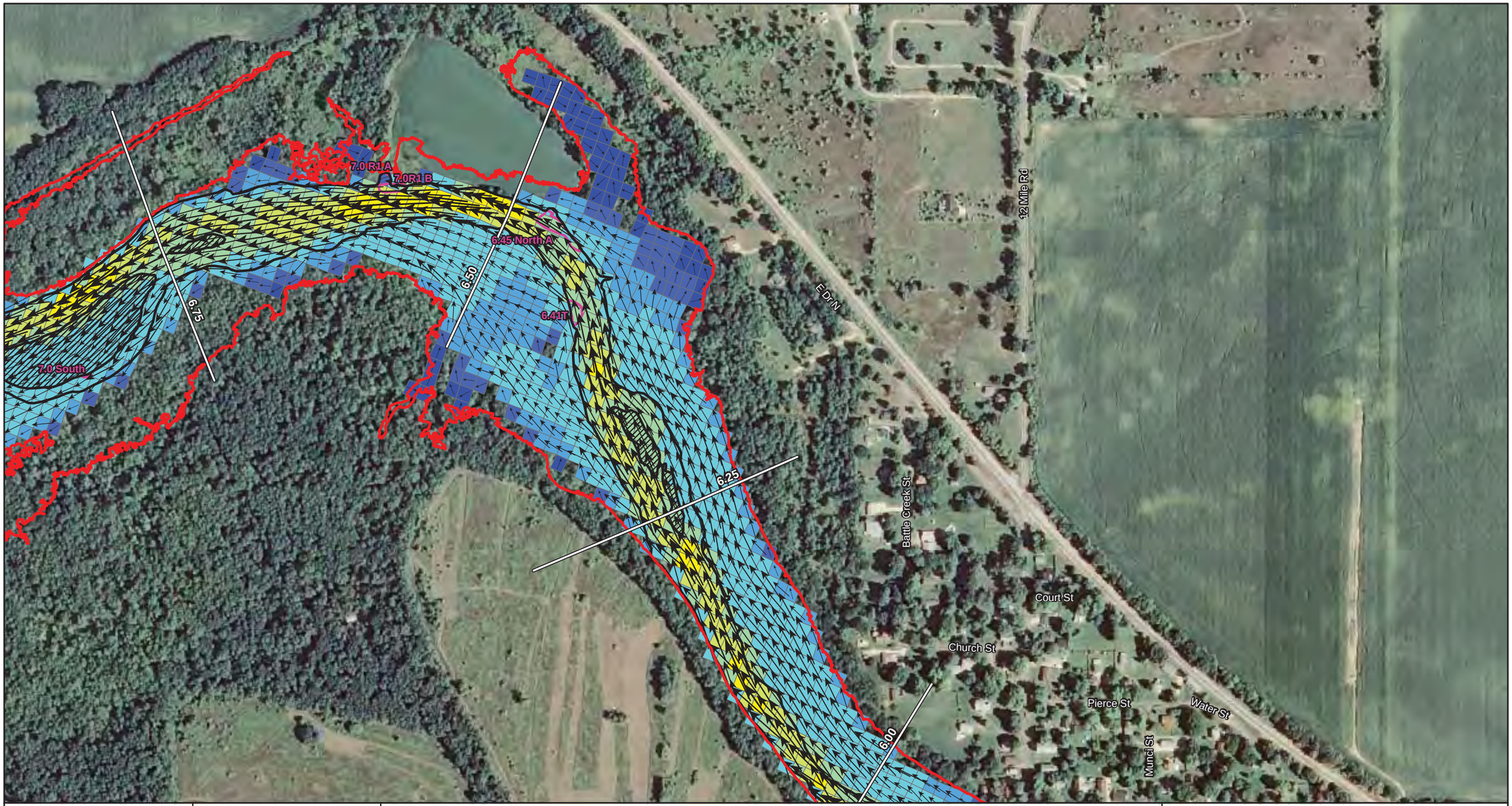
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 04.98 - MP 06.03

SHEET 4 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

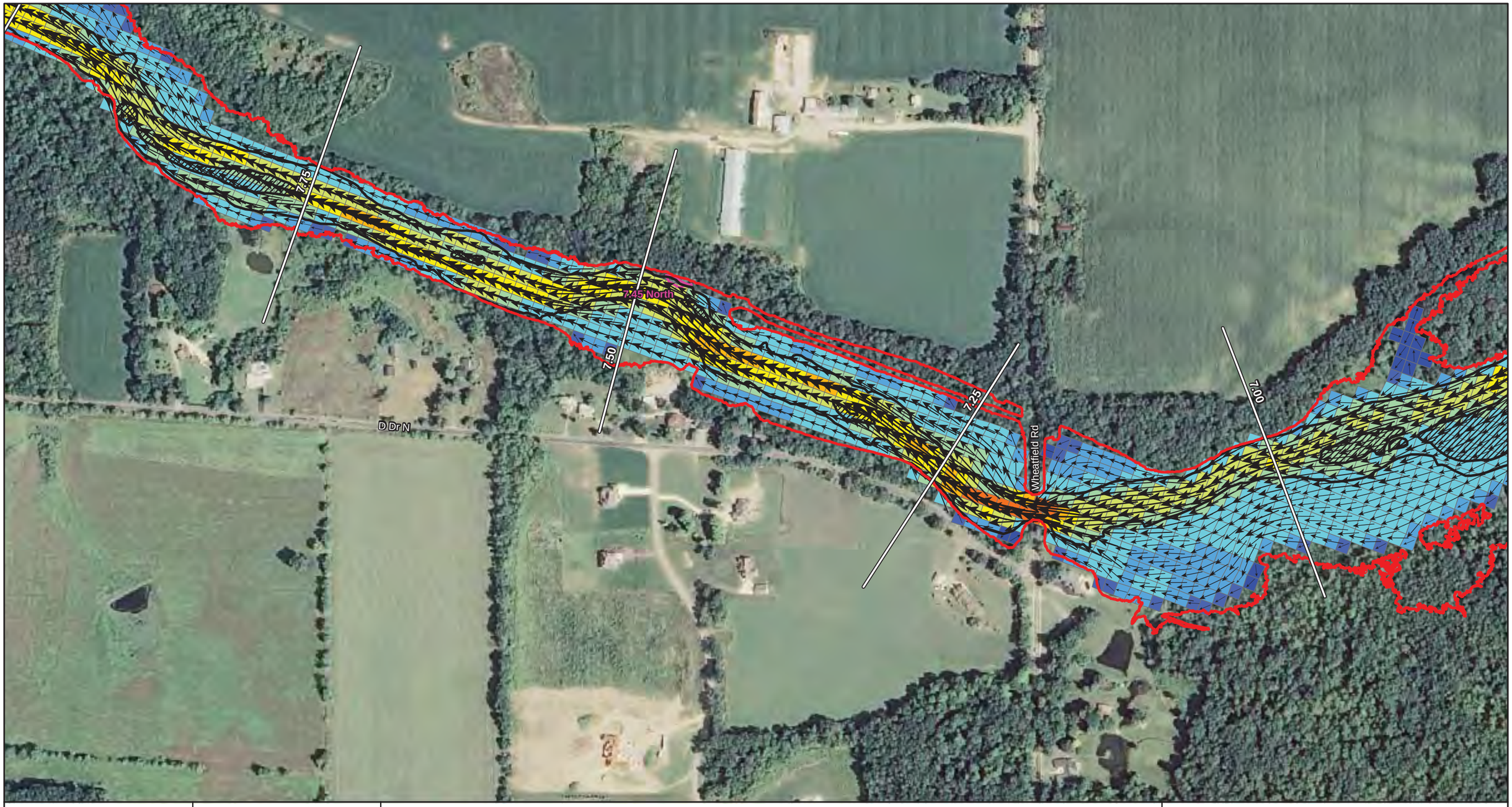
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 06.03 - MP 06.85

SHEET 5 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

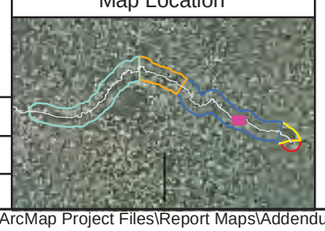
Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 06.85 - MP 07.95

SHEET 6 OF 45

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

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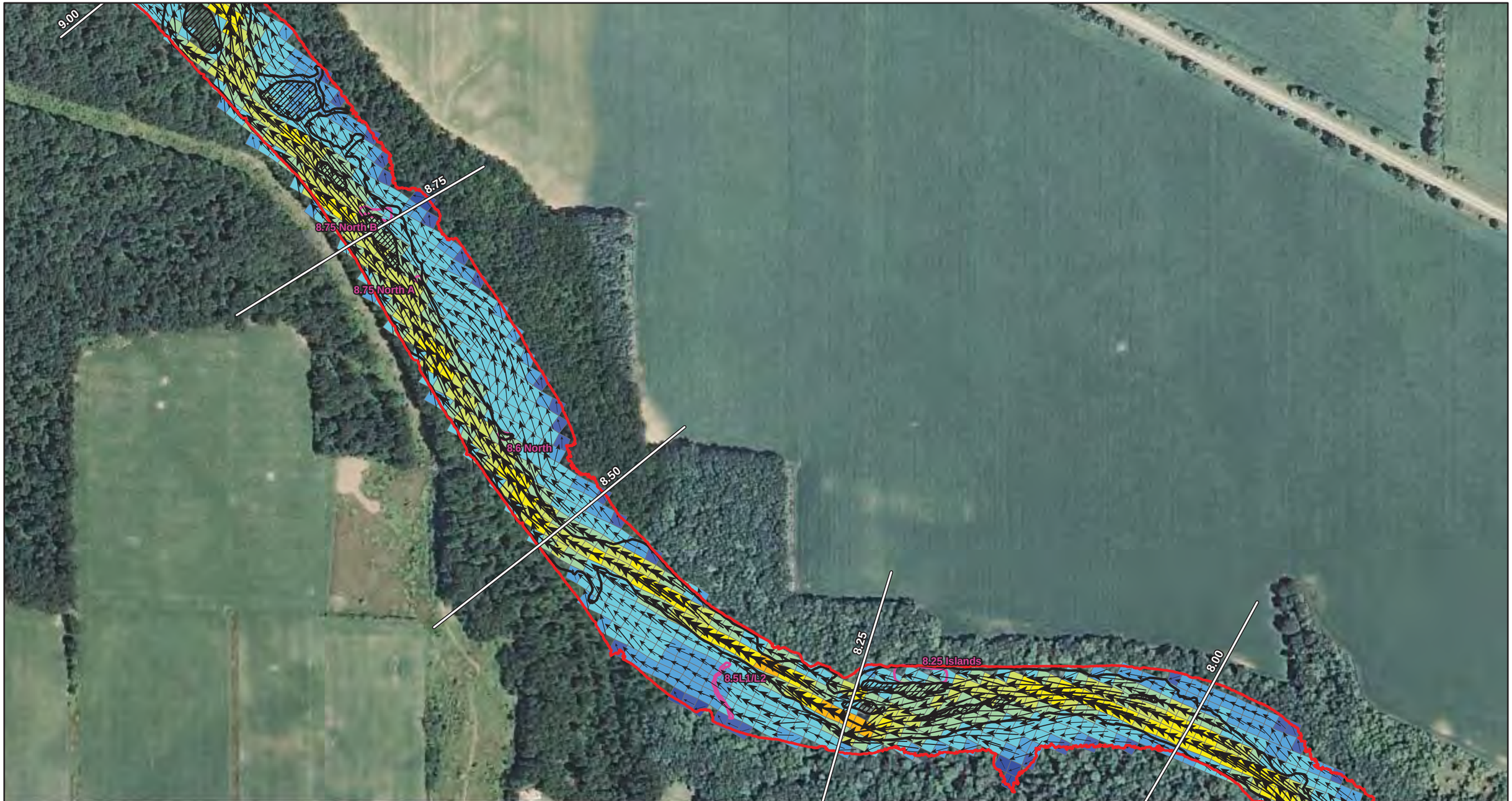
Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT



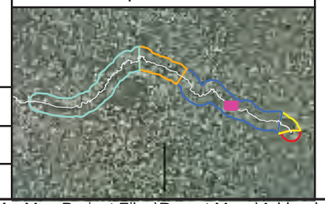
ENBRIDGE

Drawn: BRS 4/30/2012

Approved: DBR 4/30/2012

Project #: 106-4186

Map Location



Legend

Velocity (ft/sec)

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 07.95 - MP 08.93

SHEET 7 OF 45

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

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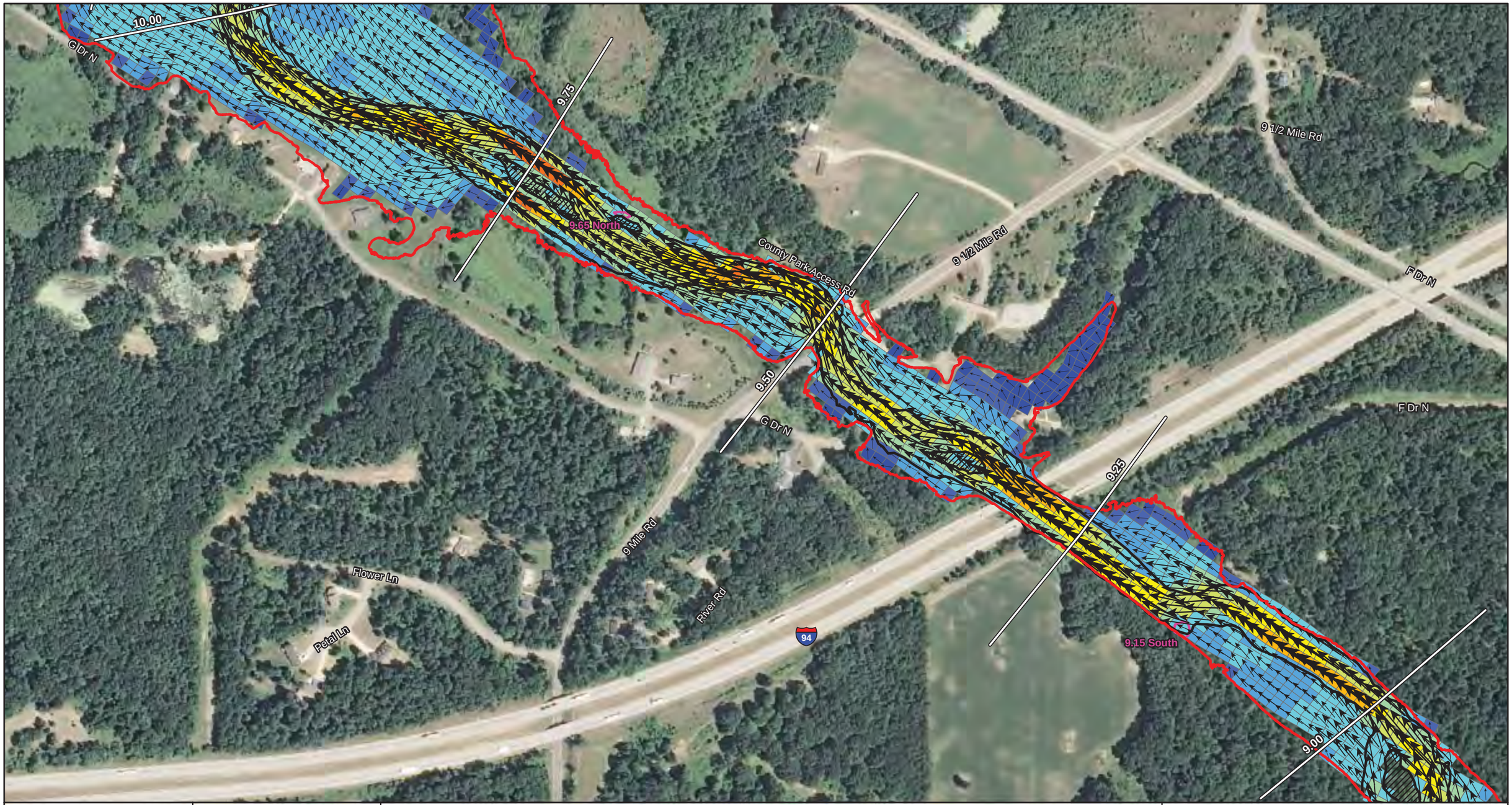
Aerial Photography Date: July & August 2009

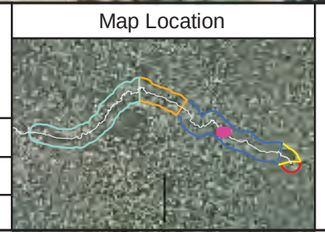
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 08.93 - MP 10.00

SHEET 8 OF 45

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

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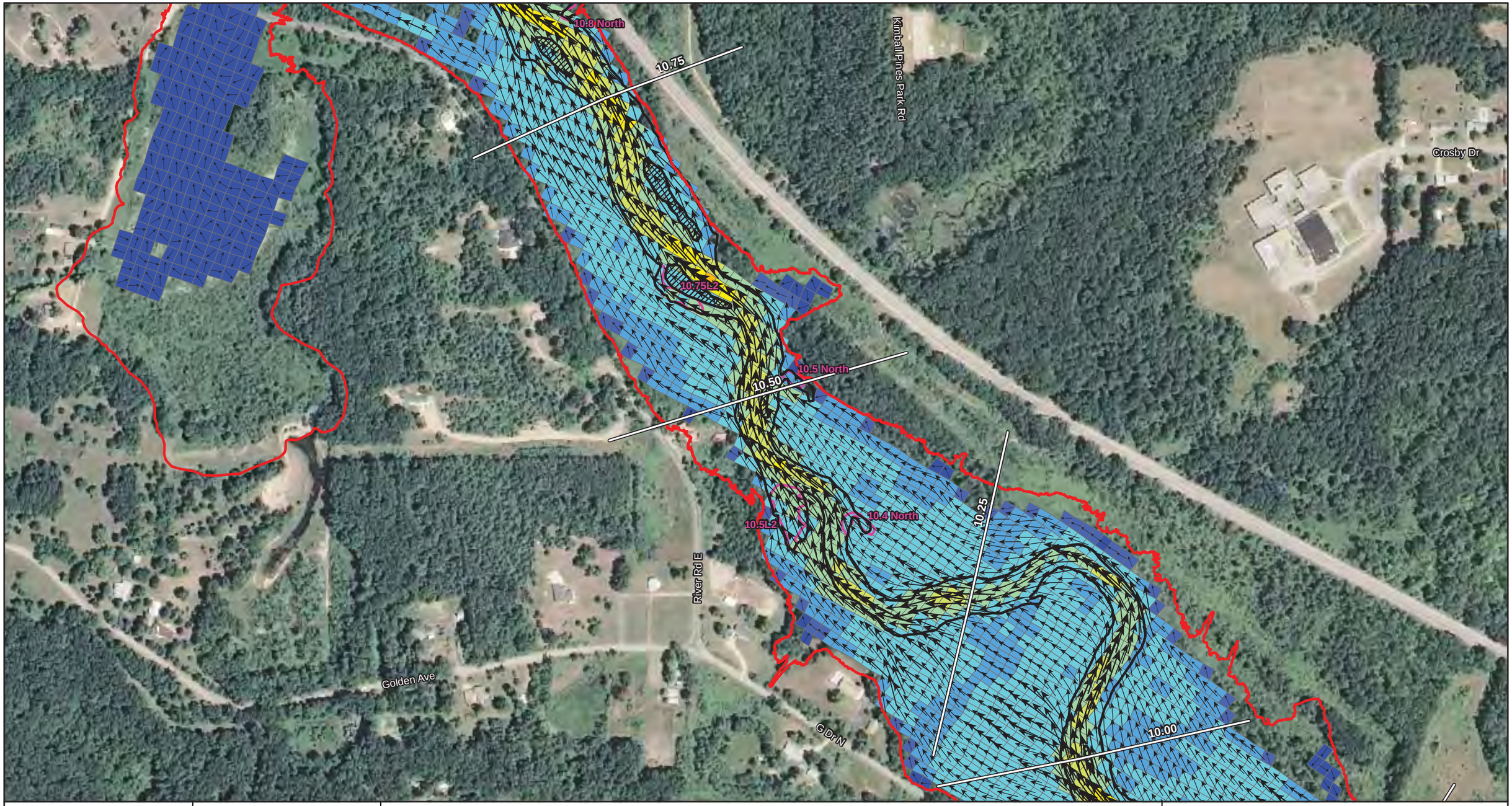
Aerial Photography Date: July & August 2009

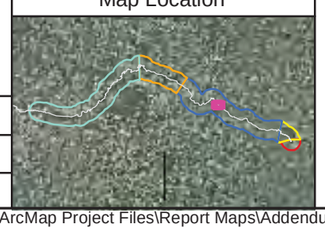
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 10.00 - MP 10.80

SHEET 9 OF 45

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

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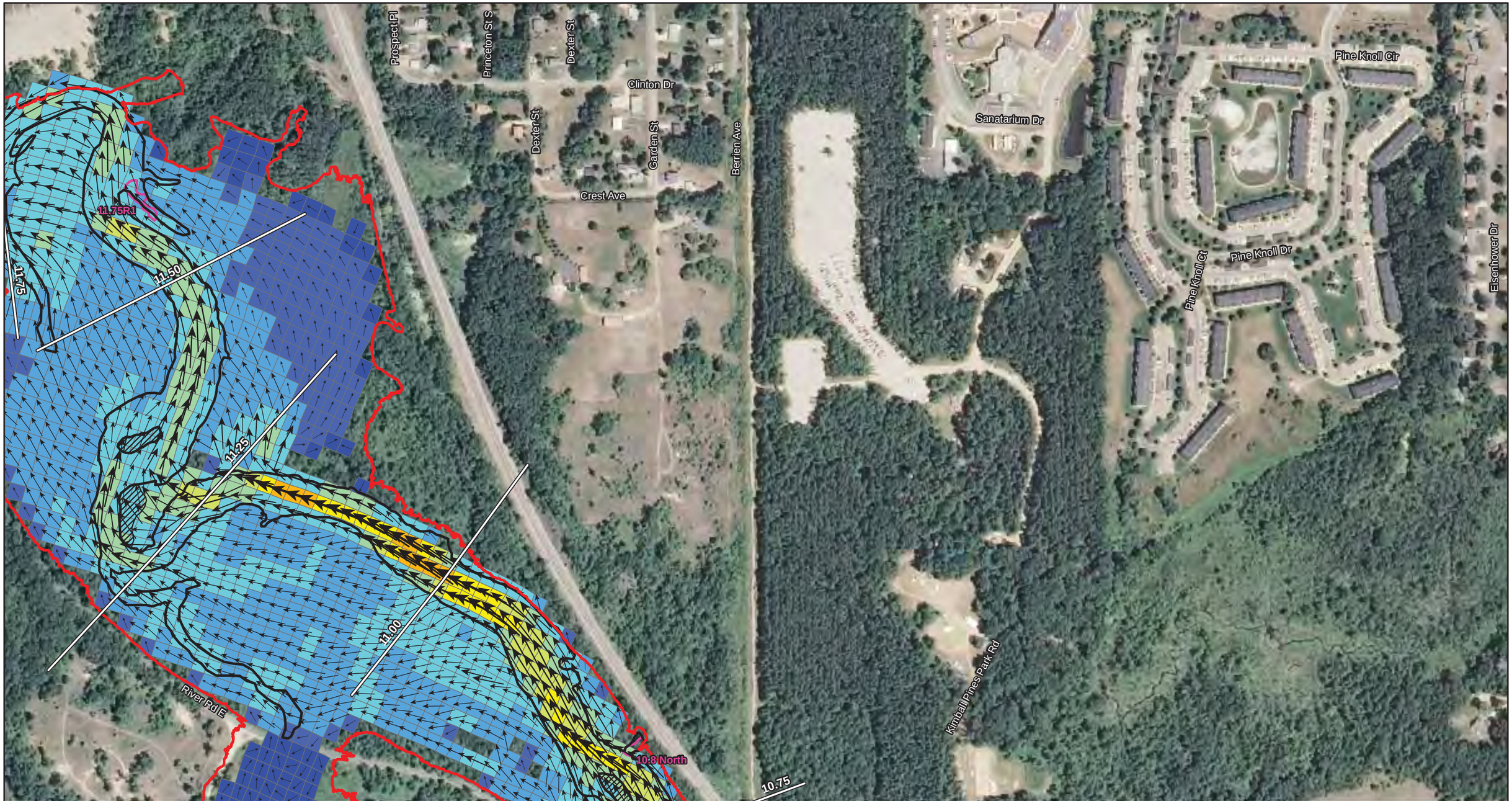
Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 10.80 - MP 11.70

SHEET 10 OF 45

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

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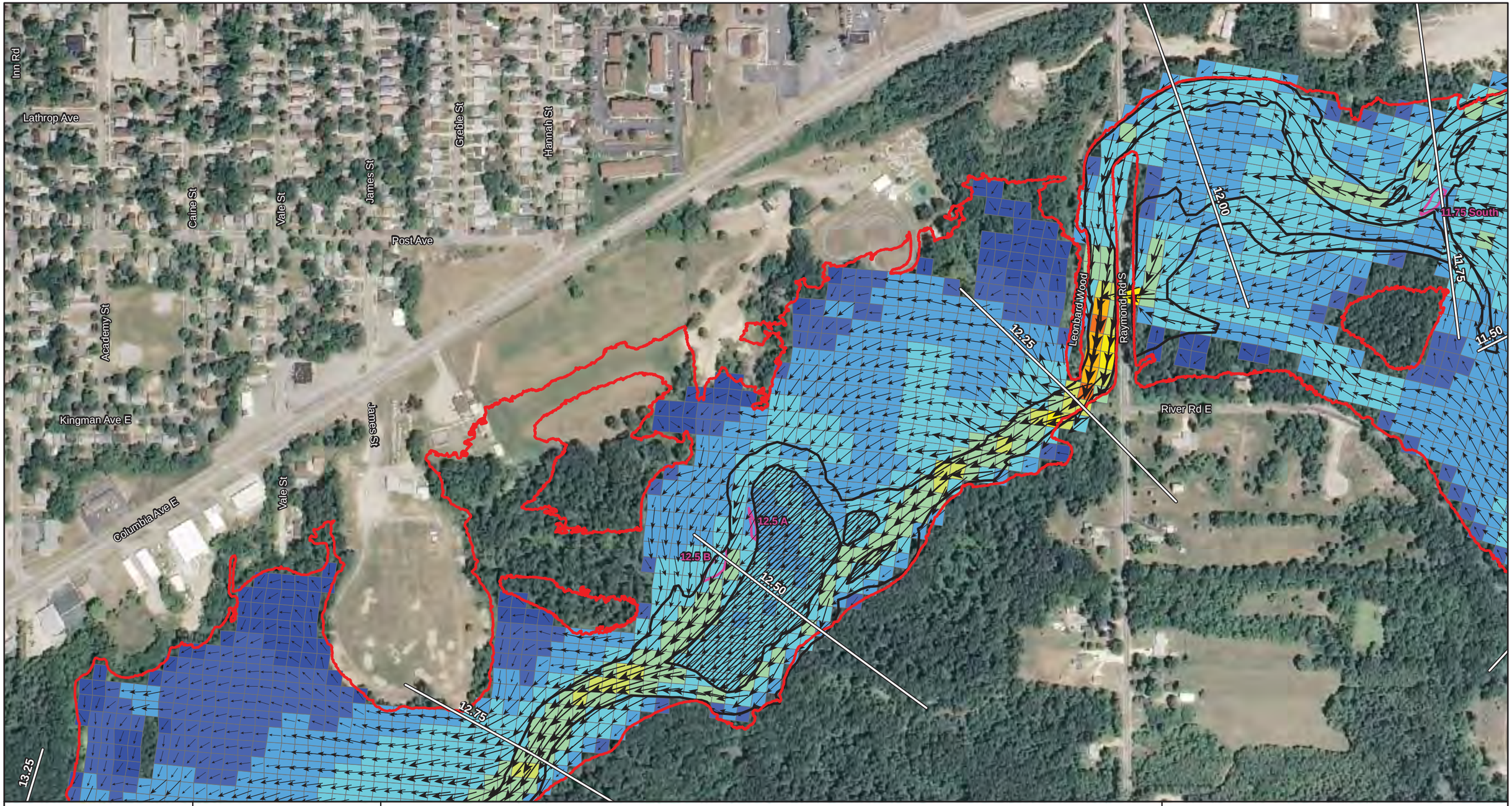
Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 11.70 - MP 12.77

SHEET 11 OF 45

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

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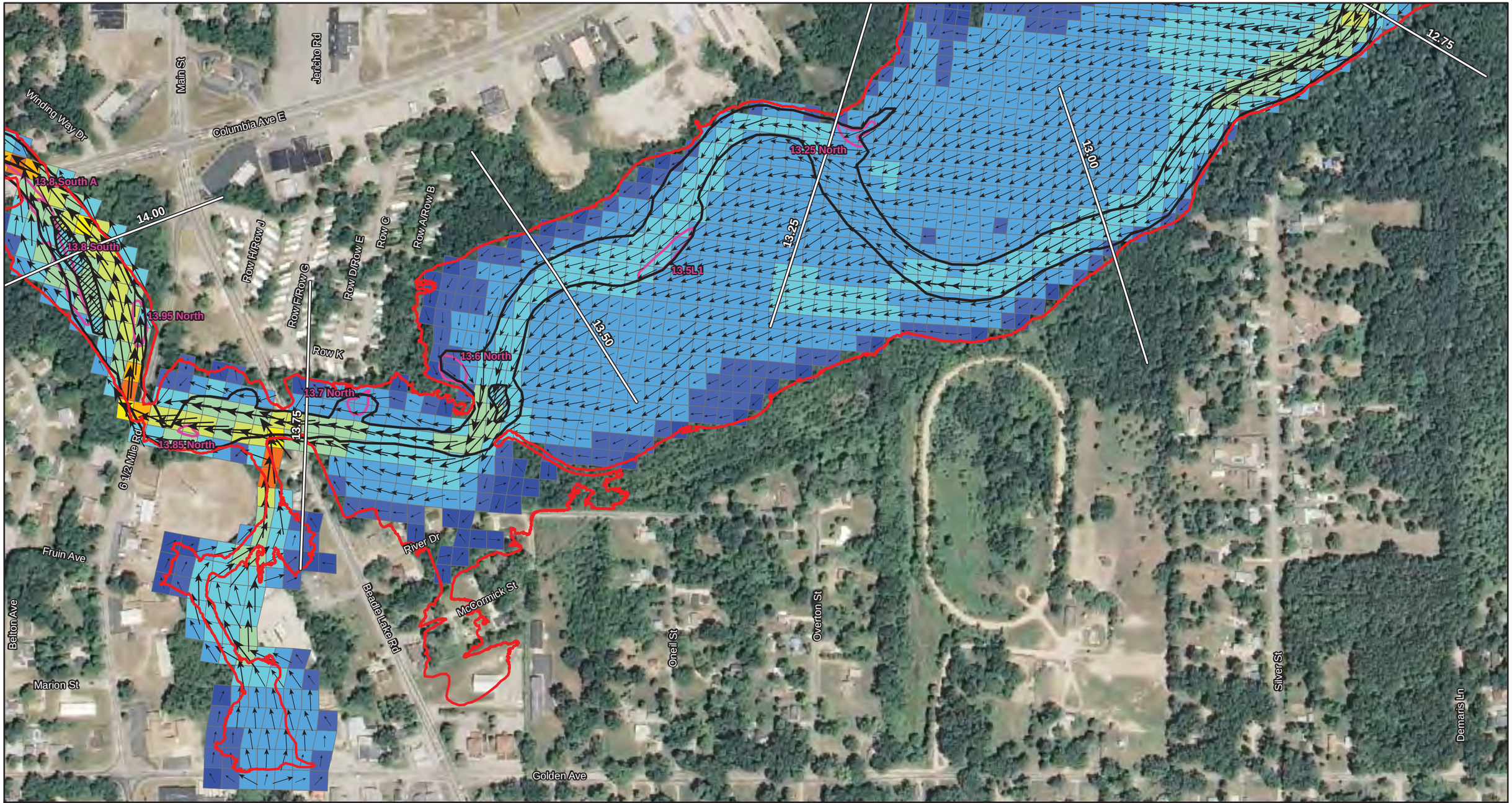
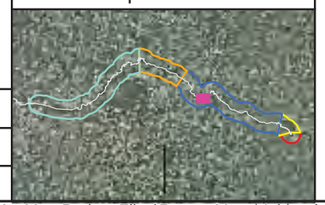
Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 12.77 - MP 14.00

SHEET 12 OF 45

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

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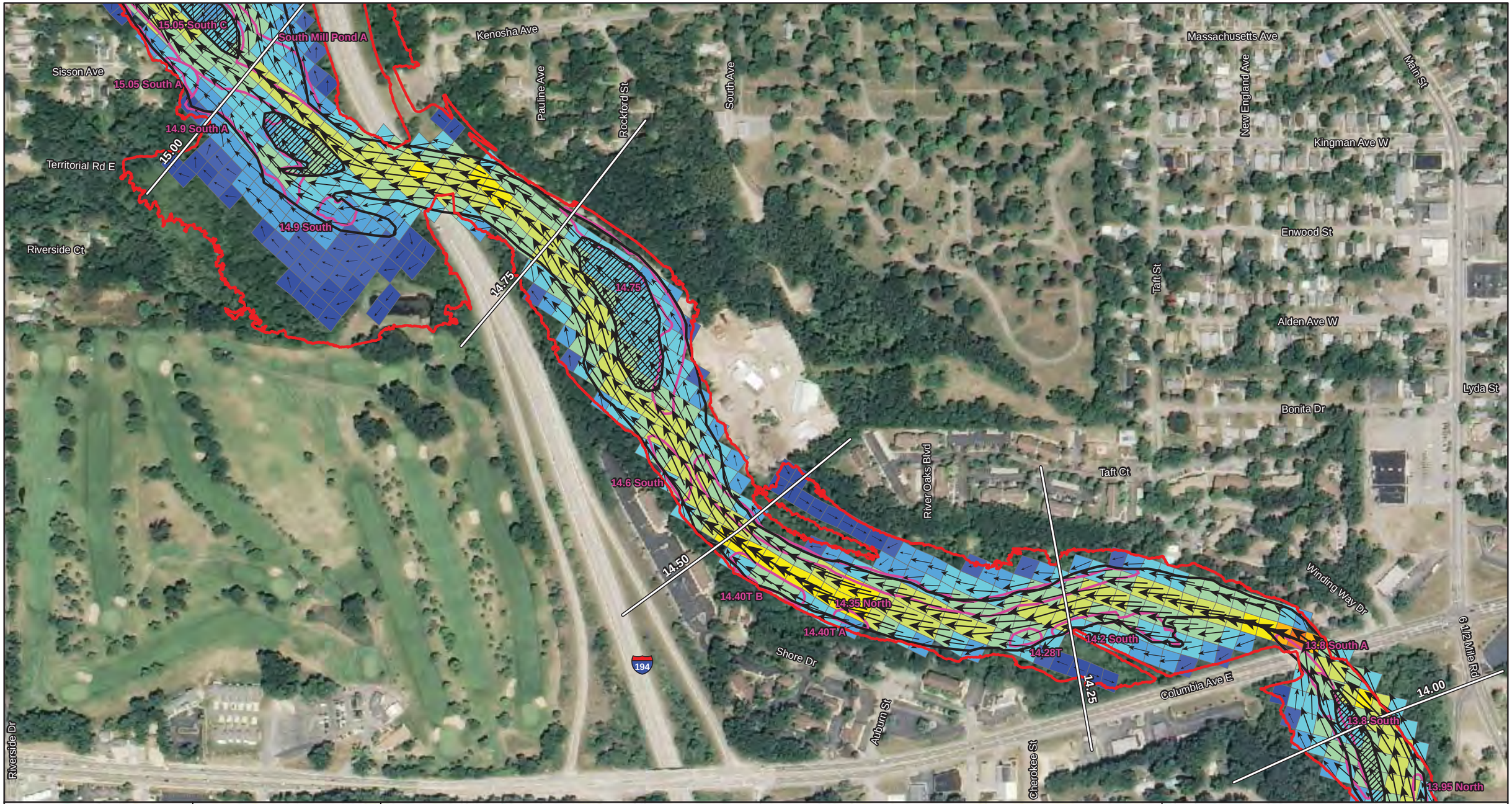
Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 14.00 - MP 15.05

SHEET 13 OF 45

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

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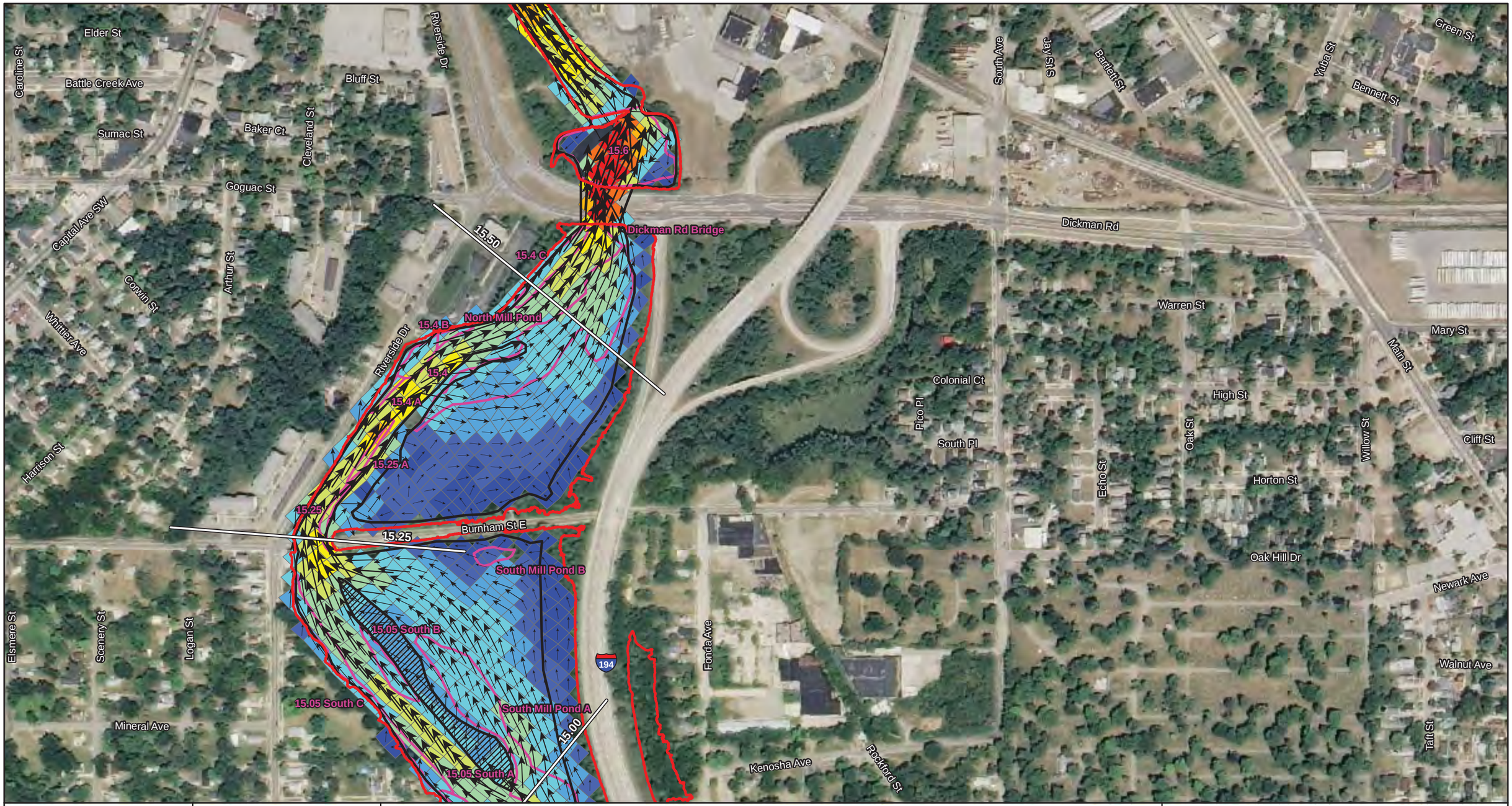
Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

N

0 175 350 700
Scale in Feet

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 15.05 - MP 15.71

SHEET 14 OF 45

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

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Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT

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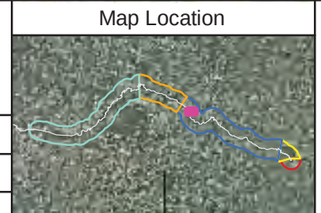
Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

N

0 175 350 700
Scale in Feet

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 15.71 - MP 16.38

SHEET 15 OF 45

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

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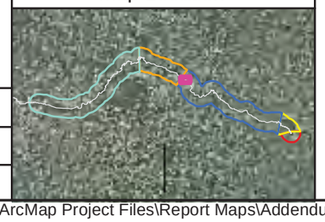
Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 16.38 - MP 17.30

SHEET 16 OF 45

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

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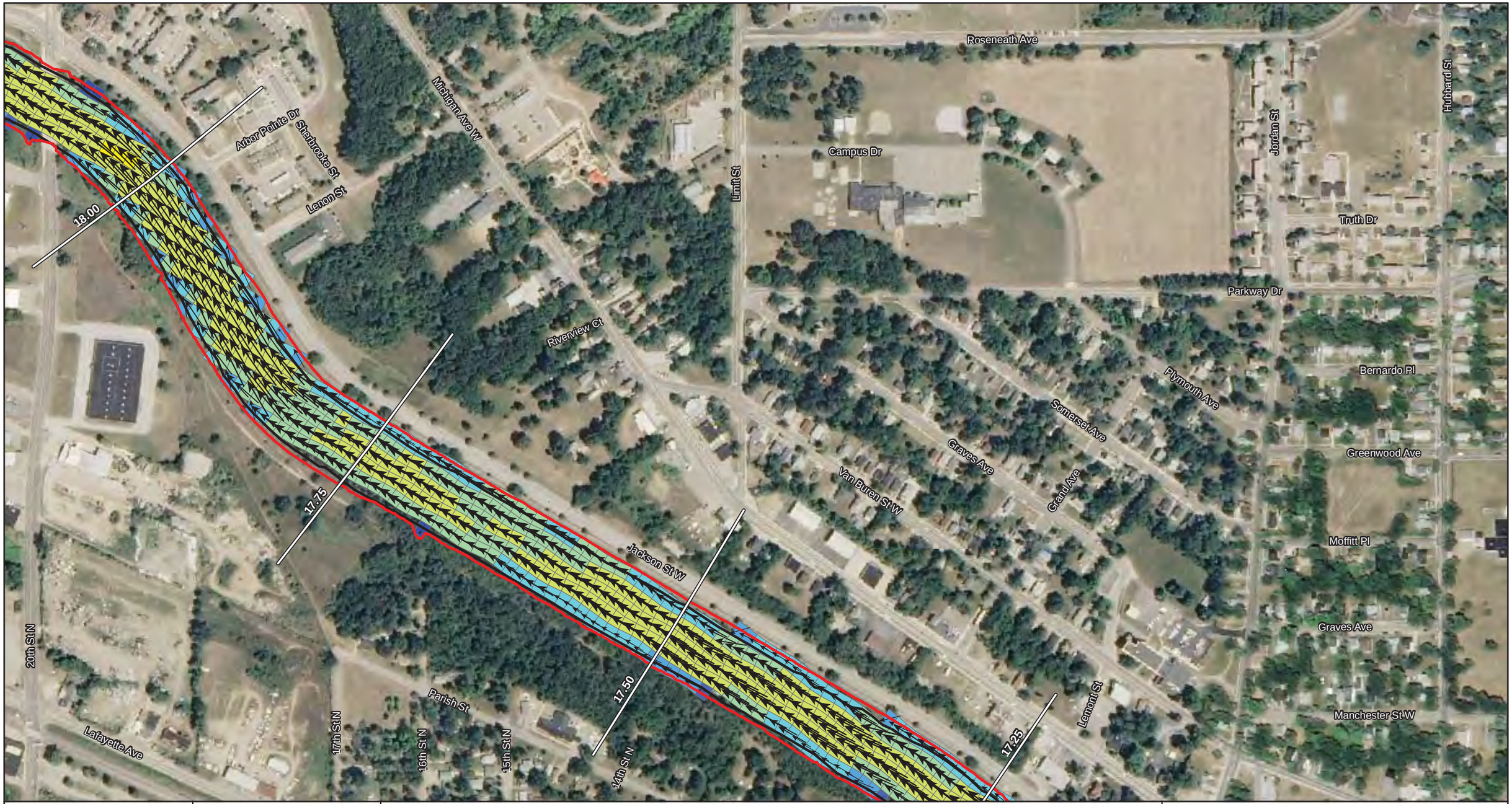
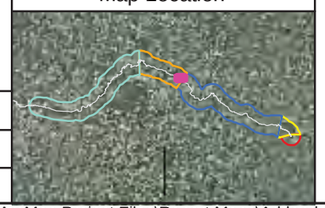
Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

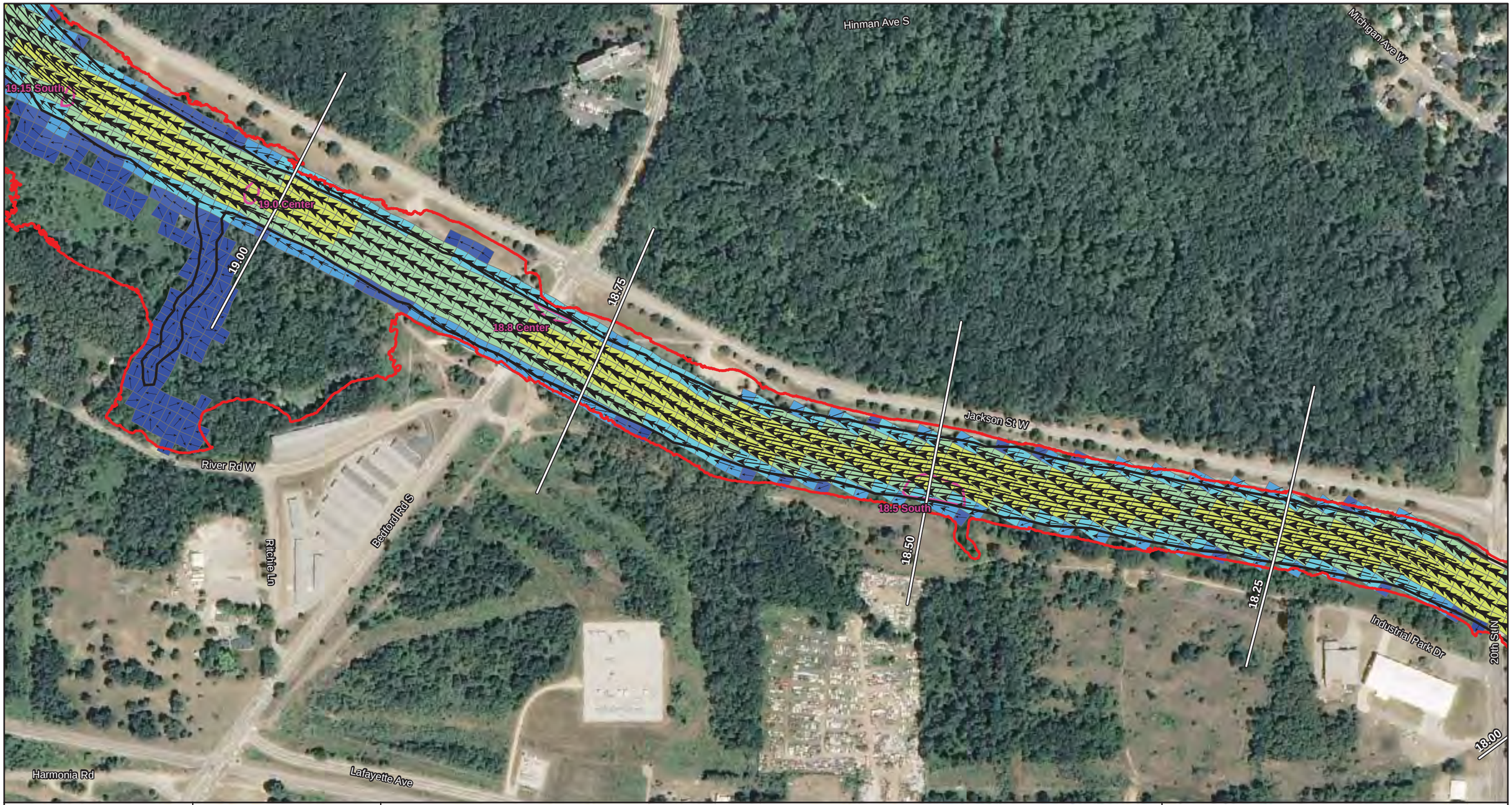
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 17.30 - MP 18.11

SHEET 17 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

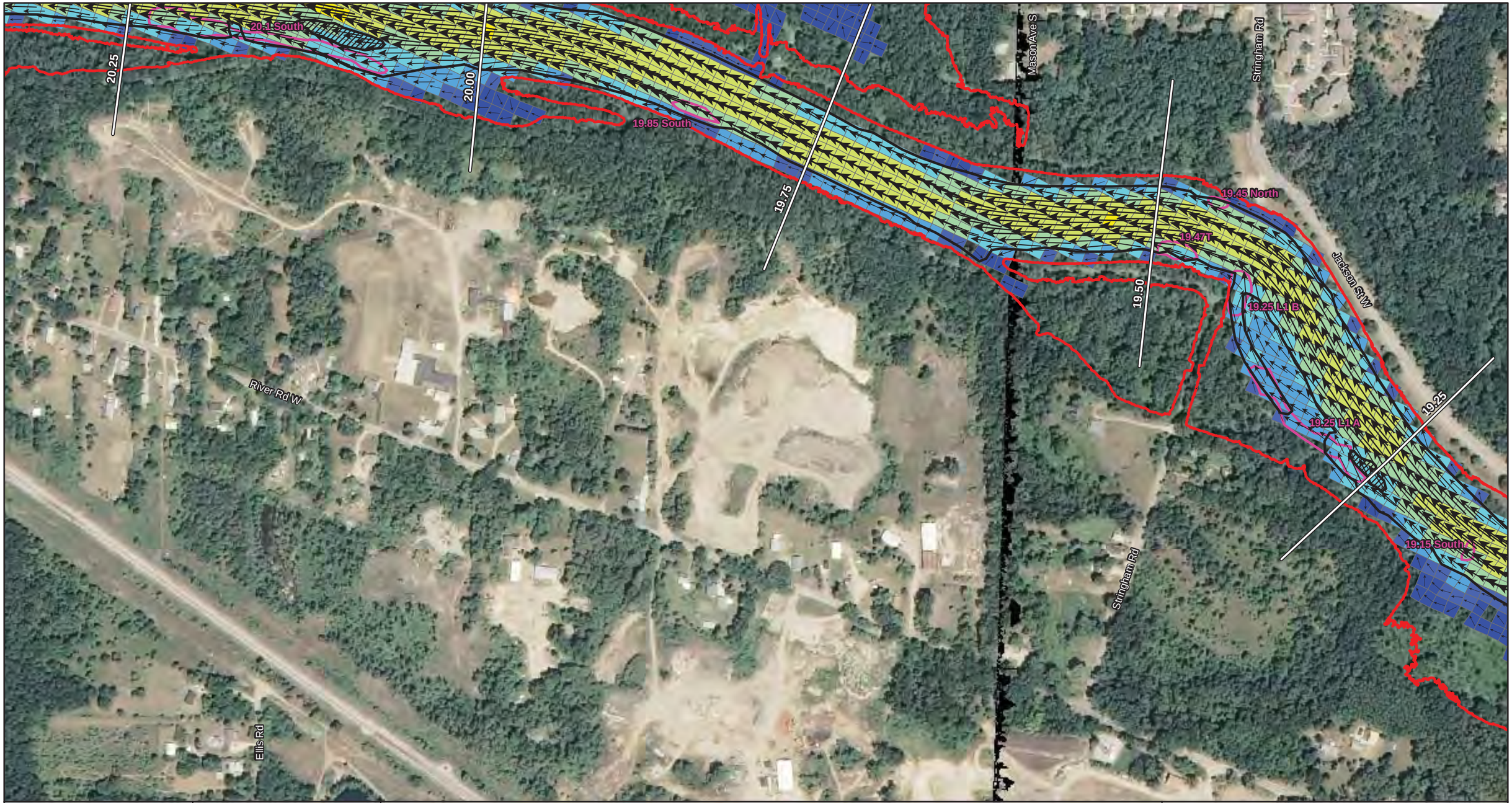
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 18.11 - MP 19.18

SHEET 18 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
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- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

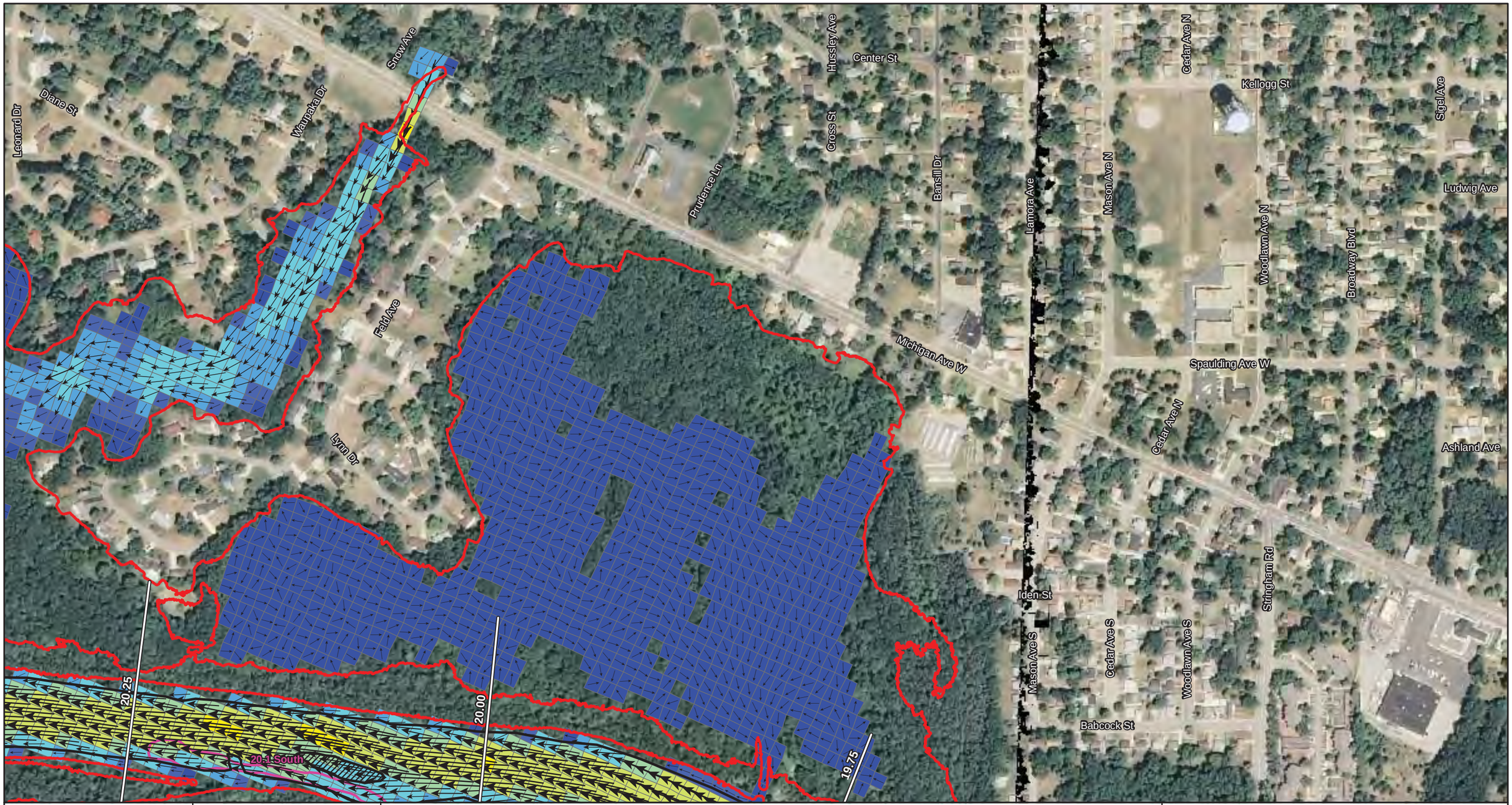
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 19.18 - MP 20.00

SHEET 19 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

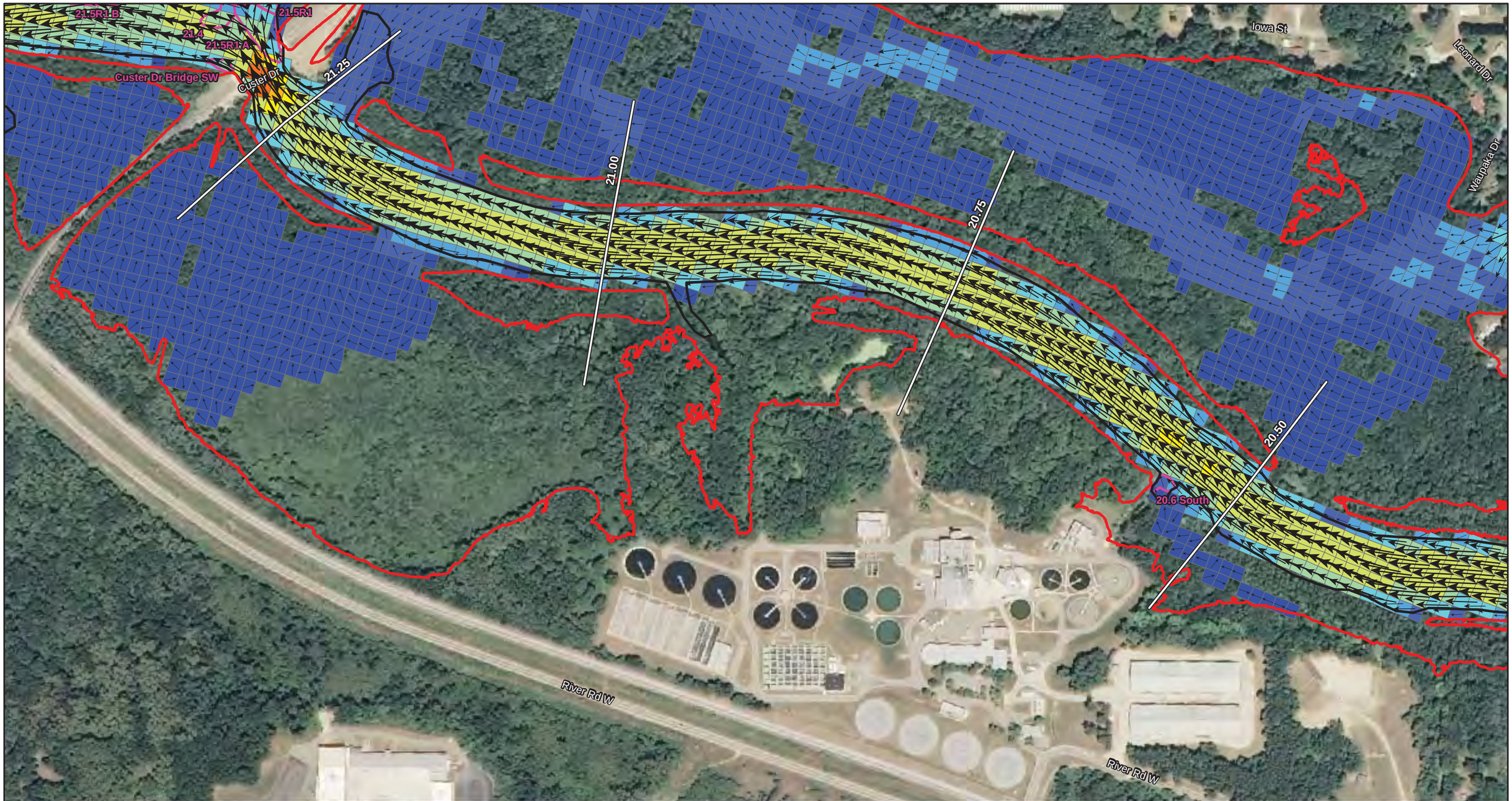
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 20.00 - MP 20.32

SHEET 20 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

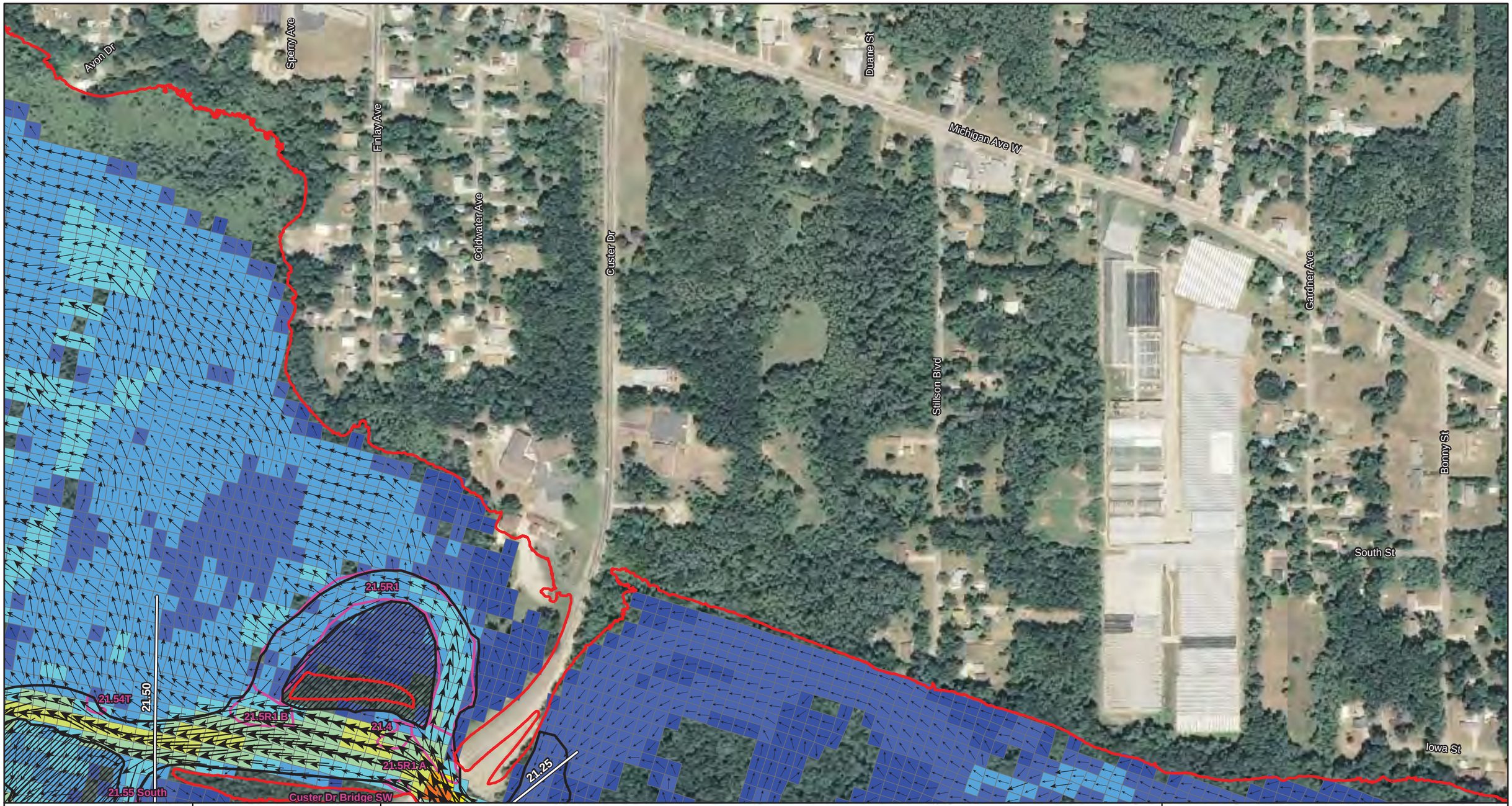
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 20.32 - MP 21.36

SHEET 21 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
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- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

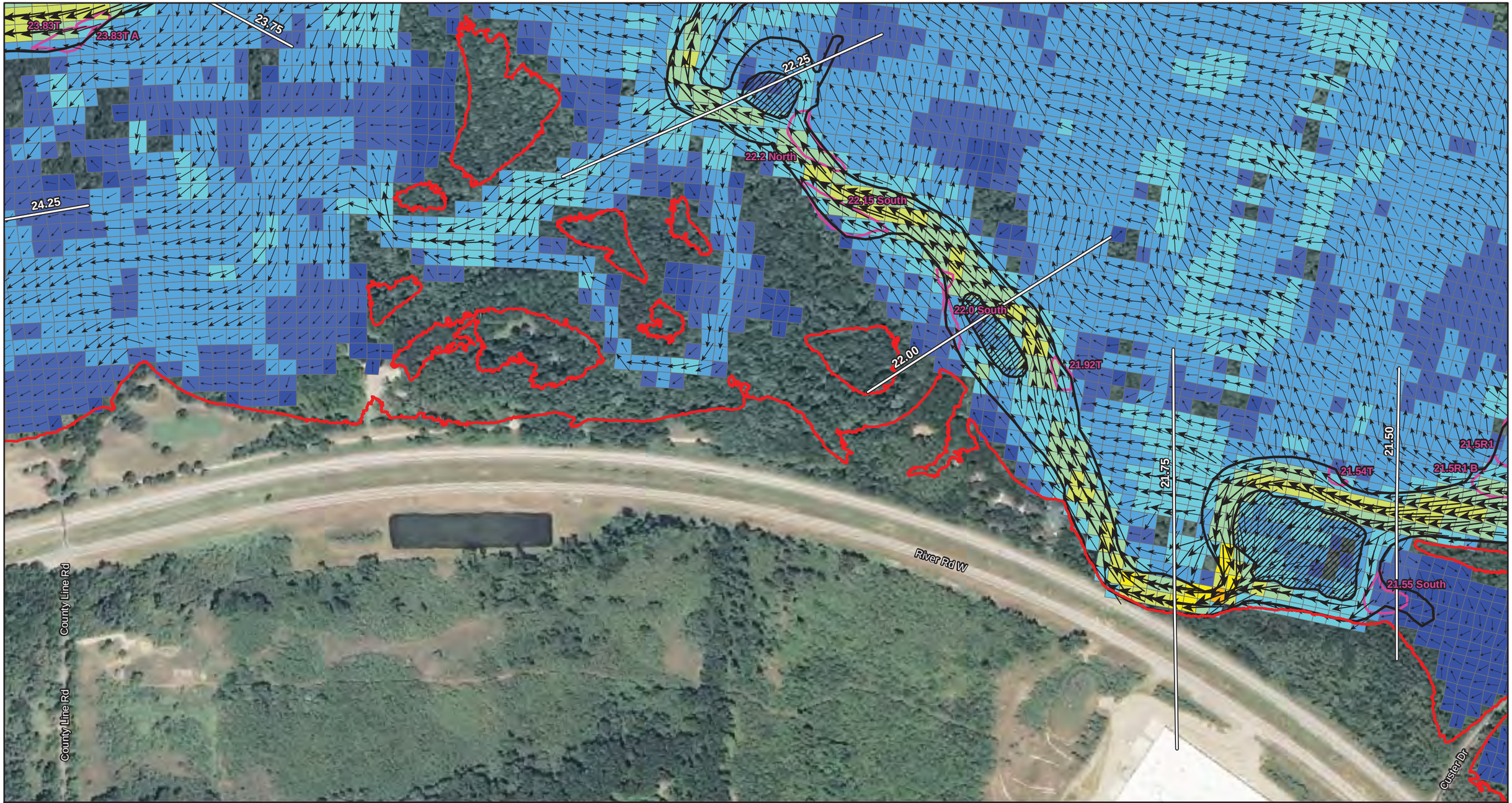
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 21.36 - MP 21.59

SHEET 22 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

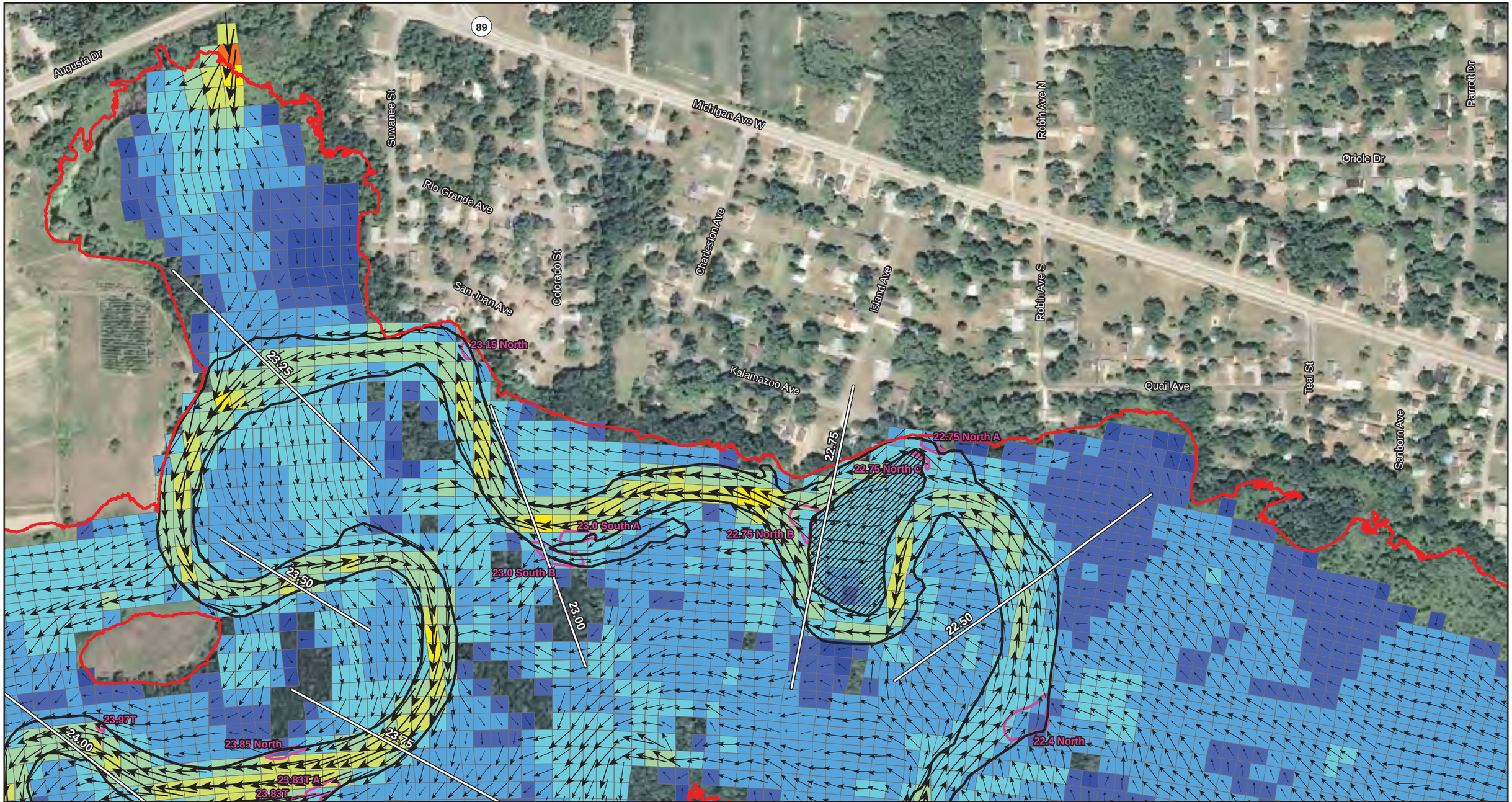
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 21.59 - MP 22.33

SHEET 23 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
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- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

N

0 175 350 700
Scale in Feet

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 22.33 - MP 24.01

SHEET 24 OF 45

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

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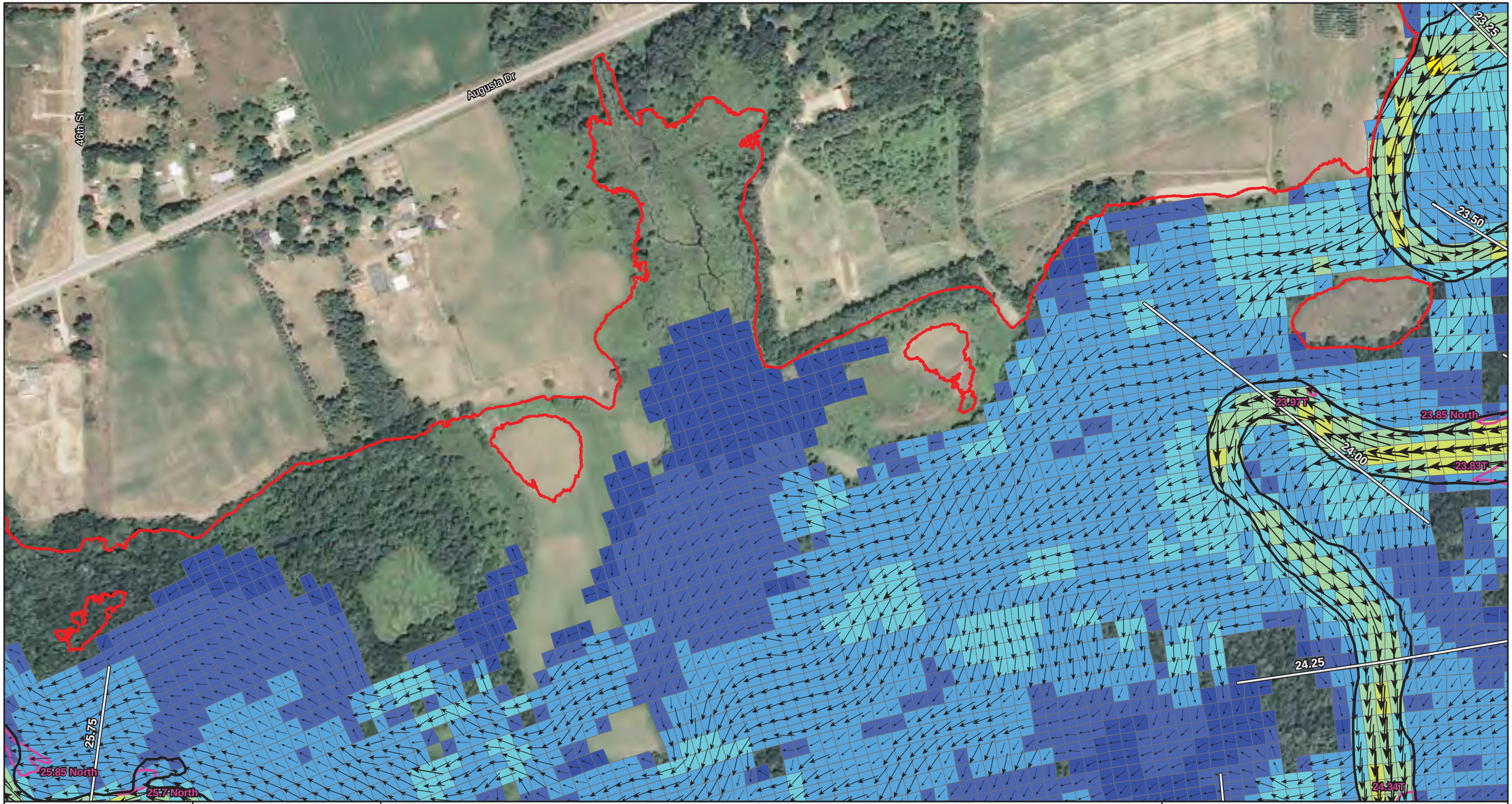
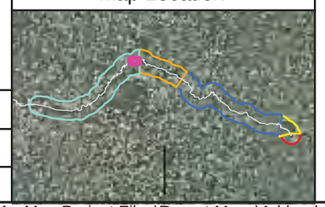
Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
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- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

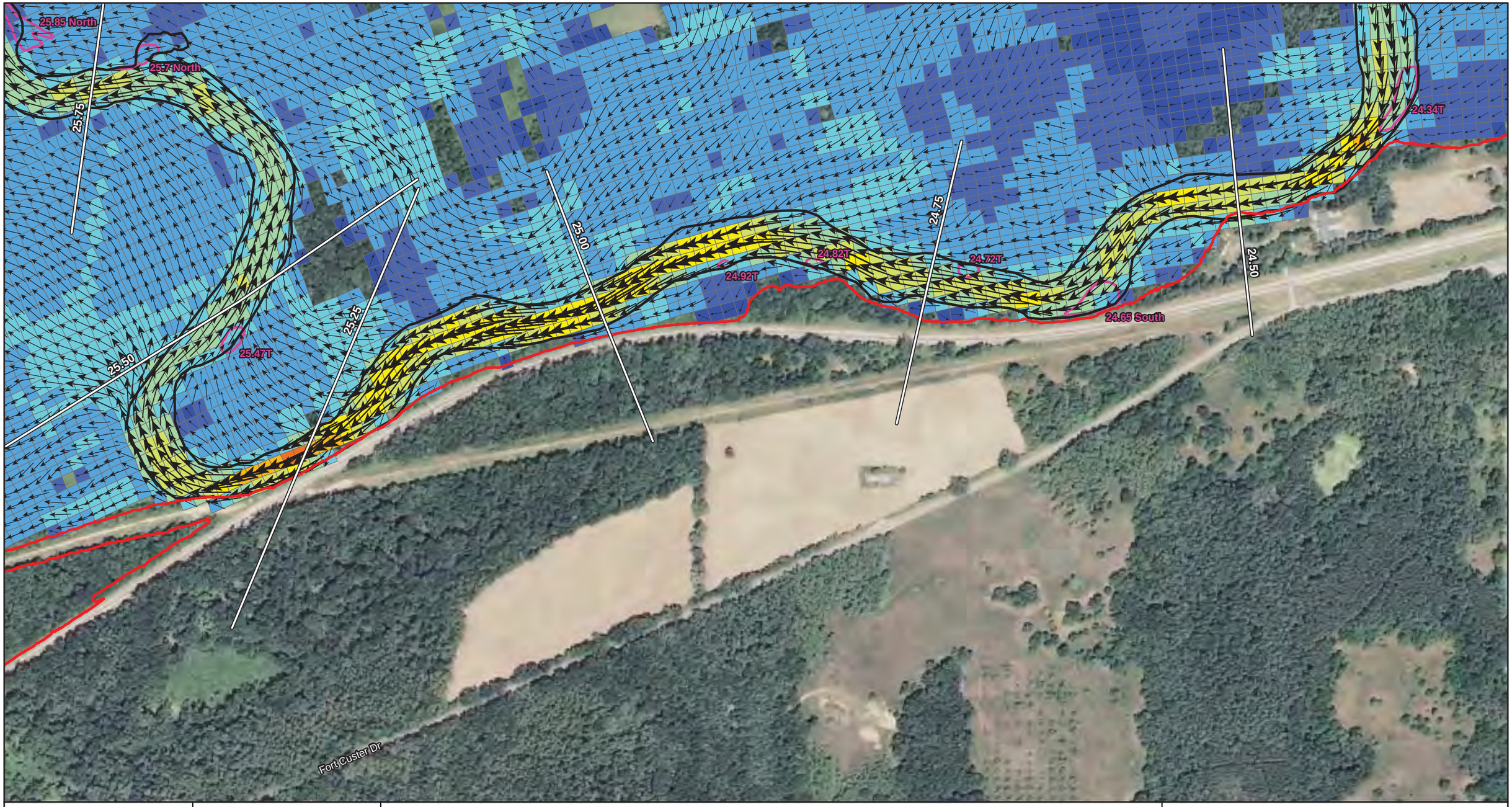
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 24.01 - MP 24.33

SHEET 25 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



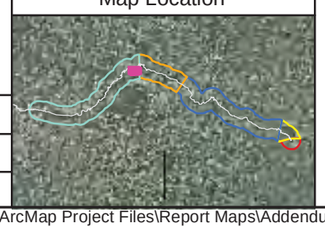
ENBRIDGE

Drawn: BRS 4/30/2012

Approved: DBR 4/30/2012

Project #: 106-4186

Map Location



Legend

Velocity (ft/sec)

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- 0.1 - 0.25 ft/sec
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- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 24.33 - MP 25.79

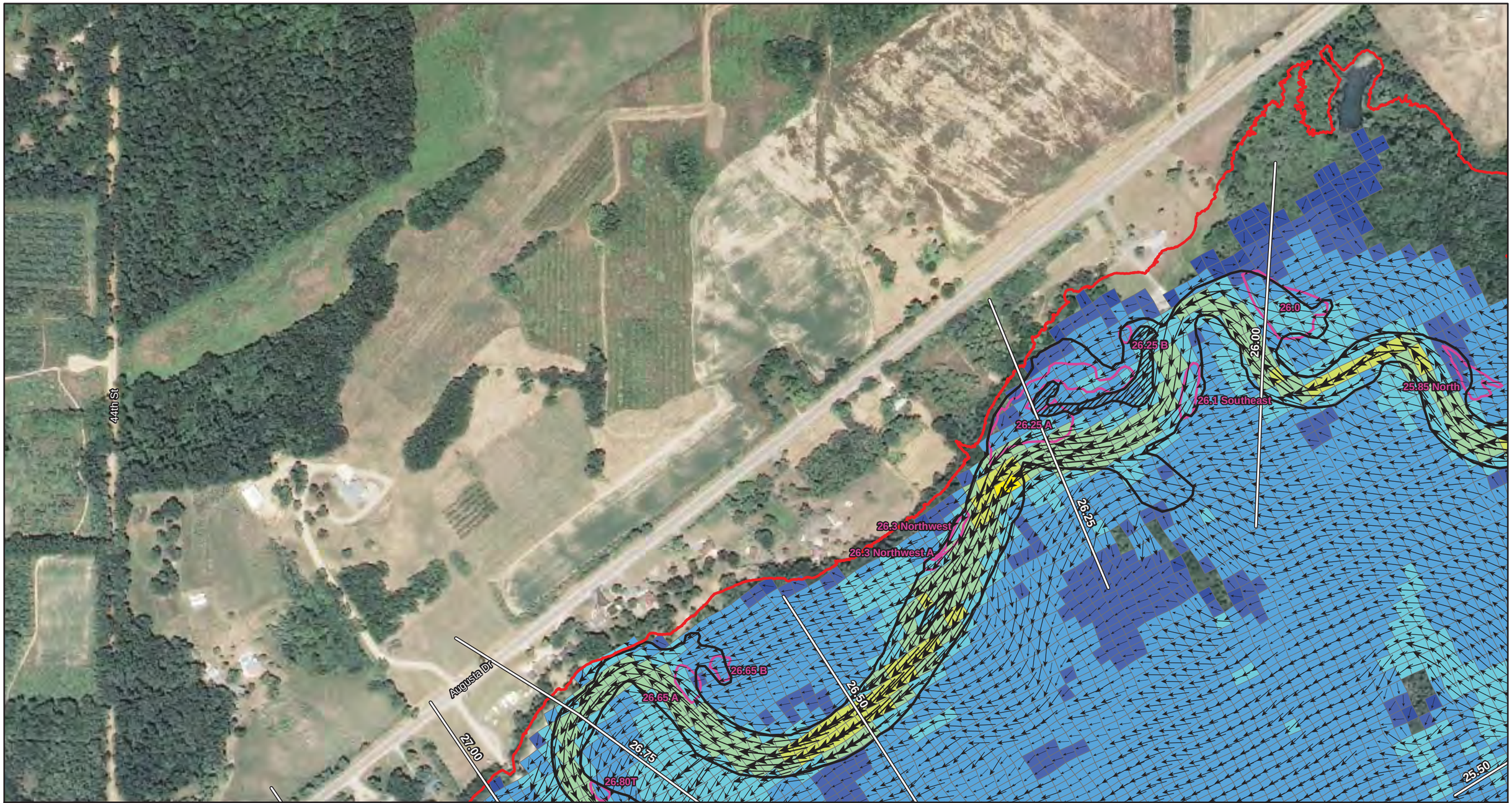
SHEET 26 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

N

0 175 350 700
Scale in Feet

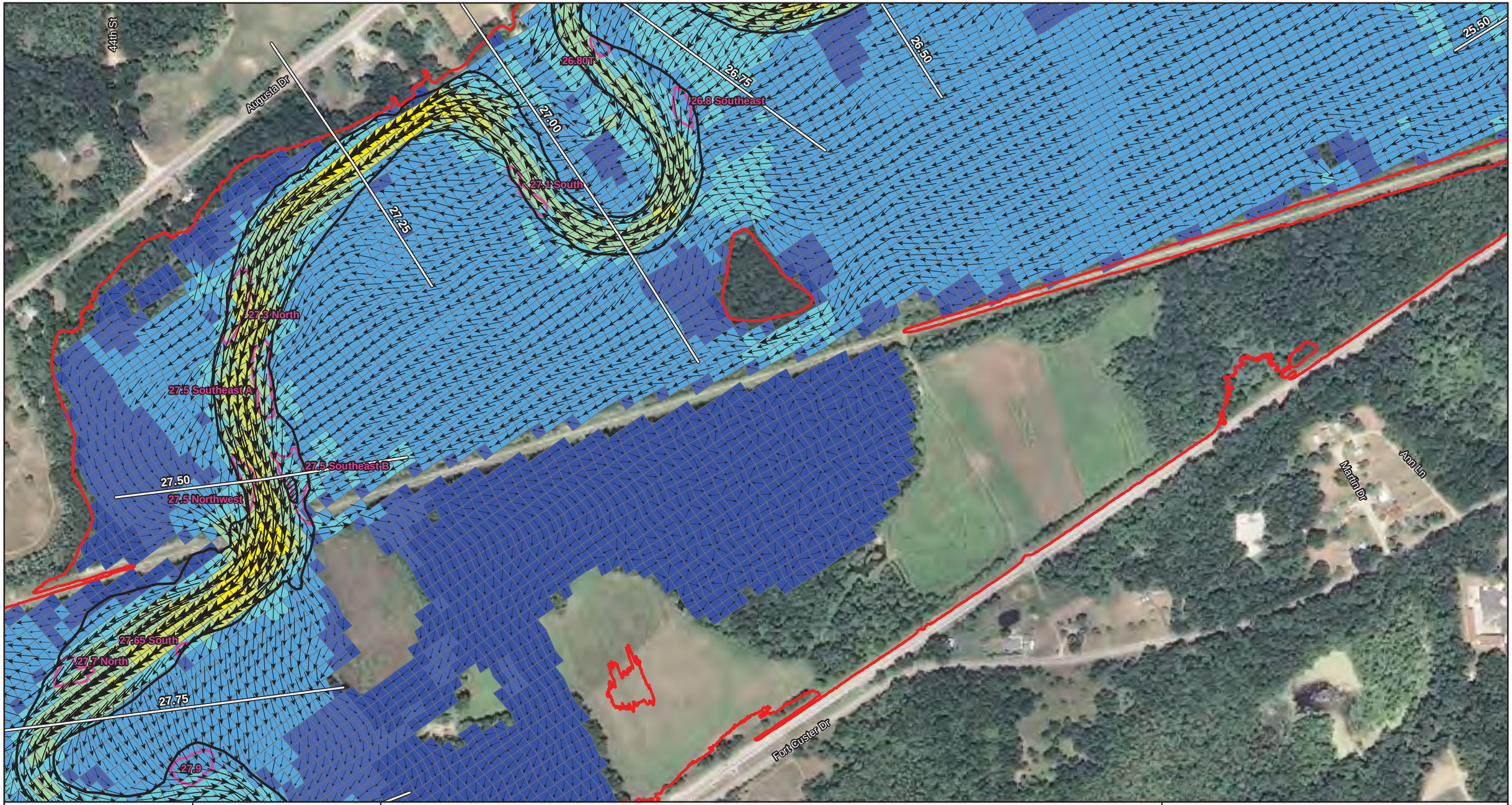
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 24.33 - MP 25.79

SHEET 27 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

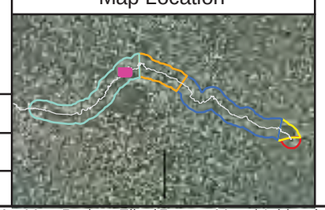
Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
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- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
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- 3.0 - 4.0 ft/sec
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- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
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N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 26.80 - MP 27.80

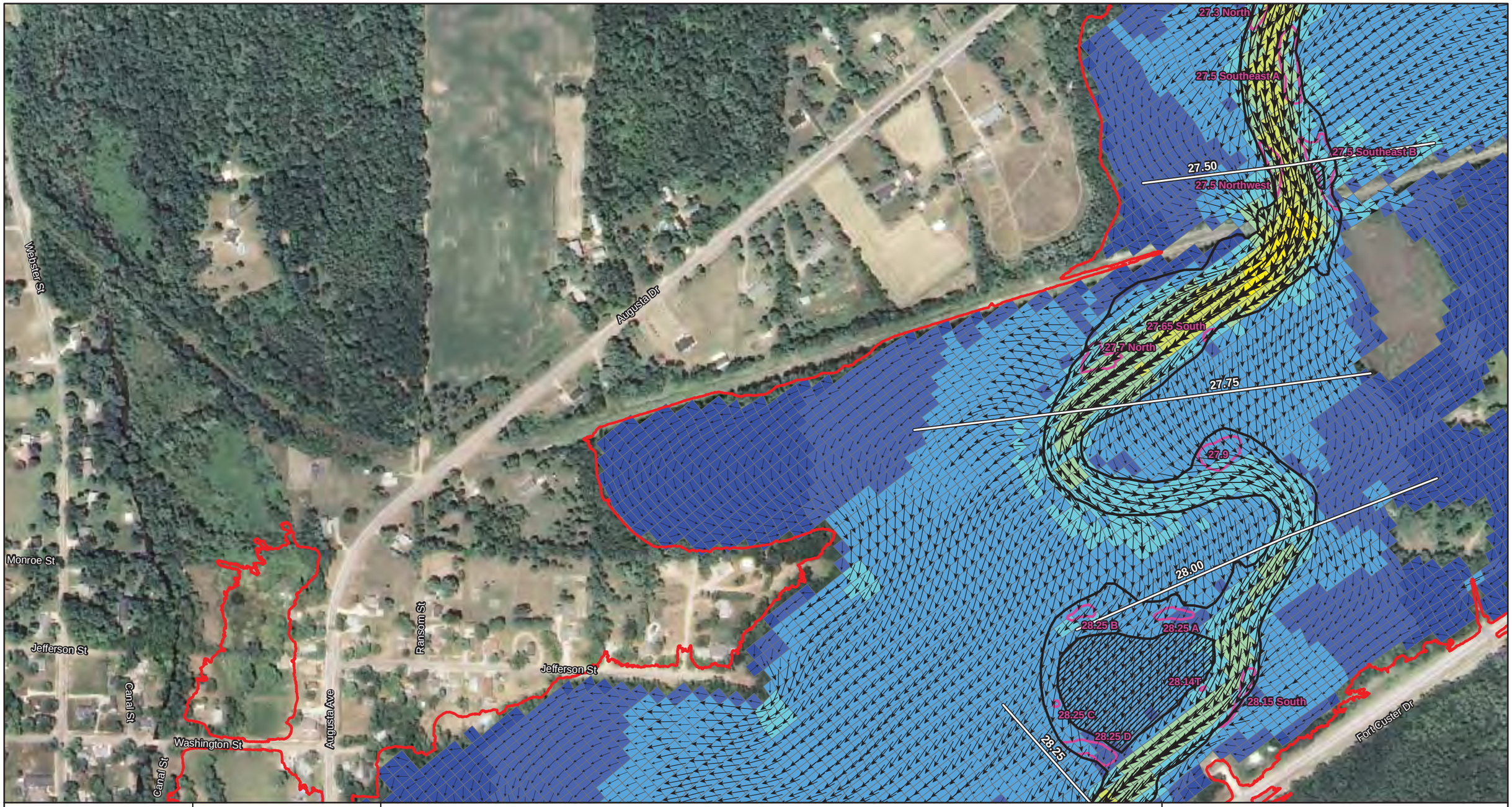
SHEET 28 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009

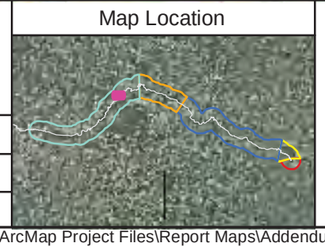
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
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N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 26.80 - MP 27.80

SHEET 29 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009

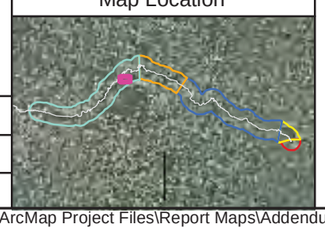
ENBRIDGE

Drawn: BRS 4/30/2012

Approved: DBR 4/30/2012

Project #: 106-4186

Map Location



Legend

Velocity (ft/sec)

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

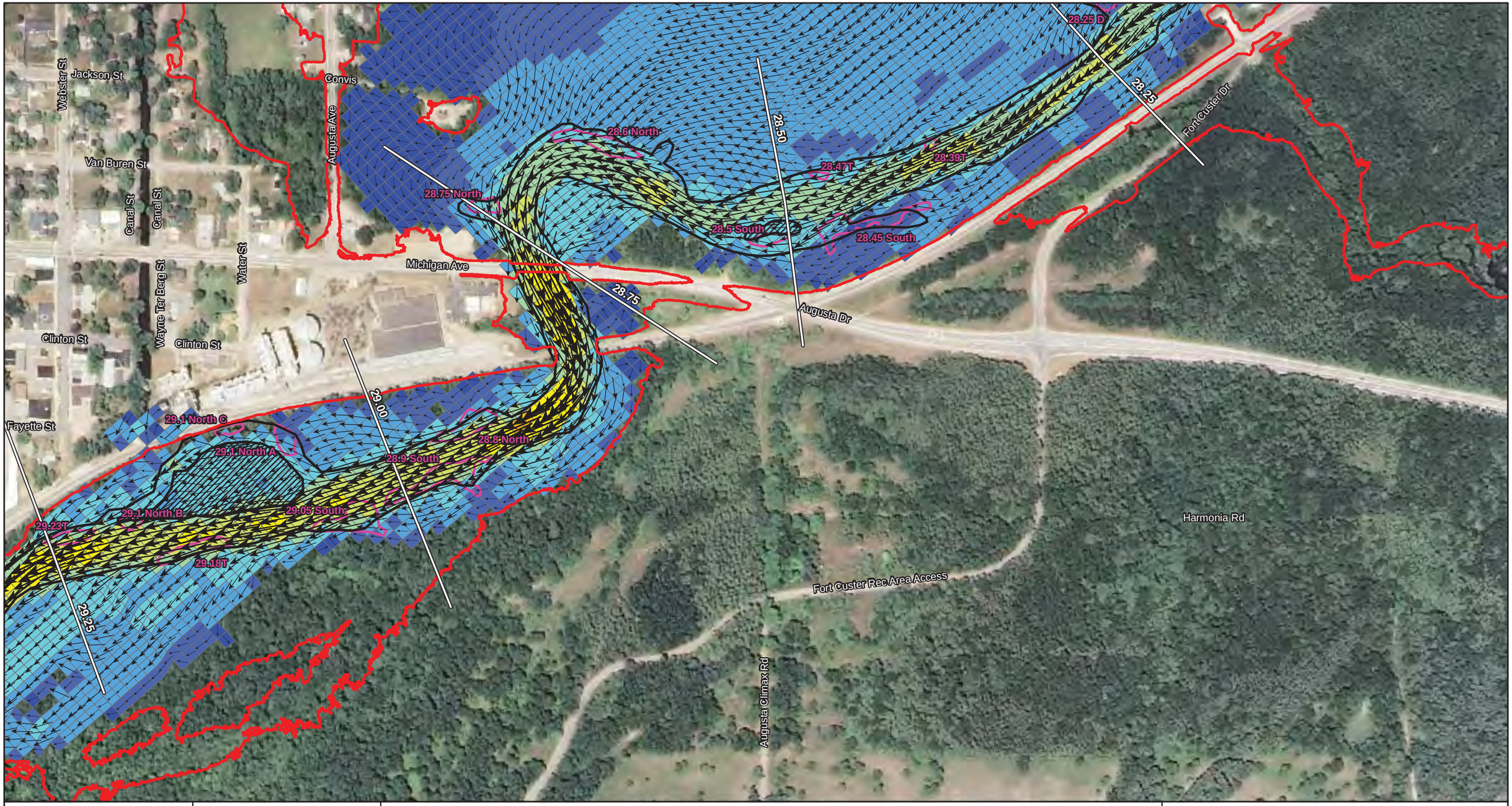
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 27.80SE - MP 28.22SE

SHEET 30 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



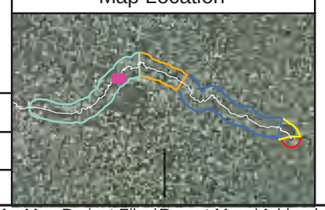
ENBRIDGE

Drawn: BRS 4/30/2012

Approved: DBR 4/30/2012

Project #: 106-4186

Map Location



Legend

Velocity (ft/sec)

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 28.22 - MP 29.20

SHEET 31 OF 45

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

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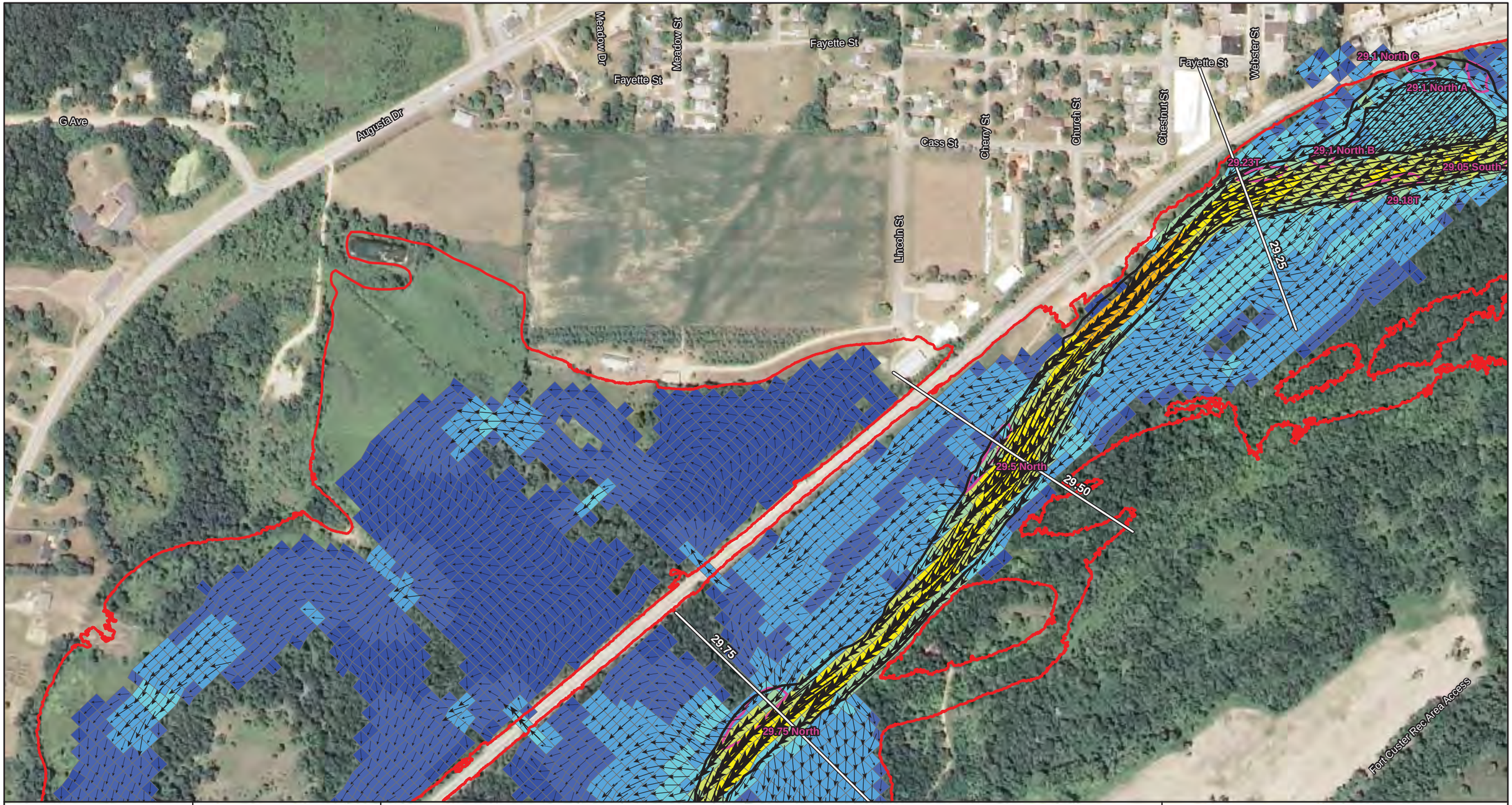
Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 29.20 - MP 29.82

SHEET 32 OF 45

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

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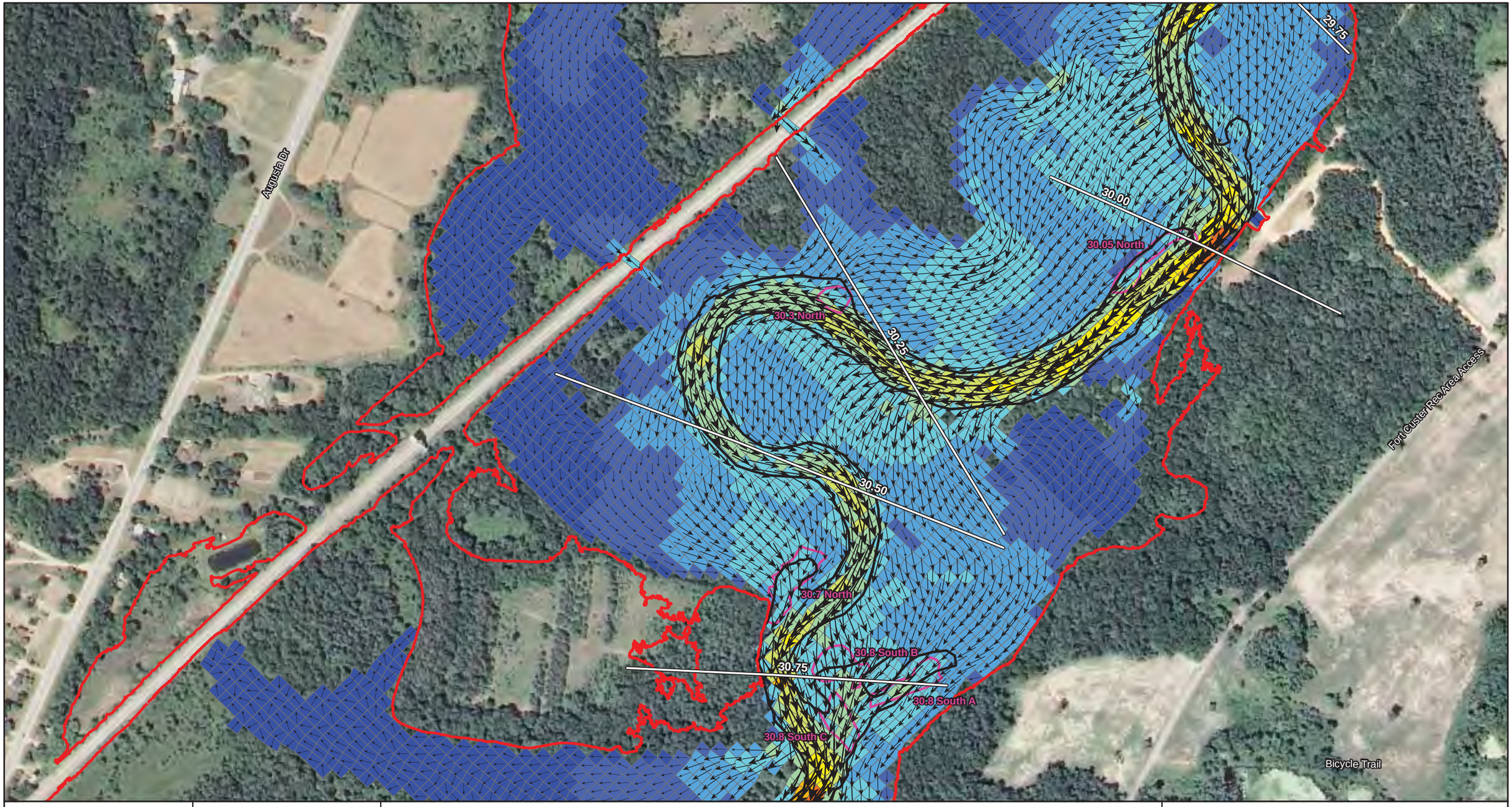
Aerial Photography Date: July & August 2009

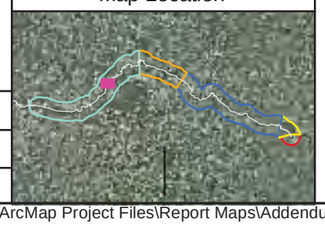
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 29.82 - MP 30.84

SHEET 33 OF 45

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

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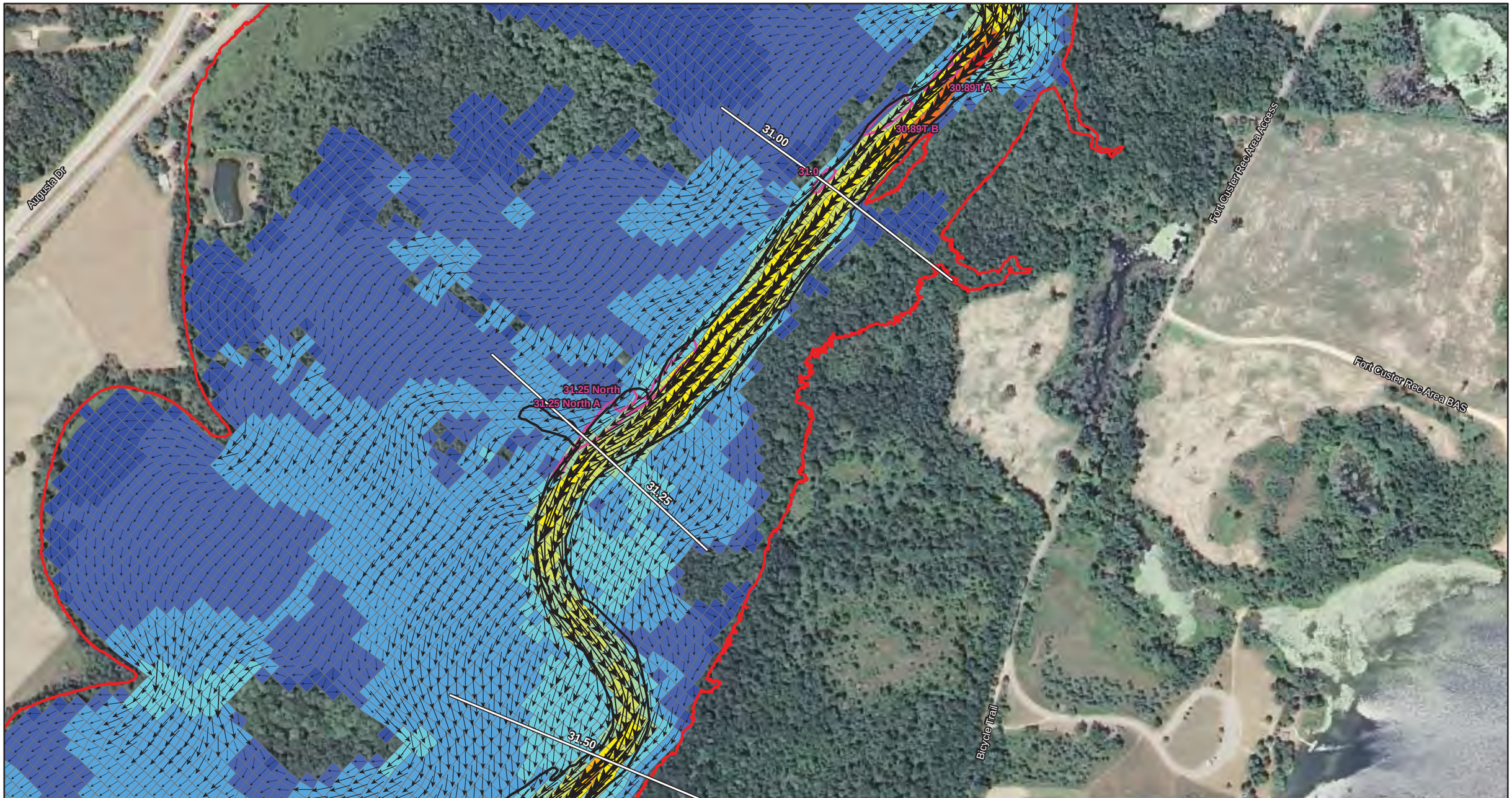
Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 30.84 - MP 31.40

SHEET 34 OF 45

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

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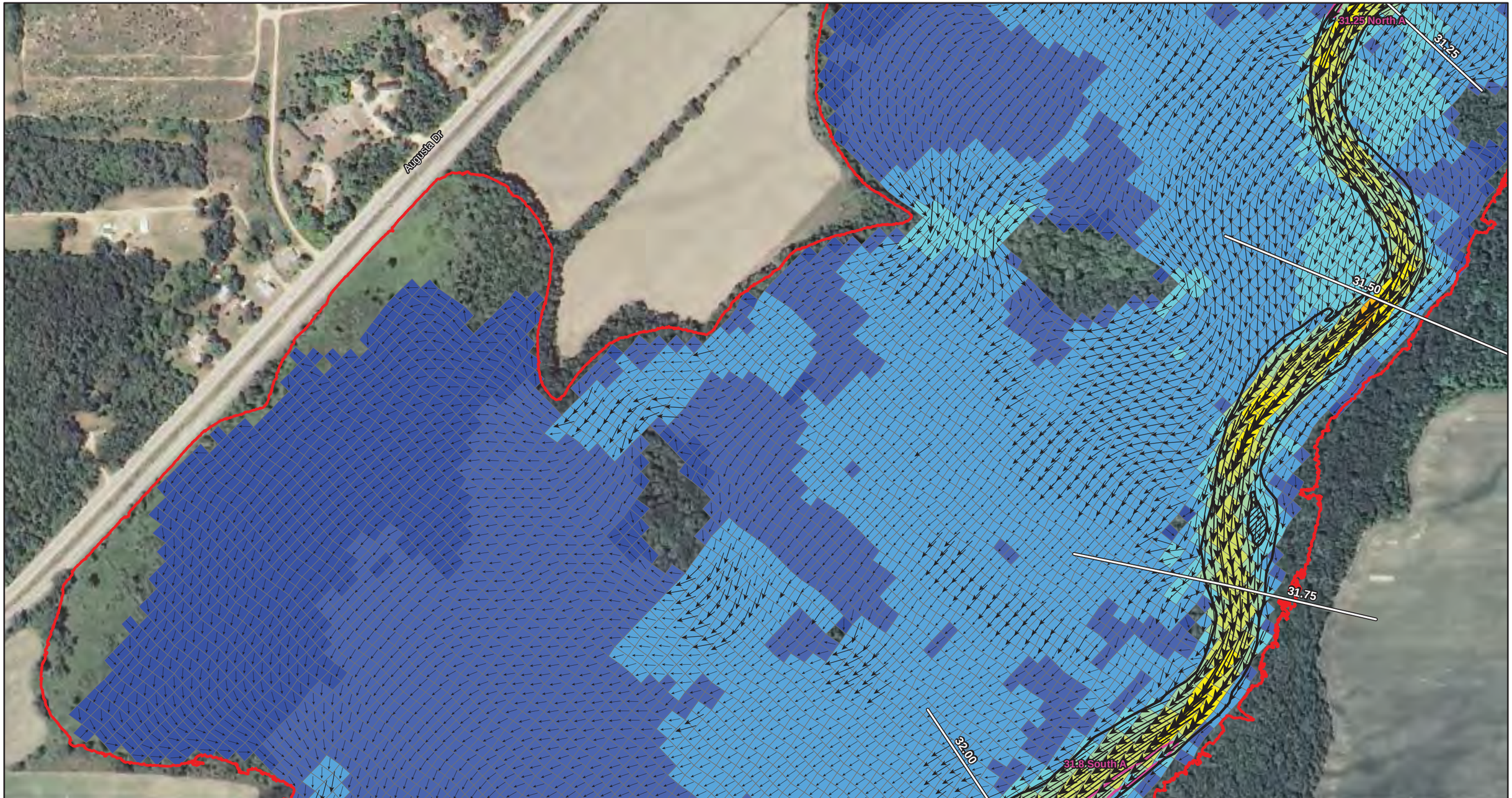
Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 31.40 - MP 31.94

SHEET 35 OF 45

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

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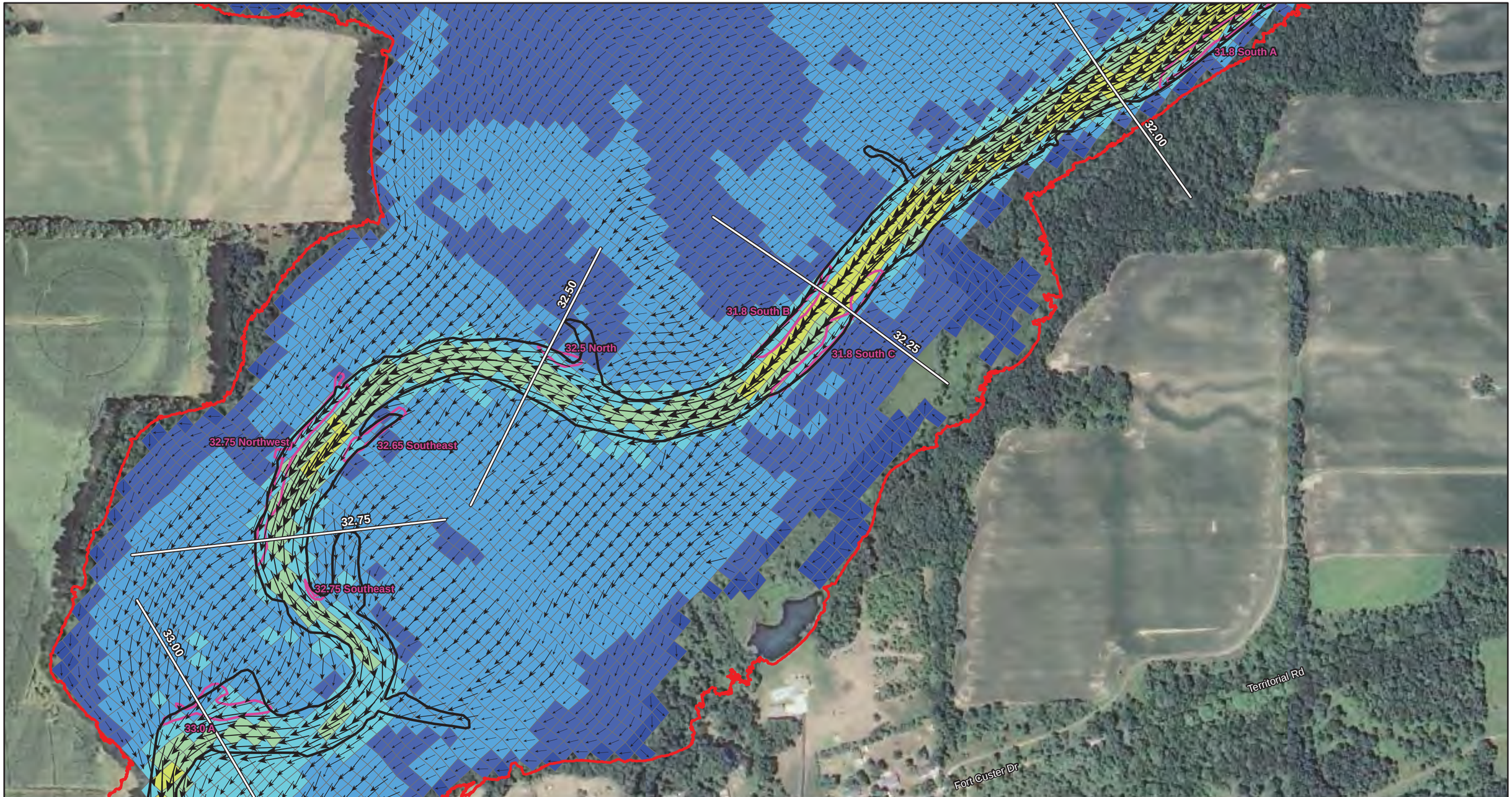
Aerial Photography Date: July & August 2009

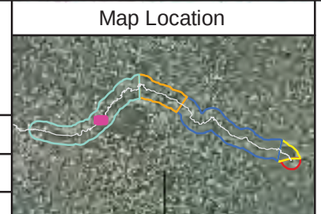
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 31.94 - MP 33.00

SHEET 36 OF 45

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

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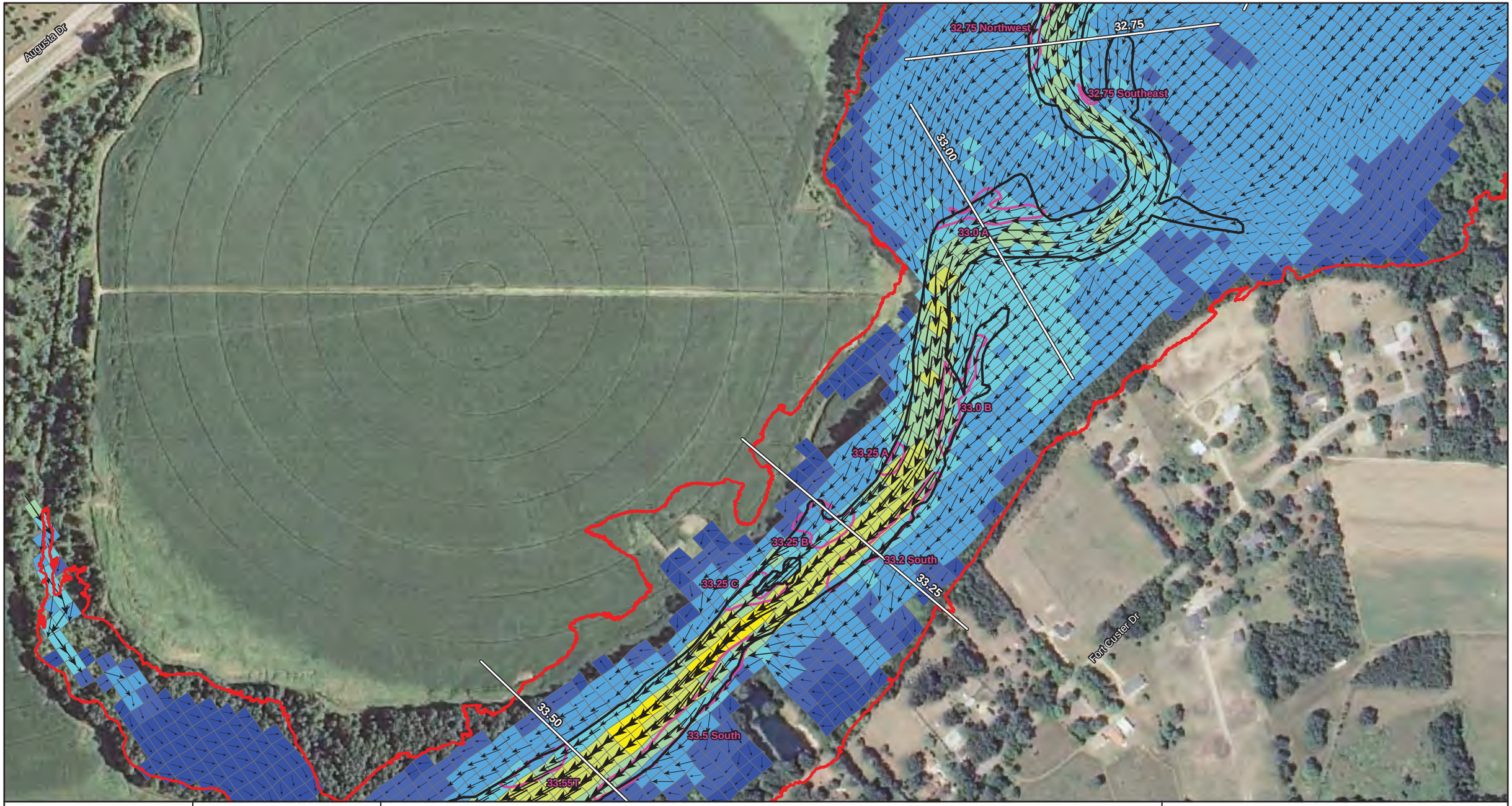
Aerial Photography Date: July & August 2009

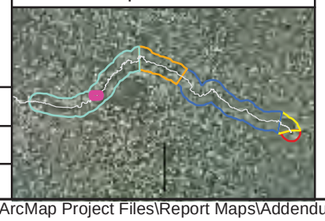
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 33.00 - MP 33.52

SHEET 37 OF 45

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

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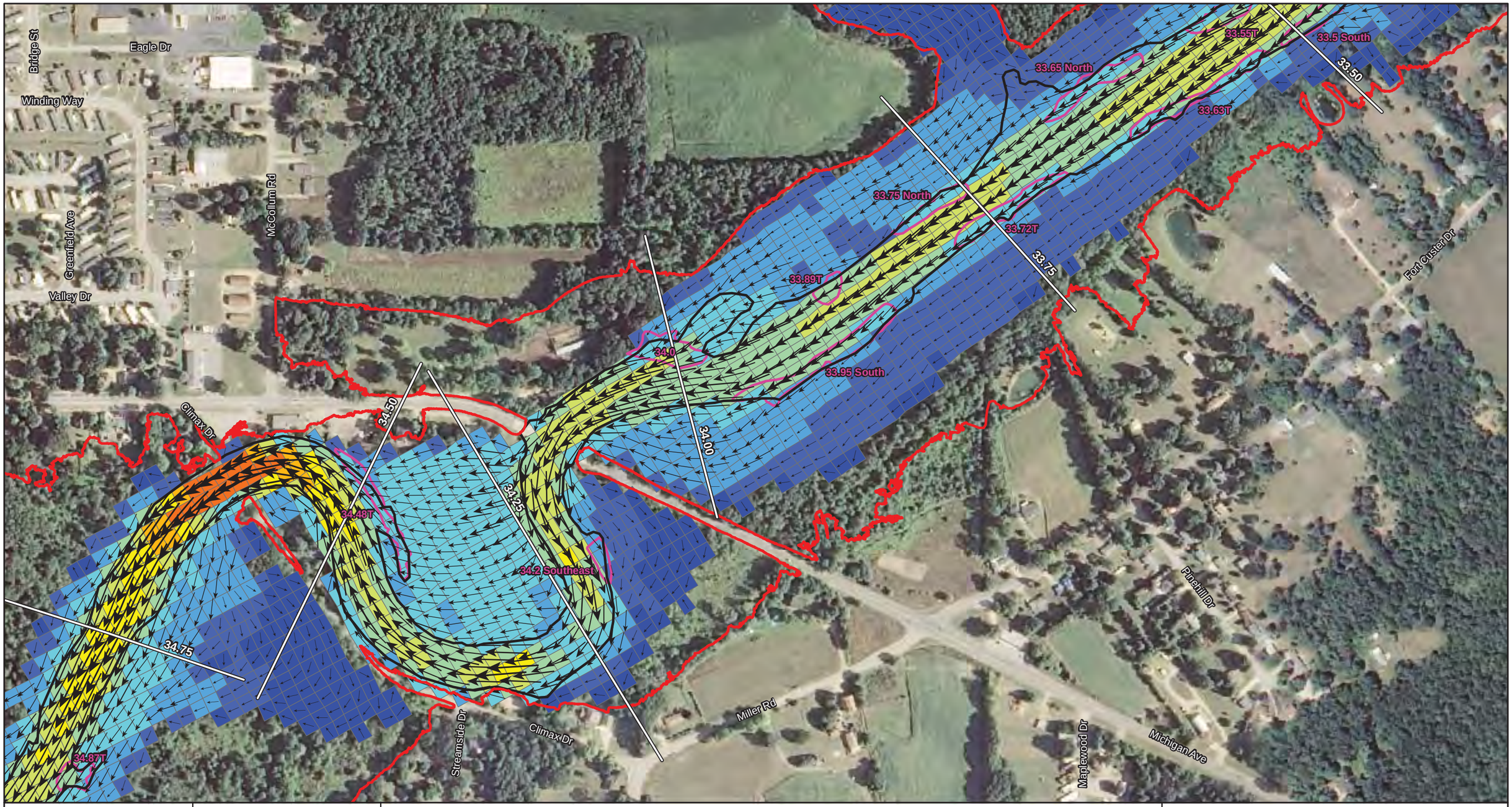
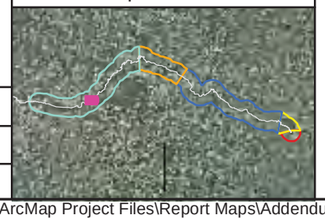
Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 33.52 - MP 34.70

SHEET 38 OF 45

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

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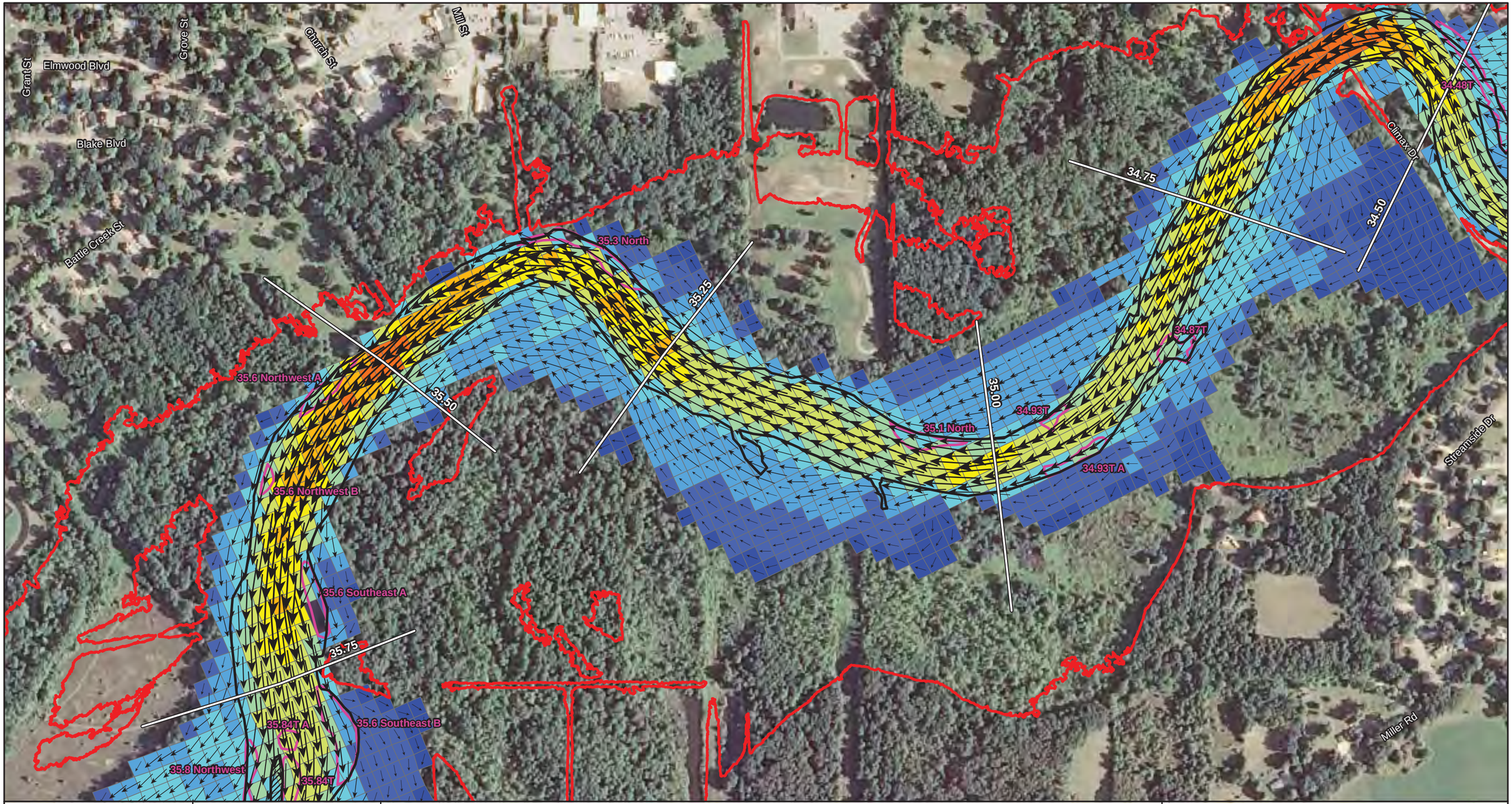
Aerial Photography Date: July & August 2009

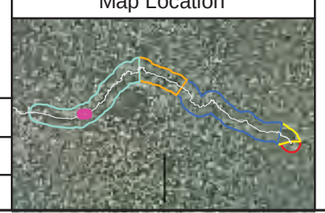
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 34.70 - MP 35.75

SHEET 39 OF 45

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

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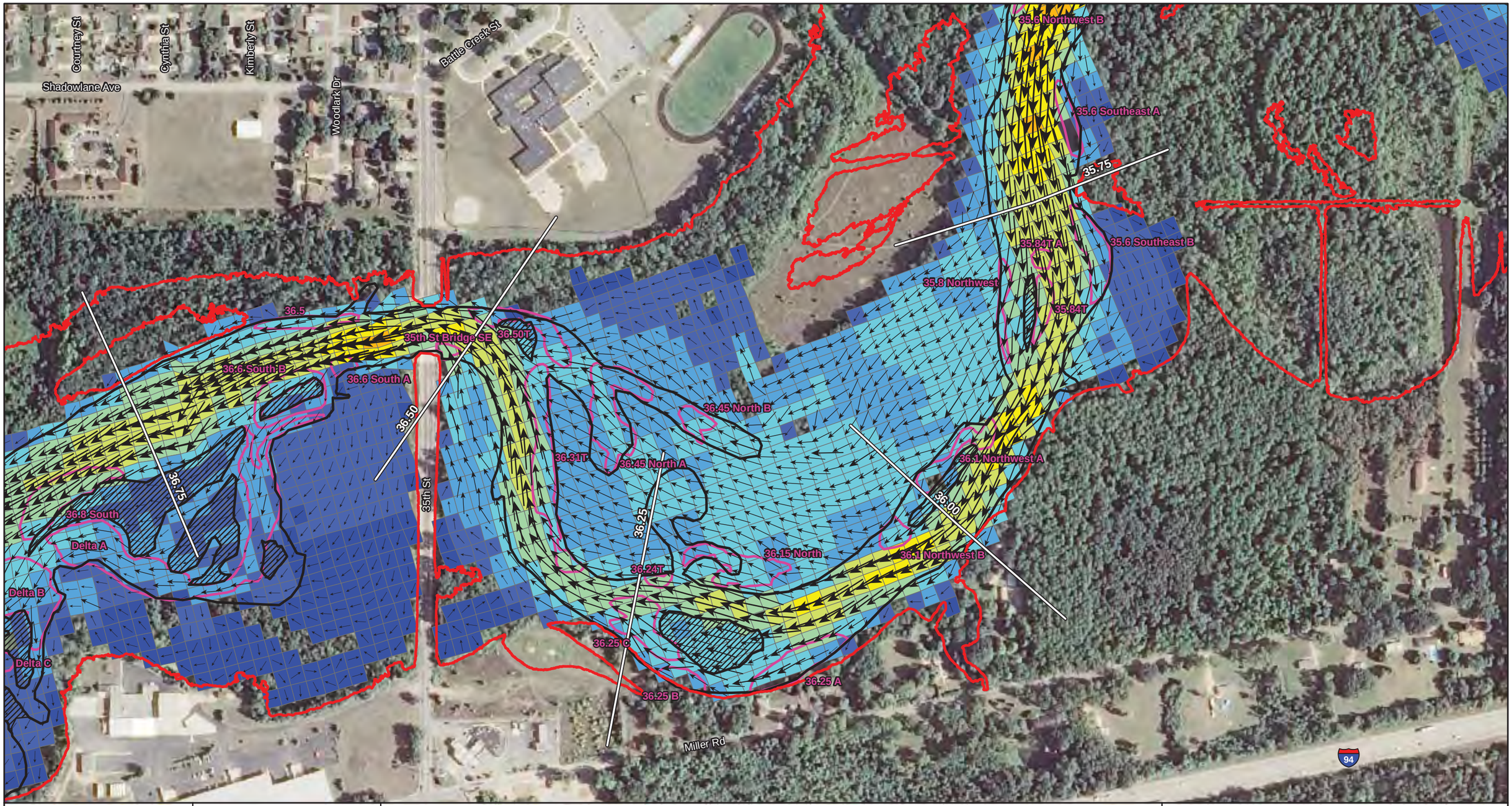
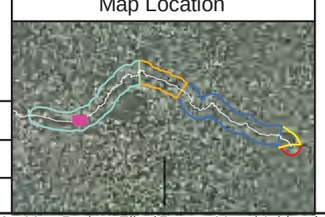
Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

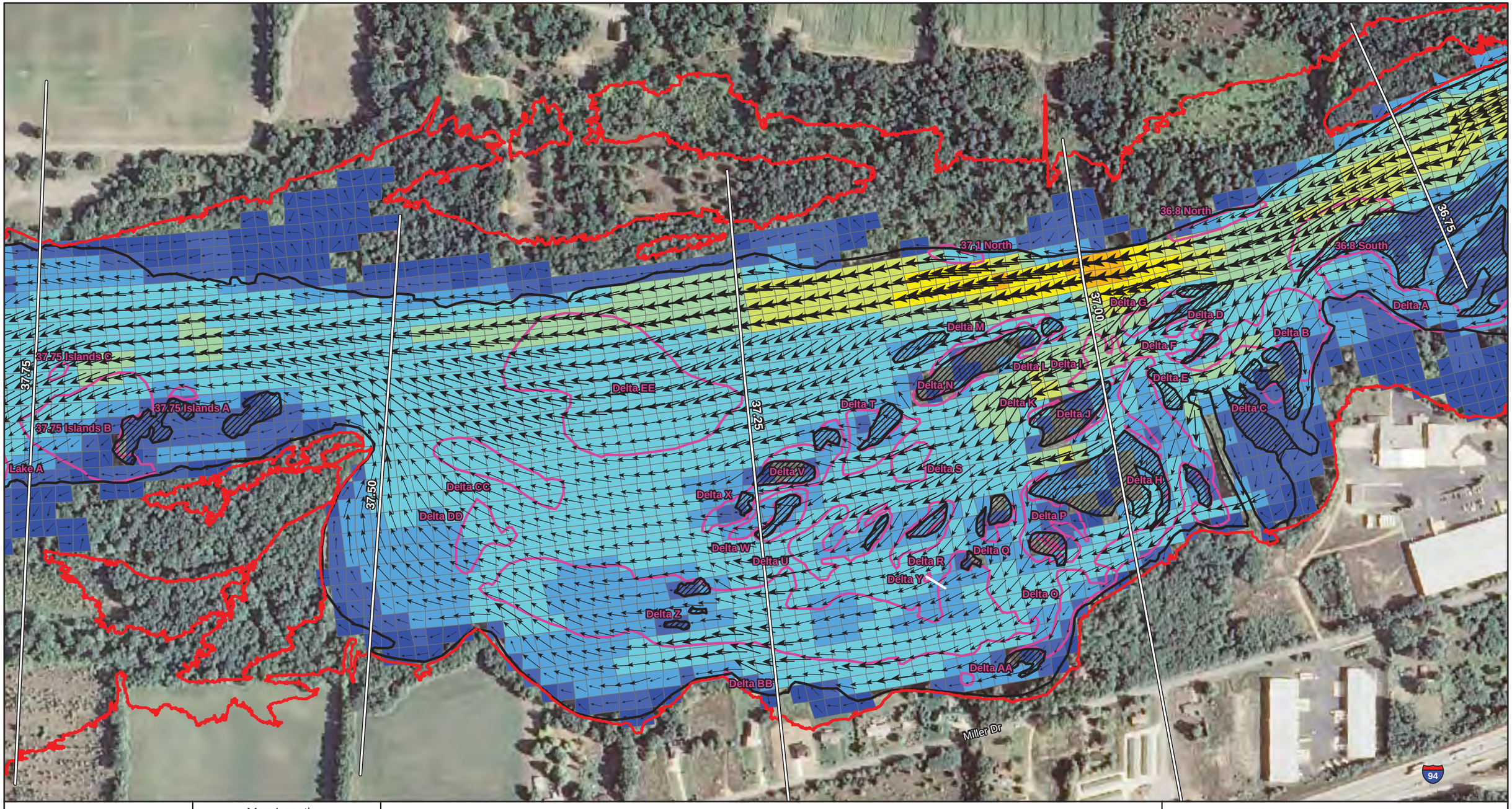
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 35.75 - MP 36.75

SHEET 40 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

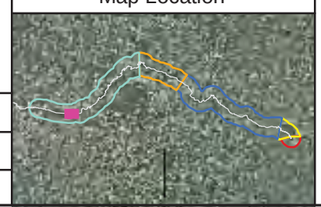
Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

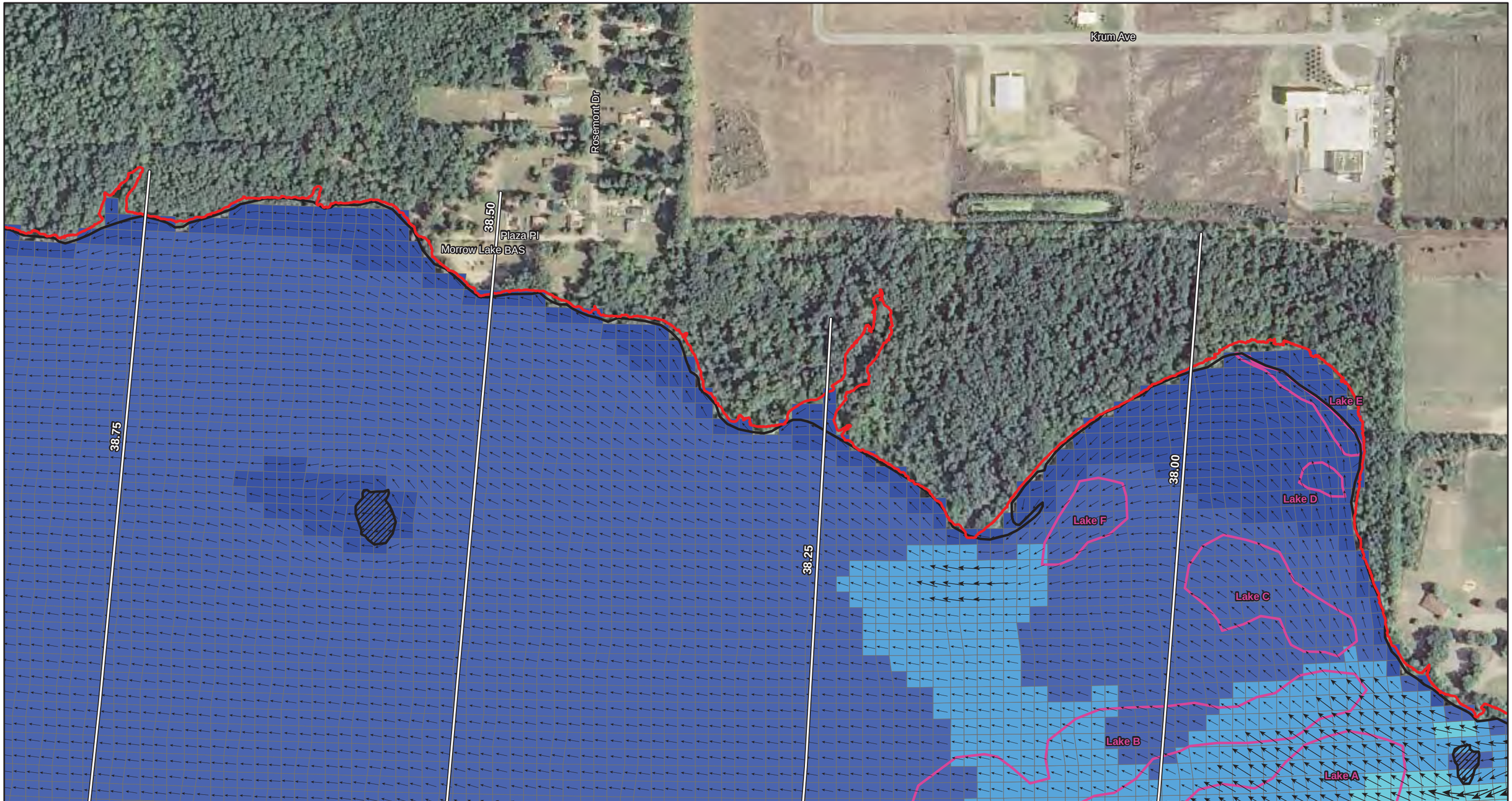
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 36.75 - MP 37.75

SHEET 41 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn: BRS 4/30/2012

Approved: DBR 4/30/2012

Project #: 106-4186

Map Location

Legend

Velocity (ft/sec)

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

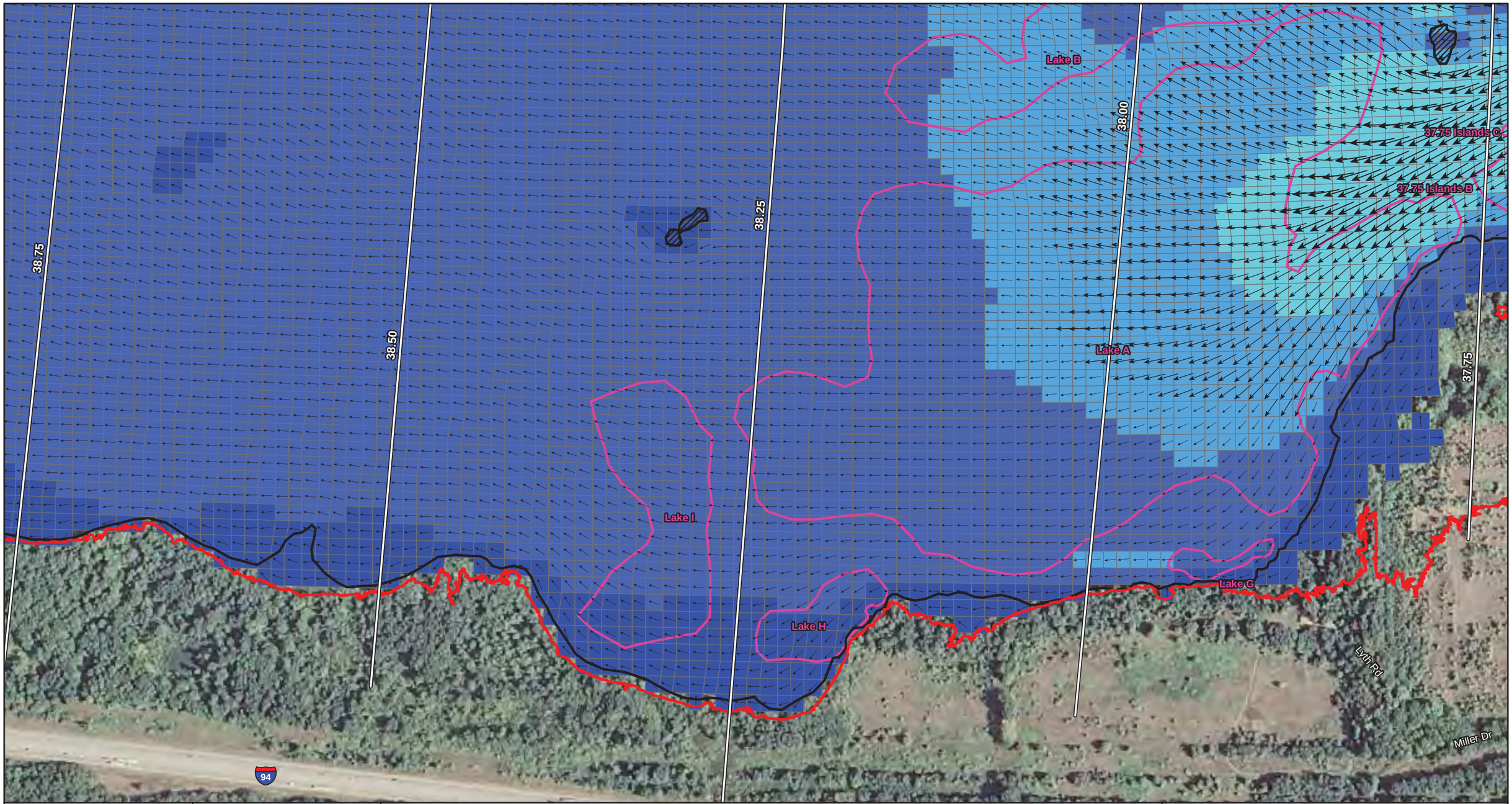
FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 37.75N - MP 38.80N

SHEET 42 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

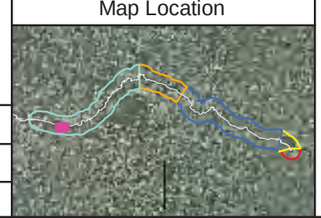
Aerial Photography Date: July & August 2009



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
cfs = Cubic Feet Per Second

N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 37.75S - MP 38.80S

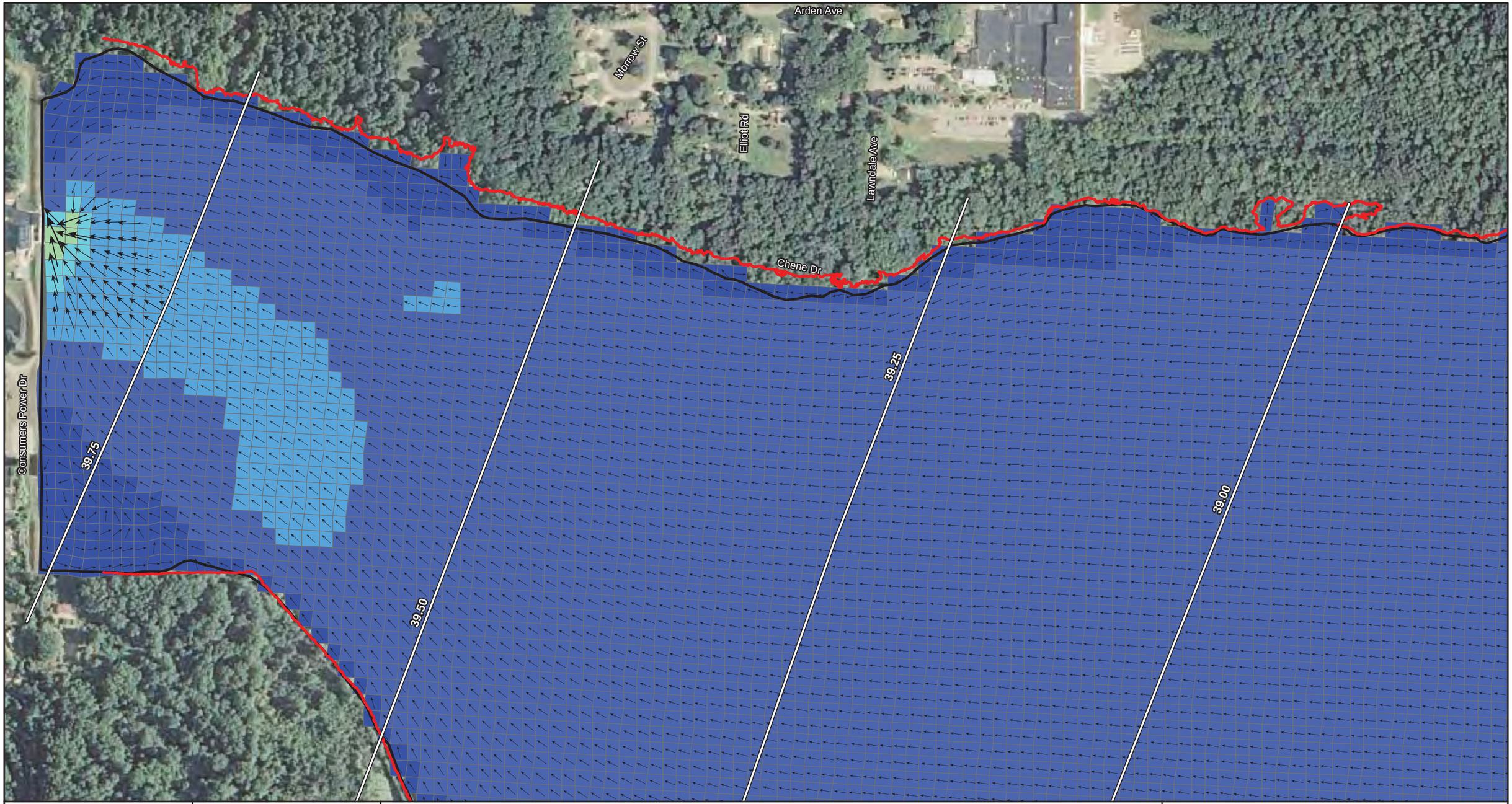
SHEET 43 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009

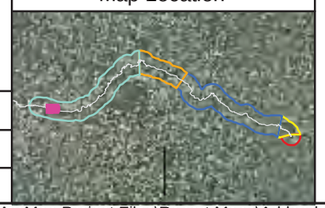
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
- < 0.1 ft/sec
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- 0.5 - 1.0 ft/sec
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
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0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 38.80N - MP 39.95N

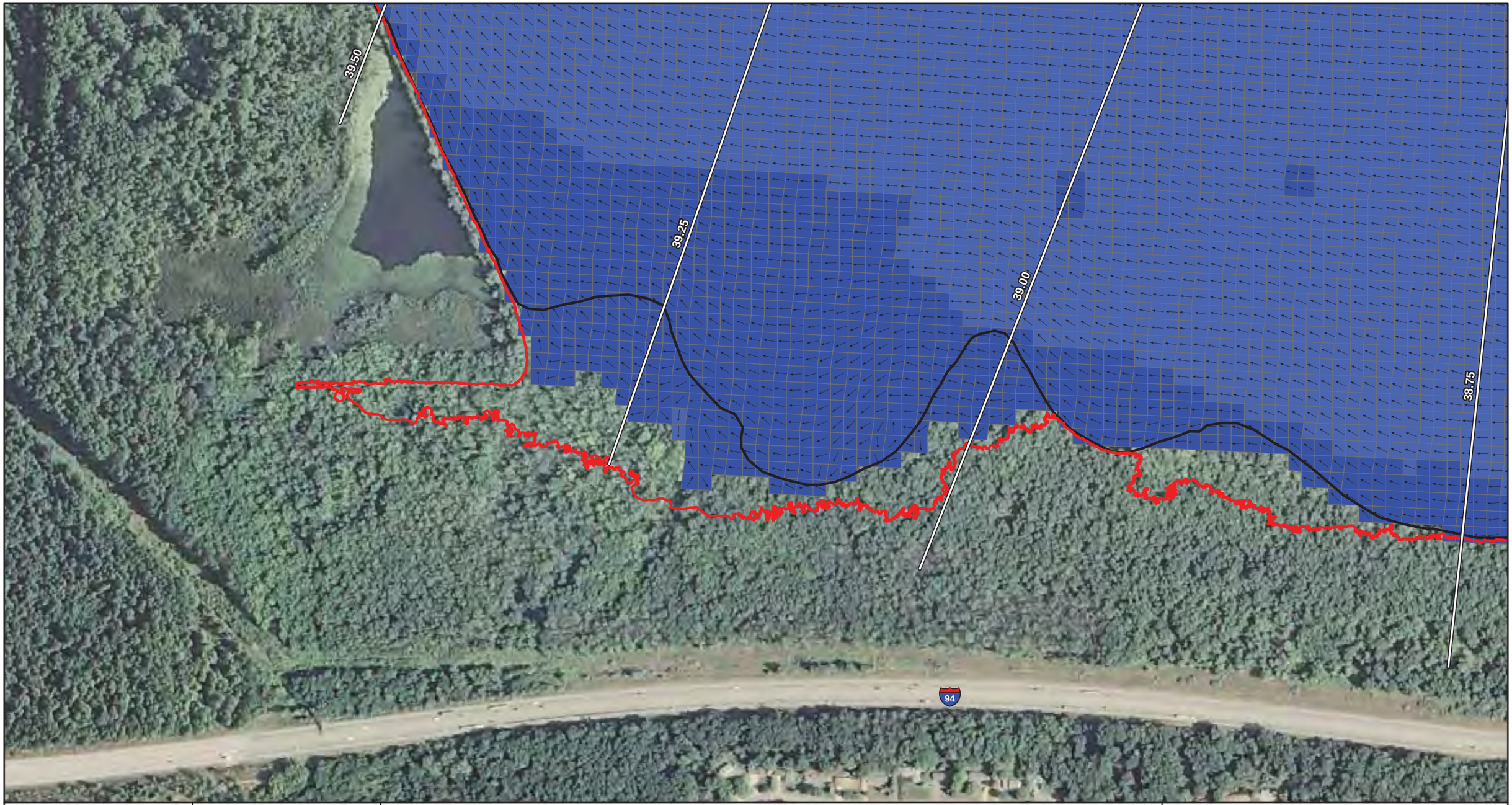
SHEET 44 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009

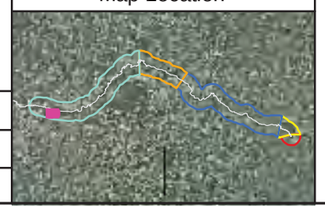
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec)
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

- Flow Direction and Relative Magnitude
- Channel Bankline
- Island Bankline
- HEC-RAS 100-Year Floodplain
- Spring 2011 Submerged Oil Delineation Areas
- Quarter Mile Grid Segment

ft/sec = Feet Per Second
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N

0 175 350 700
Scale in Feet

Kalamazoo River near Battle Creek USGS gage daily average discharge: 2,930 cfs

FLOODPLAIN GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
JULY 26, 2010 MODEL RUN
MP 38.80S - MP 39.95S

SHEET 45 OF 45

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

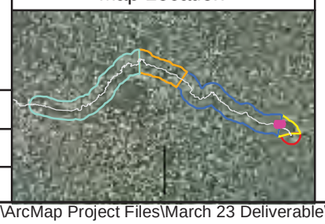
X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Floodplain Grid Velocity With Delineation Areas July 26, 2010.mxd

Aerial Photography Date: July & August 2009

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 01.95 - MP 02.75

SHEET 1 OF 56

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

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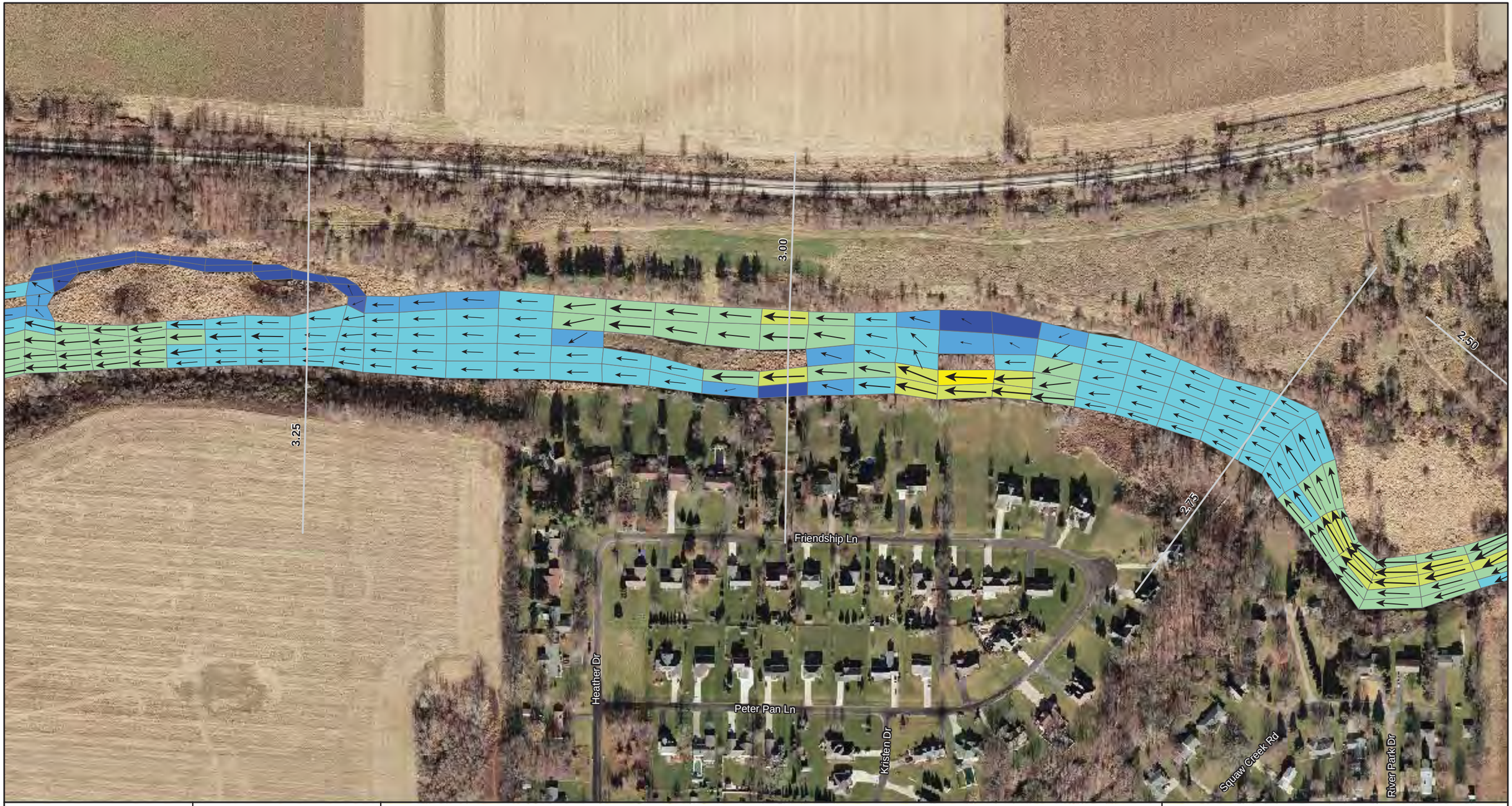
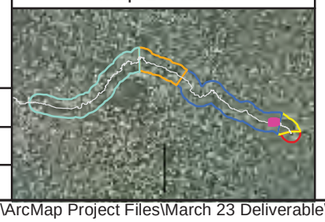
Aerial Photography Date: November 2011



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 02.60 - MP 03.40

SHEET 2 OF 56

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
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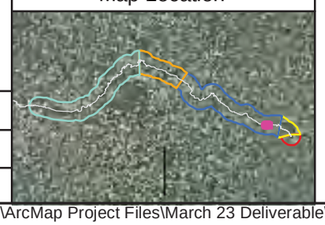
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 03.40 - MP 04.20

SHEET 3 OF 56

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

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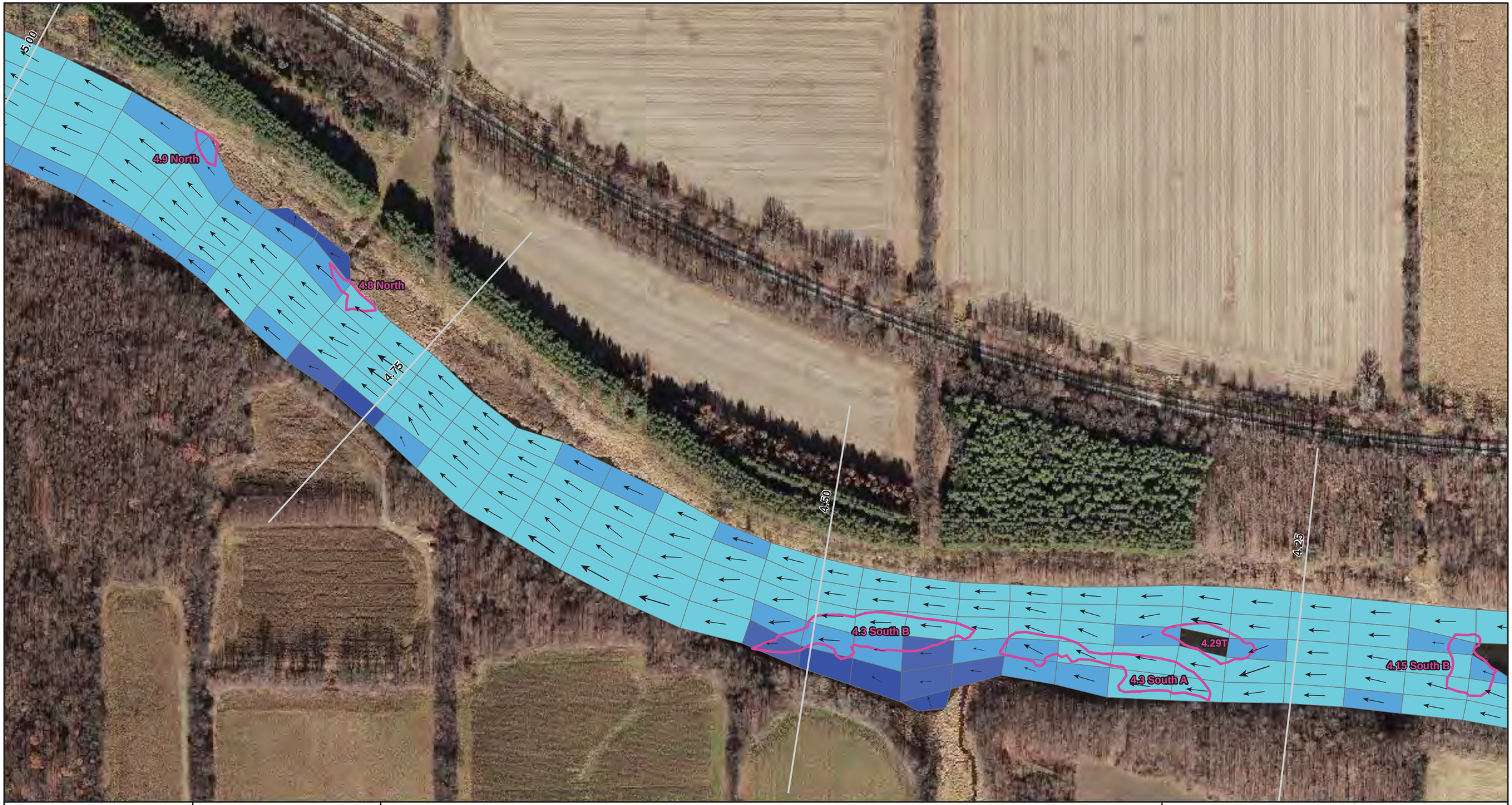
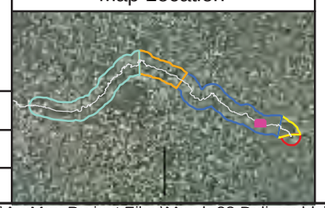
Aerial Photography Date: November 2011



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 04.15 - MP 05.00

SHEET 4 OF 56

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

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Aerial Photography Date: November 2011

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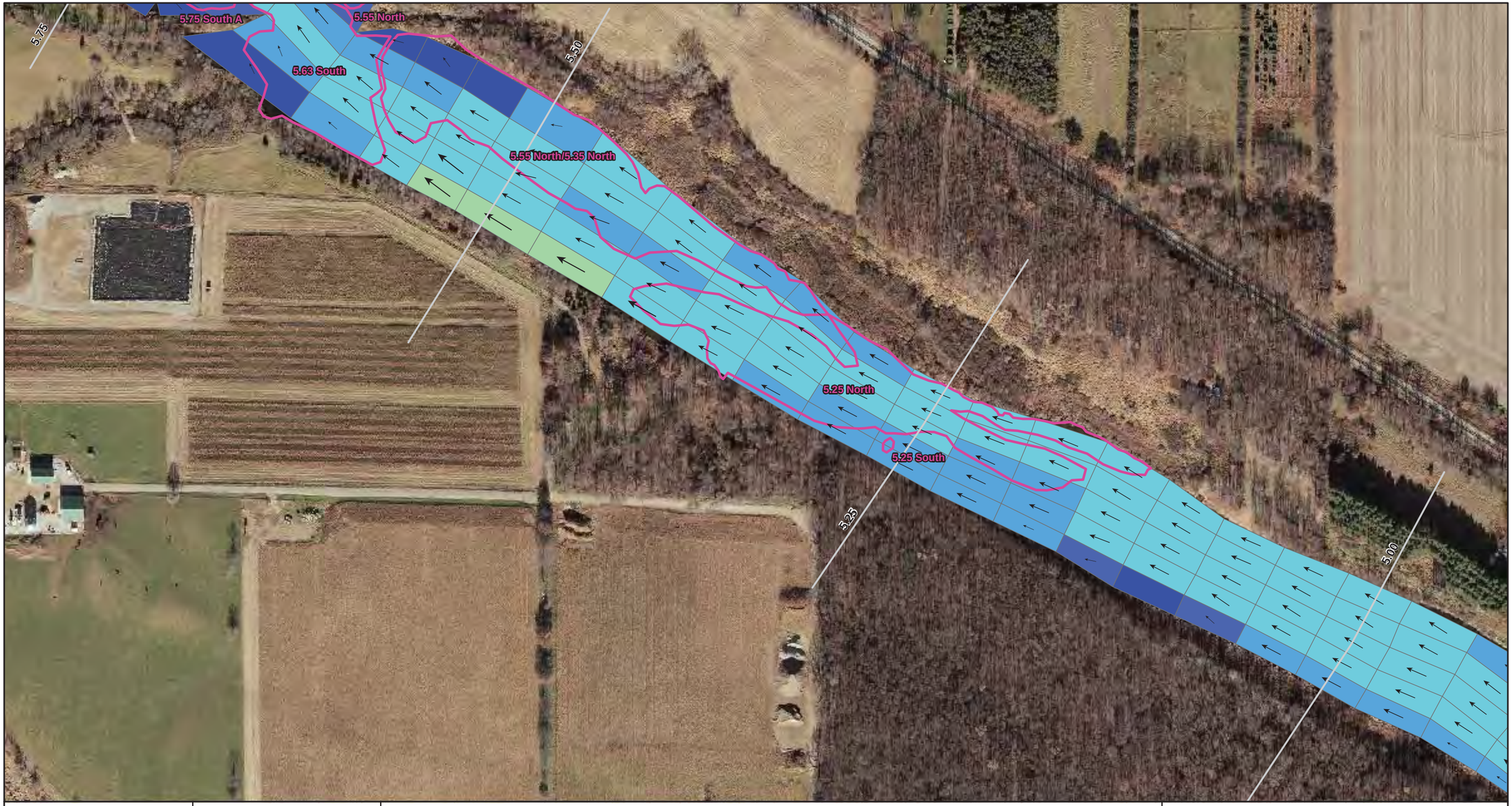


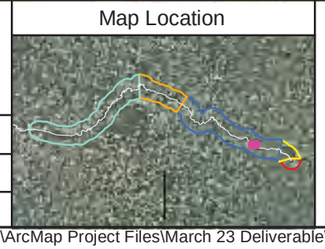
ENBRIDGE

Drawn: BRS 4/30/2012

Approved: DBR 4/30/2012

Project #: 106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 04.90 - MP 05.65

SHEET 5 OF 56

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

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Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 05.65 - MP 06.30

SHEET 6 OF 56

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

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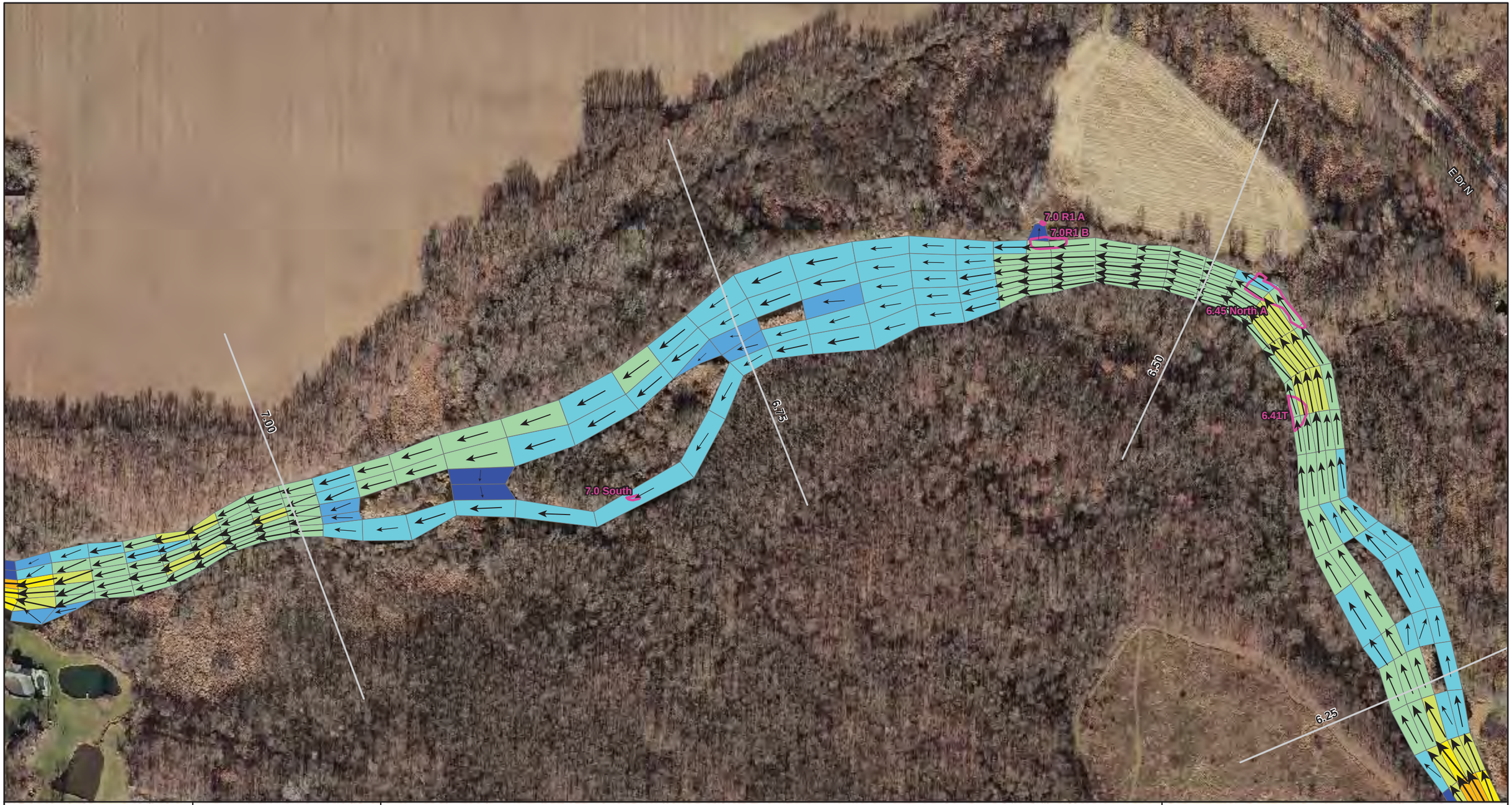
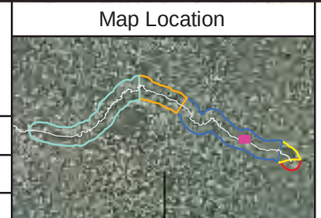
Aerial Photography Date: November 2011



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
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- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 06.20 - MP 07.15

SHEET 7 OF 56

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

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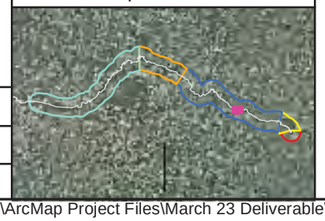
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 07.15 - MP 07.95

SHEET 8 OF 56

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

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Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
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- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 07.90 - MP 08.75

SHEET 9 OF 56

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

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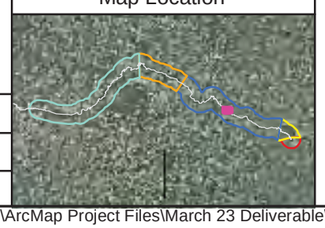
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

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- 0.1 - 0.25 ft/sec
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- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 08.70 - MP 09.30

SHEET 10 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

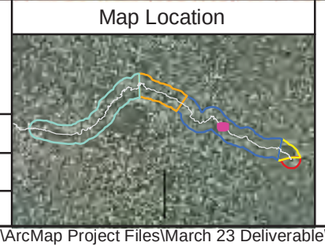
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 09.25 - MP 10.05

SHEET 11 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

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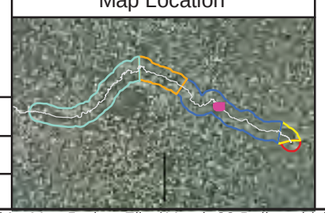
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 10.00 - MP 10.65

SHEET 12 OF 56

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

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Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
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Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 10.60 - MP 11.40

SHEET 13 OF 56

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

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US EPA ARCHIVE DOCUMENT

ENBRIDGE

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Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

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Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 11.10 - MP 12.45

SHEET 14 OF 56

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

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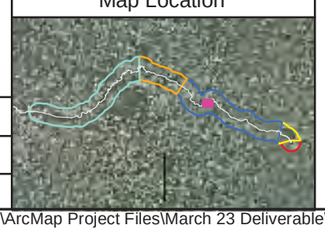
Aerial Photography Date: November 2011

ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

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- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

← Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

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Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 12.30 - MP 13.05

SHEET 15 OF 56

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

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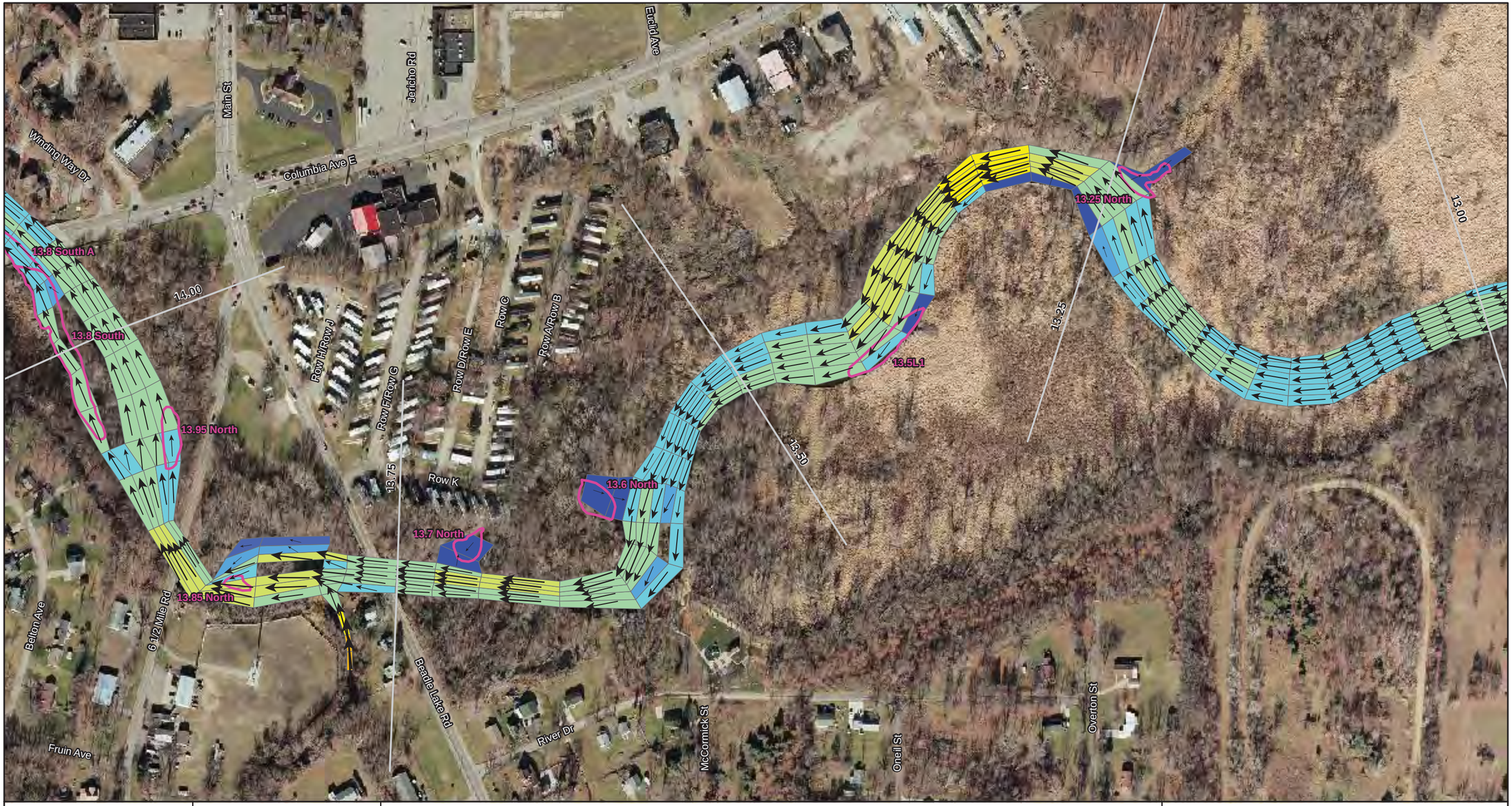
Aerial Photography Date: November 2011



ENBRIDGE

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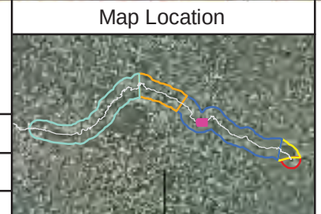
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
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- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 13.00 - MP 14.10

SHEET 16 OF 56

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

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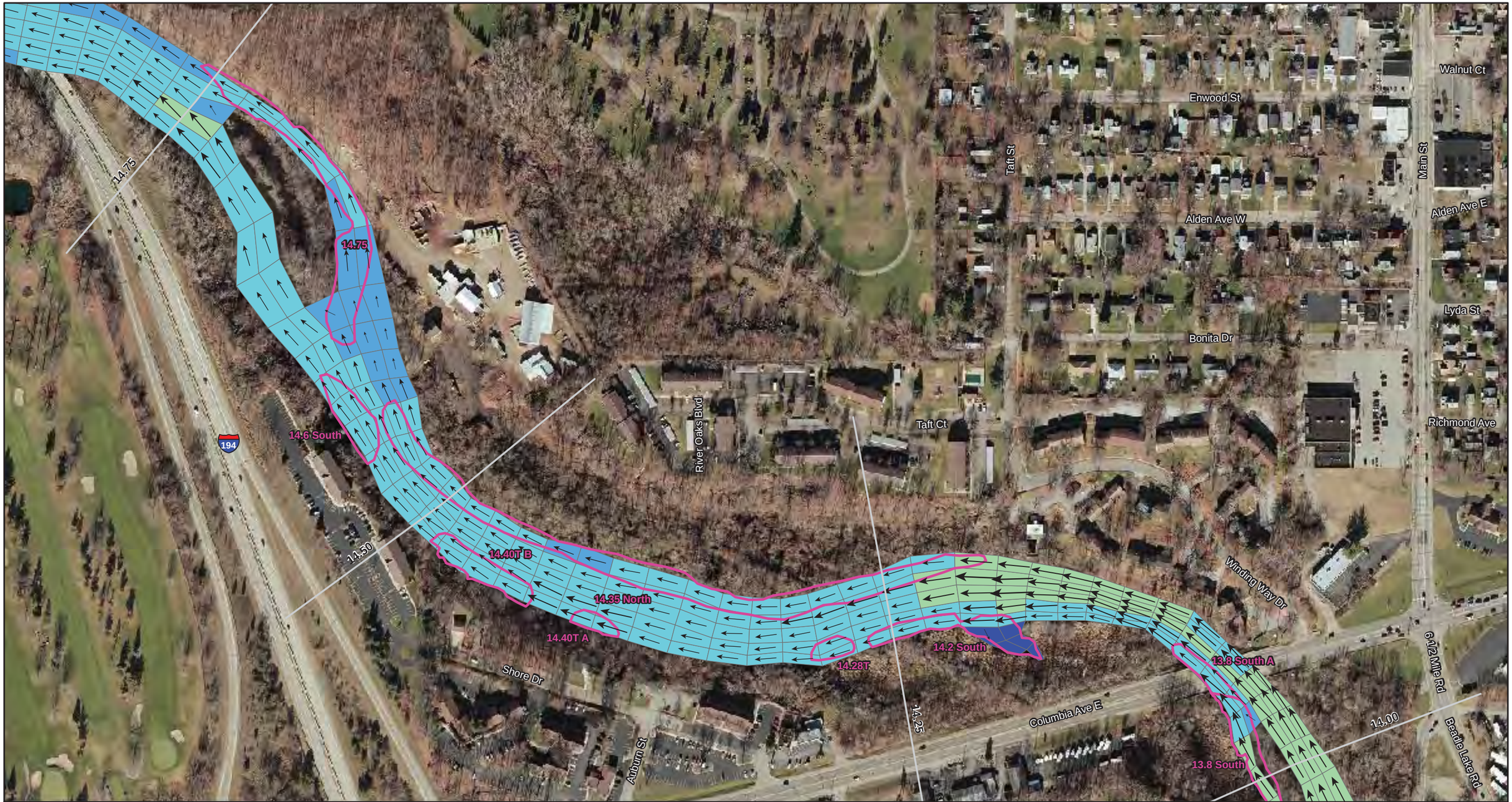
Aerial Photography Date: November 2011



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
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- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 14.00 - MP 14.85

SHEET 17 OF 56

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

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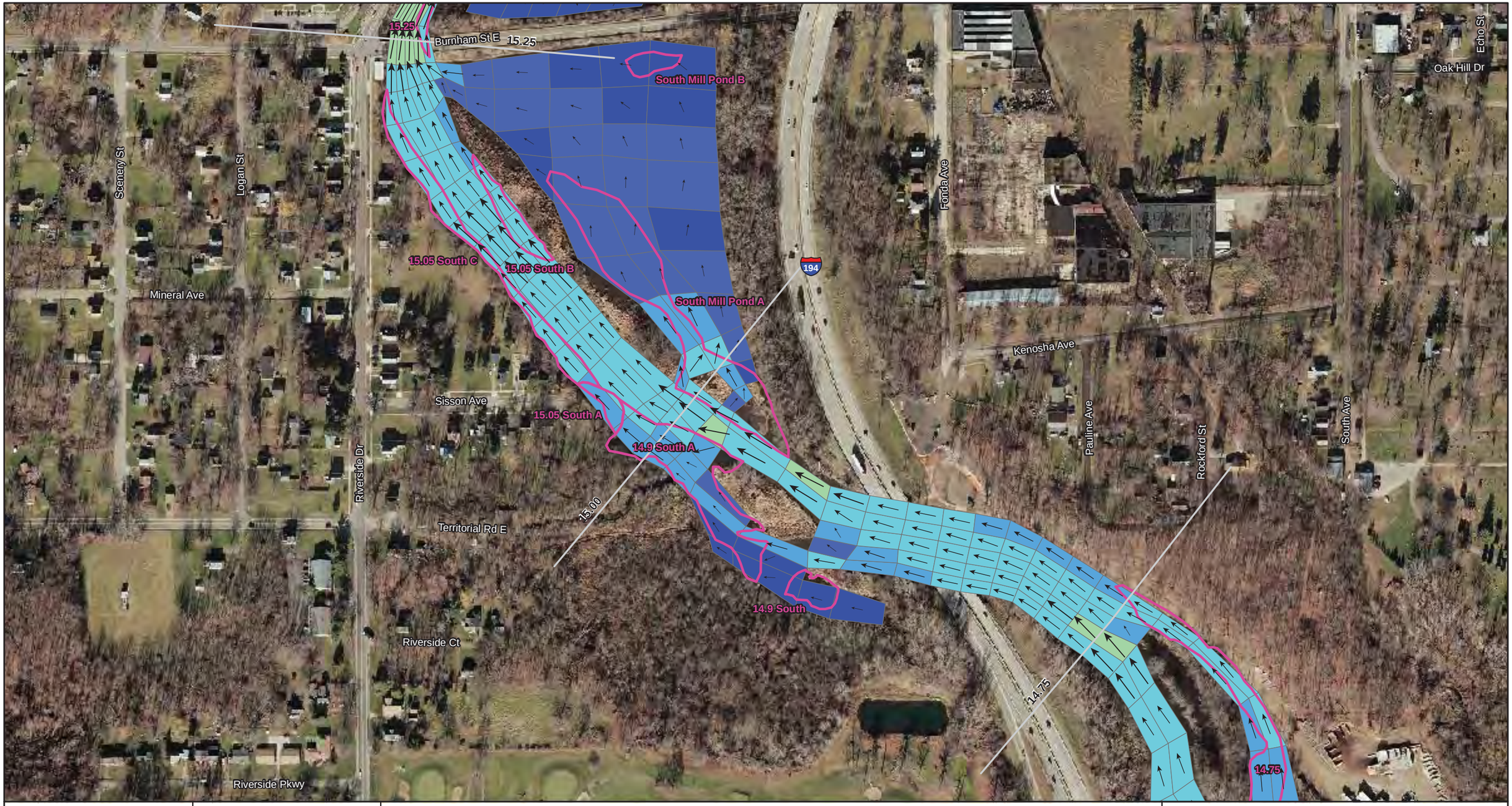
Aerial Photography Date: November 2011

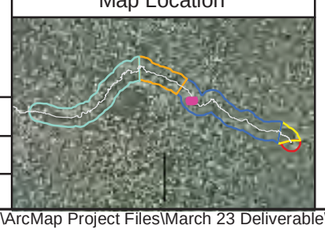
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 14.65 - MP 15.25

SHEET 18 OF 56

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

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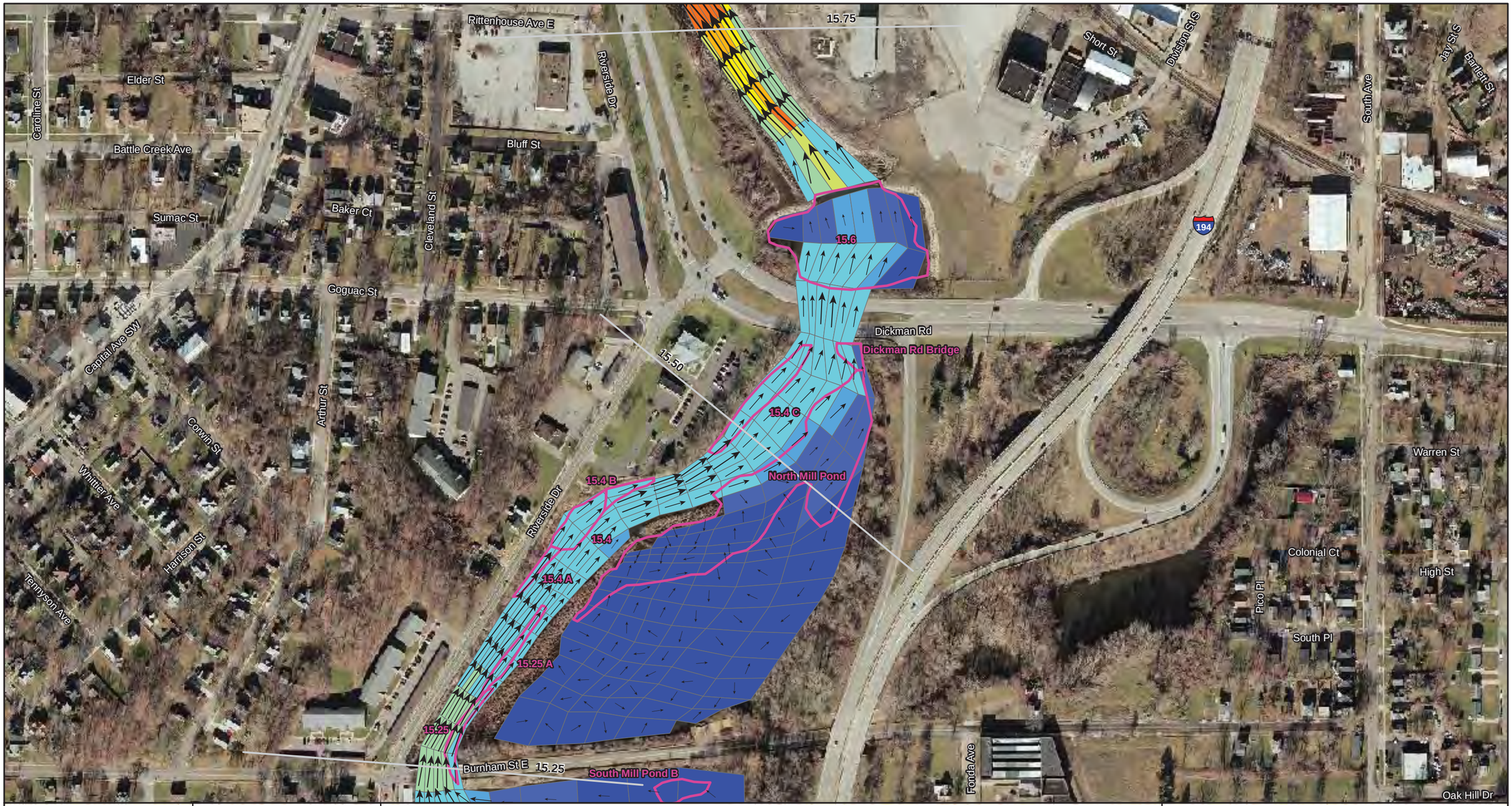
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 15.25 - MP 15.75

SHEET 19 OF 56

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

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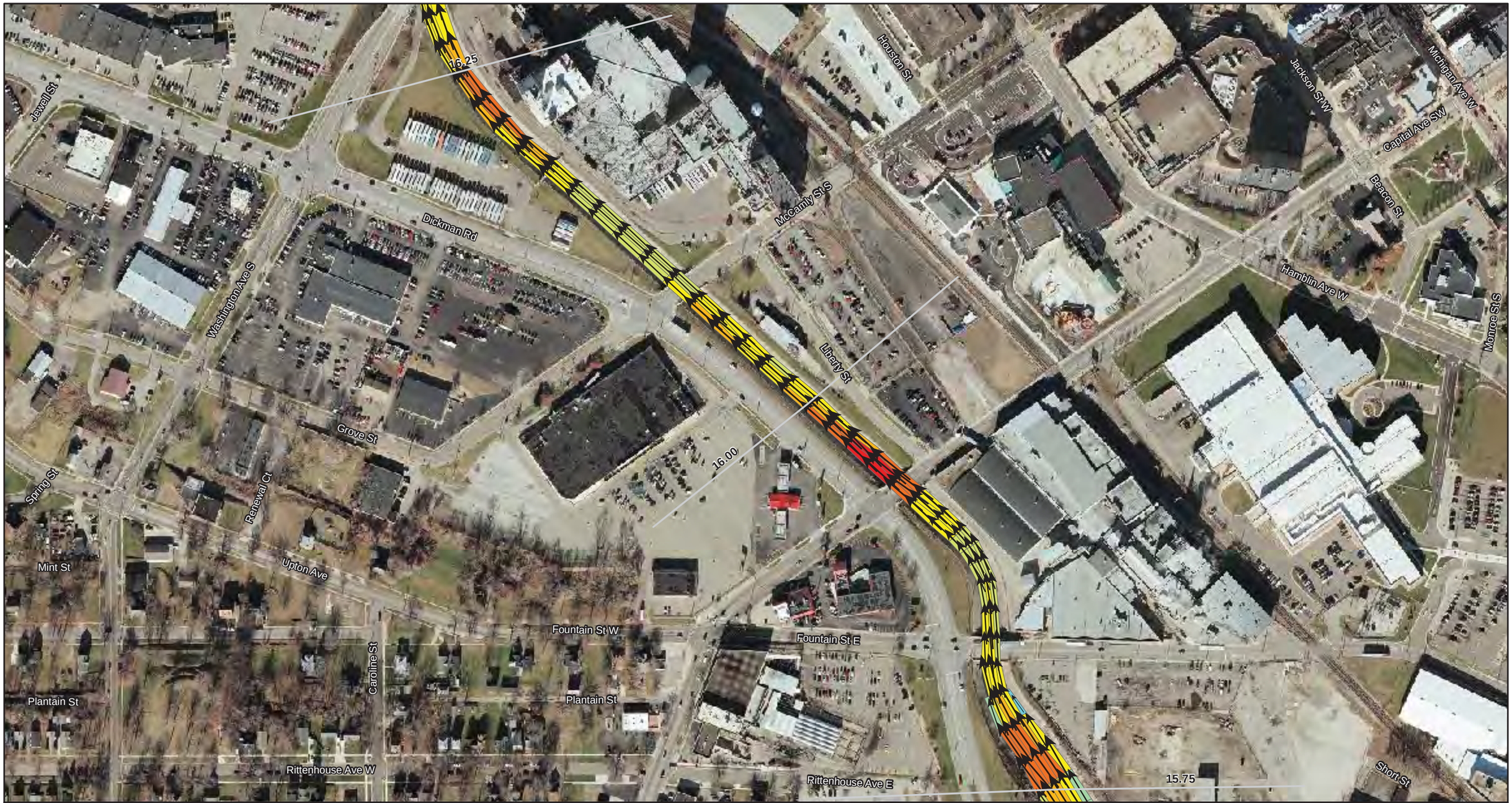
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS	4/30/2012
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Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 15.75 - MP 16.30

SHEET 20 OF 56

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

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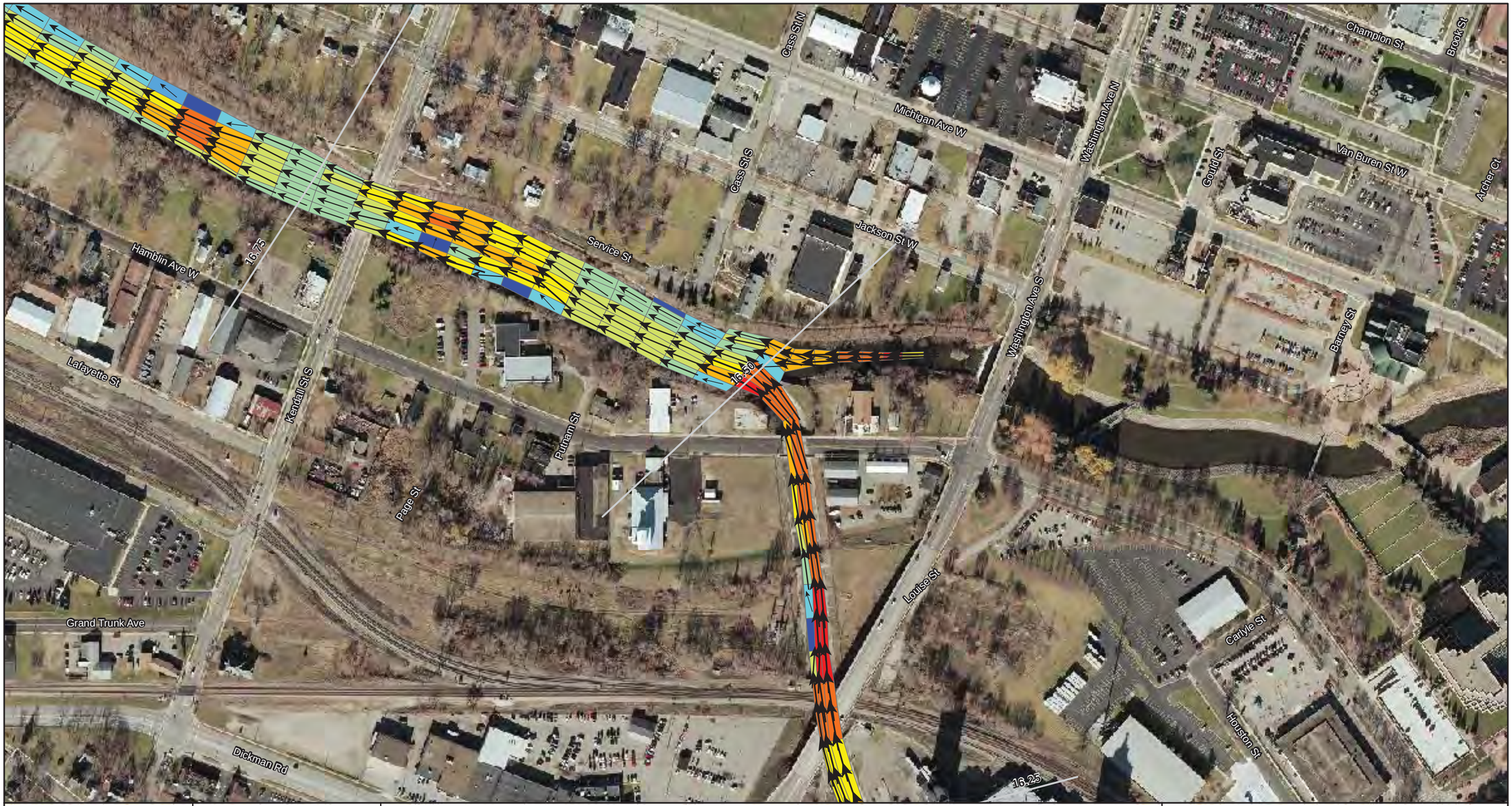
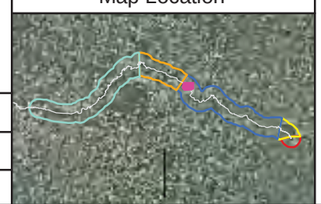


ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 16.30 - MP 16.95

SHEET 21 OF 56

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

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US EPA ARCHIVE DOCUMENT

ENBRIDGE

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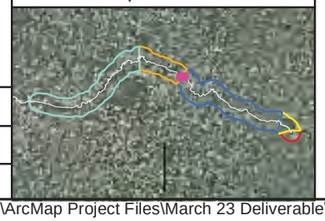
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
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Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

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Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 16.85 - MP 17.60

SHEET 22 OF 56

ENBRIDGE LINE 6B MP 608
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ENBRIDGE ENERGY, LIMITED PARTNERSHIP

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US EPA ARCHIVE DOCUMENT

ENBRIDGE

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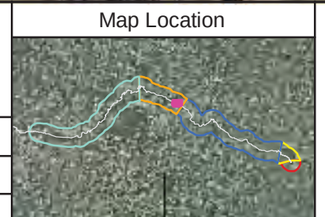
Map Location



Legend

Velocity (ft/sec) - November 3, 2011

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- 3.0 - 4.0 ft/sec
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Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

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Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 17.60 - MP 18.40

SHEET 23 OF 56

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

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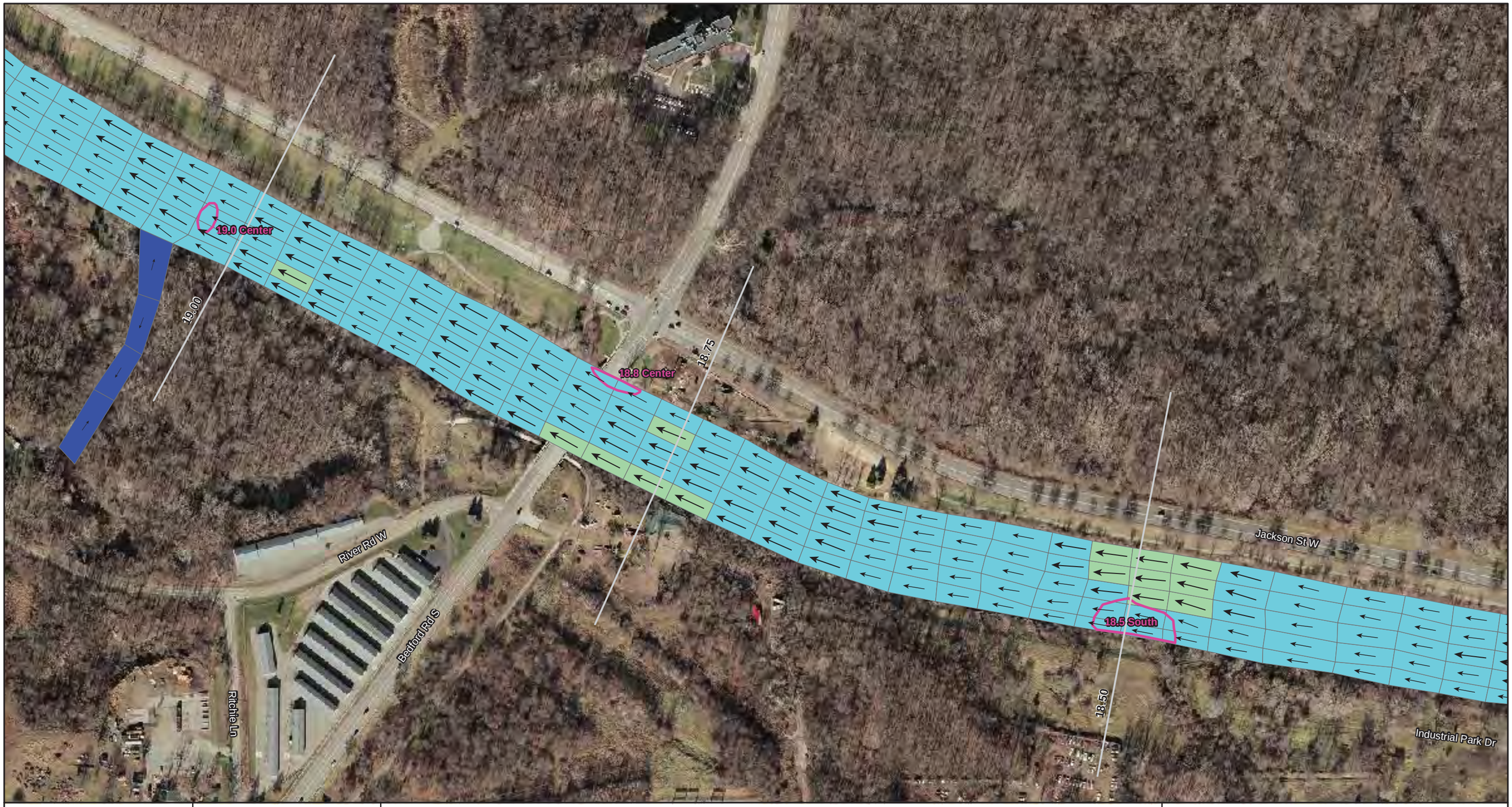
Aerial Photography Date: November 2011



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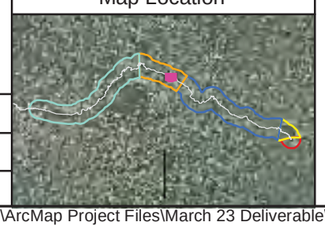
Map Location



Legend

Velocity (ft/sec) - November 3, 2011

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Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

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Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 18.30 - MP 19.15

SHEET 24 OF 56

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

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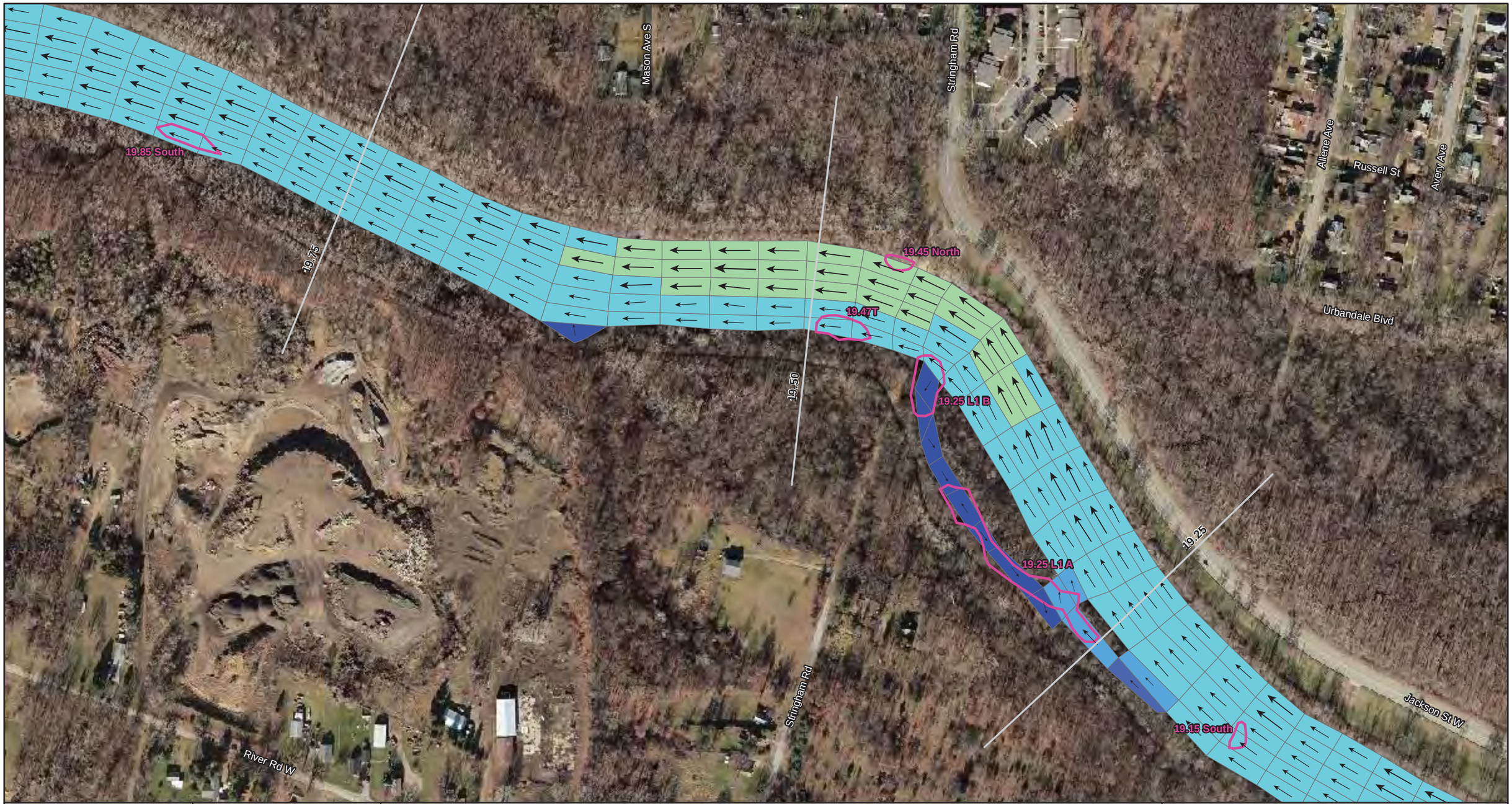
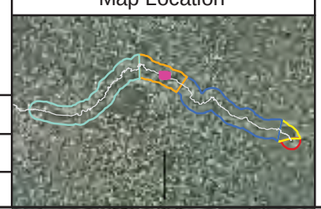


ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

← Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

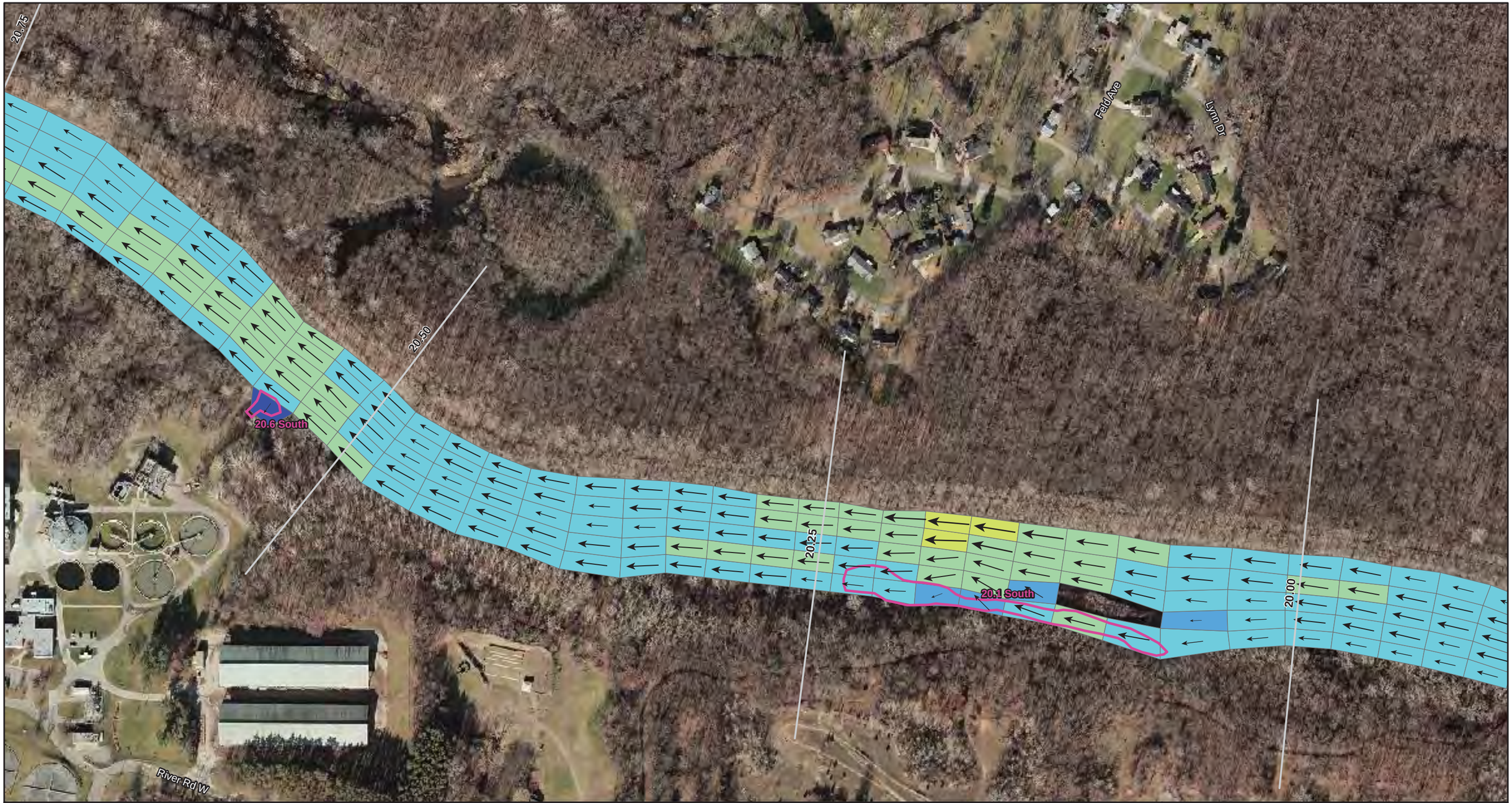
MP 19.10 - MP 19.95

SHEET 25 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

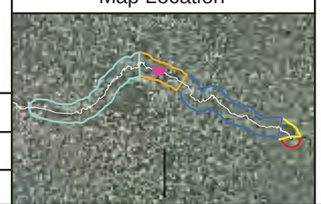
Aerial Photography Date: November 2011



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

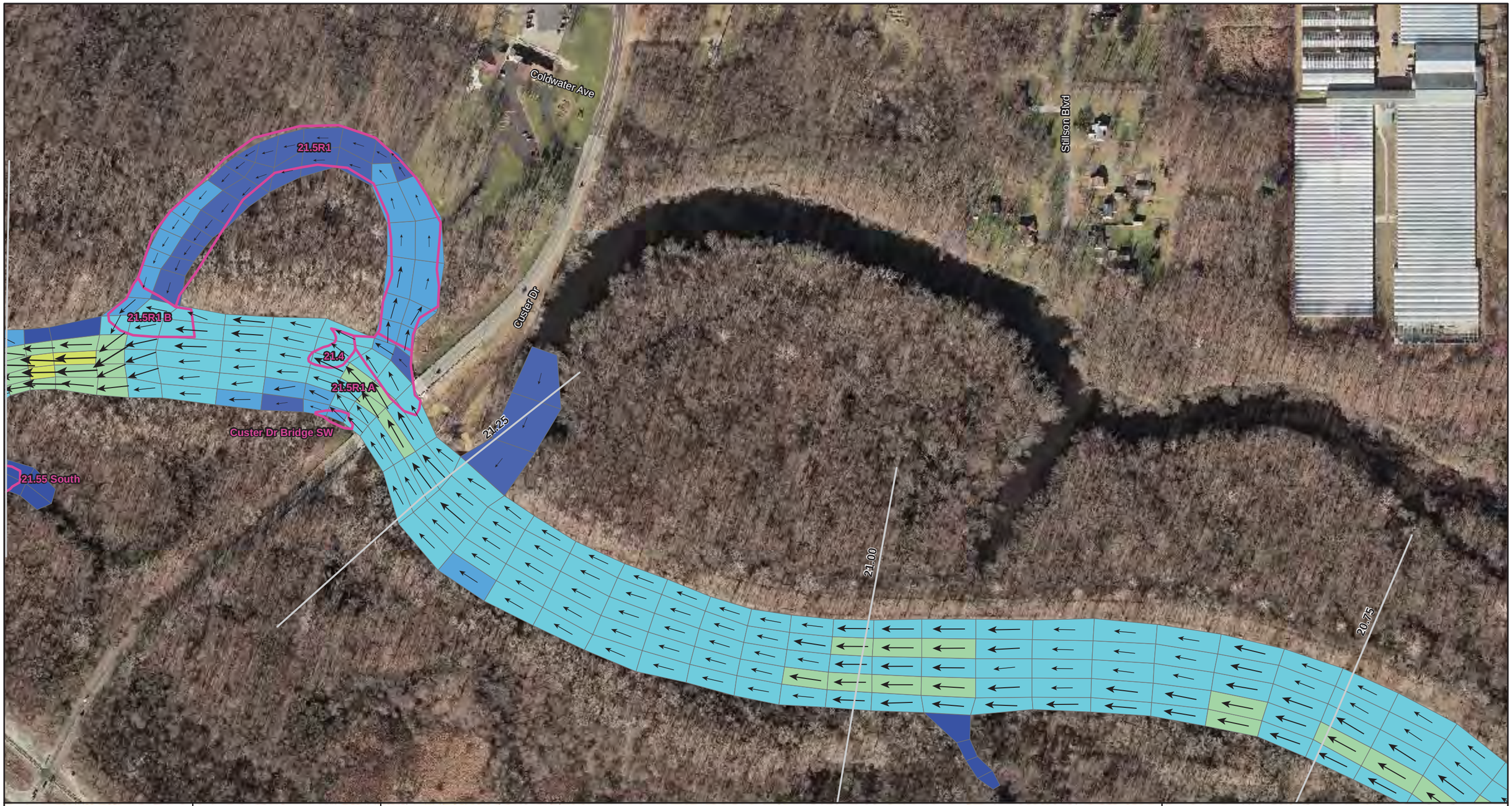
MP 19.90 - MP 20.75

SHEET 26 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 20.70 - MP 21.50

SHEET 27 OF 56

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

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Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 21.35 - MP 22.15

SHEET 28 OF 56

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

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Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 22.15 - MP 22.90

SHEET 29 OF 56

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

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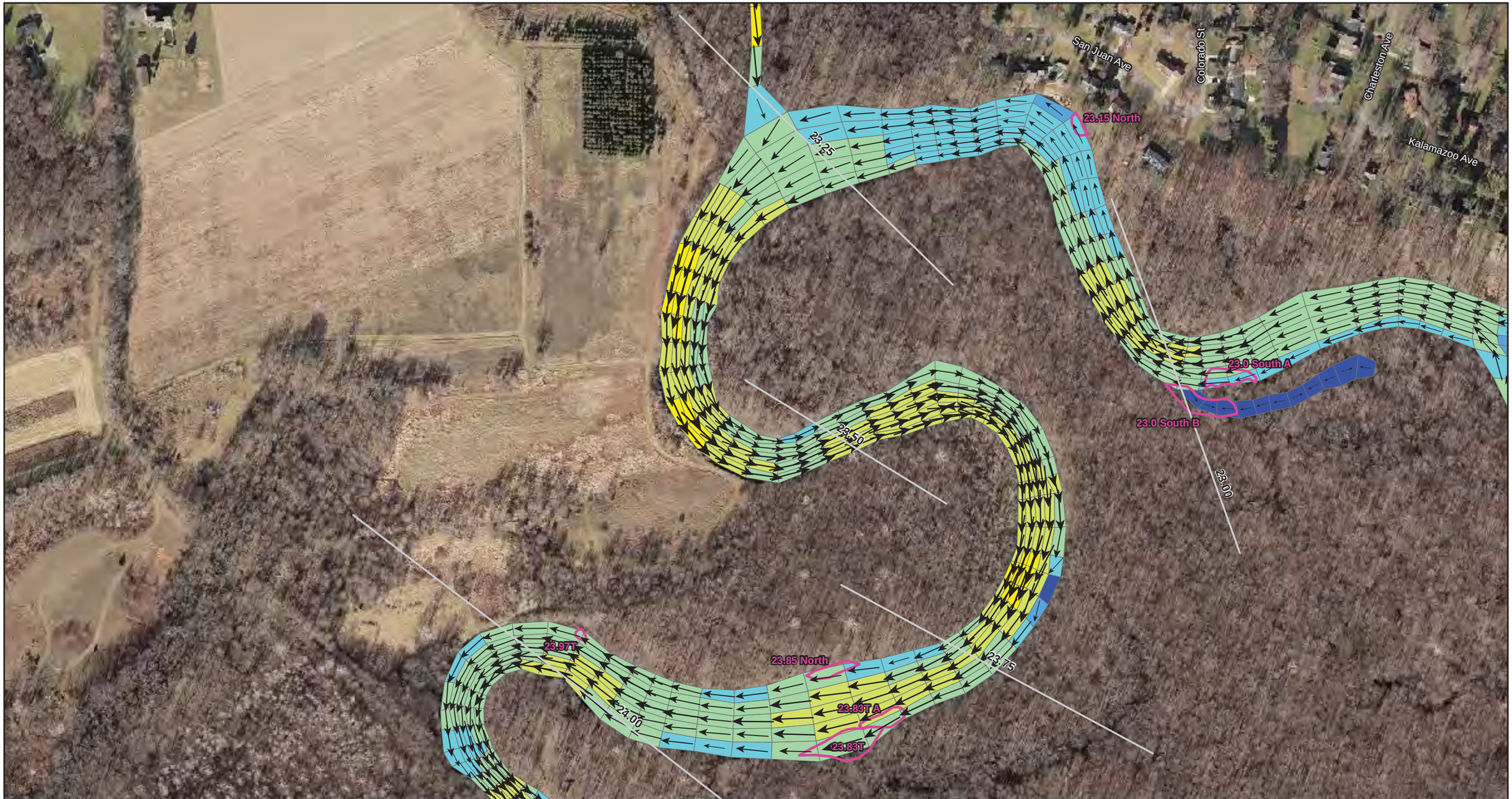
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

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Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 22.80 - MP 24.10

SHEET 30 OF 56

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

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Aerial Photography Date: November 2011

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 24.10 - MP 24.85

SHEET 31 OF 56

ENBRIDGE LINE 6B MP 608
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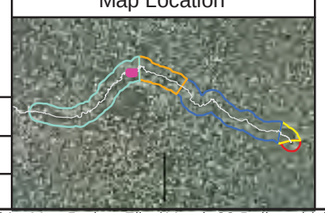
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 24.80 - MP 25.65

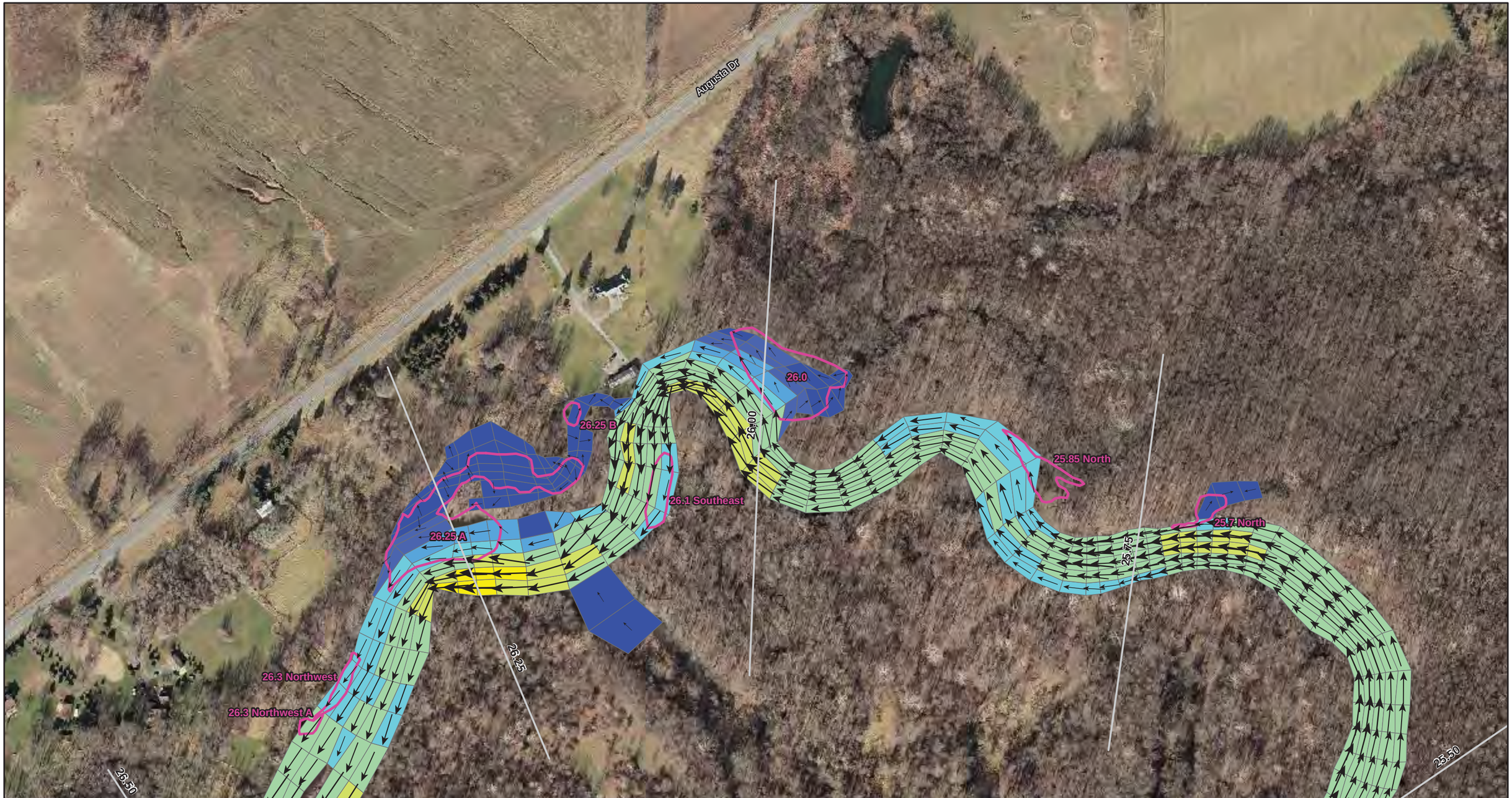
SHEET 32 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 25.55 - MP 26.40

SHEET 33 OF 56

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

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Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

← Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 26.40 - MP 27.45

SHEET 34 OF 56

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

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Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 27.45 - MP 28.10

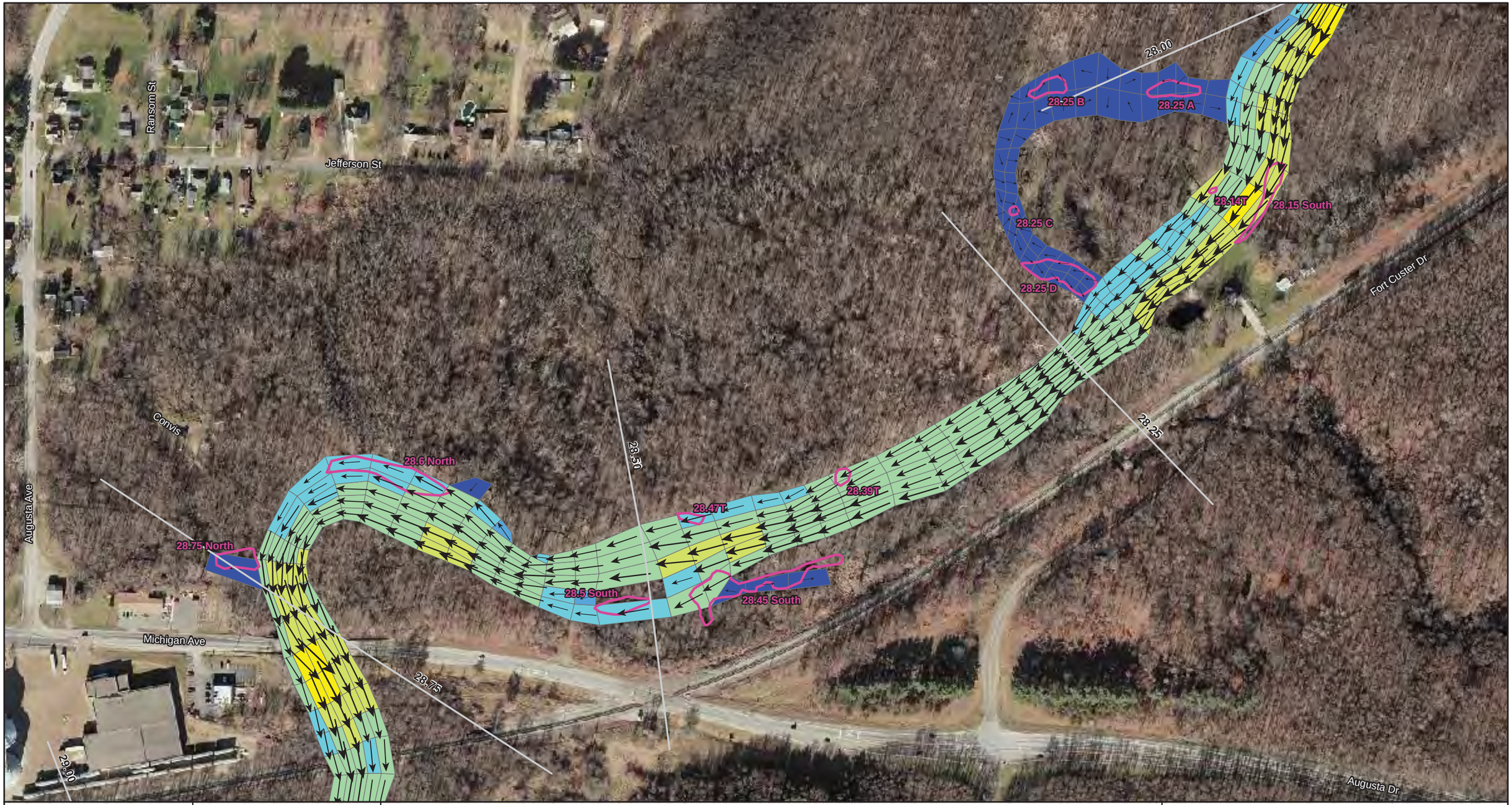
SHEET 35 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011

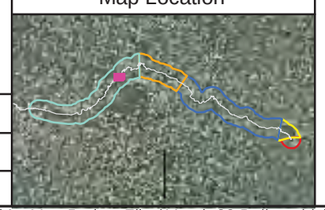
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 28.05 - MP 28.85

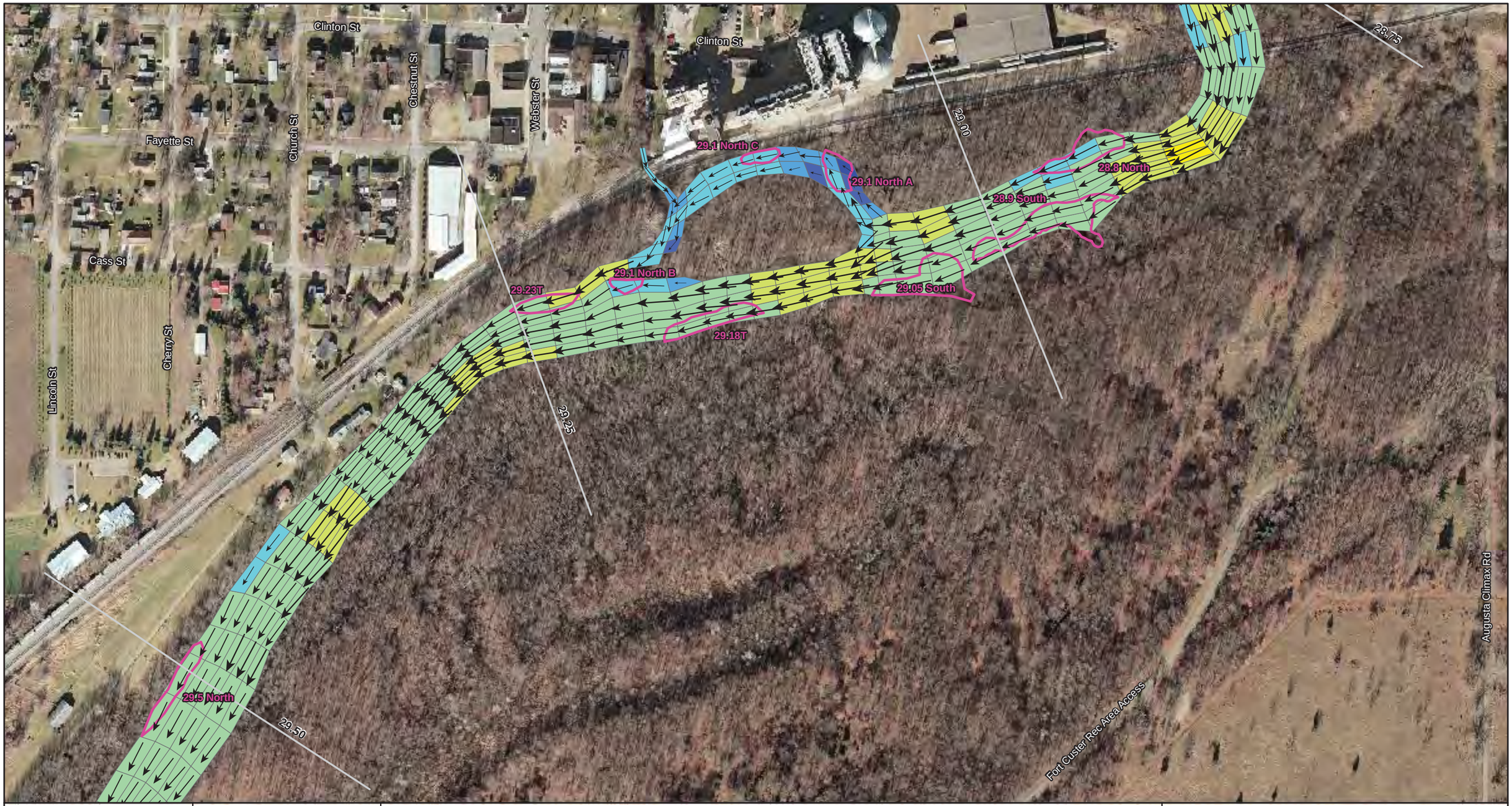
SHEET 36 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011

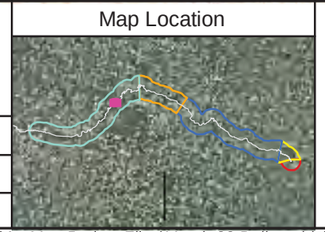
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 28.85 - MP29.55

SHEET 37 OF 56

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

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Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 29.50 - MP29.95

SHEET 38 OF 56

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

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Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
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- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 29.95 - MP 30.80

SHEET 39 OF 56

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

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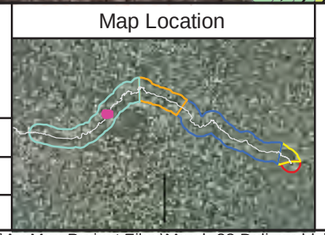
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



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- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
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- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 30.75 - MP 31.25

SHEET 40 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

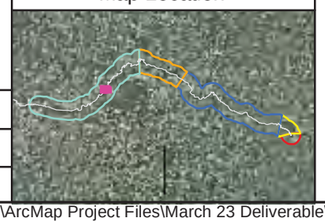
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 31.25 - MP 31.70

SHEET 41 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 31.65 - MP 32.25

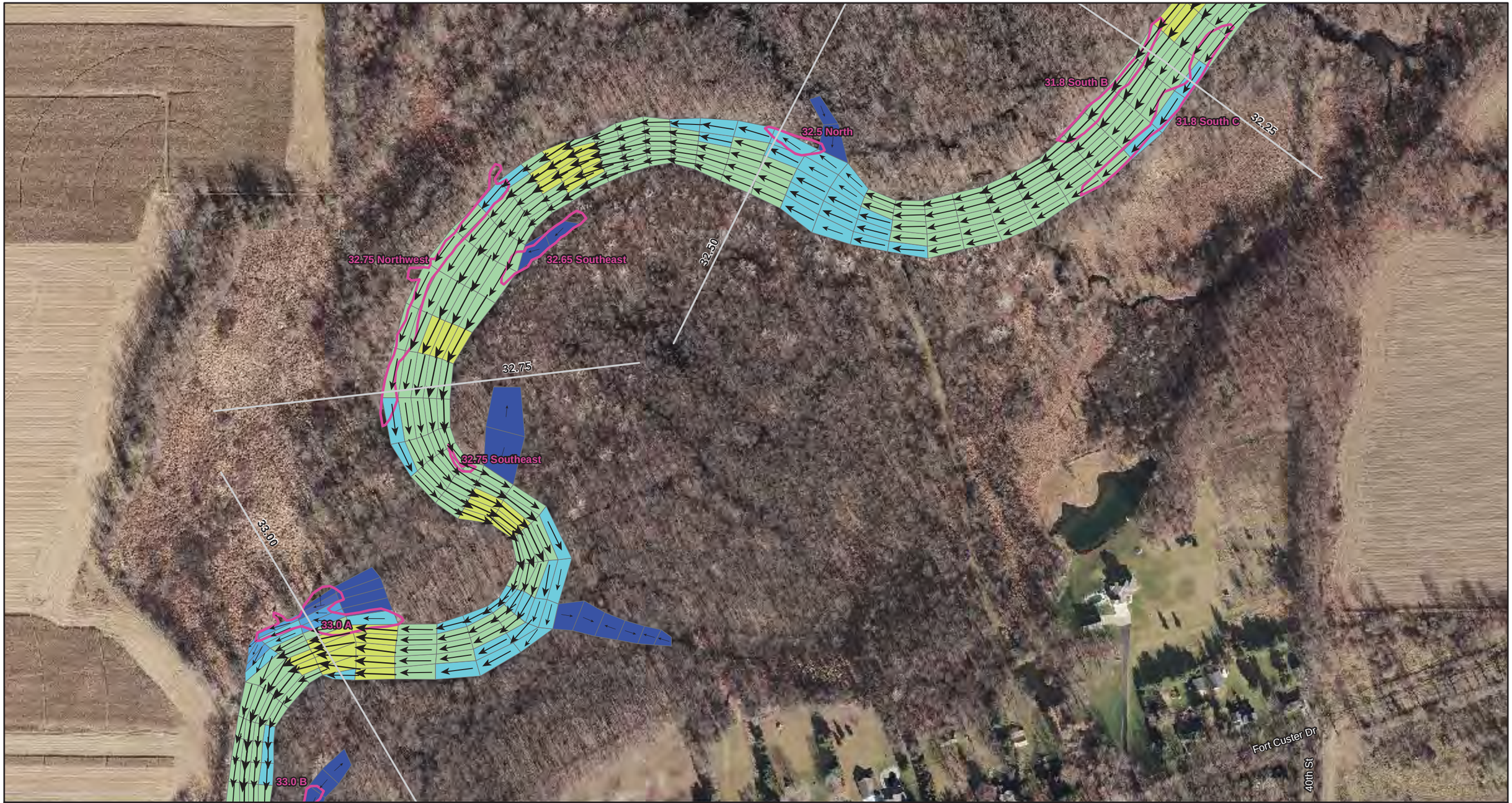
SHEET 42 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 32.25 - MP 33.10

SHEET 43 OF 56

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

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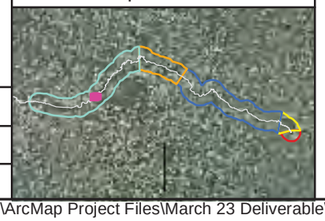
Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

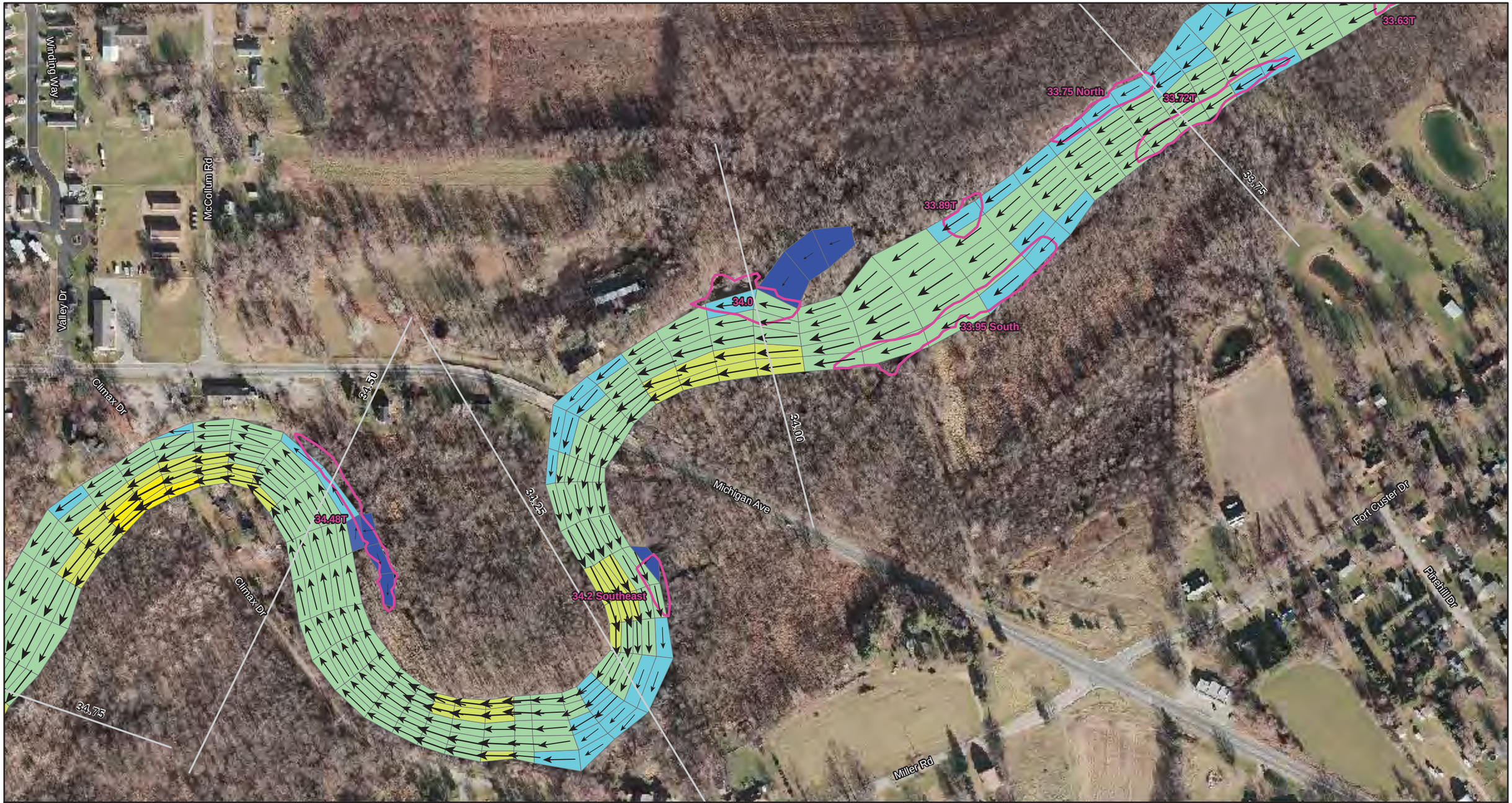
MP 33.10 - MP 33.70

SHEET 44 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 33.70 - MP 34.70

SHEET 45 OF 56

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

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Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 34.70 - MP 35.75

SHEET 46 OF 56

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

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Aerial Photography Date: November 2011

ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

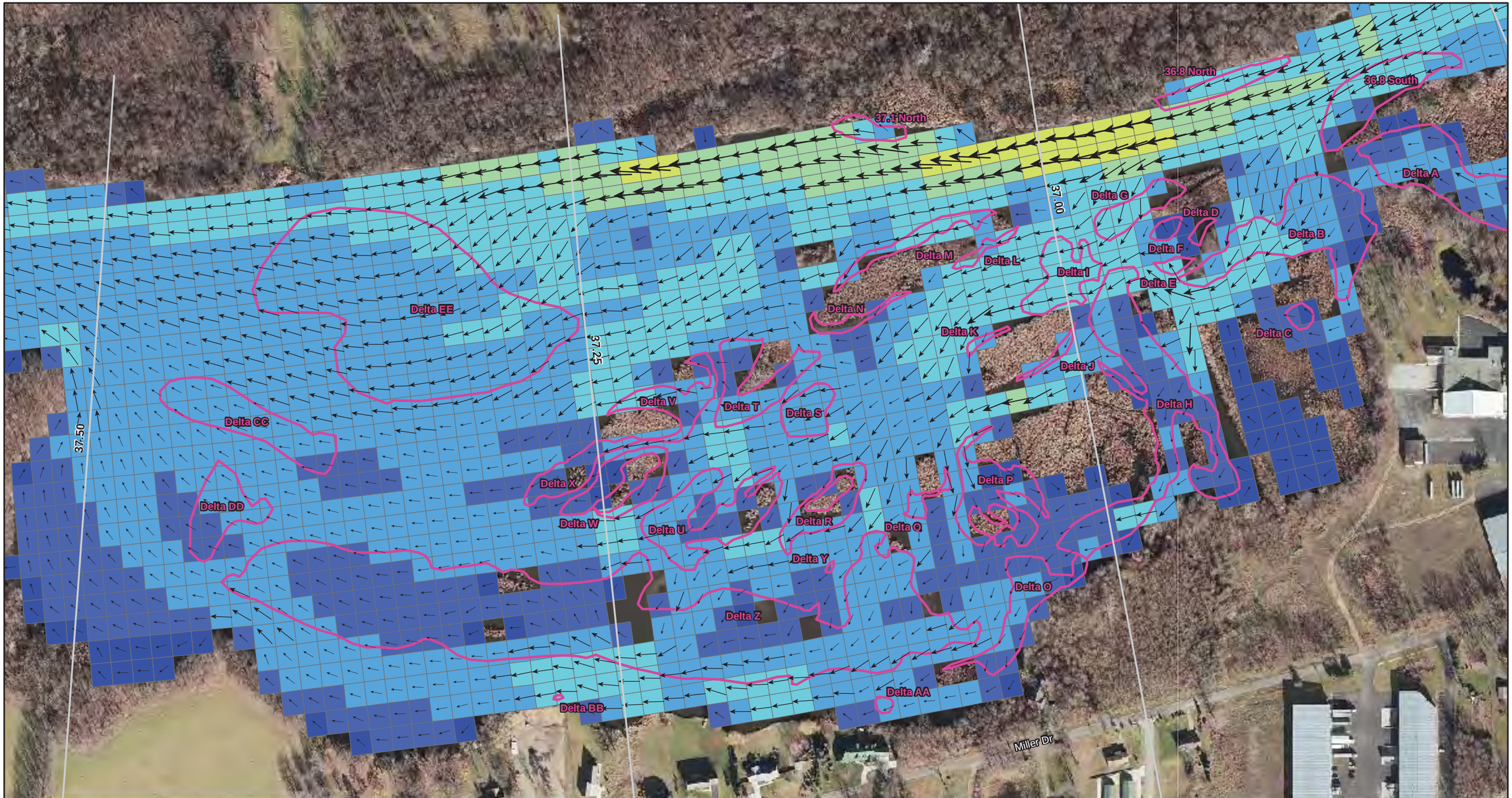
MP 35.75 - MP 36.80

SHEET 47 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011



ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 36.80 - MP 37.55

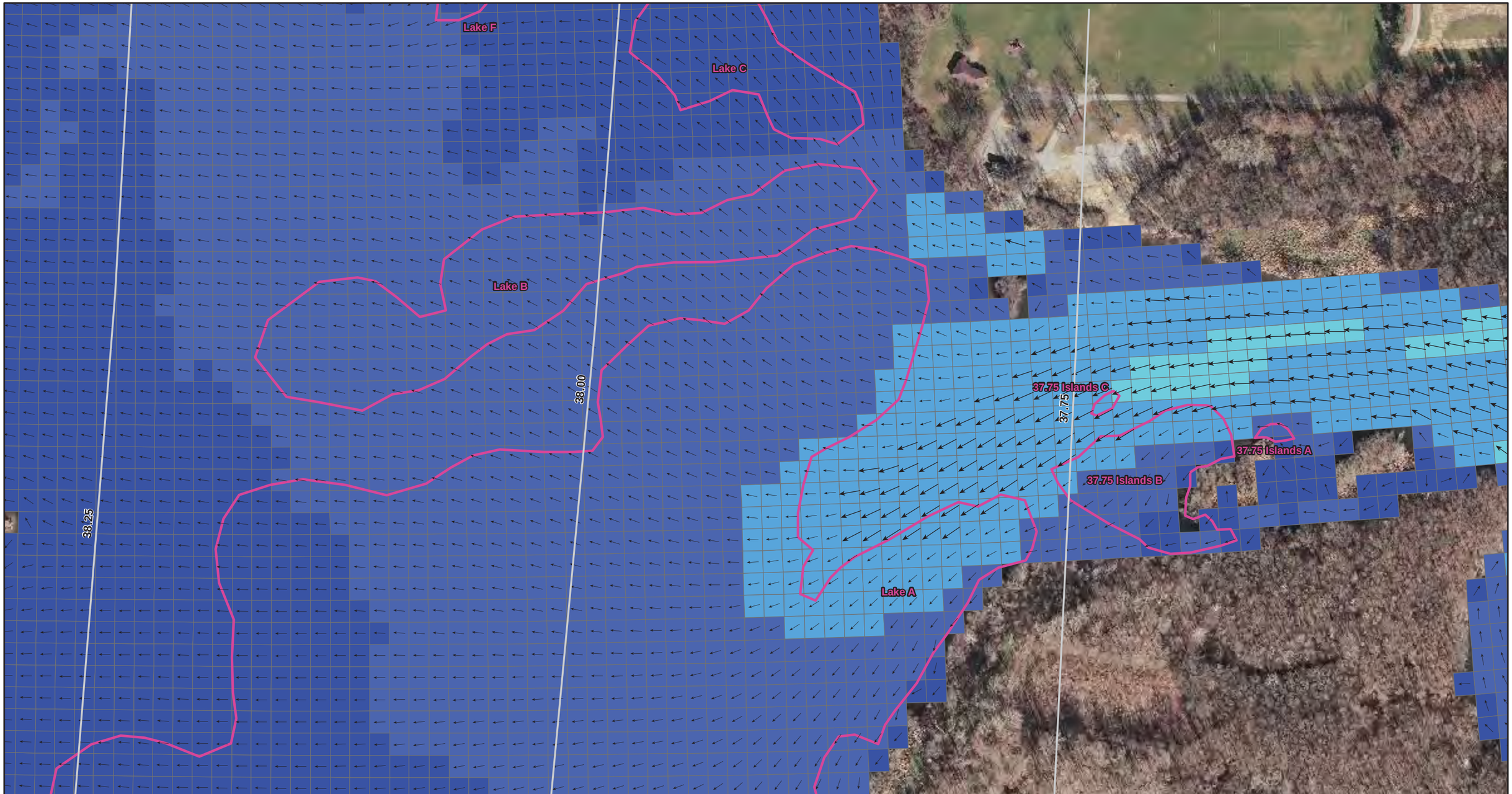
SHEET 48 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011

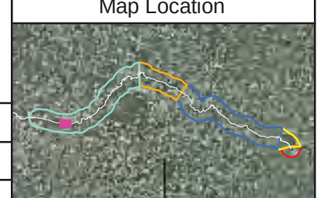
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 37.55 - MP 38.30

SHEET 49 OF 56

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

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Aerial Photography Date: November 2011

ENBRIDGE

Drawn:	BRS 4/30/2012
Approved:	DBR 4/30/2012
Project #:	106-4186

Map Location

Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

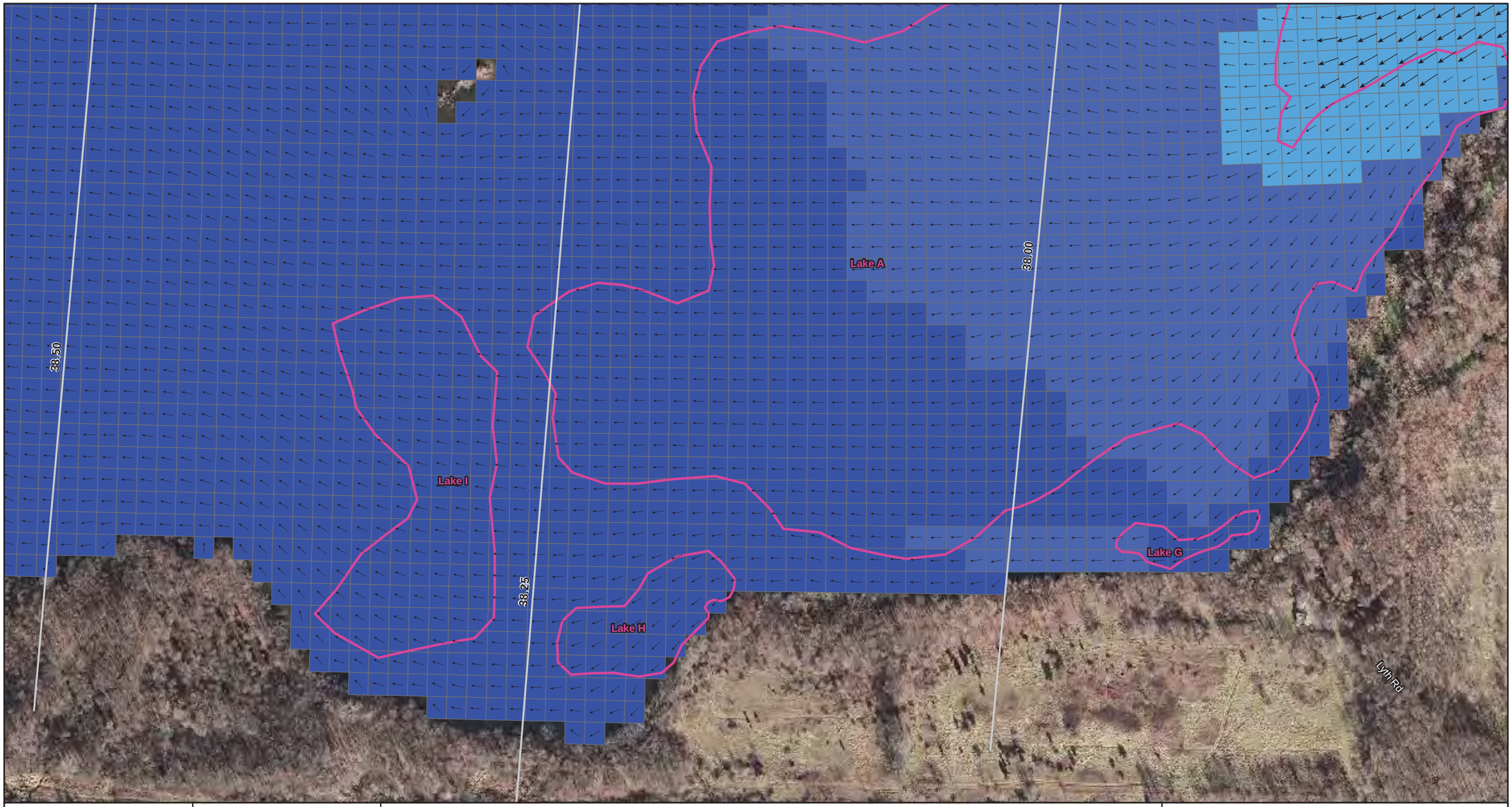
MP 37.80 - MP 38.60N

SHEET 50 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

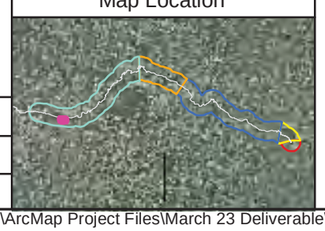
Aerial Photography Date: November 2011



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 37.80 - MP 38.60S

SHEET 51 OF 56

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

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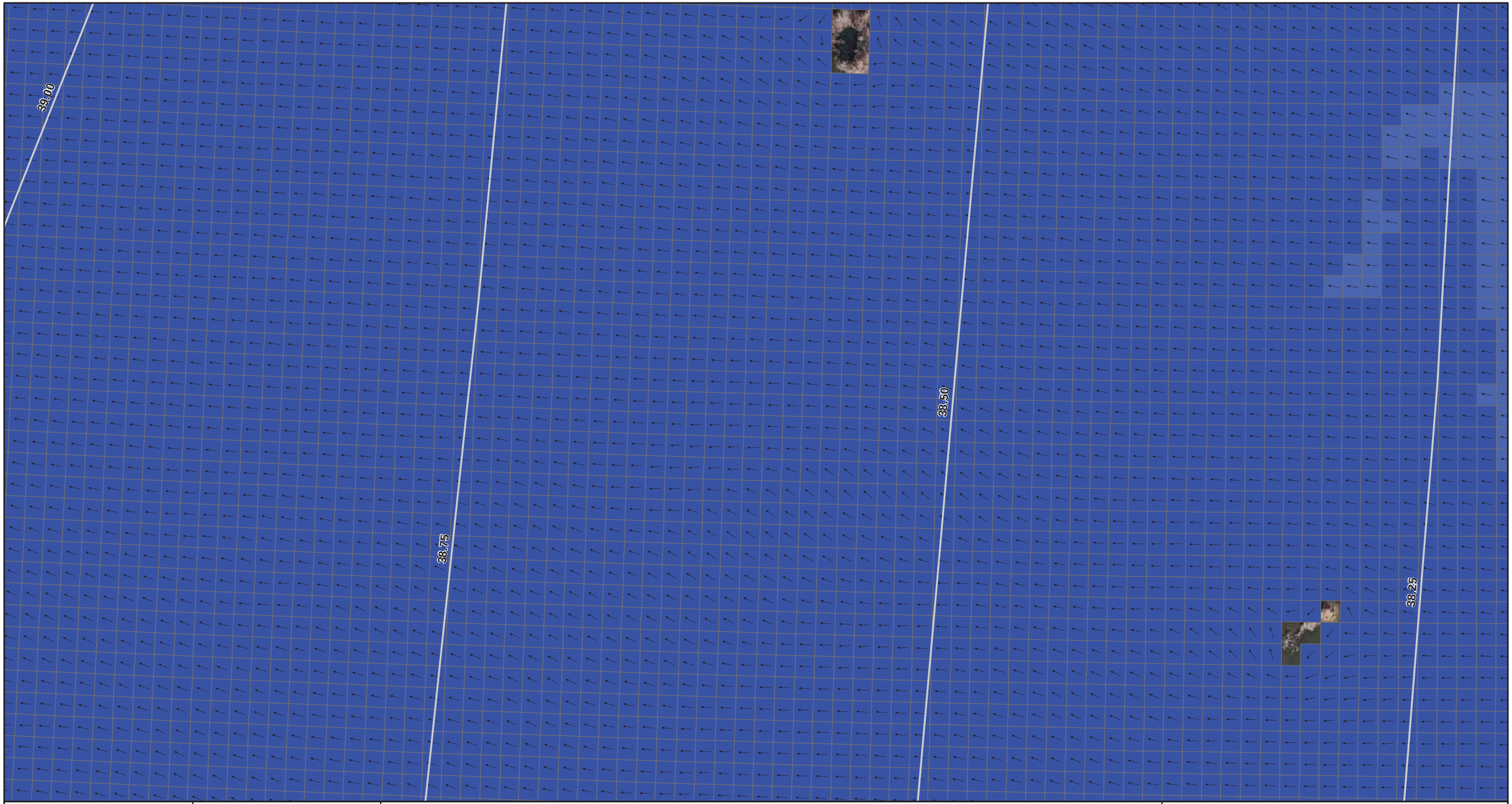
Aerial Photography Date: November 2011



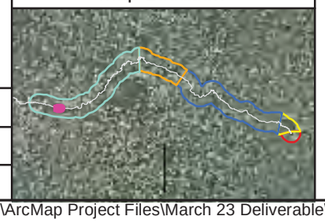
ENBRIDGE

Drawn: BRS 4/30/2012

Approved: DBR 4/30/2012

Project #: 106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

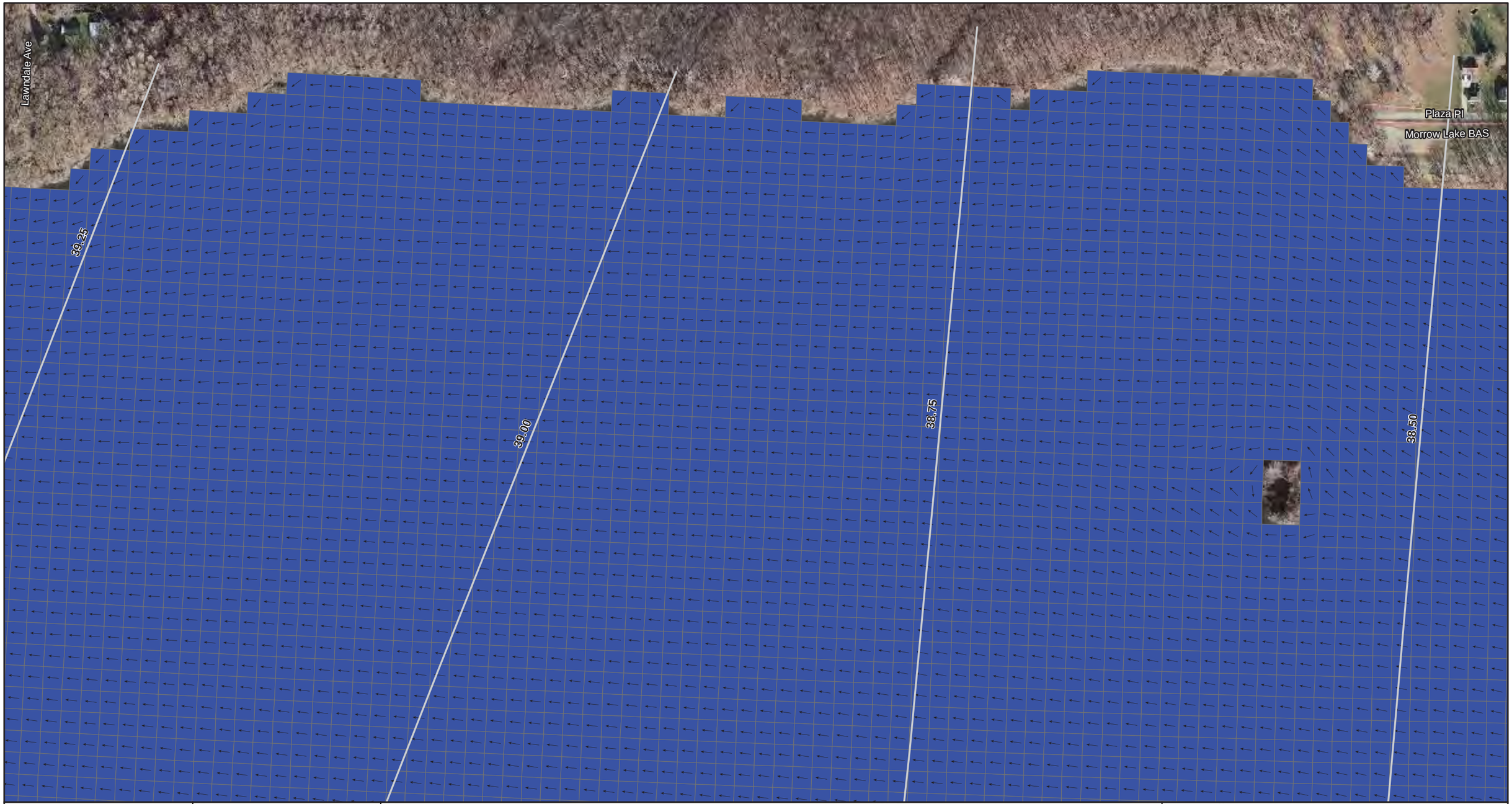
MP 38.25 - MP 39.00C

SHEET 52 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

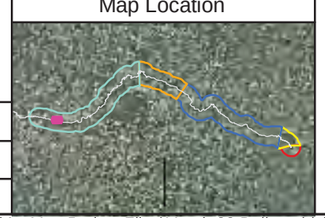
Aerial Photography Date: November 2011



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
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- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
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Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

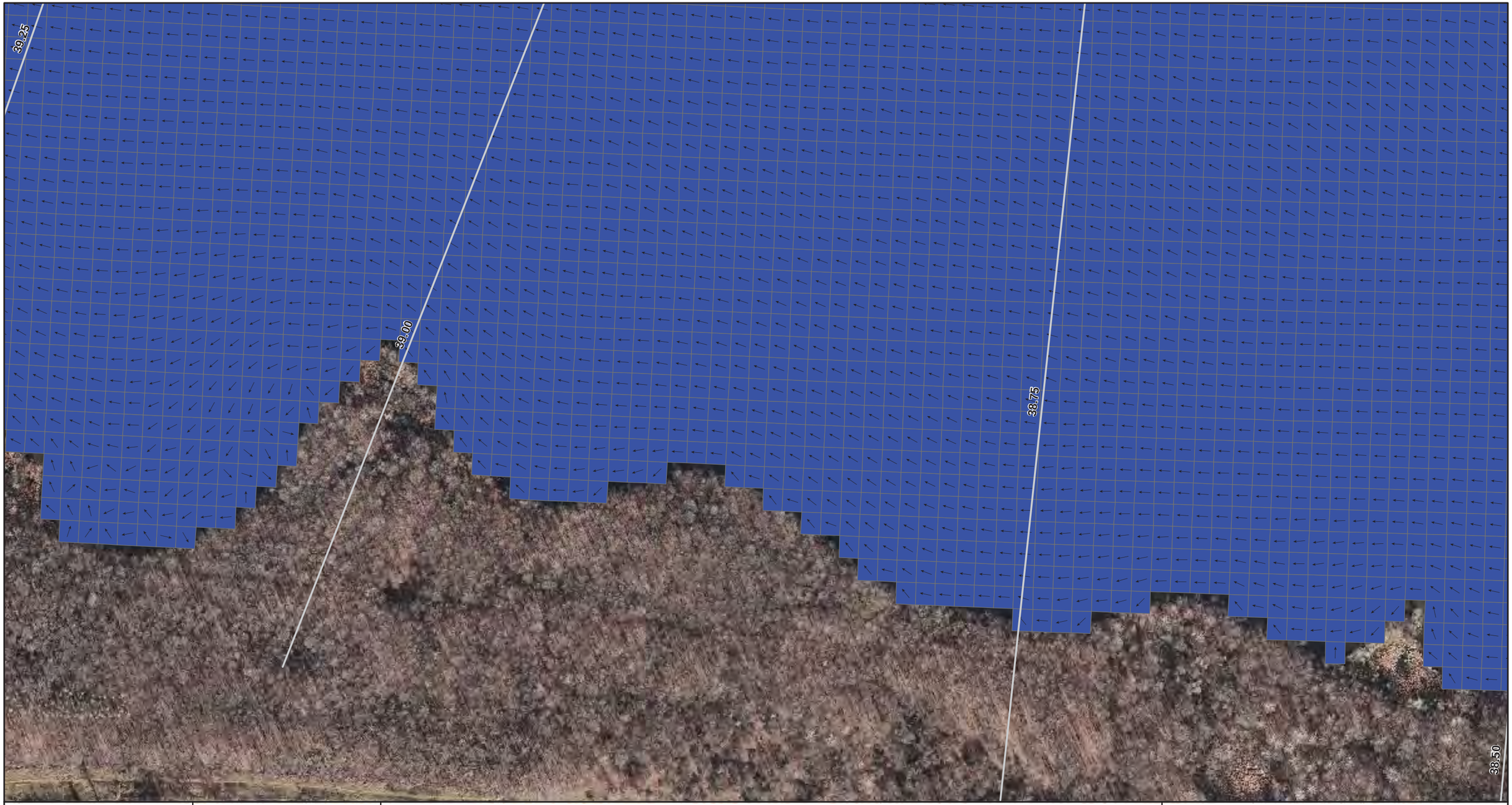
MP 38.50 - MP 39.25N

SHEET 53 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011



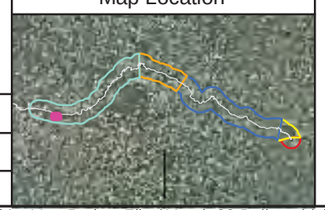
ENBRIDGE

Drawn: BRS 4/30/2012

Approved: DBR 4/30/2012

Project #: 106-4186

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
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- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 38.50 - MP 39.25S

SHEET 54 OF 56

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

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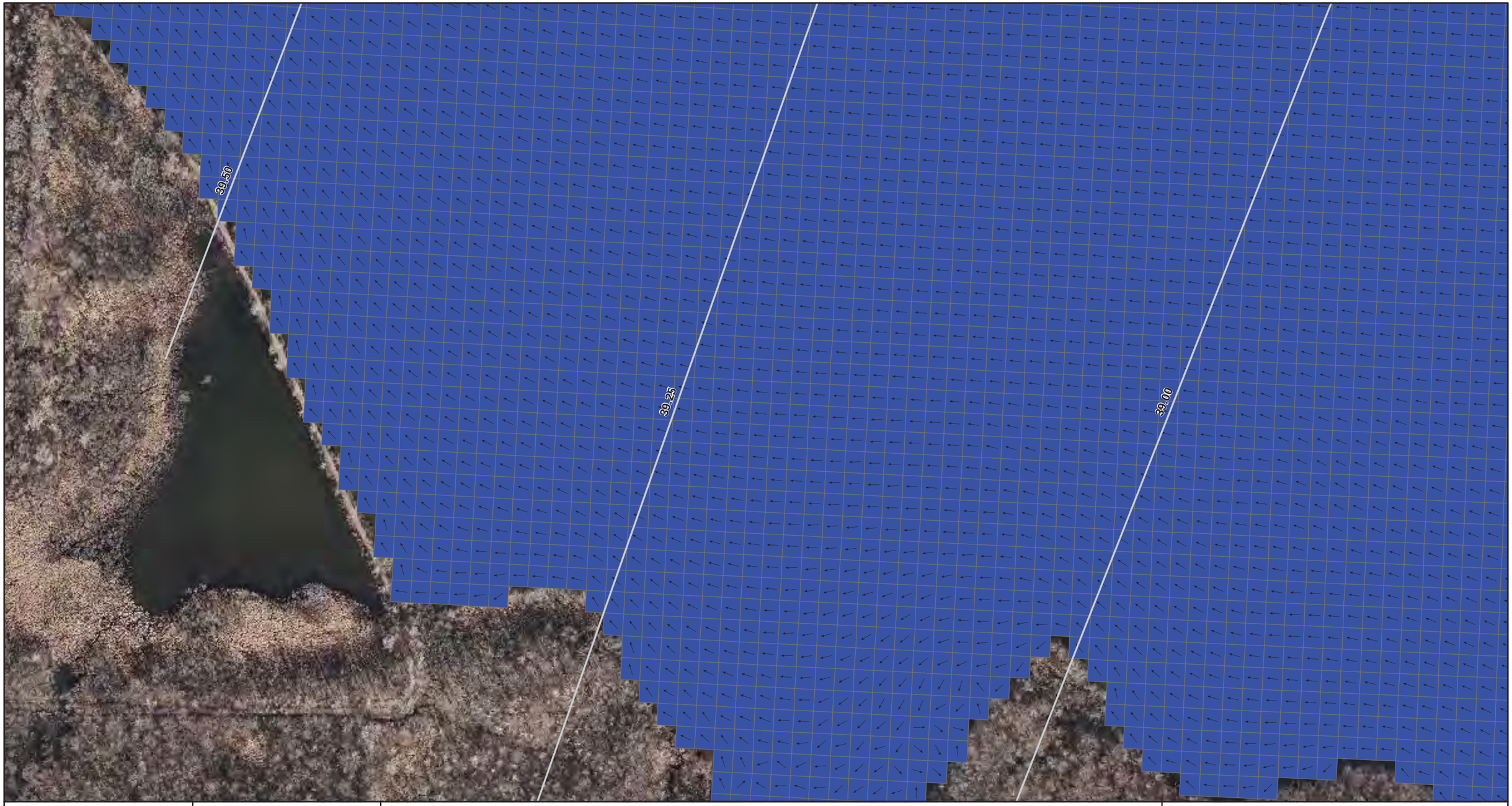
Aerial Photography Date: November 2011

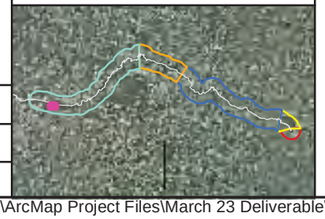
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 38.90 - MP 39.60S

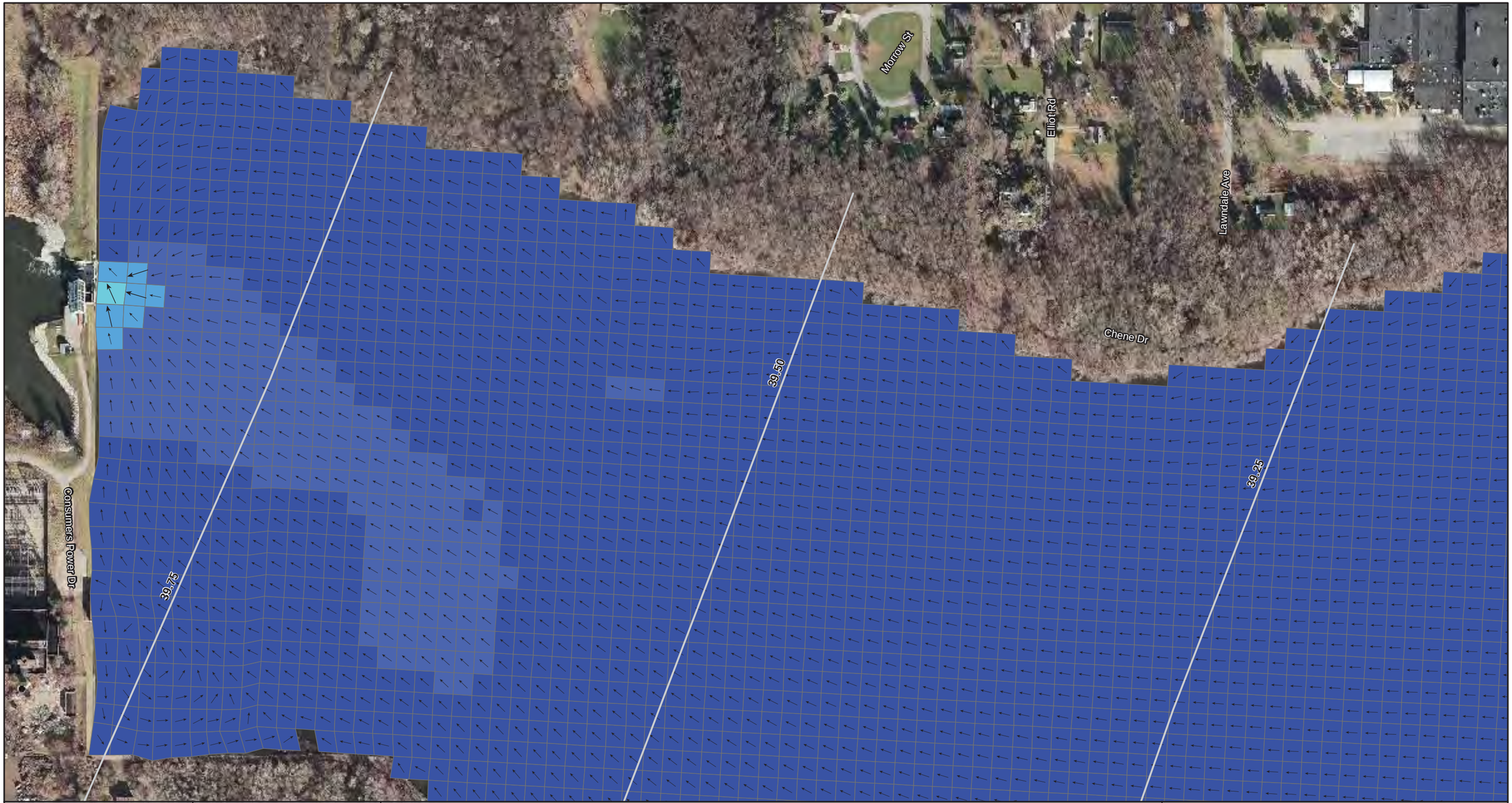
SHEET 55 OF 56

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011

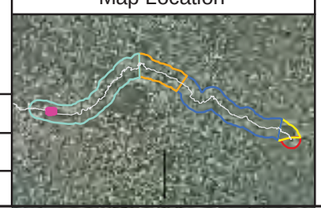
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS	4/30/2012
Approved:	DBR	4/30/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - November 3, 2011

- < 0.1 ft/sec
- 0.1 - 0.25 ft/sec
- 0.25 - 0.5 ft/sec
- 0.5 - 1.0 ft/sec
- 1.0 - 1.5 ft/sec
- 1.5 - 2.0 ft/sec
- 2.0 - 2.5 ft/sec
- 2.5 - 3.0 ft/sec
- 3.0 - 4.0 ft/sec
- > 4.0 ft/sec

Flow Direction and Relative Magnitude

Spring 2011 Submerged Oil Delineation Areas

Quarter Mile Grid Segment

ft/sec = Feet Per Second

cfs = Cubic Feet Per Second

Kalamazoo River near Battle Creek USGS gage daily average discharge: 642 cfs

N

0 125 250 500

Scale in Feet

RIVERINE GRID: VELOCITY WITH
SPRING 2011 SUBMERGED OIL DELINEATION AREAS
NOVEMBER 3, 2011 MODEL RUN

MP 39.15 - MP 39.85

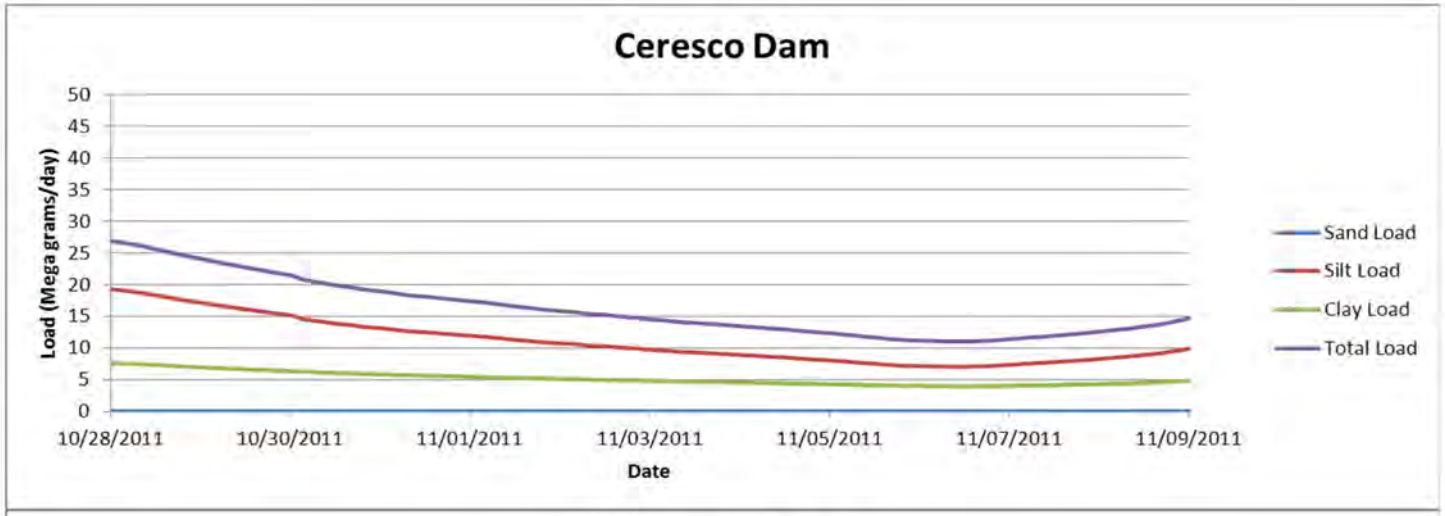
SHEET 56 OF 56

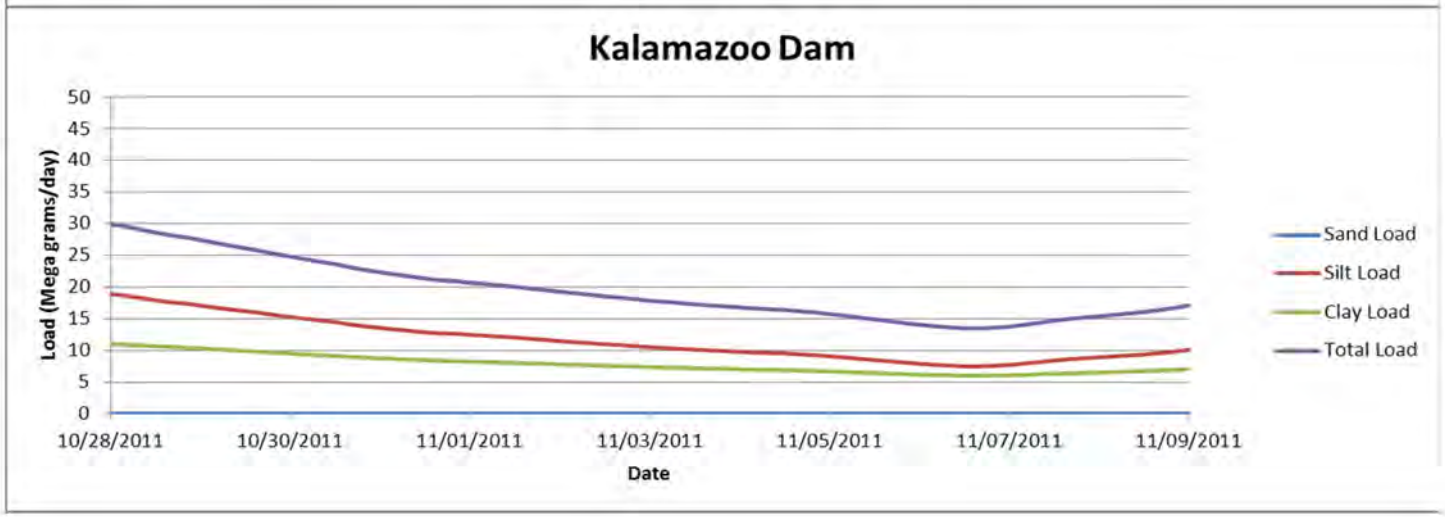
ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Riverine_Velocity_Nov3_2011.mxd

Aerial Photography Date: November 2011

US EPA ARCHIVE DOCUMENT





ENBRIDGE

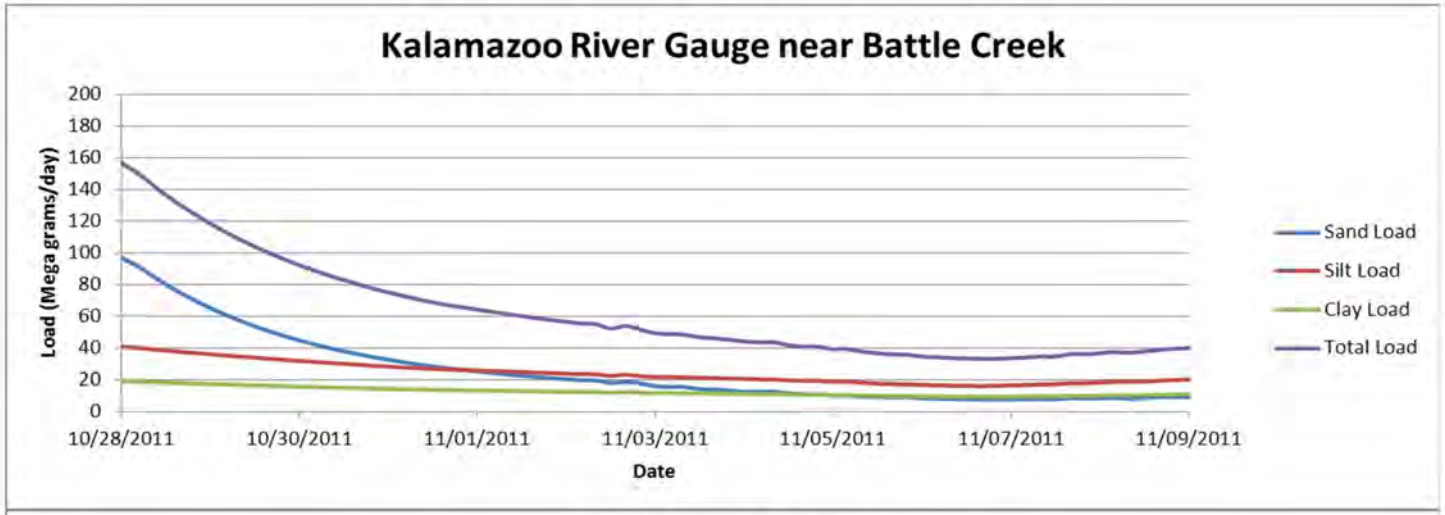
Drawn:	JLH	04/17/2012
Approved:	DBR	04/17/2012
Project #:	106-4186	

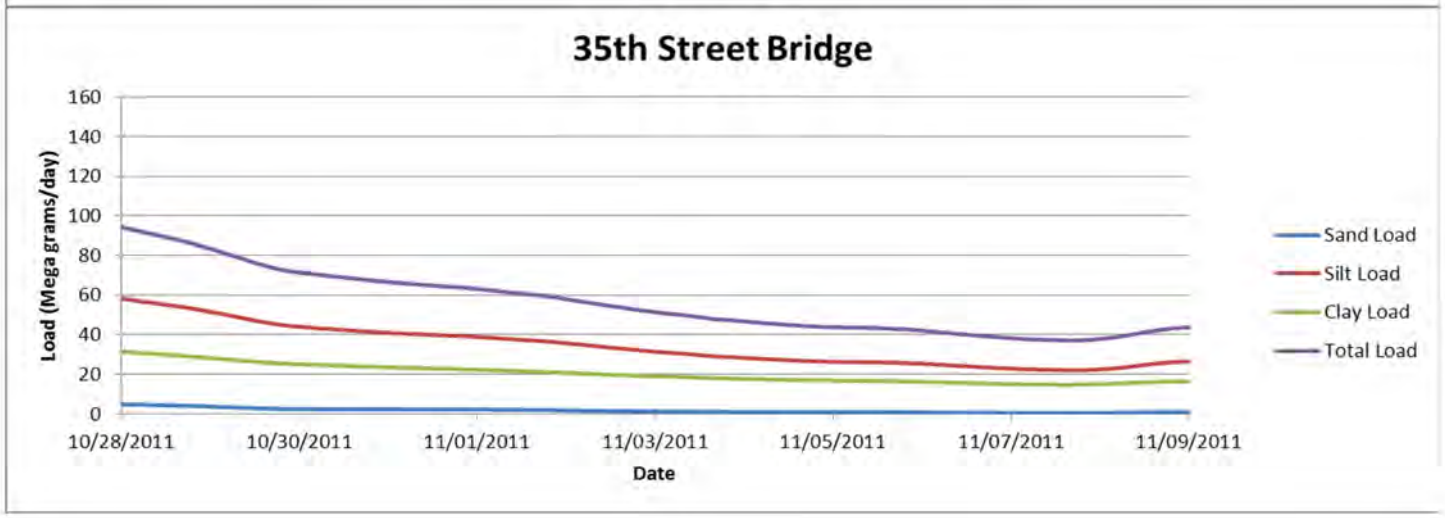
RIVERINE SIMULATED SEDIMENT MASS FLUX (MEGAGRAMS PER DAY) IN KALAMAZOO RIVER CALIBRATION

SHEET 1 OF 6

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

US EPA ARCHIVE DOCUMENT





ENBRIDGE

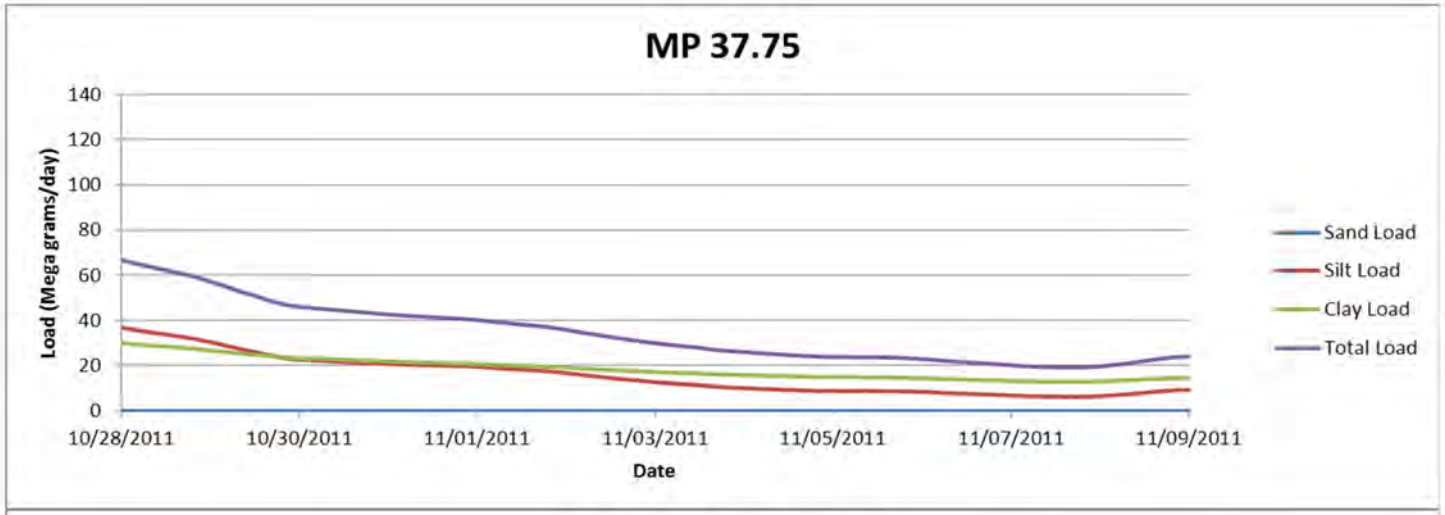
Drawn:	JLH	04/17/2012
Approved:	DBR	04/17/2012
Project #:	106-4186	

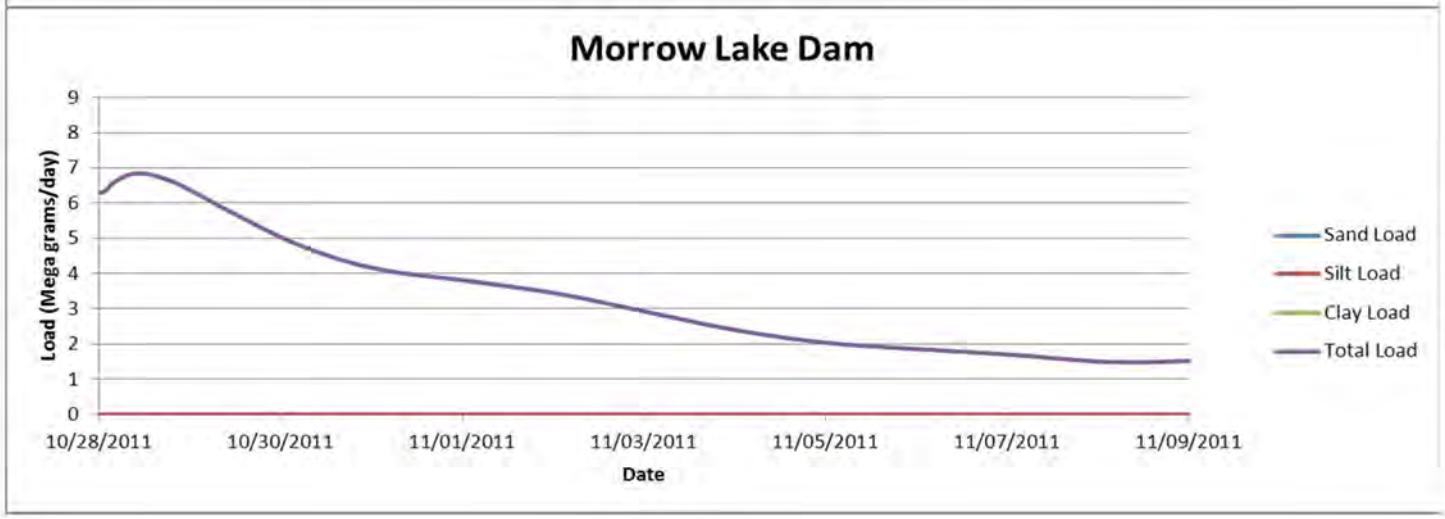
RIVERINE SIMULATED SEDIMENT MASS FLUX (MEGAGRAMS PER DAY) IN KALAMAZOO RIVER CALIBRATION

SHEET 2 OF 6

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

US EPA ARCHIVE DOCUMENT





ENBRIDGE

Drawn:	JLH	04/17/2012
Approved:	DBR	04/17/2012
Project #:	106-4186	

Footnotes:

Morrow Lake Dam Total Load = Clay Load
Morrow Lake Dam Silt Load = Sand Load

RIVERINE SIMULATED SEDIMENT MASS FLUX (MEGAGRAMS PER DAY) IN KALAMAZOO RIVER CALIBRATION

SHEET 3 OF 6

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

US EPA ARCHIVE DOCUMENT

Date	Time	Ceresco Dam			Kalamazoo Dam			Kalamazoo River Gauge Near Battle Creek			35th Street Bridge			Delta Neck			Morrow Dam		
		Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)
10/28/2011	12:00 AM	0.0	19.3	7.6	0.0	18.9	11.0	97.1	40.8	19.0	4.8	58.2	31.3	0.0	36.9	30.0	0.0	0.0	6.3
10/28/2011	4:00 AM	0.0	19.0	7.5	0.0	18.7	10.9	92.2	40.1	18.8	4.6	57.1	30.8	0.0	35.7	29.4	0.0	0.0	6.6
10/28/2011	7:59 AM	0.0	18.7	7.4	0.0	18.3	10.8	86.0	39.2	18.5	4.4	56.1	30.3	0.0	34.7	28.9	0.0	0.0	6.8
10/28/2011	12:00 PM	0.0	18.3	7.3	0.0	17.9	10.7	80.0	38.3	18.1	4.2	55.1	29.8	0.0	33.8	28.5	0.0	0.0	6.8
10/28/2011	4:00 PM	0.0	17.9	7.2	0.0	17.6	10.6	74.6	37.5	17.9	4.1	54.1	29.3	0.0	32.8	28.0	0.0	0.0	6.7
10/28/2011	7:59 PM	0.0	17.5	7.1	0.0	17.4	10.4	69.7	36.8	17.6	3.8	52.9	28.8	0.0	31.8	27.4	0.0	0.0	6.6
10/29/2011	12:00 AM	0.0	17.2	6.9	0.0	17.1	10.3	65.1	36.0	17.3	3.6	51.5	28.1	0.0	30.5	26.8	0.0	0.0	6.4
10/29/2011	4:00 AM	0.0	16.8	6.8	0.0	16.8	10.2	61.0	35.3	17.0	3.3	50.1	27.5	0.0	28.9	26.1	0.0	0.0	6.1
10/29/2011	7:59 AM	0.0	16.4	6.7	0.0	16.5	10.0	57.1	34.5	16.8	3.0	48.6	26.9	0.0	27.4	25.5	0.0	0.0	5.9
10/29/2011	12:00 PM	0.0	16.1	6.6	0.0	16.2	9.9	53.6	33.8	16.5	2.8	47.1	26.3	0.0	26.0	24.9	0.0	0.0	5.7
10/29/2011	4:00 PM	0.0	15.8	6.5	0.0	15.9	9.8	50.4	33.2	16.2	2.5	45.8	25.7	0.0	24.6	24.2	0.0	0.0	5.5
10/29/2011	7:59 PM	0.0	15.5	6.4	0.0	15.6	9.6	47.5	32.5	15.9	2.4	44.7	25.3	0.0	23.3	23.7	0.0	0.0	5.2
10/30/2011	12:00 AM	0.0	15.2	6.3	0.0	15.3	9.5	44.8	31.8	15.7	2.3	44.0	25.0	0.0	22.7	23.4	0.0	0.0	5.0
10/30/2011	4:00 AM	0.0	14.5	6.2	0.0	15.0	9.4	42.3	31.2	15.4	2.3	43.3	24.8	0.0	22.3	23.1	0.0	0.0	4.8
10/30/2011	7:59 AM	0.0	14.2	6.1	0.0	14.7	9.2	39.9	30.6	15.2	2.2	42.8	24.5	0.0	22.0	22.9	0.0	0.0	4.7
10/30/2011	12:00 PM	0.0	13.9	6.0	0.0	14.5	9.1	37.9	30.0	15.0	2.2	42.3	24.2	0.0	21.7	22.7	0.0	0.0	4.5
10/30/2011	4:00 PM	0.0	13.6	6.0	0.0	14.1	9.0	36.0	29.4	14.7	2.2	41.8	23.9	0.0	21.4	22.4	0.0	0.0	4.4
10/30/2011	7:59 PM	0.0	13.3	5.9	0.0	13.8	8.9	34.2	28.7	14.5	2.2	41.3	23.7	0.0	21.0	22.1	0.0	0.0	4.3
10/31/2011	12:00 AM	0.0	13.1	5.8	0.0	13.6	8.8	32.5	28.2	14.3	2.2	40.9	23.5	0.0	20.8	21.9	0.0	0.0	4.2
10/31/2011	4:00 AM	0.0	12.9	5.8	0.0	13.3	8.6	31.0	27.7	14.1	2.1	40.5	23.2	0.0	20.5	21.7	0.0	0.0	4.1
10/31/2011	7:59 AM	0.0	12.6	5.7	0.0	13.1	8.6	29.6	27.2	13.9	2.1	40.2	23.0	0.0	20.3	21.5	0.0	0.0	4.0
10/31/2011	12:00 PM	0.0	12.5	5.6	0.0	12.9	8.5	28.3	26.7	13.7	2.1	39.9	22.8	0.0	20.2	21.3	0.0	0.0	4.0
10/31/2011	4:00 PM	0.0	12.3	5.6	0.0	12.7	8.4	27.1	26.4	13.6	2.1	39.5	22.6	0.0	20.0	21.1	0.0	0.0	3.9
10/31/2011	7:59 PM	0.0	12.1	5.5	0.0	12.7	8.3	26.1	26.2	13.4	2.1	39.3	22.4	0.0	19.8	20.9	0.0	0.0	3.9
11/1/2011	12:00 AM	0.0	11.9	5.5	0.0	12.5	8.2	25.1	25.8	13.3	2.1	38.8	22.2	0.0	19.5	20.7	0.0	0.0	3.8
11/1/2011	4:00 AM	0.0	11.8	5.4	0.0	12.3	8.2	24.2	25.5	13.1	2.0	38.3	21.9	0.0	19.1	20.4	0.0	0.0	3.8
11/1/2011	7:59 AM	0.0	11.5	5.3	0.0	12.2	8.1	23.3	25.1	13.0	2.0	37.8	21.7	0.0	18.7	20.2	0.0	0.0	3.7
11/1/2011	12:00 PM	0.0	11.3	5.3	0.0	12.0	8.0	22.5	24.8	12.9	1.9	37.3	21.5	0.0	18.3	20.0	0.0	0.0	3.6
11/1/2011	4:00 PM	0.0	11.1	5.2	0.0	11.8	7.9	21.7	24.4	12.7	1.8	36.9	21.2	0.0	17.9	19.7	0.0	0.0	3.6
11/1/2011	7:59 PM	0.0	10.9	5.2	0.0	11.7	7.9	20.9	24.1	12.6	1.8	36.4	21.0	0.0	17.4	19.5	0.0	0.0	3.5
11/2/2011	12:00 AM	0.0	10.7	5.1	0.0	11.5	7.8	20.3	23.7	12.5	1.6	35.6	20.7	0.0	16.7	19.1	0.0	0.0	3.5

ENBRIDGE

Drawn: JLH 04/17/2012

Approved: DBR 04/17/2012

Project #: 106-4186

Footnotes:

Mg=Megagram

RIVERINE SIMULATED SEDIMENT MASS FLUX (MEGAGRAMS PER DAY) IN KALAMAZOO RIVER CALIBRATION

SHEET 4 OF 6

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

US EPA ARCHIVE DOCUMENT

Date	Time	Ceresco Dam			Kalamazoo Dam			Kalamazoo River Gauge Near Battle Creek			35th Street Bridge			Delta Neck			Morrow Dam		
		Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)
11/2/2011	4:00 AM	0.0	10.6	5.1	0.0	11.3	7.7	19.7	23.4	12.4	1.5	34.9	20.3	0.0	16.0	18.8	0.0	0.0	3.4
11/2/2011	7:59 AM	0.0	10.3	5.0	0.0	11.2	7.7	19.5	23.3	12.3	1.4	34.2	20.0	0.0	15.3	18.4	0.0	0.0	3.3
11/2/2011	12:00 PM	0.0	10.3	4.9	0.0	11.0	7.6	17.9	22.3	11.9	1.3	33.4	19.7	0.0	14.5	18.1	0.0	0.0	3.2
11/2/2011	4:00 PM	0.0	10.1	4.9	0.0	10.9	7.5	18.6	23.1	12.3	1.3	32.7	19.4	0.0	13.9	17.8	0.0	0.0	3.1
11/2/2011	7:59 PM	0.0	9.9	4.9	0.0	10.7	7.4	17.6	22.2	11.8	1.2	31.9	19.1	0.0	13.3	17.5	0.0	0.0	3.0
11/3/2011	12:00 AM	0.0	9.7	4.8	0.0	10.5	7.4	16.0	21.7	11.6	1.1	31.4	18.9	0.0	12.7	17.2	0.0	0.0	2.9
11/3/2011	4:00 AM	0.0	9.6	4.8	0.0	10.4	7.3	15.5	21.7	11.6	1.1	30.8	18.7	0.0	12.2	17.0	0.0	0.0	2.8
11/3/2011	7:59 AM	0.0	9.4	4.7	0.0	10.2	7.2	15.4	21.4	11.5	1.0	30.3	18.5	0.0	11.8	16.8	0.0	0.0	2.7
11/3/2011	12:00 PM	0.0	9.3	4.7	0.0	10.1	7.2	14.1	21.1	11.5	1.0	29.6	18.2	0.0	11.4	16.5	0.0	0.0	2.7
11/3/2011	4:00 PM	0.0	9.2	4.6	0.0	10.0	7.1	13.9	20.9	11.3	0.9	29.0	17.9	0.0	10.8	16.2	0.0	0.0	2.6
11/3/2011	7:59 PM	0.0	9.0	4.6	0.0	9.9	7.1	13.3	20.6	11.2	0.9	28.7	17.8	0.0	10.4	16.0	0.0	0.0	2.5
11/4/2011	12:00 AM	0.0	8.9	4.5	0.0	9.8	7.0	12.5	20.5	11.1	0.8	28.2	17.6	0.0	10.2	15.9	0.0	0.0	2.4
11/4/2011	4:00 AM	0.0	8.8	4.5	0.0	9.7	7.0	12.4	20.1	11.0	0.8	27.8	17.4	0.0	9.8	15.7	0.0	0.0	2.3
11/4/2011	7:59 AM	0.0	8.6	4.5	0.0	9.6	6.9	12.5	20.1	11.0	0.8	27.4	17.3	0.0	9.6	15.5	0.0	0.0	2.3
11/4/2011	12:00 PM	0.0	8.5	4.4	0.0	9.5	6.9	11.4	19.5	10.7	0.8	27.1	17.1	0.0	9.4	15.4	0.0	0.0	2.2
11/4/2011	4:00 PM	0.0	8.3	4.4	0.0	9.4	6.8	10.9	19.3	10.6	0.7	26.7	17.0	0.0	9.1	15.2	0.0	0.0	2.1
11/4/2011	7:59 PM	0.0	8.2	4.3	0.0	9.3	6.8	10.9	19.2	10.6	0.7	26.4	16.8	0.0	9.0	15.1	0.0	0.0	2.1
11/5/2011	12:00 AM	0.0	8.0	4.3	0.0	9.1	6.7	10.2	18.6	10.4	0.7	26.2	16.8	0.0	8.9	15.0	0.0	0.0	2.0
11/5/2011	4:00 AM	0.0	7.9	4.2	0.0	8.9	6.6	10.1	18.7	10.4	0.7	26.1	16.7	0.0	8.9	14.9	0.0	0.0	2.0
11/5/2011	7:59 AM	0.0	7.7	4.2	0.0	8.7	6.5	9.4	18.1	10.1	0.7	26.1	16.7	0.0	8.9	14.9	0.0	0.0	2.0
11/5/2011	12:00 PM	0.0	7.5	4.1	0.0	8.5	6.4	9.0	17.6	10.0	0.7	26.0	16.6	0.0	8.9	14.8	0.0	0.0	1.9
11/5/2011	4:00 PM	0.0	7.3	4.1	0.0	8.3	6.3	8.8	17.3	9.8	0.7	25.8	16.4	0.0	8.8	14.7	0.0	0.0	1.9
11/5/2011	7:59 PM	0.0	7.2	4.1	0.0	8.1	6.2	9.0	17.0	9.7	0.7	25.6	16.3	0.0	8.7	14.6	0.0	0.0	1.9
11/6/2011	12:00 AM	0.0	7.1	4.0	0.0	7.9	6.2	8.3	16.7	9.6	0.7	25.3	16.1	0.0	8.5	14.4	0.0	0.0	1.9
11/6/2011	4:00 AM	0.0	7.1	4.0	0.0	7.7	6.1	8.1	16.5	9.5	0.5	24.9	15.9	0.0	8.3	14.2	0.0	0.0	1.8
11/6/2011	7:59 AM	0.0	7.0	4.0	0.0	7.6	6.1	7.9	16.3	9.5	0.5	24.4	15.7	0.0	7.9	14.0	0.0	0.0	1.8
11/6/2011	12:00 PM	0.0	7.0	4.0	0.0	7.5	6.0	7.8	16.1	9.4	0.5	24.0	15.5	0.0	7.7	13.8	0.0	0.0	1.8
11/6/2011	4:00 PM	0.0	7.1	4.0	0.0	7.5	6.0	7.6	16.1	9.4	0.5	23.5	15.3	0.0	7.5	13.6	0.0	0.0	1.8
11/6/2011	7:59 PM	0.0	7.2	4.0	0.0	7.6	6.0	7.6	16.2	9.4	0.5	23.2	15.1	0.0	7.2	13.4	0.0	0.0	1.7
11/7/2011	12:00 AM	0.0	7.3	4.0	0.0	7.7	6.0	7.7	16.5	9.4	0.4	22.8	15.0	0.0	7.0	13.3	0.0	0.0	1.7
11/7/2011	4:00 AM	0.0	7.5	4.1	0.0	7.9	6.1	7.7	16.6	9.5	0.4	22.4	14.8	0.0	6.7	13.1	0.0	0.0	1.7

ENBRIDGE

Drawn: JLH 04/17/2012

Approved: DBR 04/17/2012

Project #: 106-4186

Footnotes:

Mg=Megagram

RIVERINE SIMULATED SEDIMENT MASS FLUX (MEGAGRAMS PER DAY) IN KALAMAZOO RIVER CALIBRATION

SHEET 5 OF 6

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

US EPA ARCHIVE DOCUMENT

		Ceresco Dam			Kalamazoo Dam			Kalamazoo River Gauge Near Battle Creek			35th Street Bridge			Delta Neck			Morrow Dam		
Date	Time	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)	Sand (Mg)	Silt (Mg)	Clay (Mg)
11/7/2011	7:59 AM	0.0	7.6	4.1	0.0	8.2	6.2	8.0	16.9	9.6	0.4	22.3	14.7	0.0	6.5	12.9	0.0	0.0	1.6
11/7/2011	12:00 PM	0.0	7.8	4.2	0.0	8.4	6.3	7.6	17.2	9.7	0.4	22.1	14.7	0.0	6.4	12.9	0.0	0.0	1.6
11/7/2011	4:00 PM	0.0	7.9	4.2	0.0	8.6	6.4	8.4	17.8	9.9	0.4	22.0	14.7	0.0	6.3	12.8	0.0	0.0	1.6
11/7/2011	7:59 PM	0.0	8.1	4.3	0.0	8.8	6.4	8.2	17.9	9.9	0.4	22.0	14.7	0.0	6.4	12.9	0.0	0.0	1.5
11/8/2011	12:00 AM	0.0	8.3	4.3	0.0	8.9	6.5	8.3	18.2	10.1	0.4	22.4	15.0	0.0	6.6	13.1	0.0	0.0	1.5
11/8/2011	4:00 AM	0.0	8.5	4.4	0.0	9.1	6.6	8.6	18.5	10.3	0.5	22.9	15.2	0.0	7.1	13.3	0.0	0.0	1.5
11/8/2011	7:59 AM	0.0	8.6	4.4	0.0	9.2	6.6	8.0	18.7	10.3	0.5	23.7	15.5	0.0	7.5	13.6	0.0	0.0	1.5
11/8/2011	12:00 PM	0.0	8.9	4.5	0.0	9.4	6.7	8.6	18.8	10.4	0.7	24.7	15.8	0.0	8.2	13.9	0.0	0.0	1.5
11/8/2011	4:00 PM	0.0	9.1	4.6	0.0	9.6	6.8	9.0	19.3	10.5	0.8	25.5	16.1	0.0	8.7	14.2	0.0	0.0	1.5
11/8/2011	7:59 PM	0.0	9.5	4.7	0.0	9.8	6.9	9.1	19.7	10.7	0.8	26.1	16.3	0.0	9.2	14.5	0.0	0.0	1.5
11/9/2011	12:00 AM	0.0	9.9	4.8	0.0	10.1	7.0	9.3	20.0	10.8	0.8	26.4	16.4	0.0	9.4	14.6	0.0	0.0	1.5
11/9/2011	4:00 AM	0.0	10.5	4.9	0.0	10.4	7.2	10.6	20.9	11.2	0.8	26.6	16.4	0.0	9.4	14.6	0.0	0.0	1.5
11/9/2011	7:59 AM	0.0	11.0	5.1	0.0	10.9	7.4	9.9	21.6	11.5	0.8	26.7	16.5	0.0	9.4	14.7	0.0	0.0	1.6
11/9/2011	12:00 PM	0.0	11.6	5.2	0.0	11.4	7.6	11.5	22.2	11.7	0.8	26.8	16.6	0.0	9.4	14.7	0.0	0.0	1.6
11/9/2011	4:00 PM	0.0	12.1	5.4	0.0	12.1	7.9	12.7	23.7	12.3	0.8	27.0	16.8	0.0	9.4	14.9	0.0	0.0	1.6
11/9/2011	7:59 PM	0.0	12.6	5.5	0.0	12.7	8.1	13.1	24.3	12.5	0.8	27.5	17.0	0.0	9.6	15.1	0.0	0.0	1.7
11/10/2011	12:00 AM	0.0	13.0	5.7	0.0	13.2	8.3	13.6	25.2	12.8	0.8	28.2	17.4	0.0	10.0	15.4	0.0	0.0	1.7

ENBRIDGE

Drawn: JLH 04/17/2012

Approved: DBR 04/17/2012

Project #: 106-4186

Footnotes:

Mg=Megagram

RIVERINE SIMULATED SEDIMENT MASS FLUX (MEGAGRAMS PER DAY) IN KALAMAZOO RIVER CALIBRATION

SHEET 6 OF 6

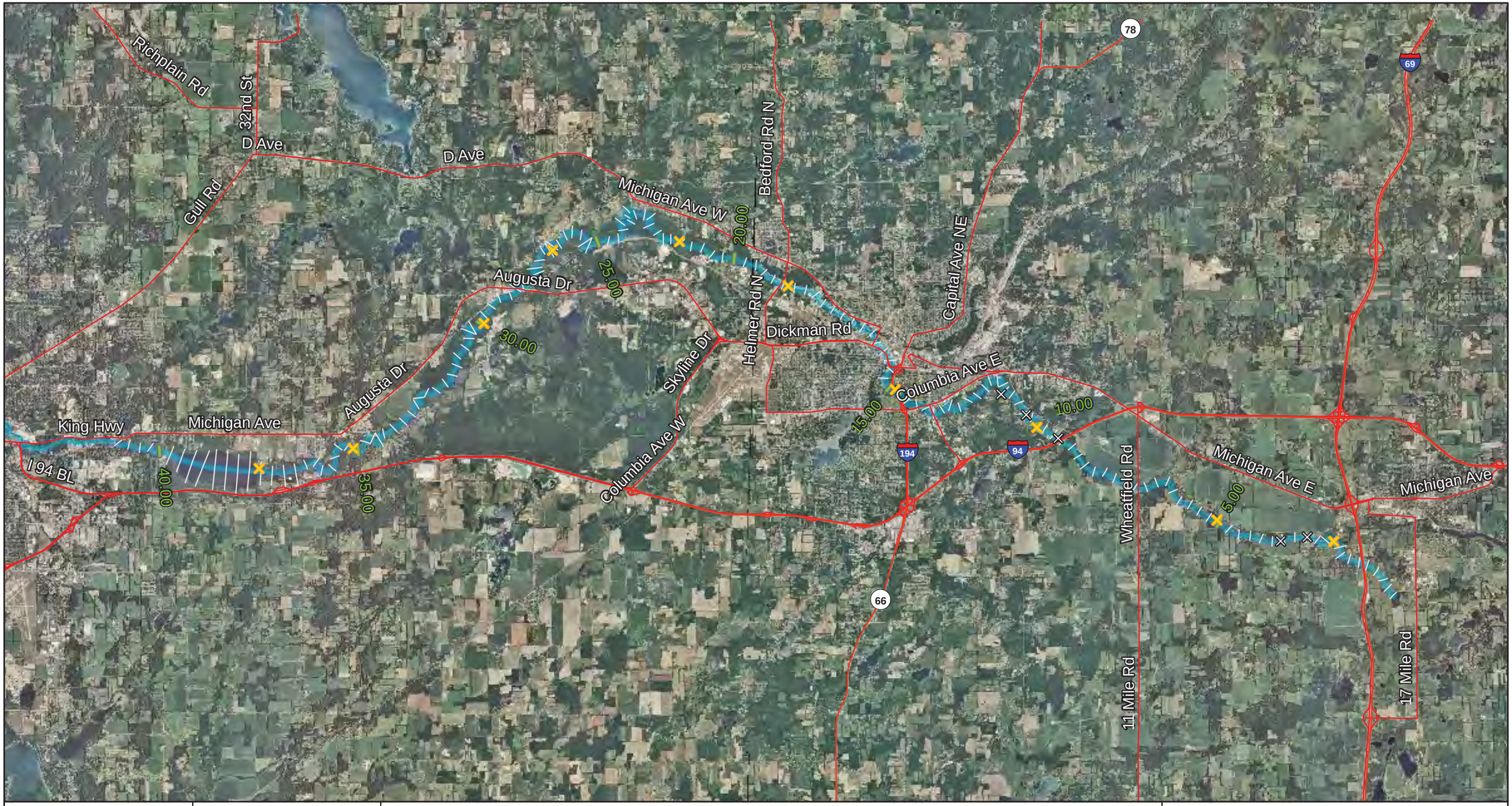
ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY,
LIMITED PARTNERSHIP

US EPA ARCHIVE DOCUMENT

Attachment 3

Tables and Figures in Response to Comment 3

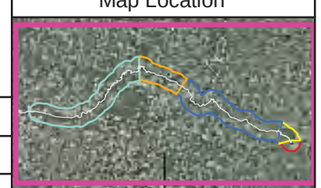
US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	BRS 5/2/2012
Approved:	DBR 5/2/2012
Project #:	106-4186

Map Location



Legend

Enbridge Staff Gages
- Calibration
- Non-Calibration
- Talmadge Creek and Kalamazoo River
- Major Road or Highway
- Five Mile Grid Segment
- Quarter Mile Grid Segment

N

0 5,000 10,000 20,000
Scale in Feet

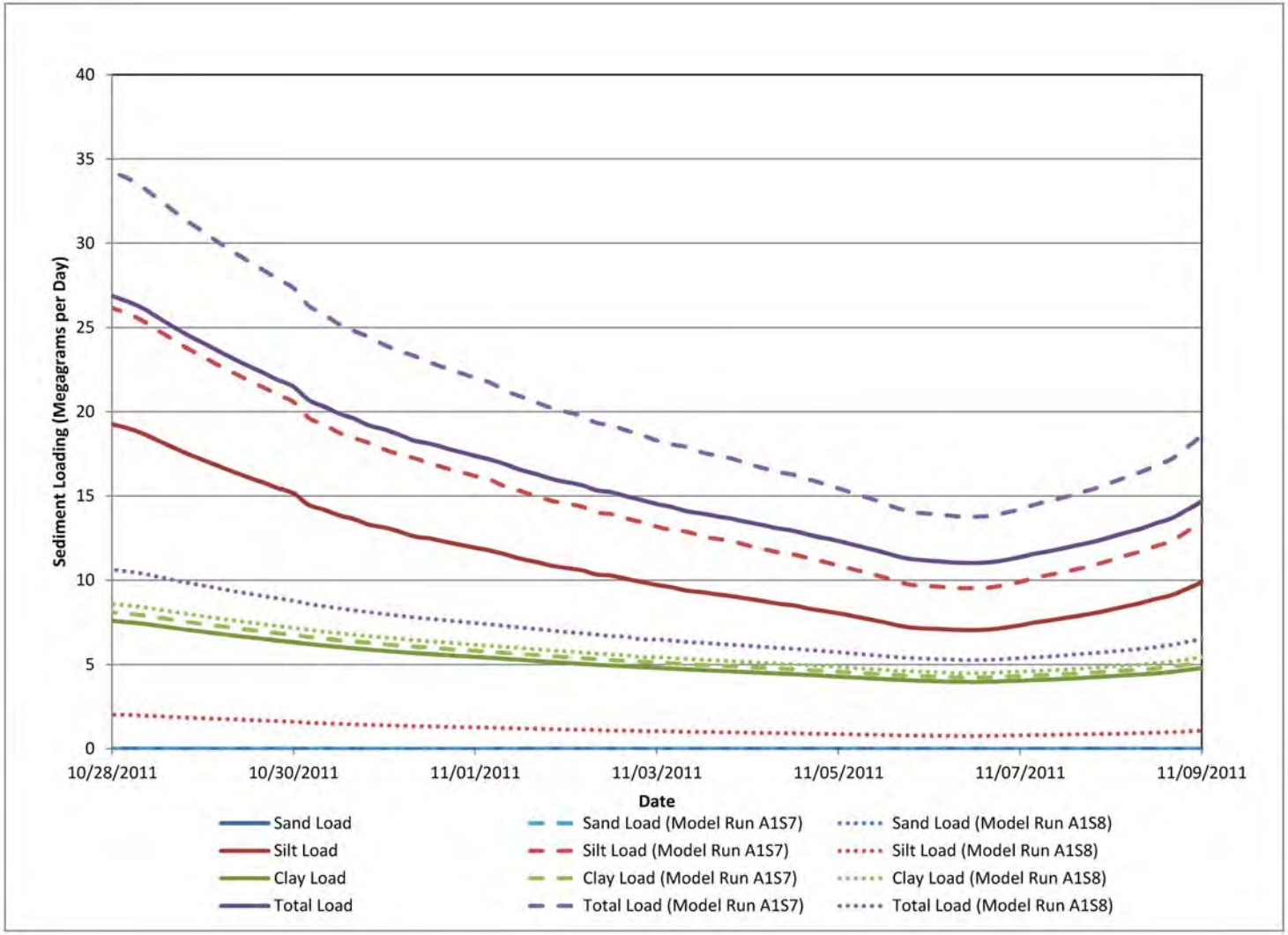
ENBRIDGE STAFF GAGES

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\Report Maps\Addendum\Enbridge_Staff_Gages.mxd

Aerial Photography Date: July & August 2009

US EPA ARCHIVE DOCUMENT



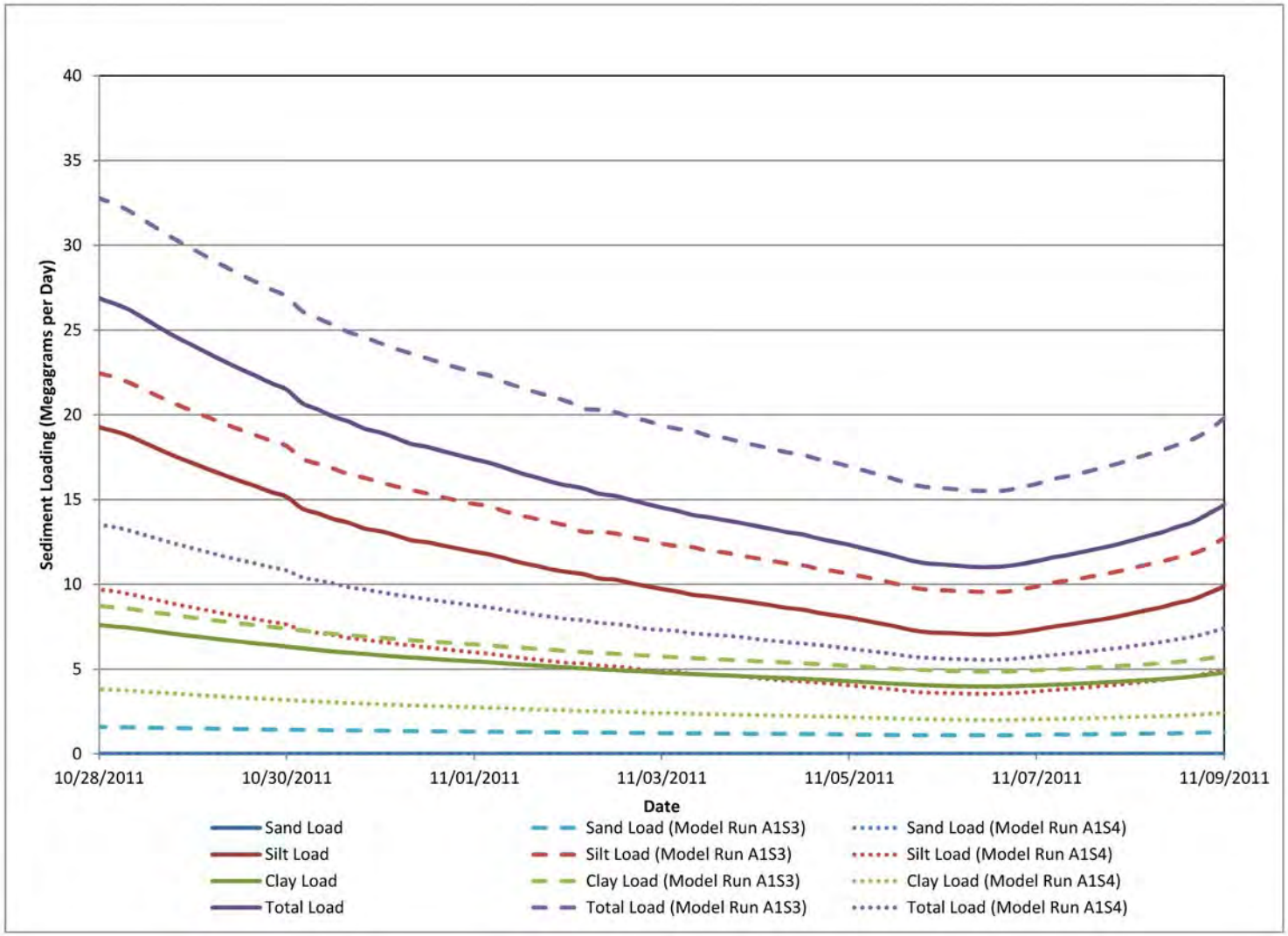
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT CERESCO DAM

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

US EPA ARCHIVE DOCUMENT



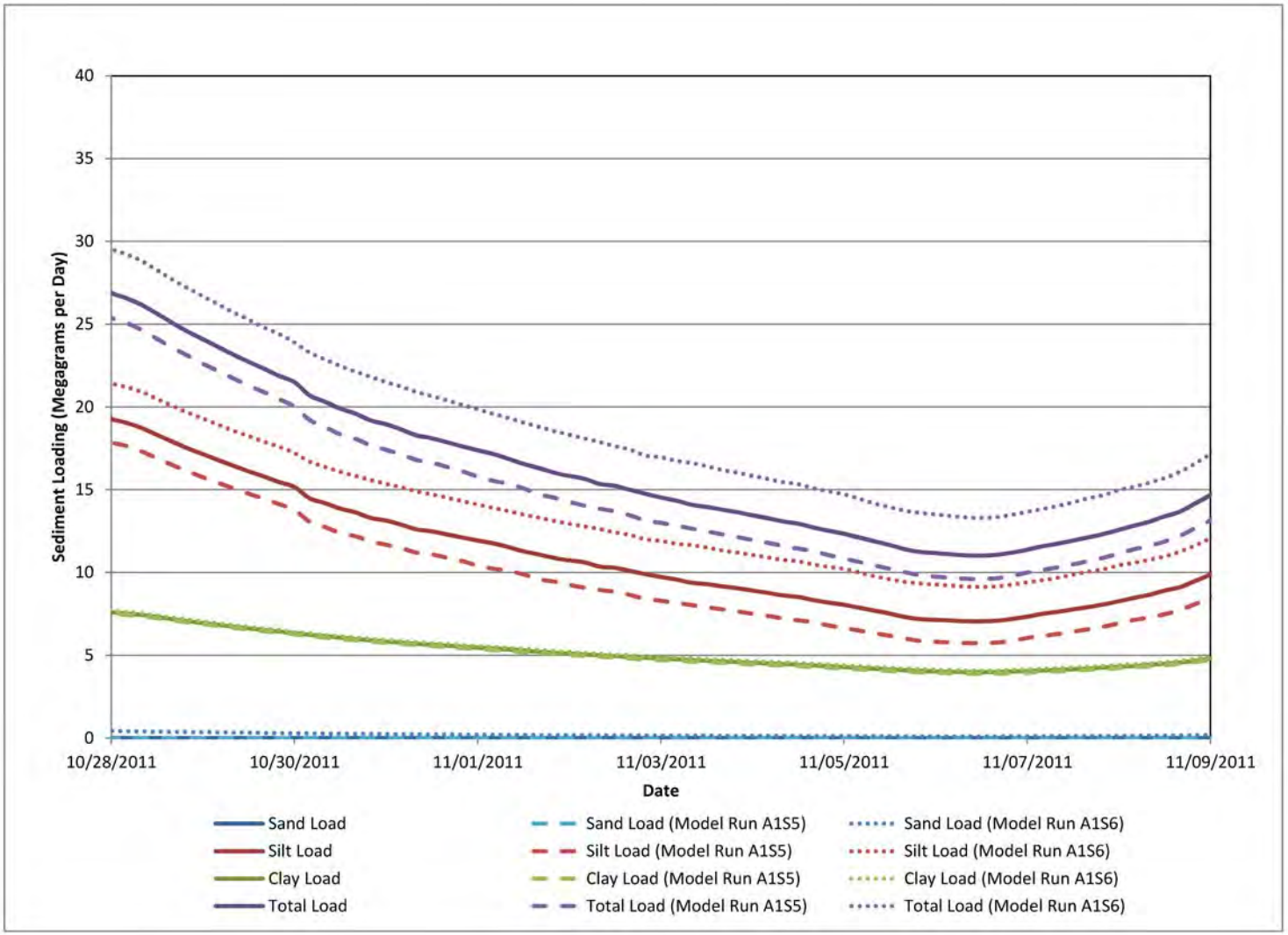
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT CERESCO DAM

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

US EPA ARCHIVE DOCUMENT



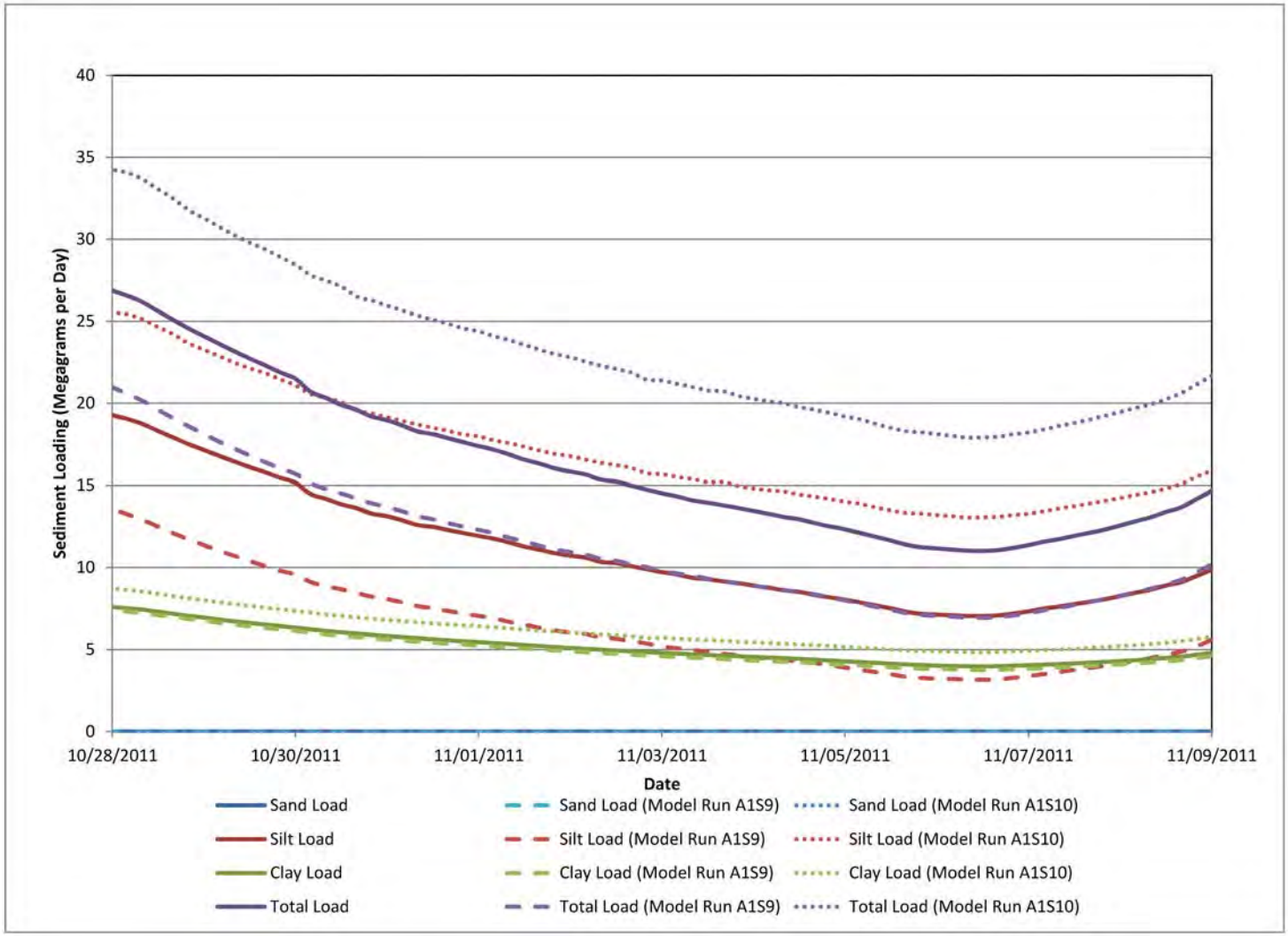
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT CERESCO DAM

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

US EPA ARCHIVE DOCUMENT



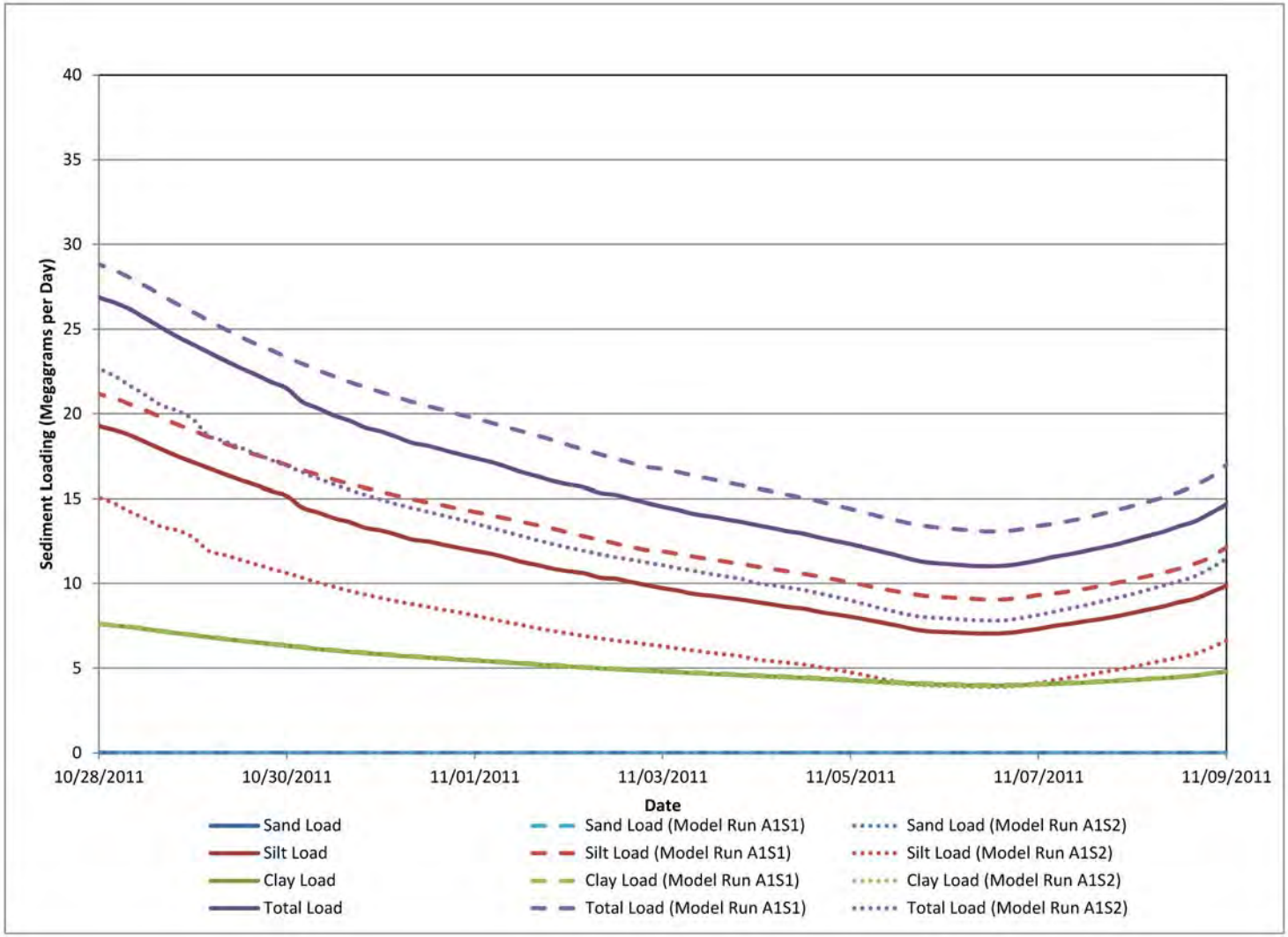
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT CERESCO DAM

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

US EPA ARCHIVE DOCUMENT



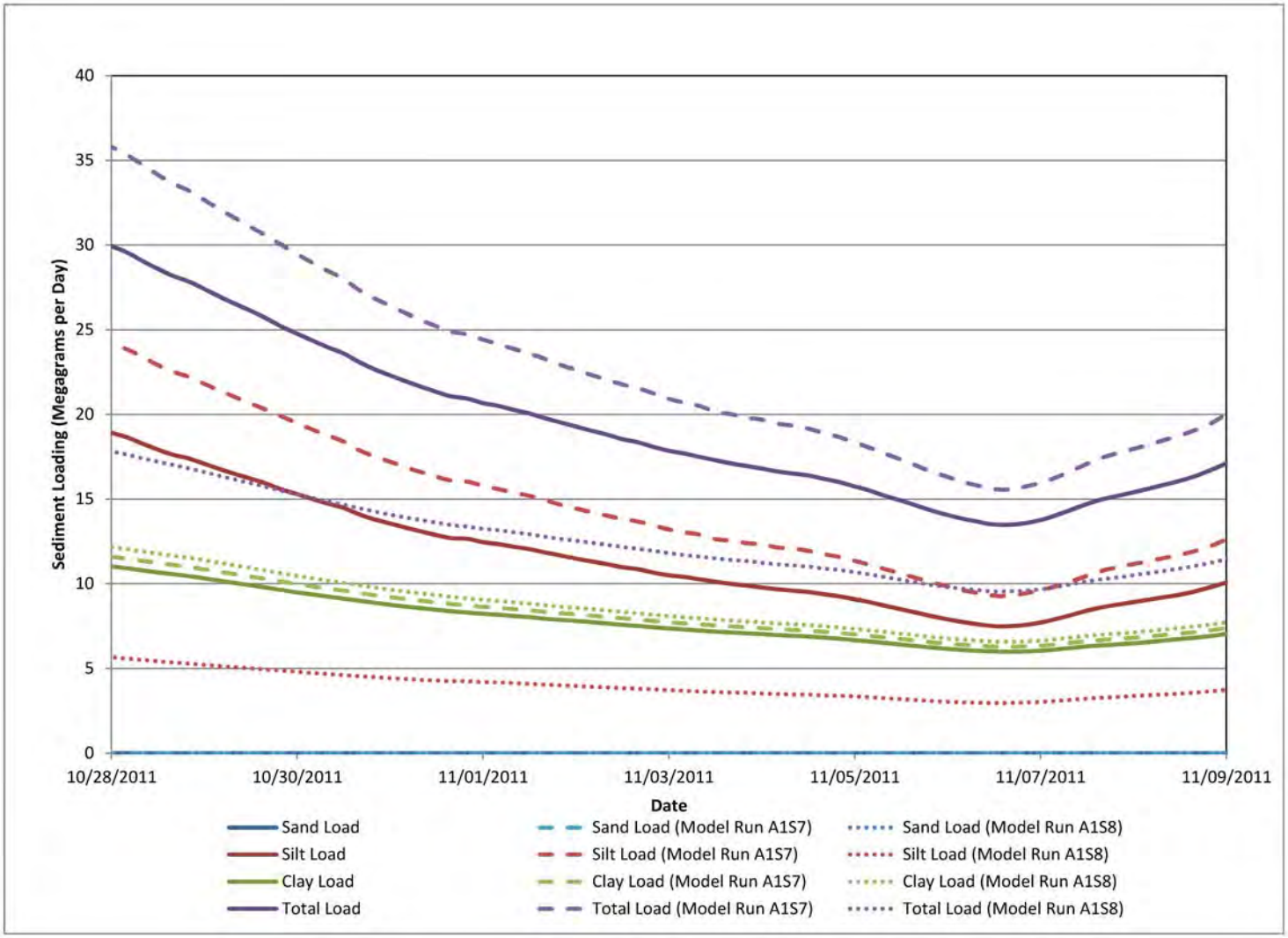
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT CERESCO DAM

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

US EPA ARCHIVE DOCUMENT



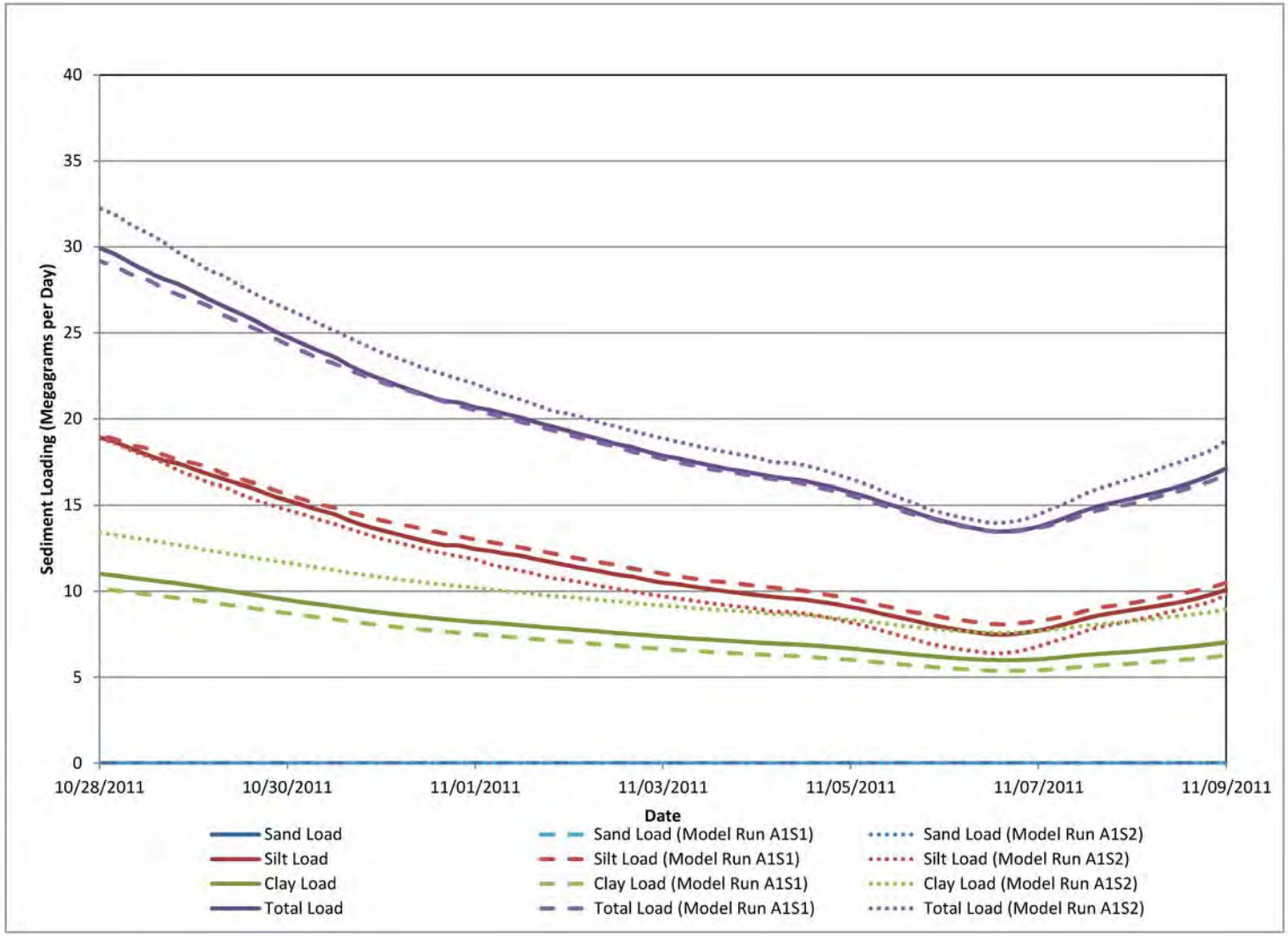
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT KALAMAZOO DAM

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

US EPA ARCHIVE DOCUMENT



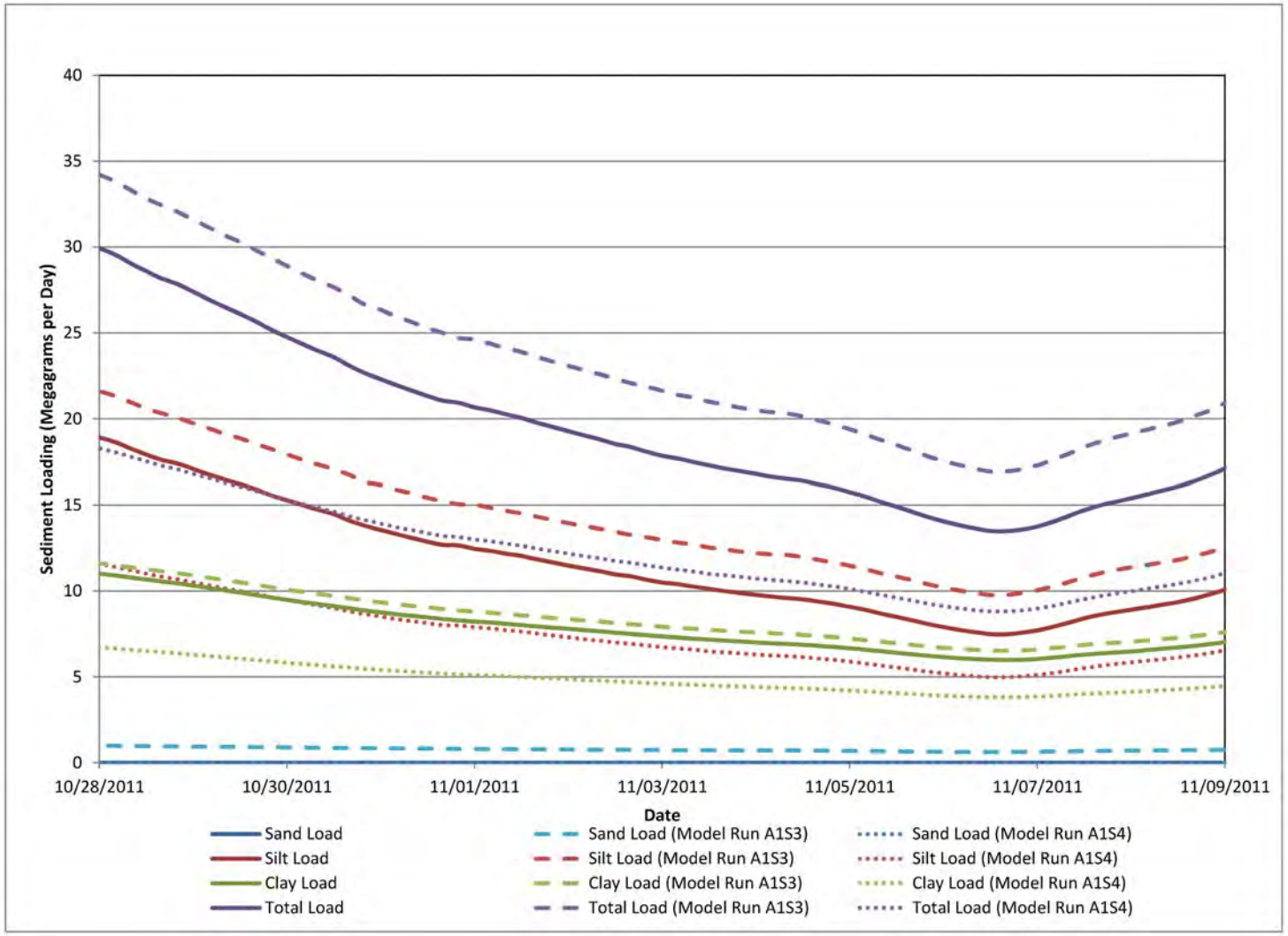
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT KALAMAZOO DAM

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

US EPA ARCHIVE DOCUMENT



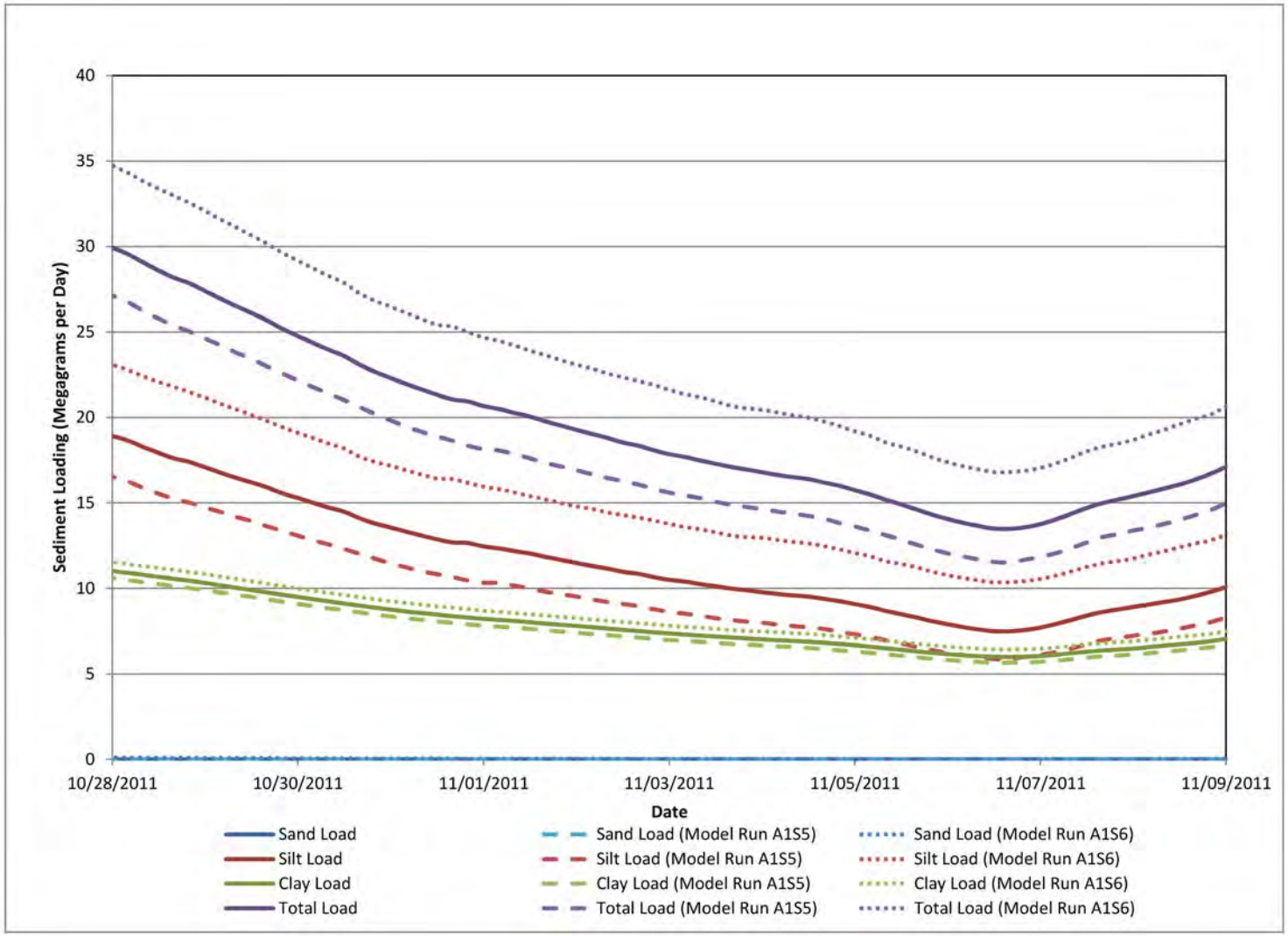
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT KALAMAZOO DAM

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

US EPA ARCHIVE DOCUMENT



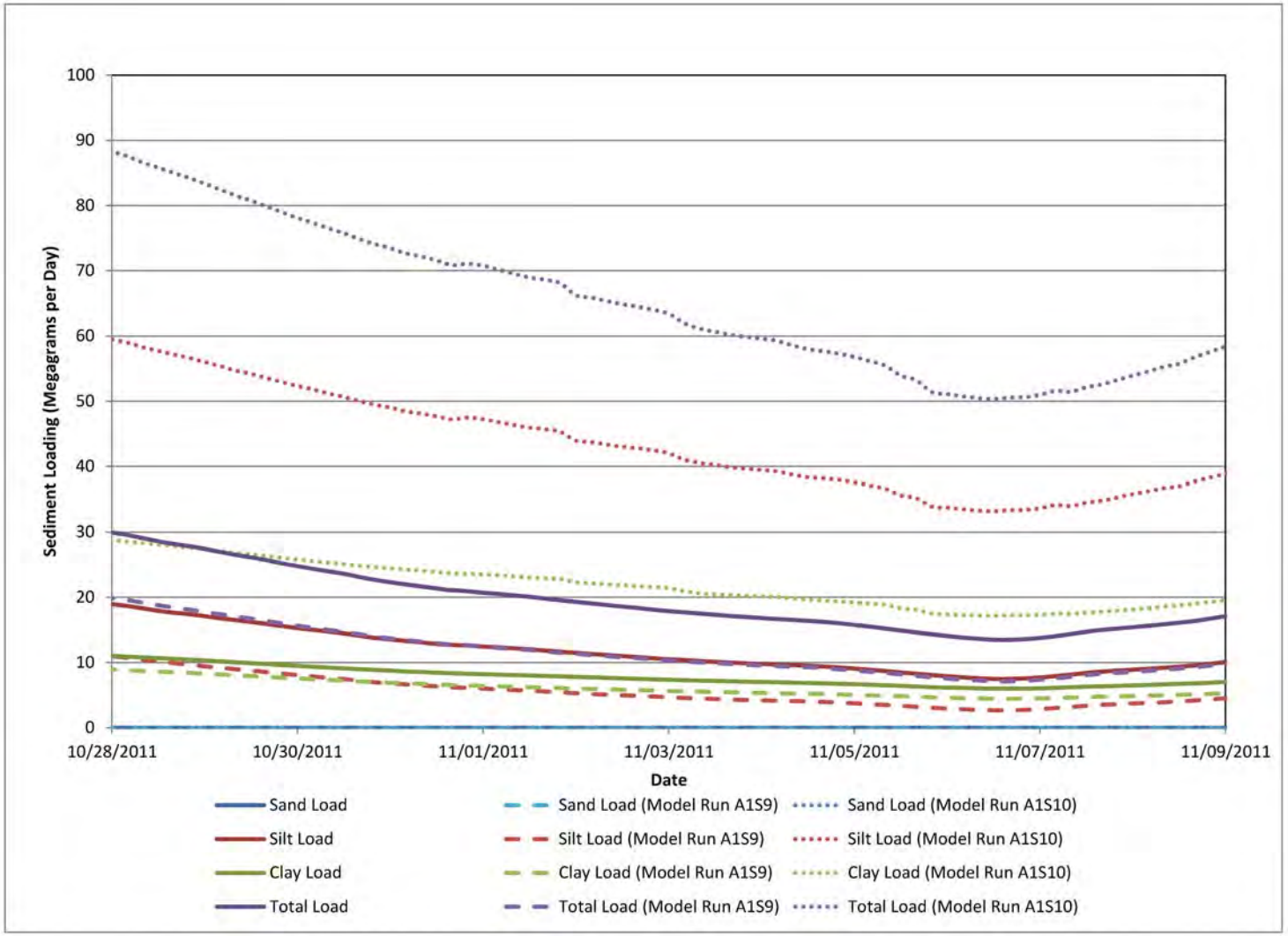
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT KALAMAZOO DAM

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

US EPA ARCHIVE DOCUMENT



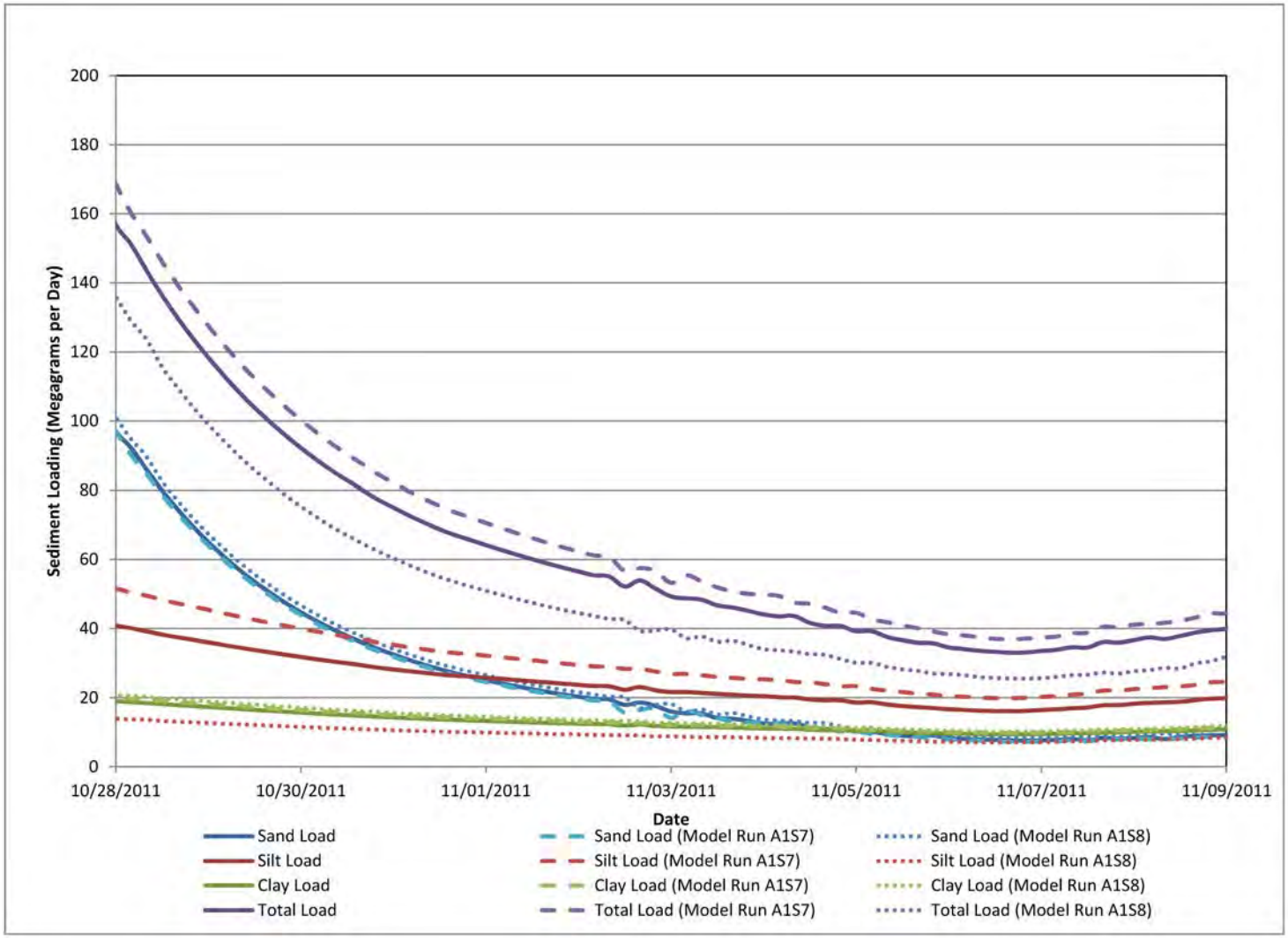
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT KALAMAZOO DAM

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

US EPA ARCHIVE DOCUMENT



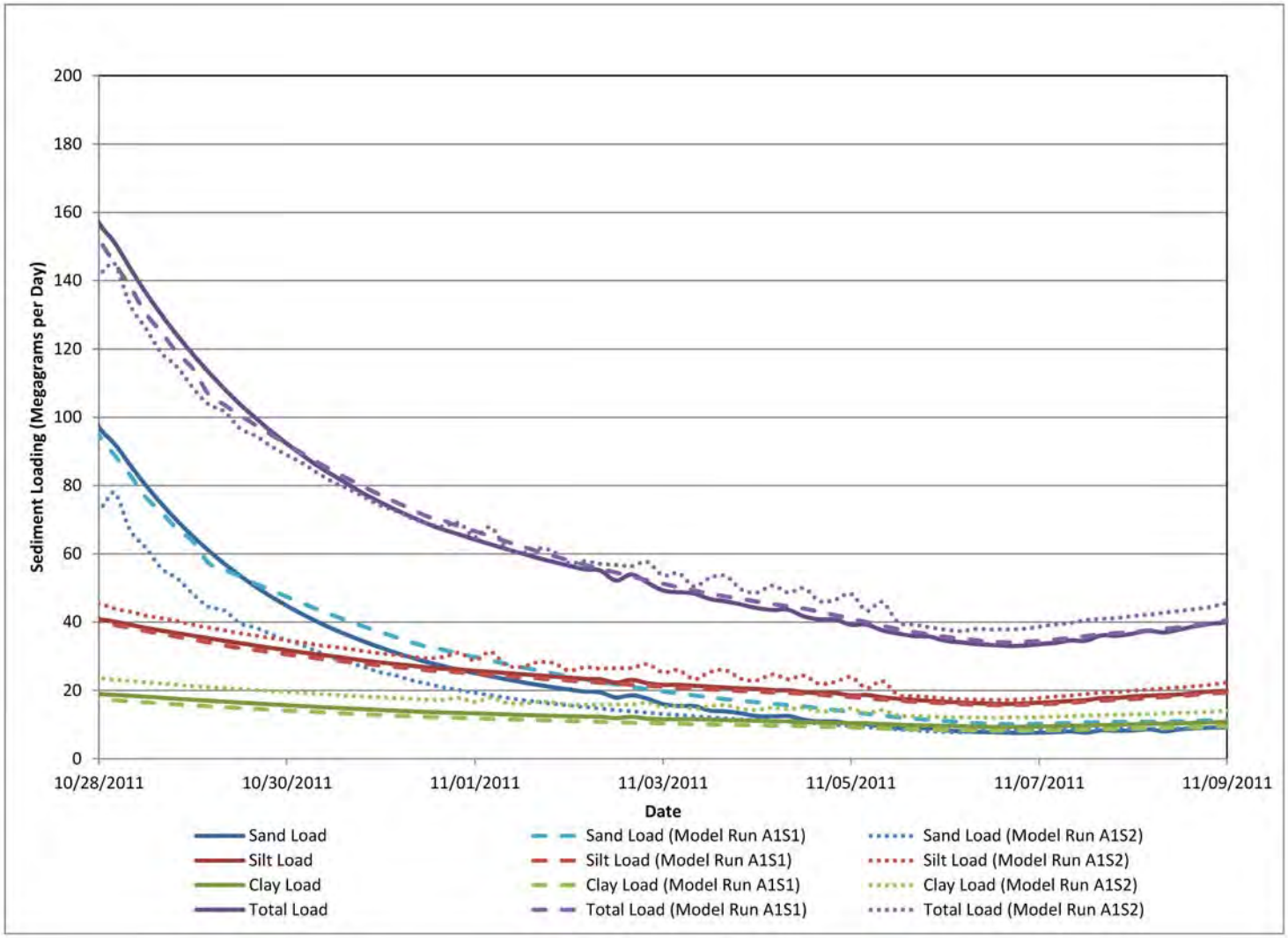
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT KALAMAZOO GAGE

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

US EPA ARCHIVE DOCUMENT



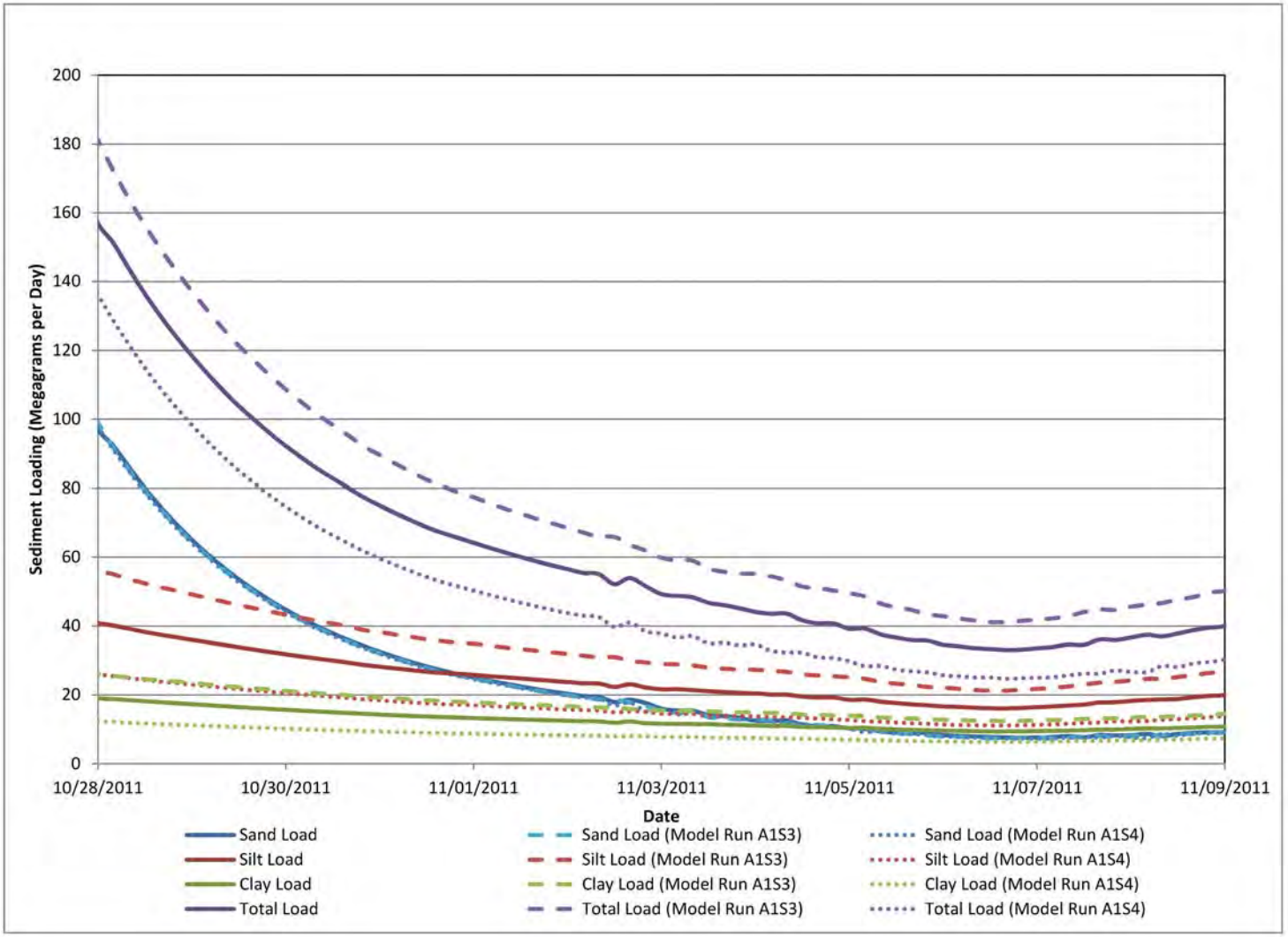
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT KALAMAZOO GAGE

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

US EPA ARCHIVE DOCUMENT



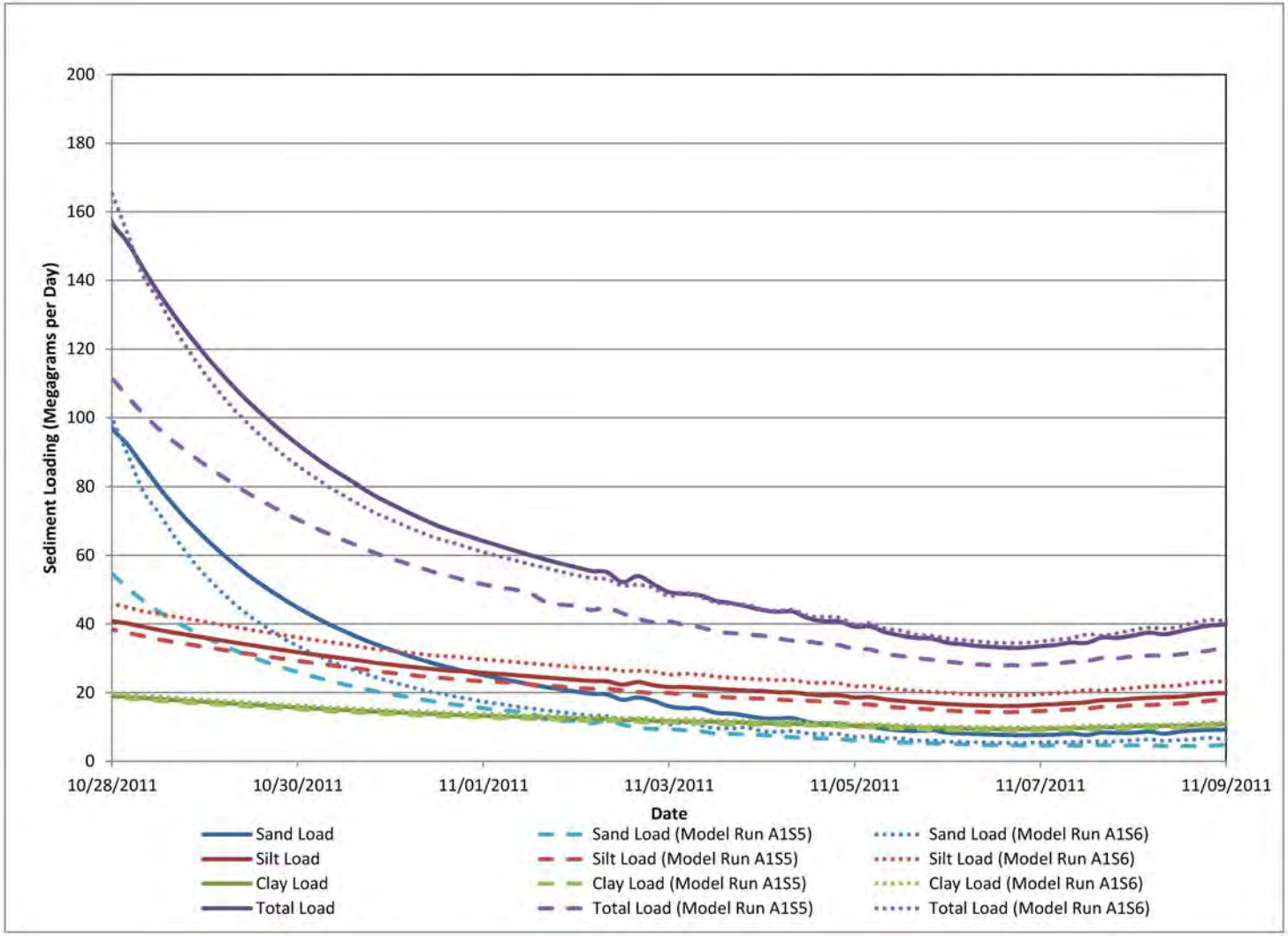
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT KALAMAZOO GAGE

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

US EPA ARCHIVE DOCUMENT



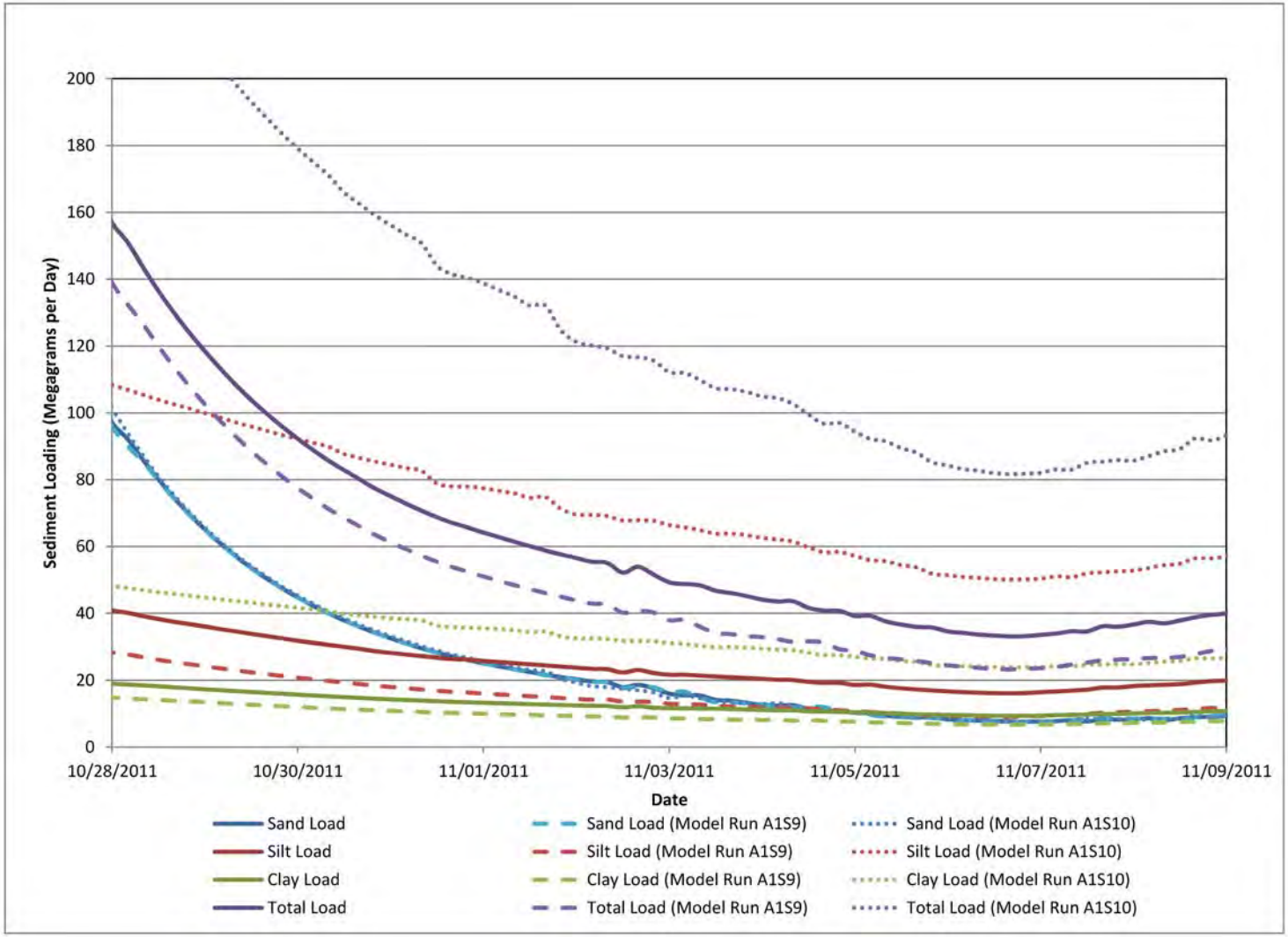
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT KALAMAZOO GAGE

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

US EPA ARCHIVE DOCUMENT



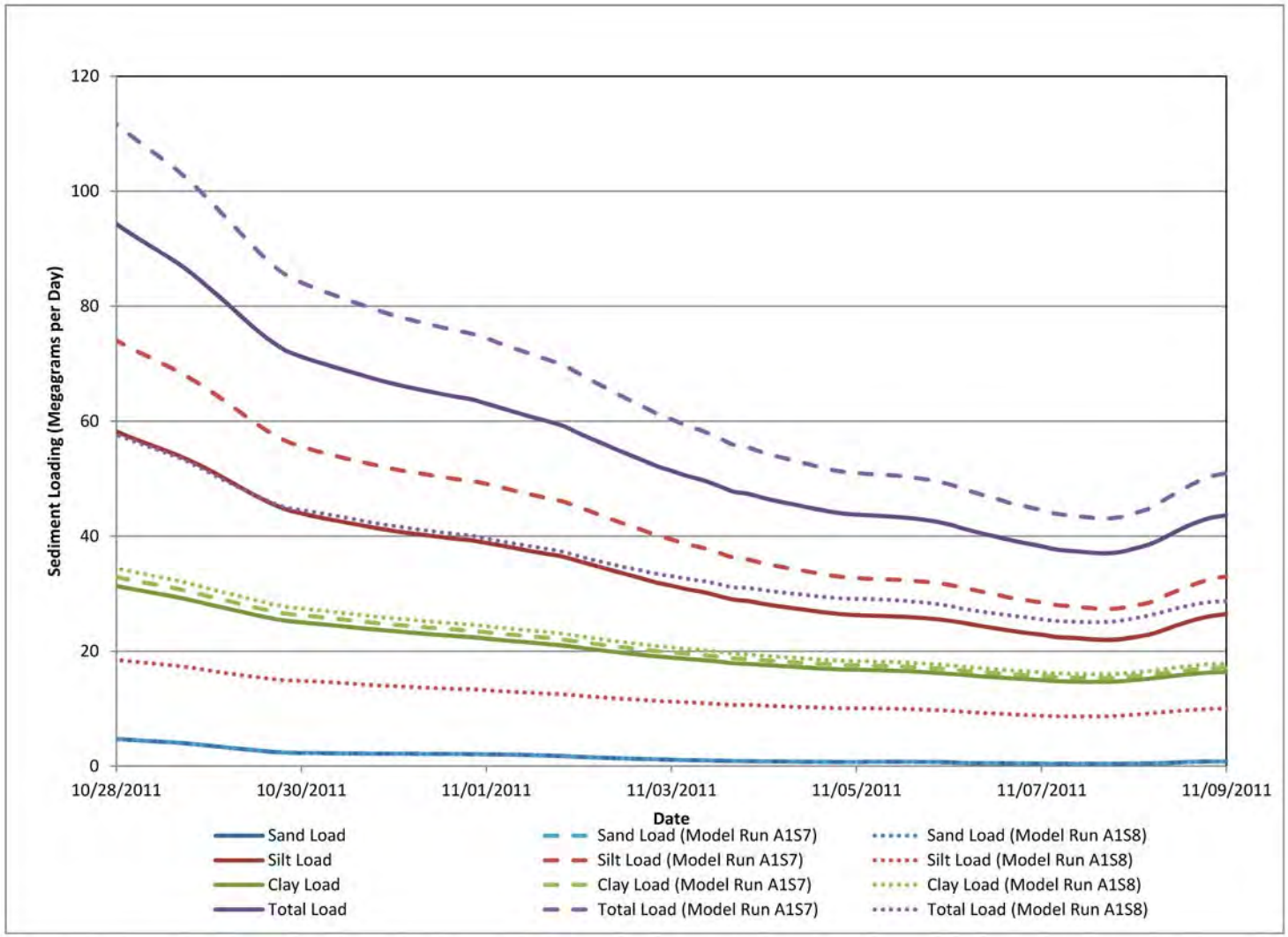
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT KALAMAZOO GAGE

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

US EPA ARCHIVE DOCUMENT



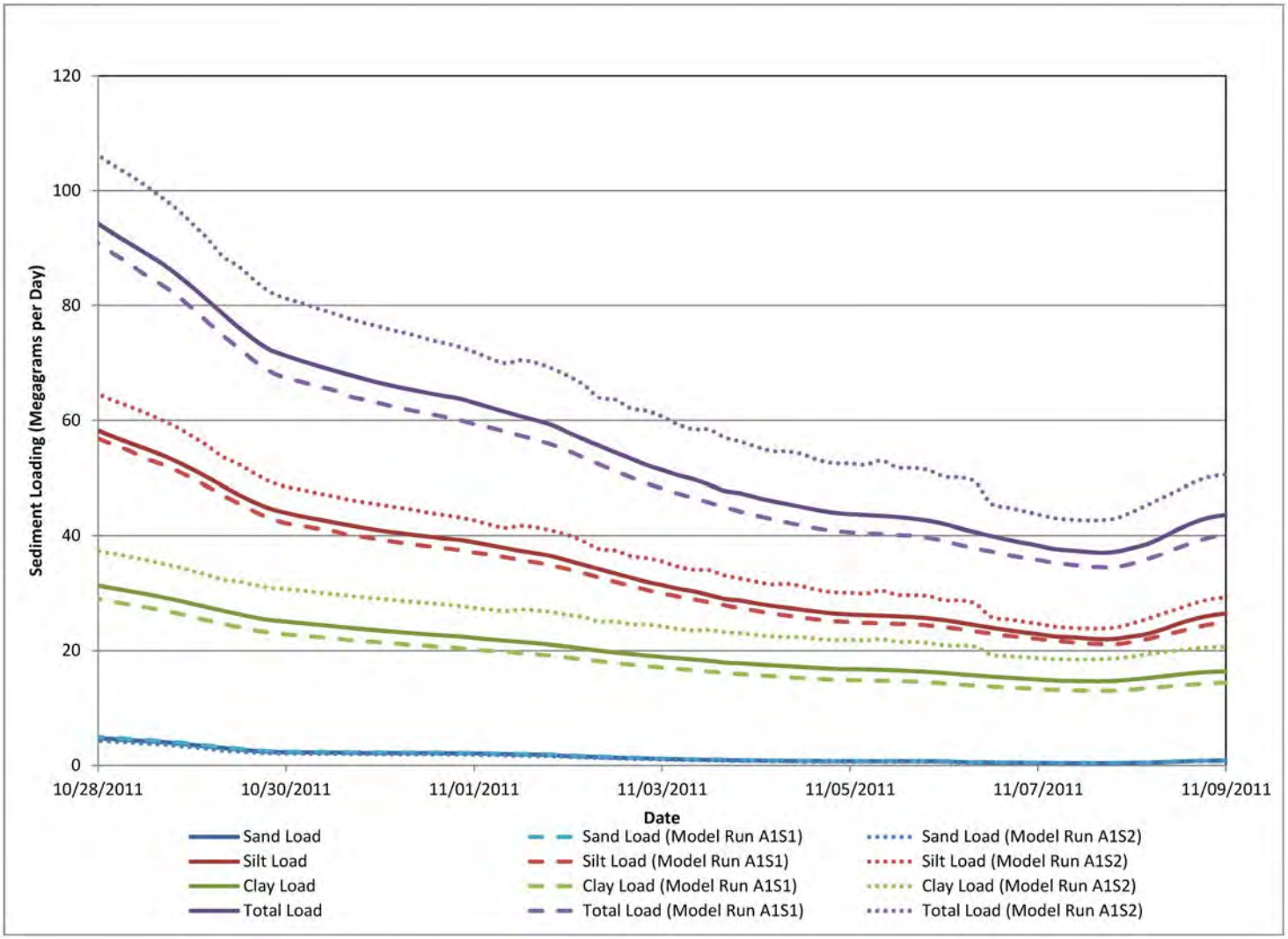
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT 35TH STREET BRIDGE

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

US EPA ARCHIVE DOCUMENT



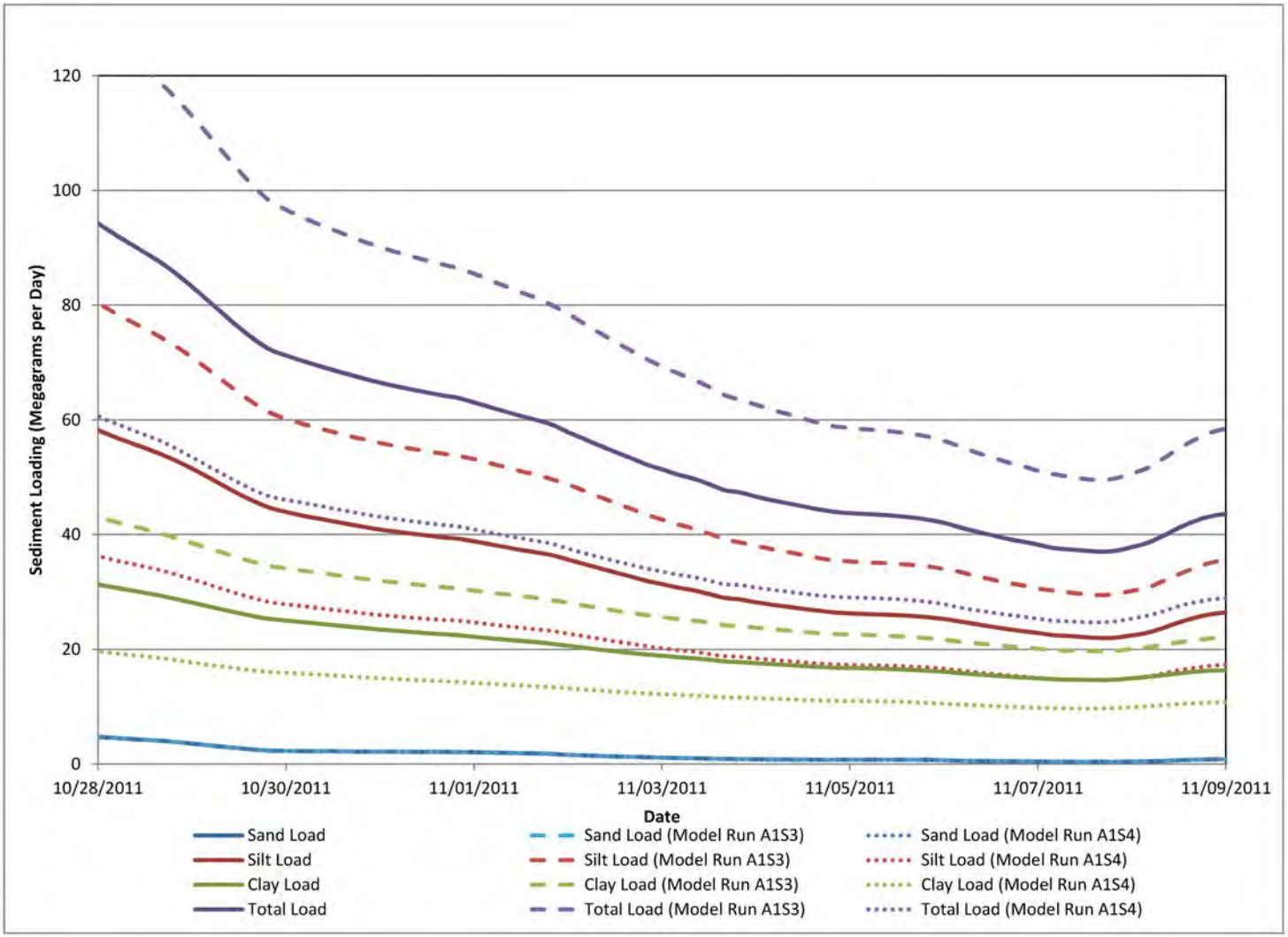
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT 35TH STREET BRIDGE

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

US EPA ARCHIVE DOCUMENT



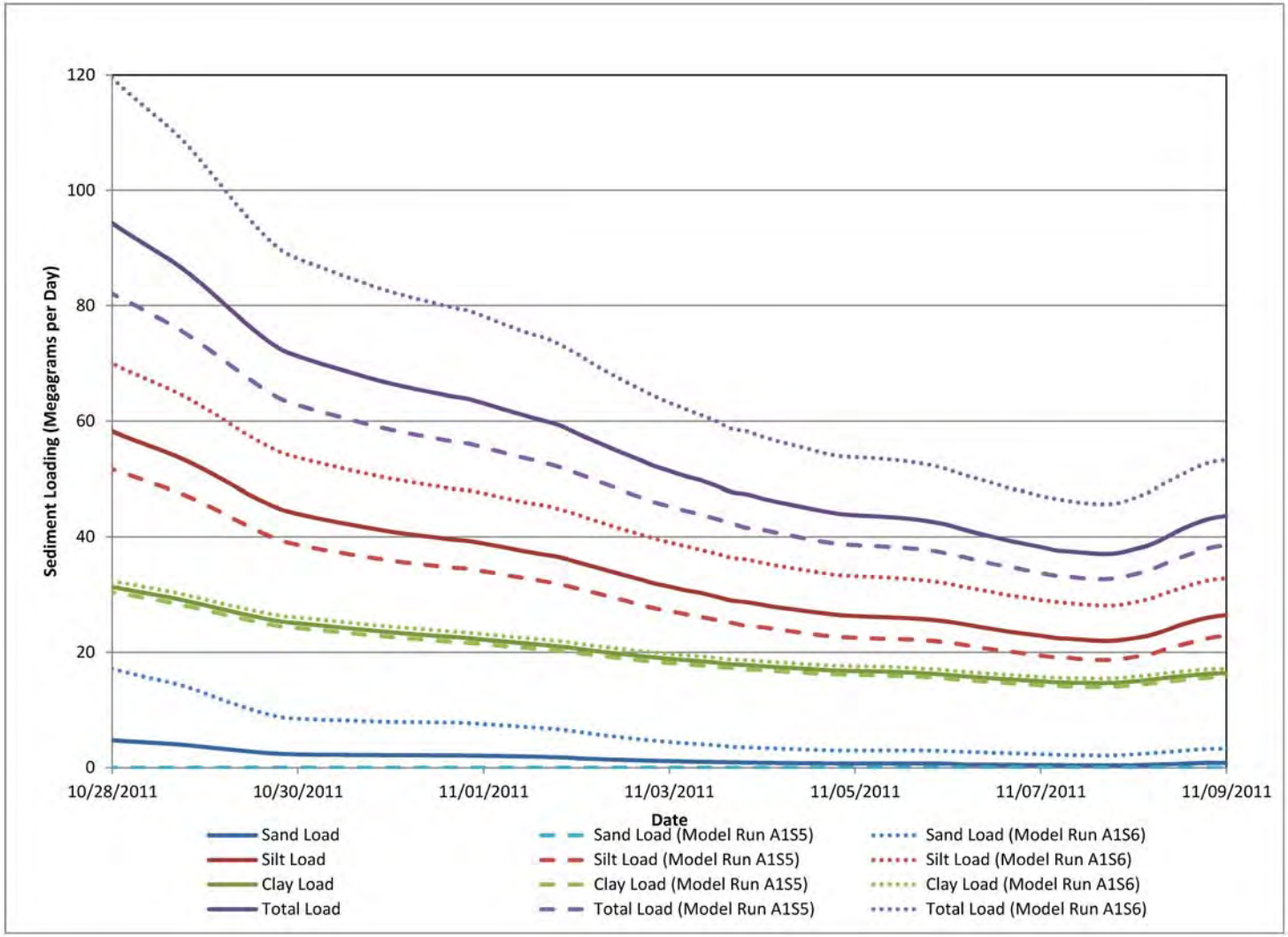
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT 35TH STREET BRIDGE

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

US EPA ARCHIVE DOCUMENT



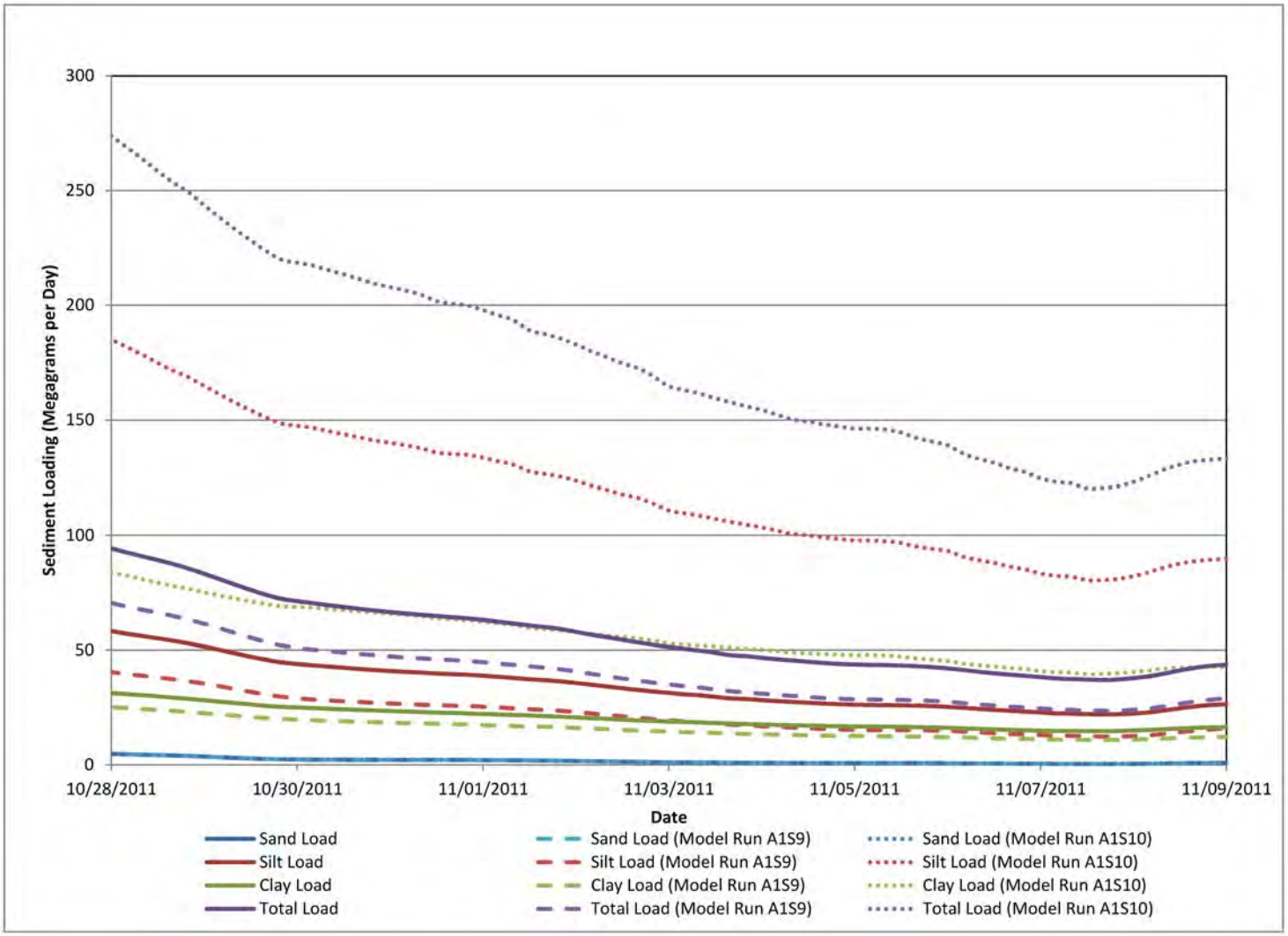
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT 35TH STREET BRIDGE

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

US EPA ARCHIVE DOCUMENT



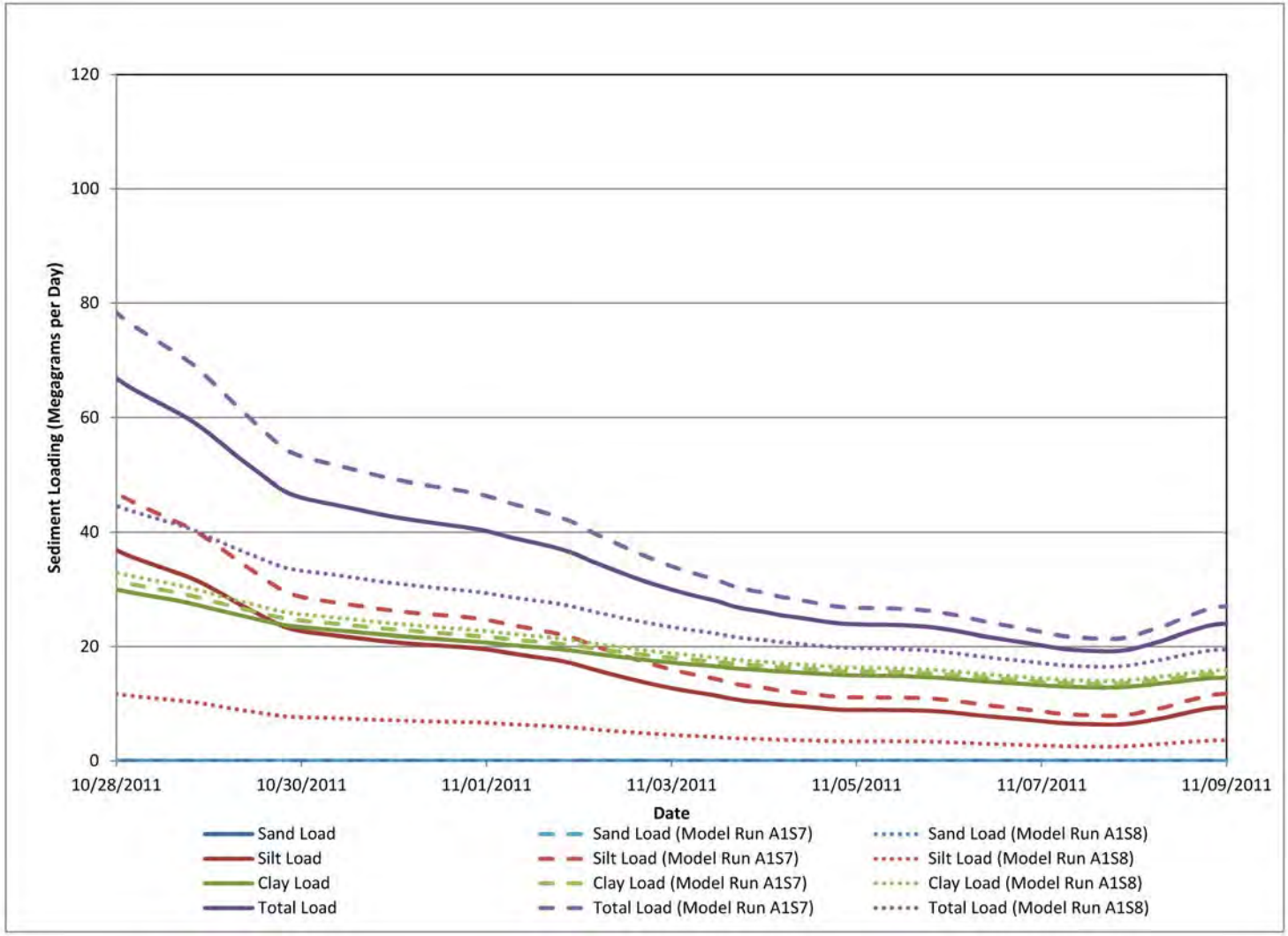
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT 35TH STREET BRIDGE

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

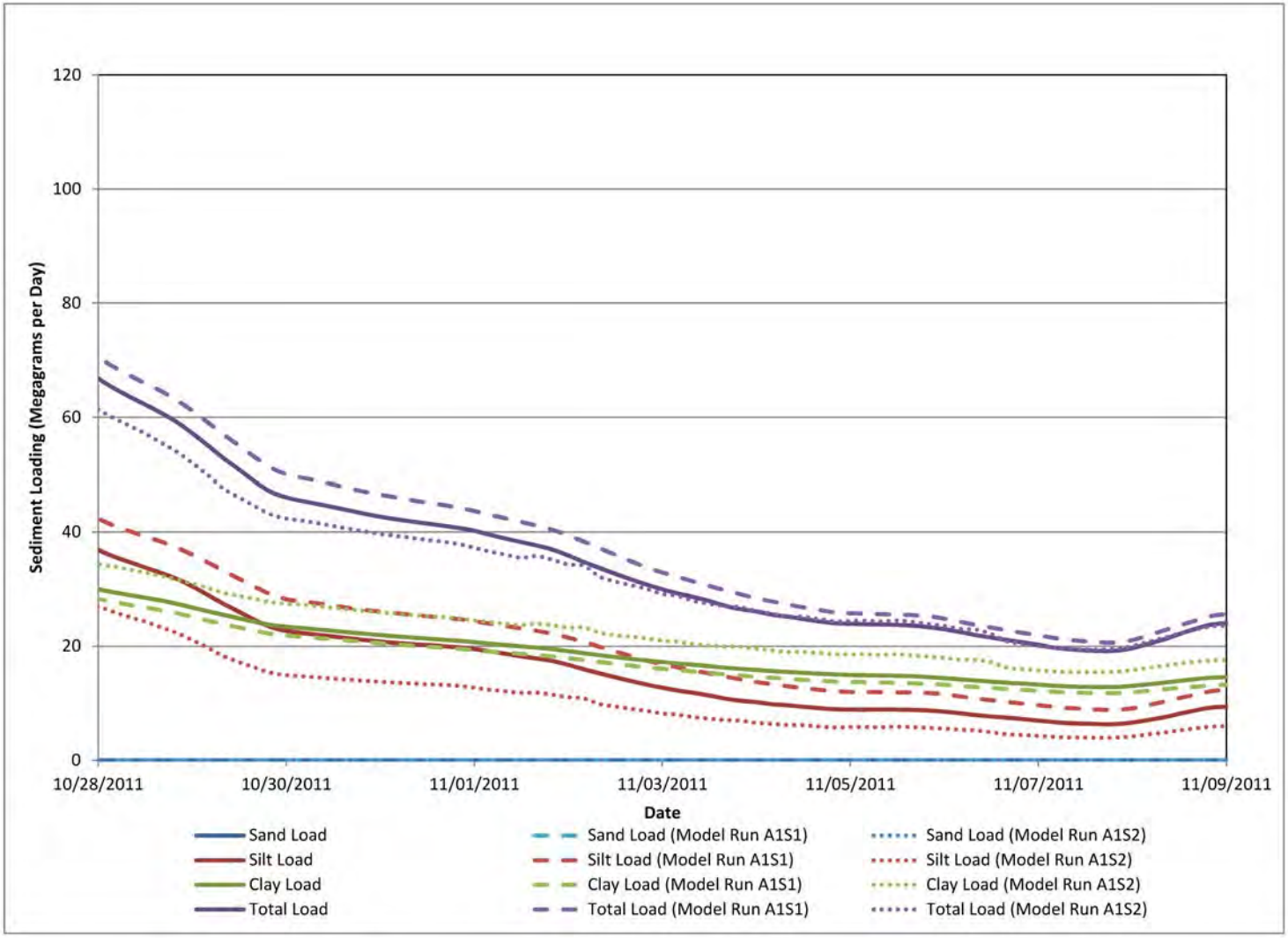
Footnotes:

MP = Mile Post

RIVERINE: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT MP 37.75

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

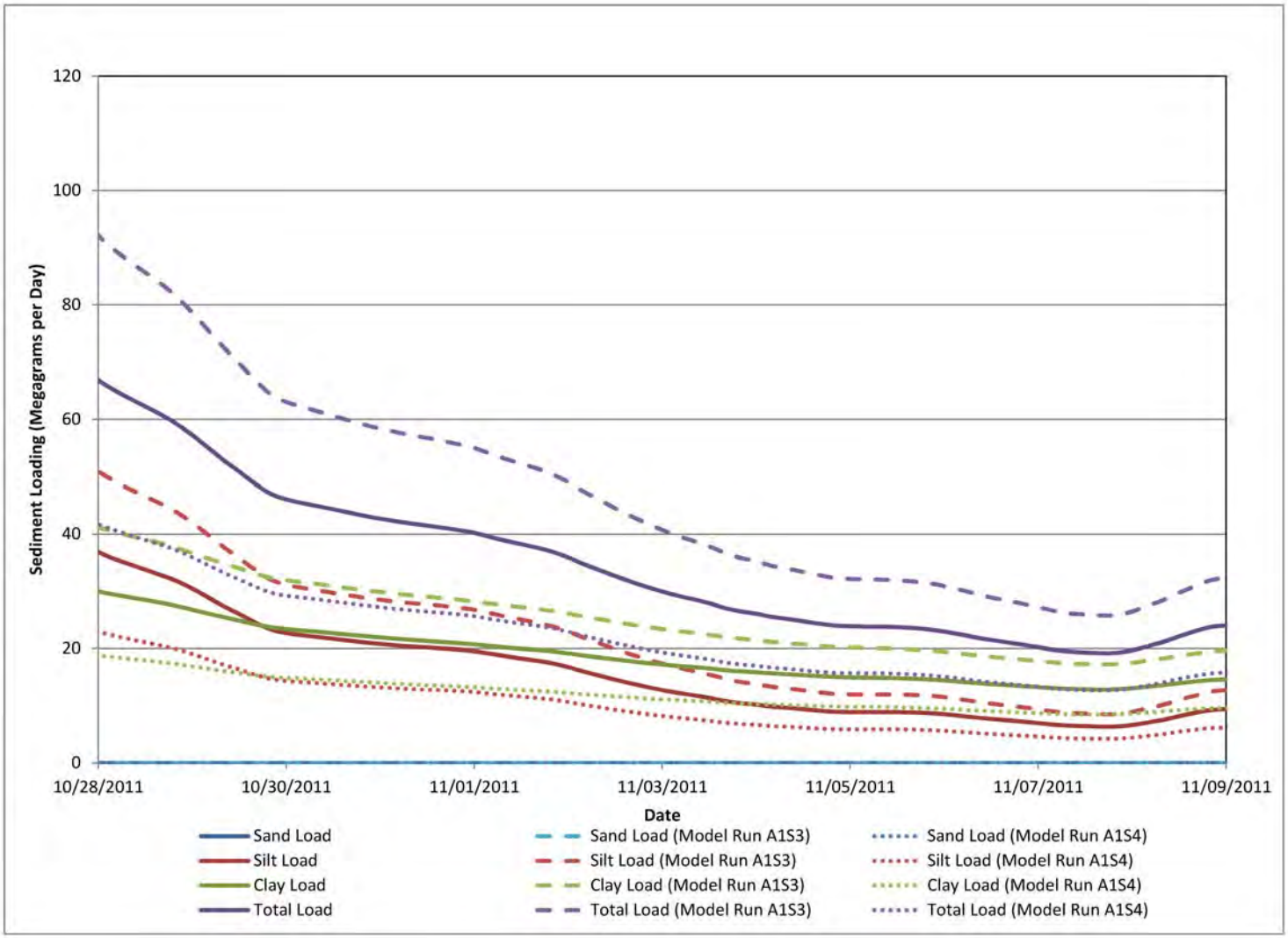
Footnotes:

MP = Mile Post

RIVERINE: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT MP 37.75

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

Footnotes:

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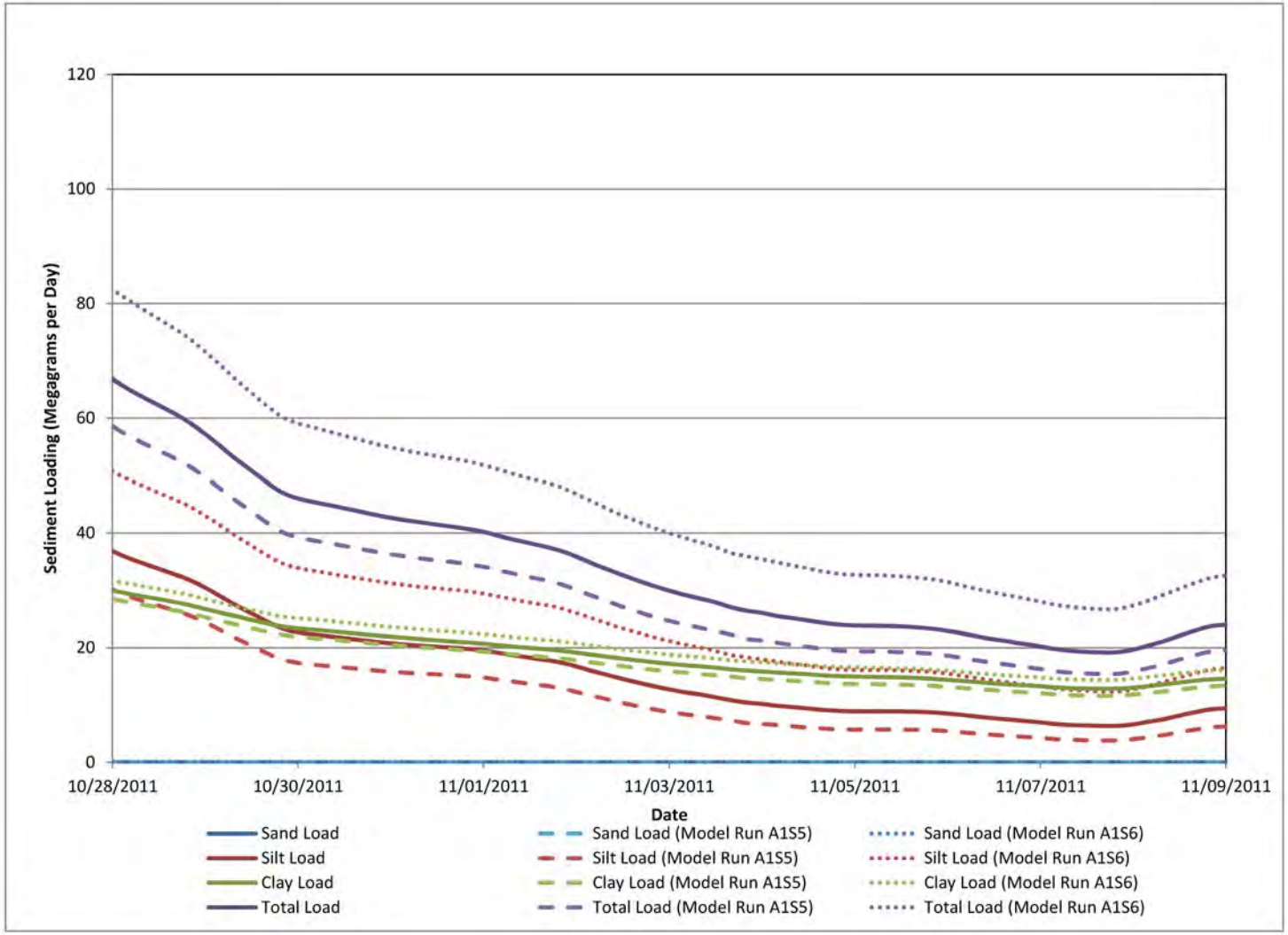
RIVERINE: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT MP 37.75

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

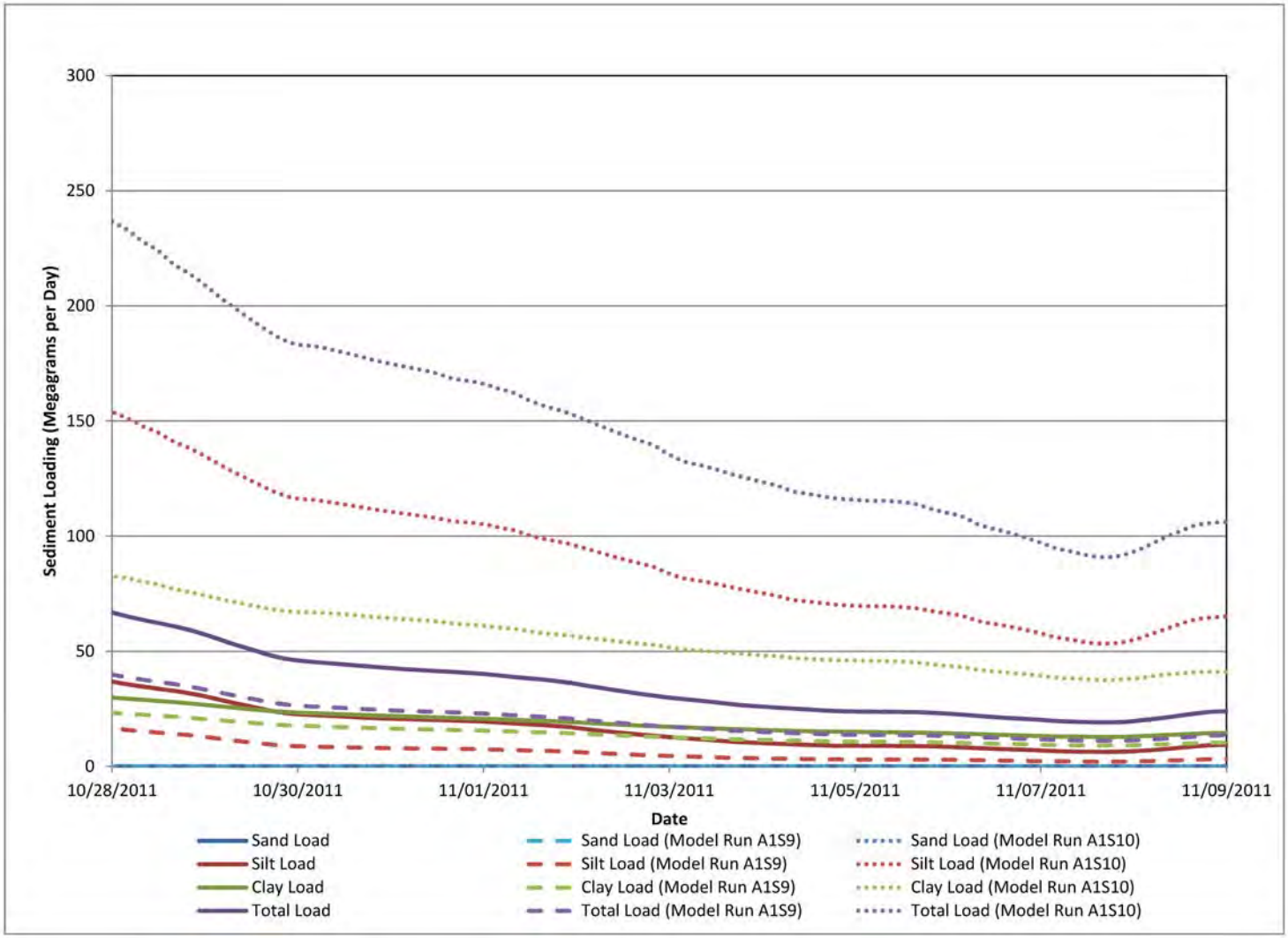
Footnotes:

MP = Mile Post

RIVERINE: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT MP 37.75

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

Footnotes:

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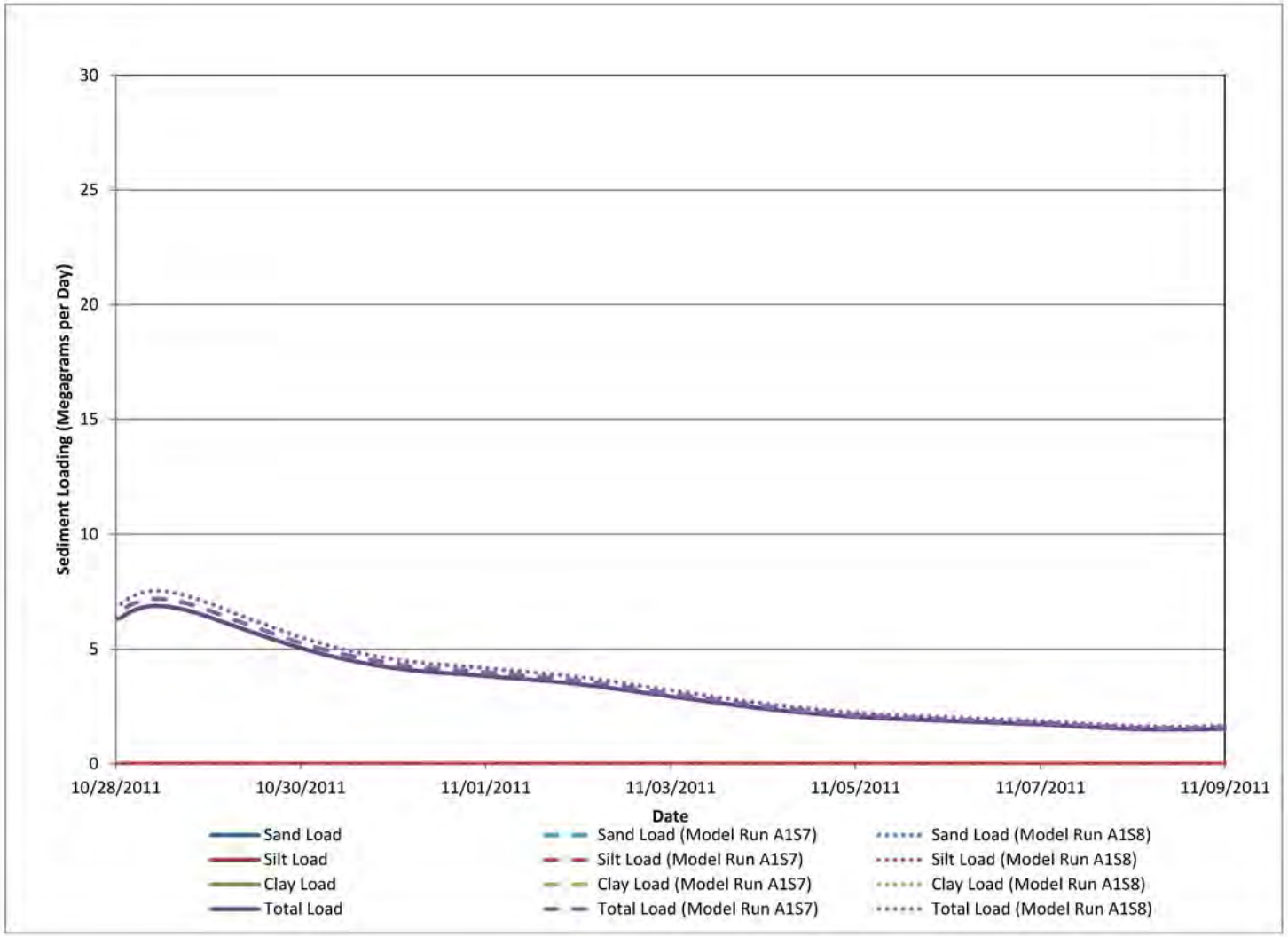
RIVERINE: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT MP 37.75

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

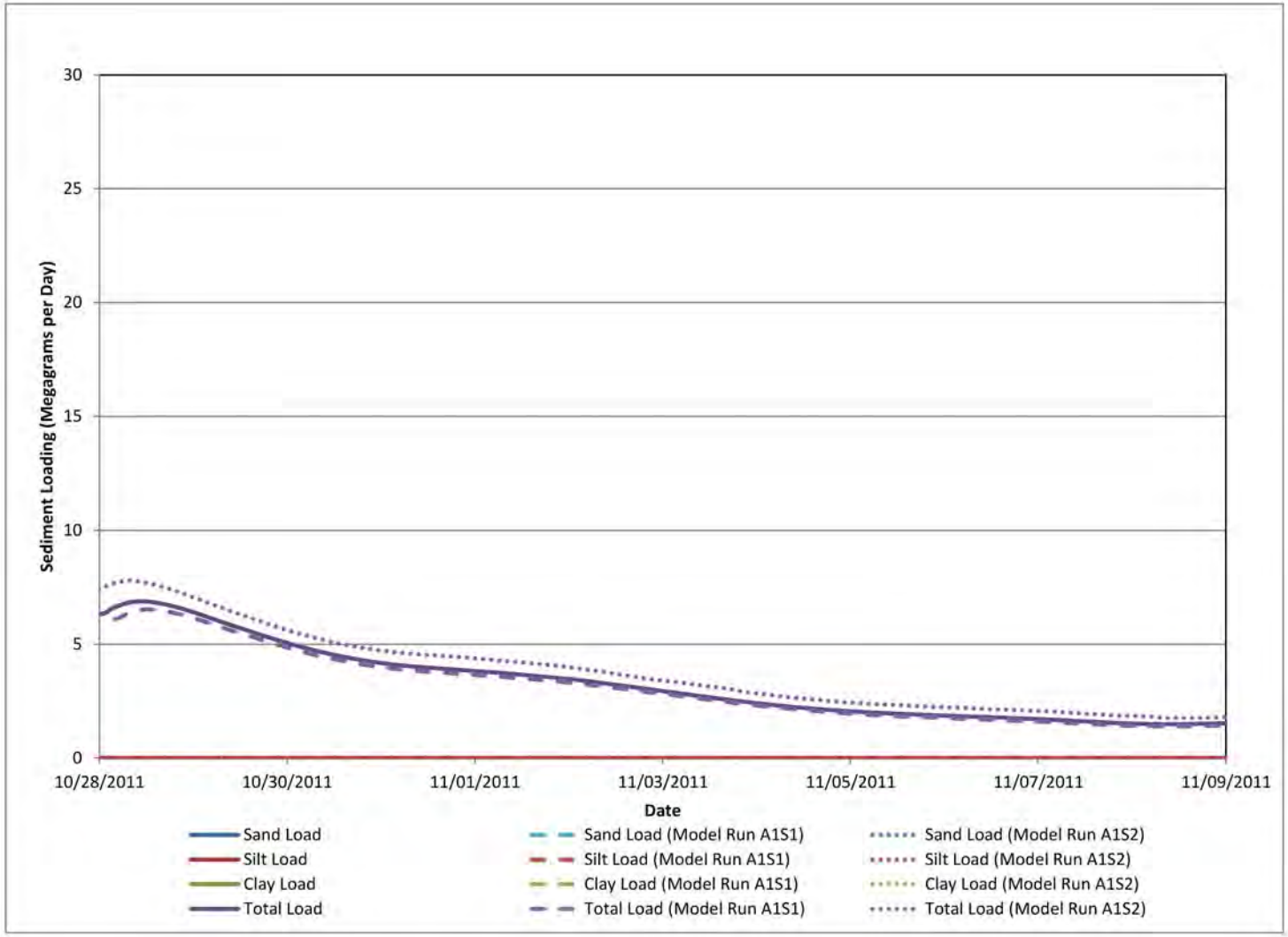
Footnotes:

Total Load = Clay Load

RIVERINE: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT MORROW LAKE DAM

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

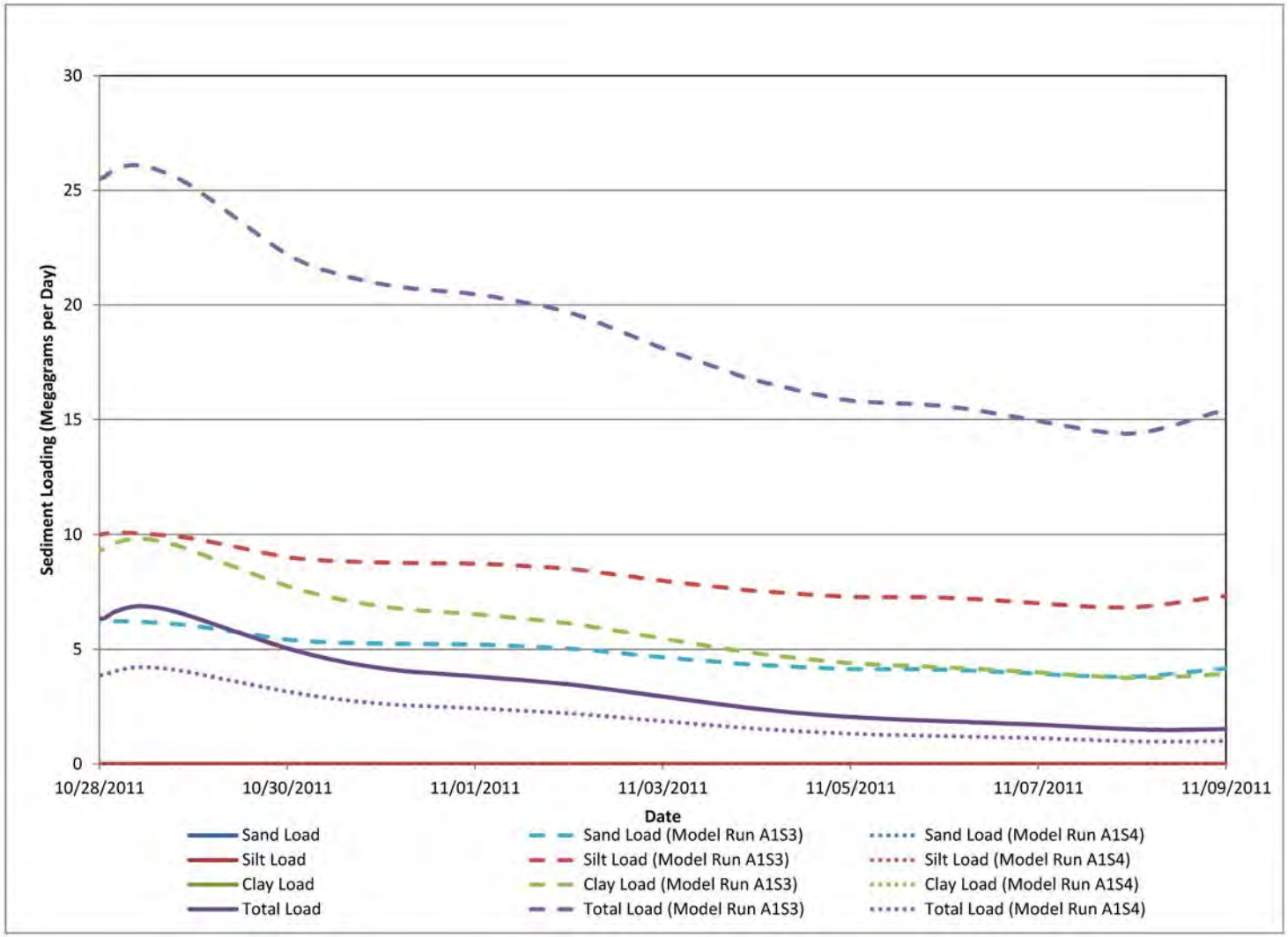
Footnotes:

Total Load = Clay Load

RIVERINE: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT MORROW LAKE DAM

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

US EPA ARCHIVE DOCUMENT



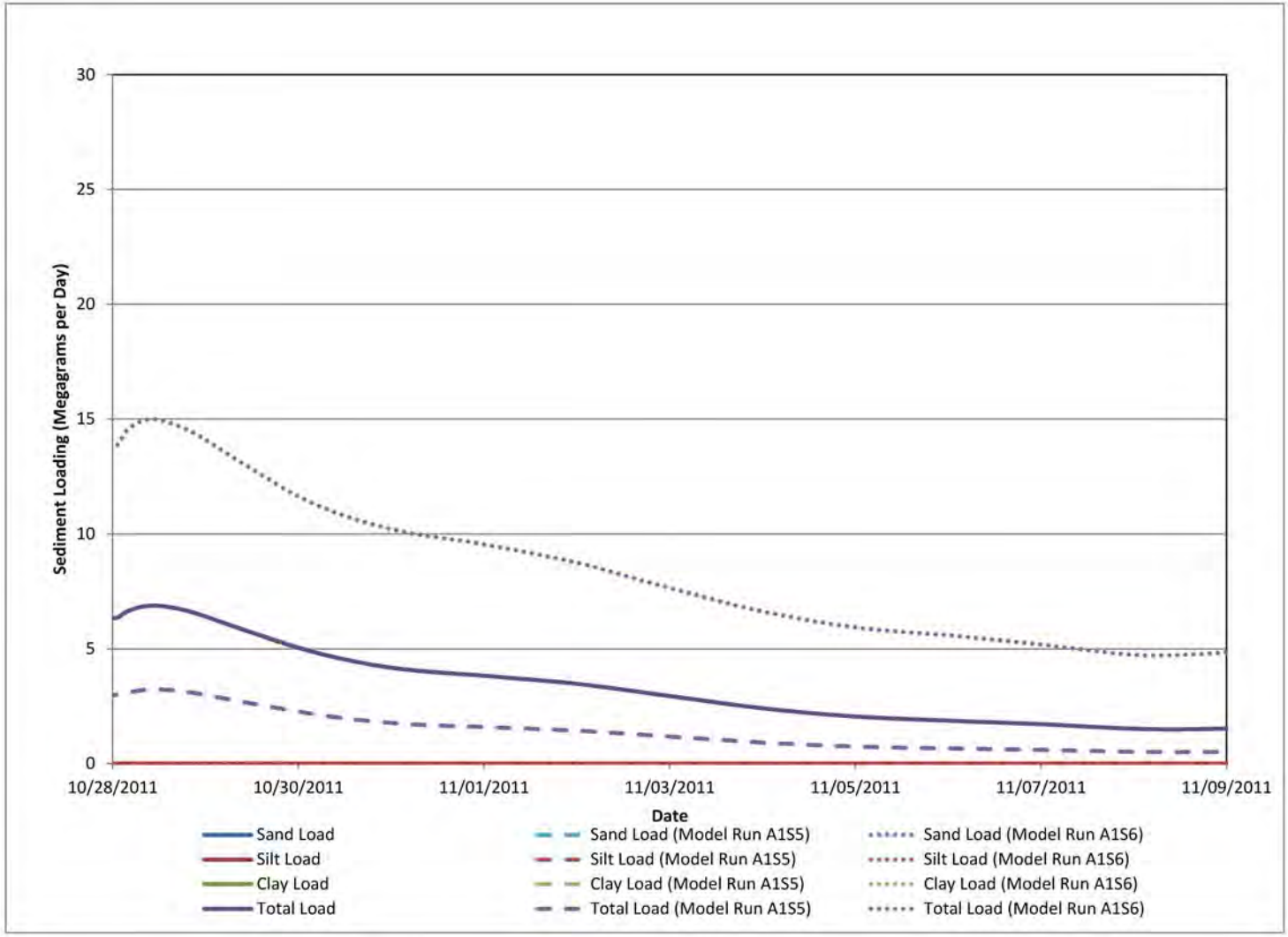
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

RIVERINE: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT MORROW LAKE DAM

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

Footnotes:

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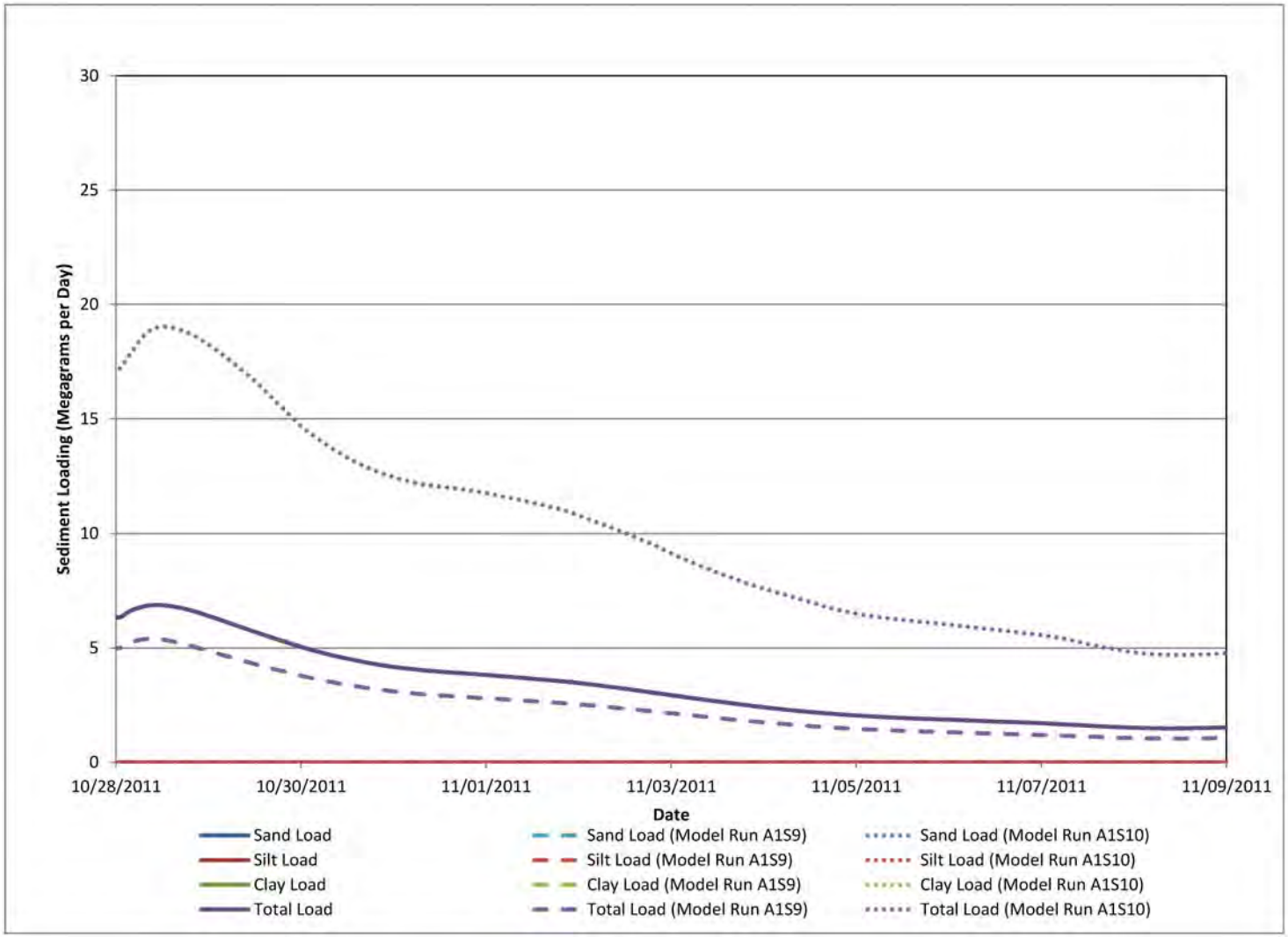
RIVERINE: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT MORROW LAKE DAM

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

Footnotes:

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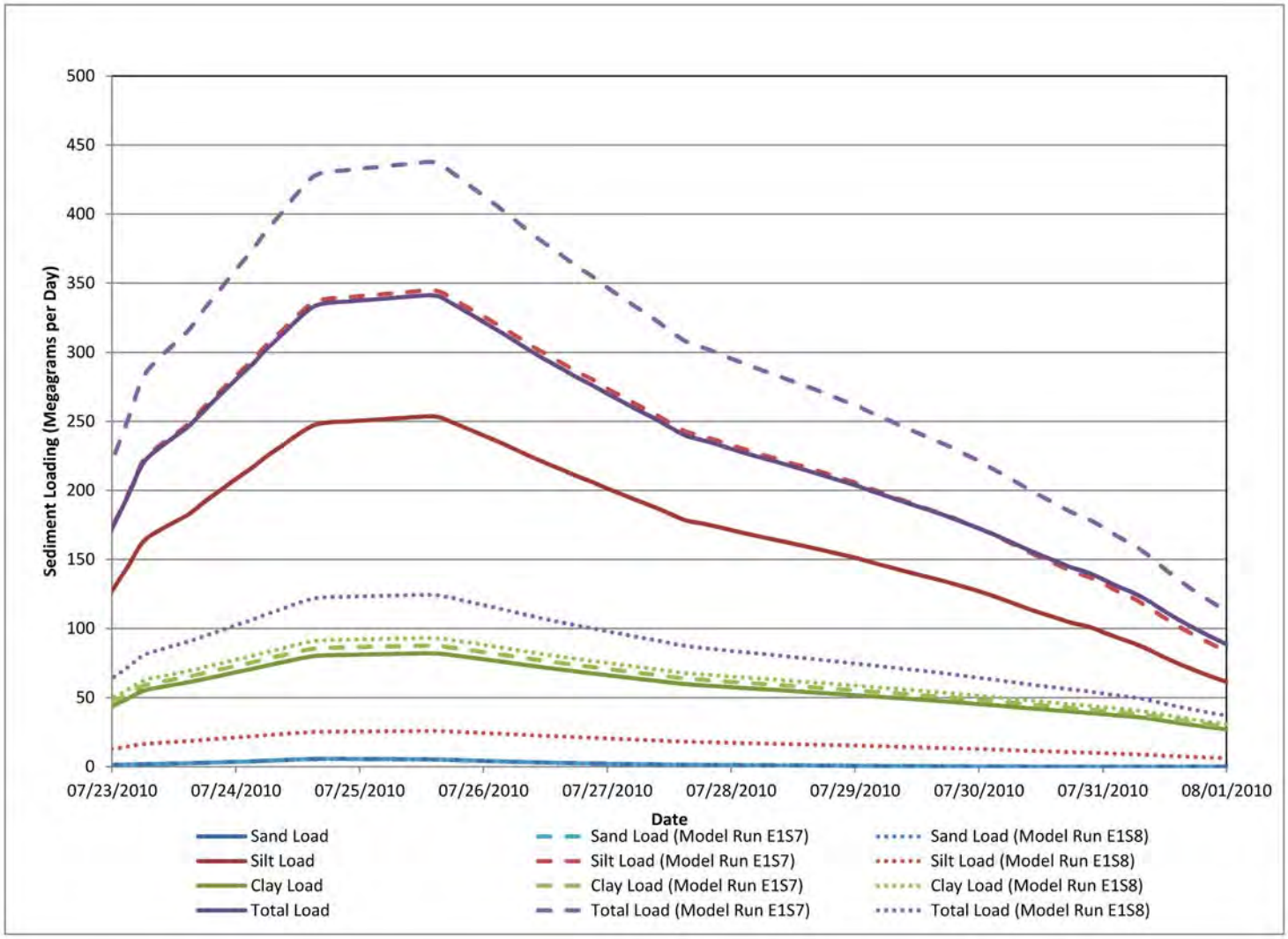
RIVERINE: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT MORROW LAKE DAM

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

US EPA ARCHIVE DOCUMENT



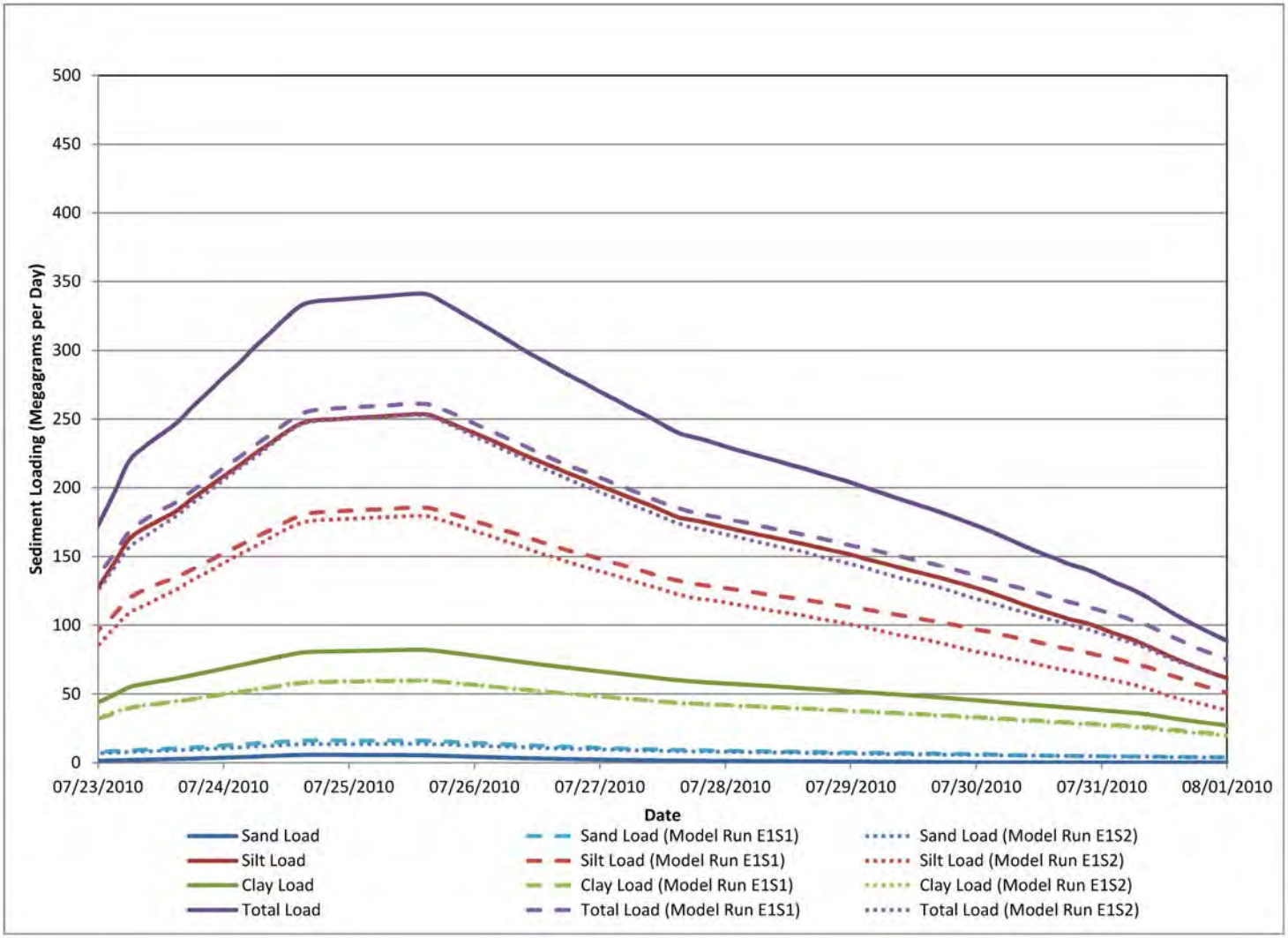
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT CERESCO DAM

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

US EPA ARCHIVE DOCUMENT



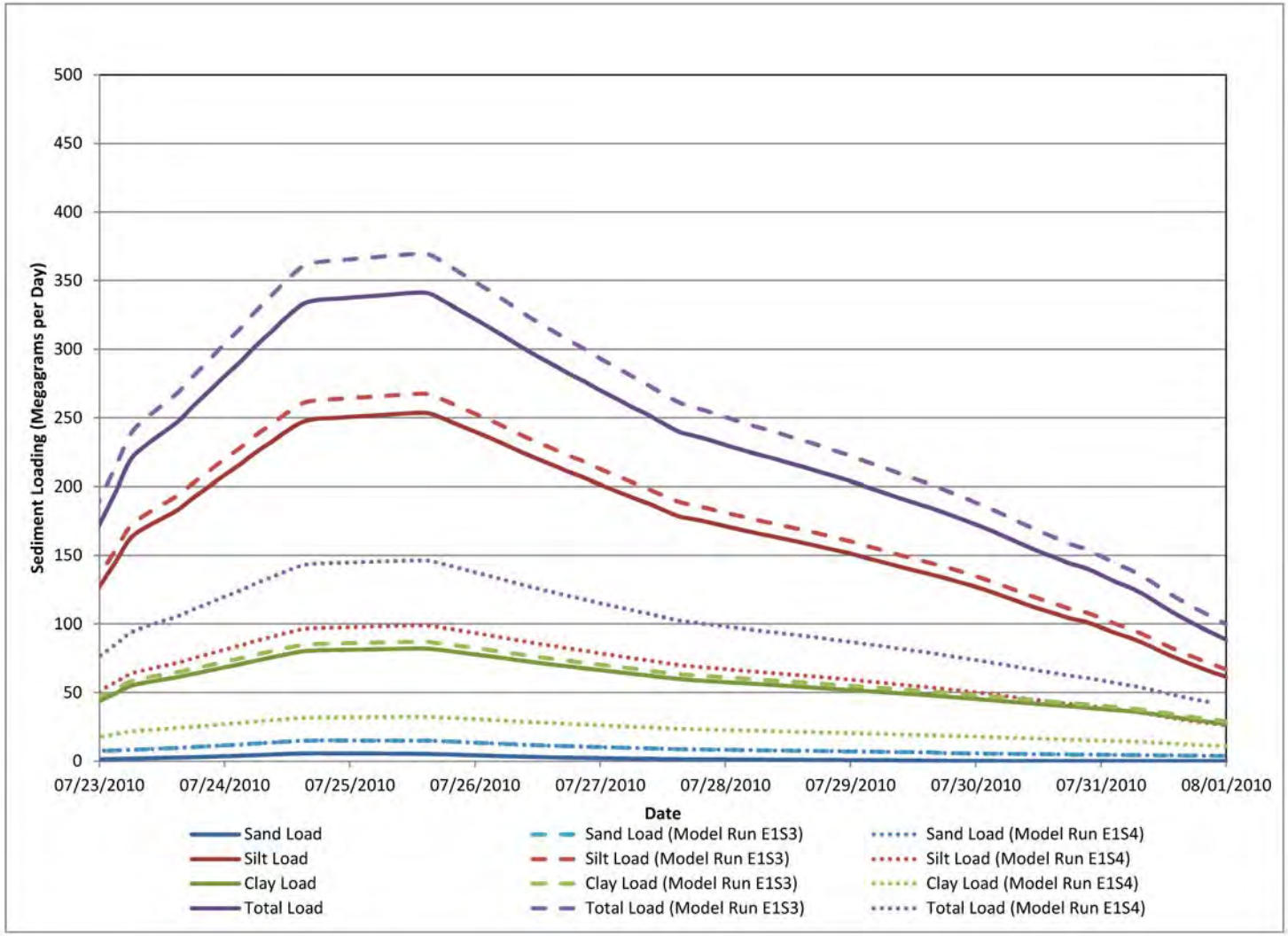
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT CERESCO DAM

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

US EPA ARCHIVE DOCUMENT



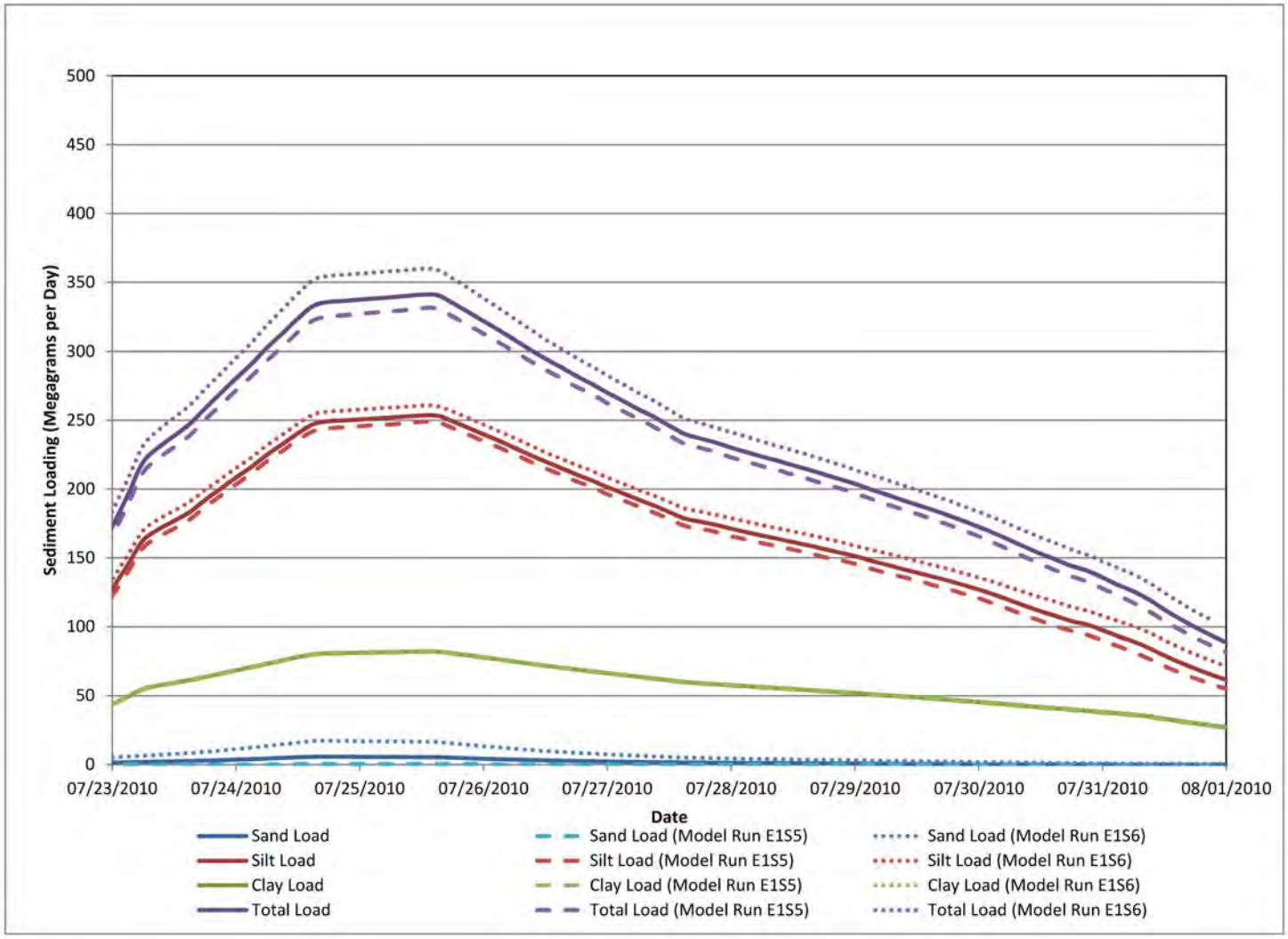
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT CERESCO DAM

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

US EPA ARCHIVE DOCUMENT



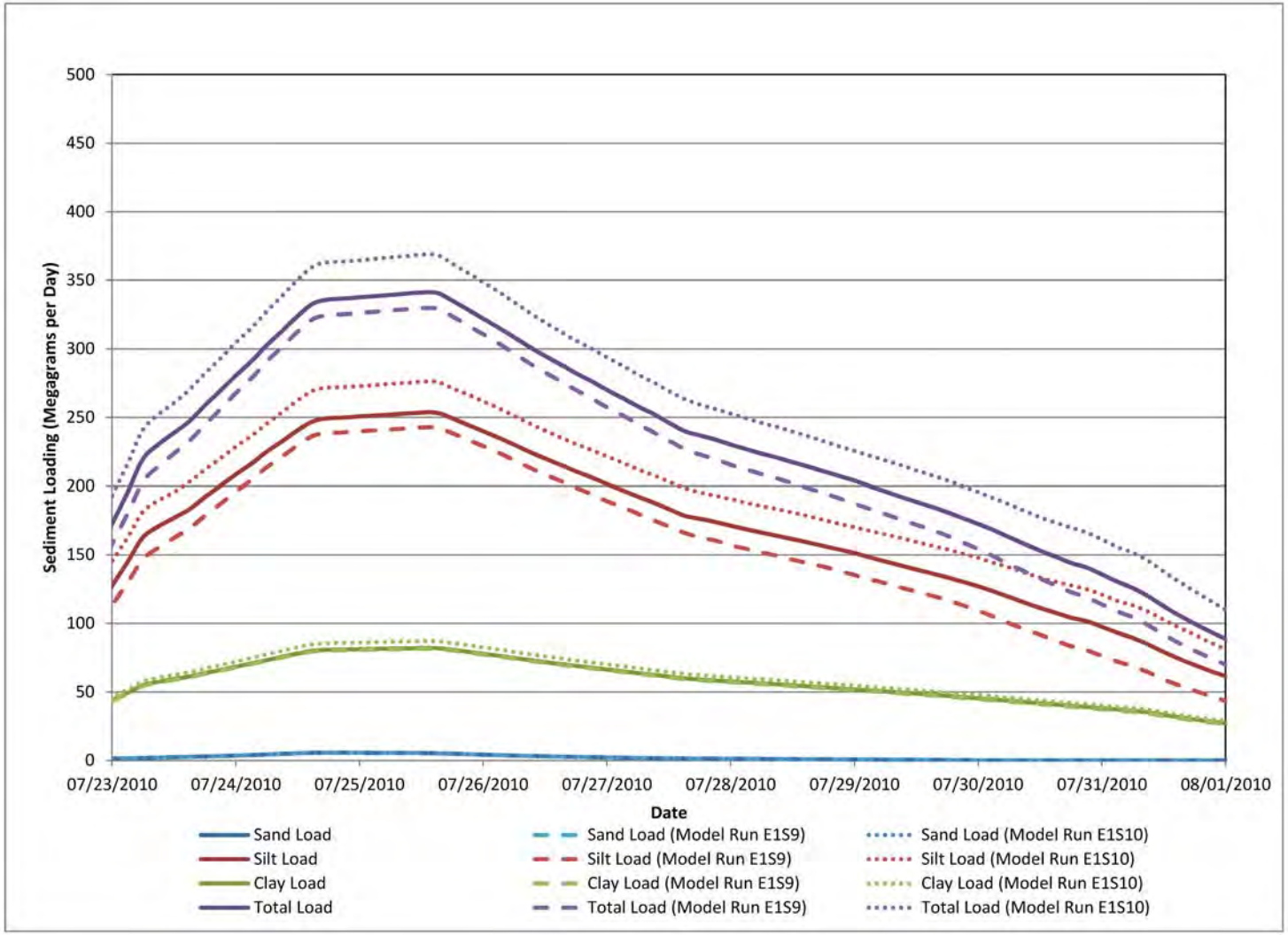
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT CERESCO DAM

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

US EPA ARCHIVE DOCUMENT



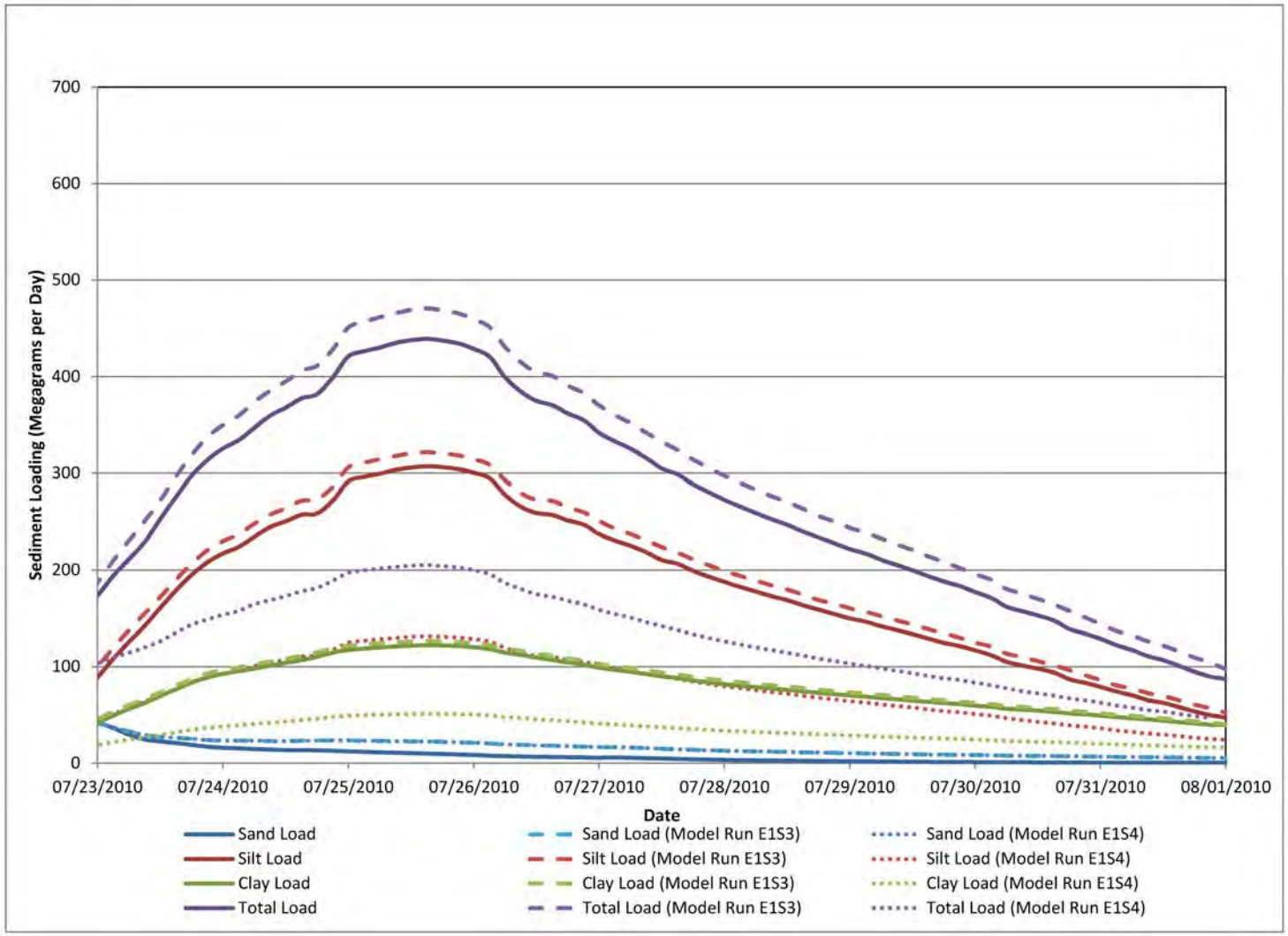
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT CERESCO DAM

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

US EPA ARCHIVE DOCUMENT



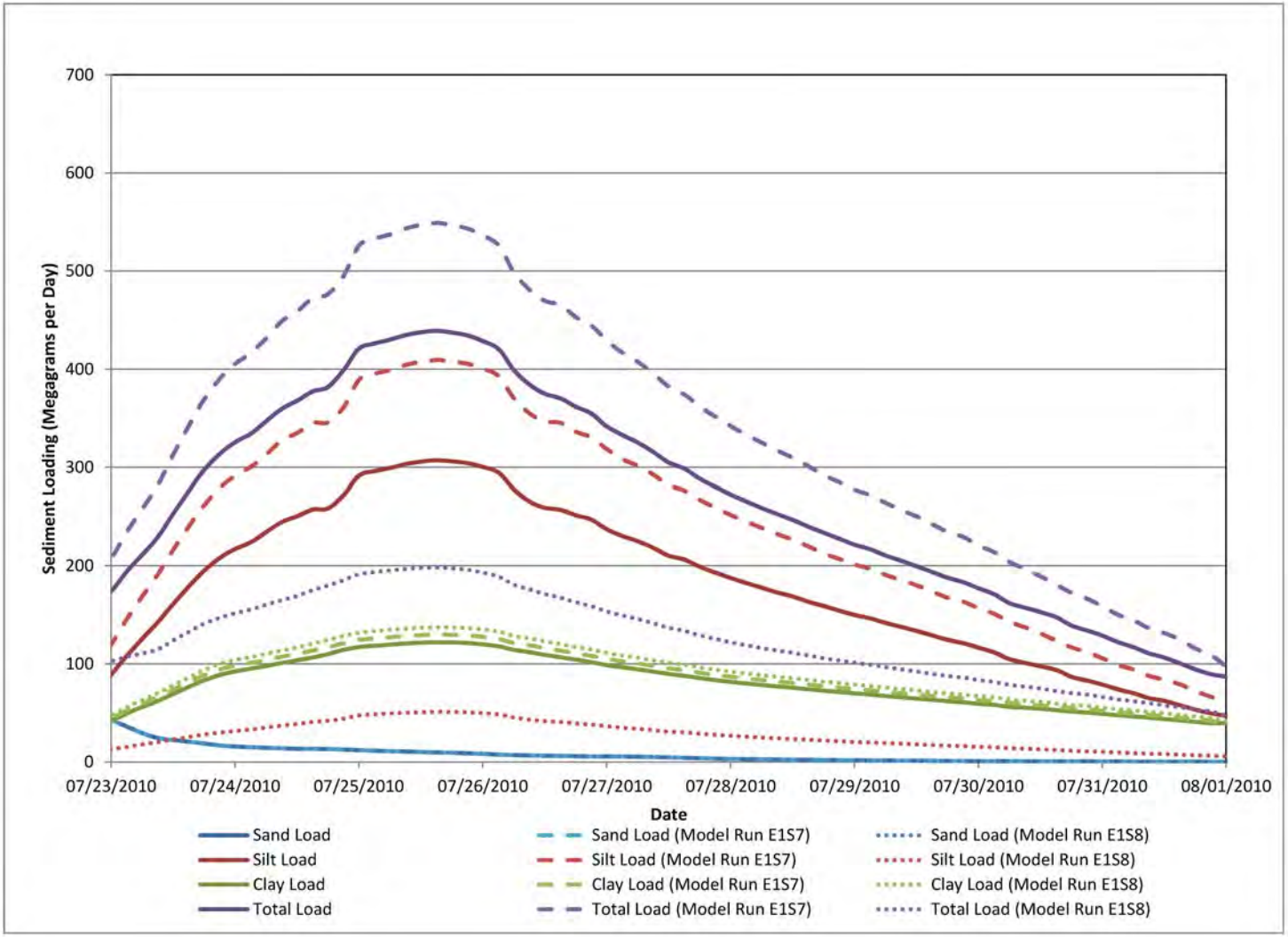
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT KALAMAZOO DAM

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

US EPA ARCHIVE DOCUMENT



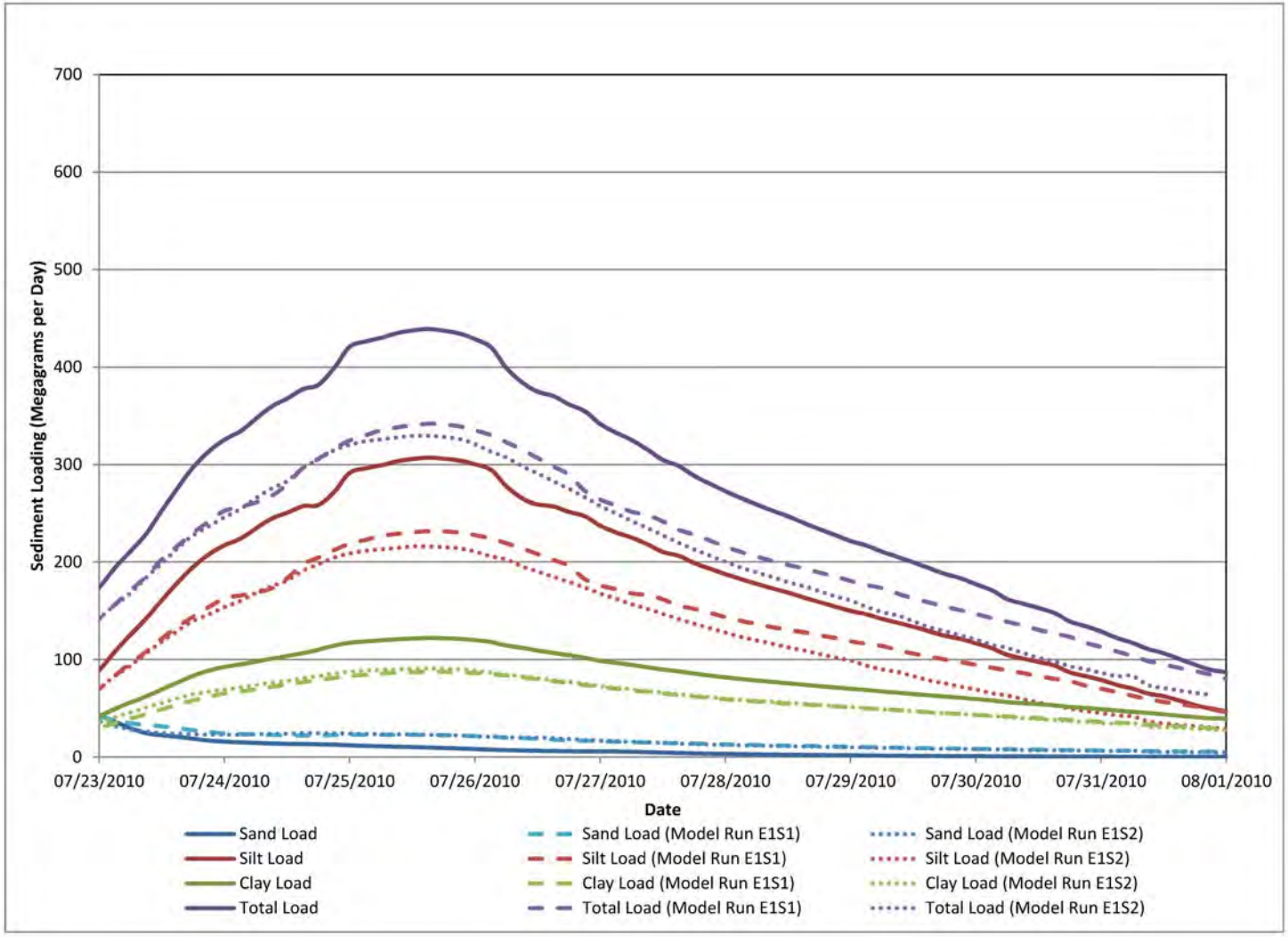
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT KALAMAZOO DAM

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

US EPA ARCHIVE DOCUMENT



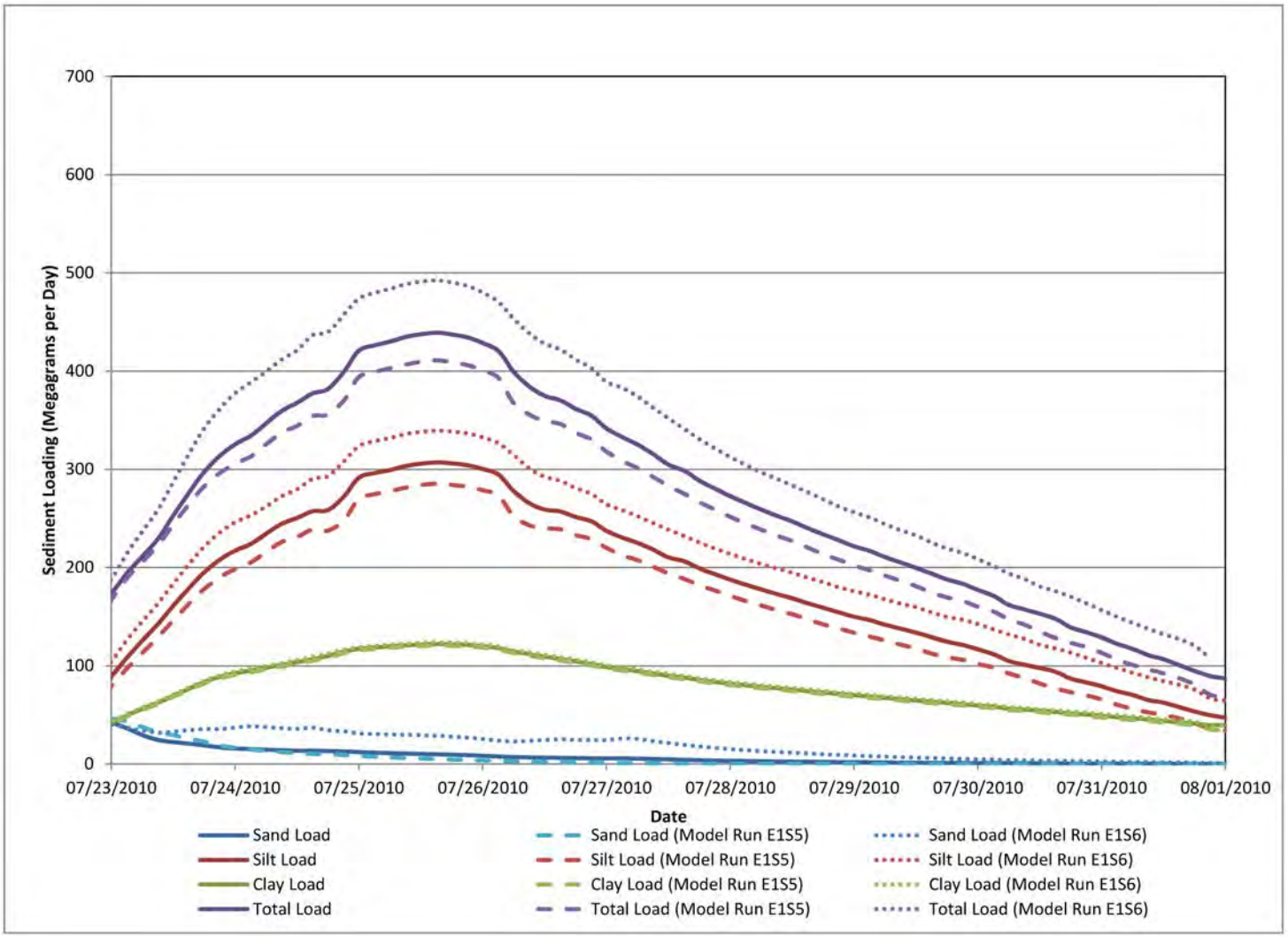
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT KALAMAZOO DAM

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
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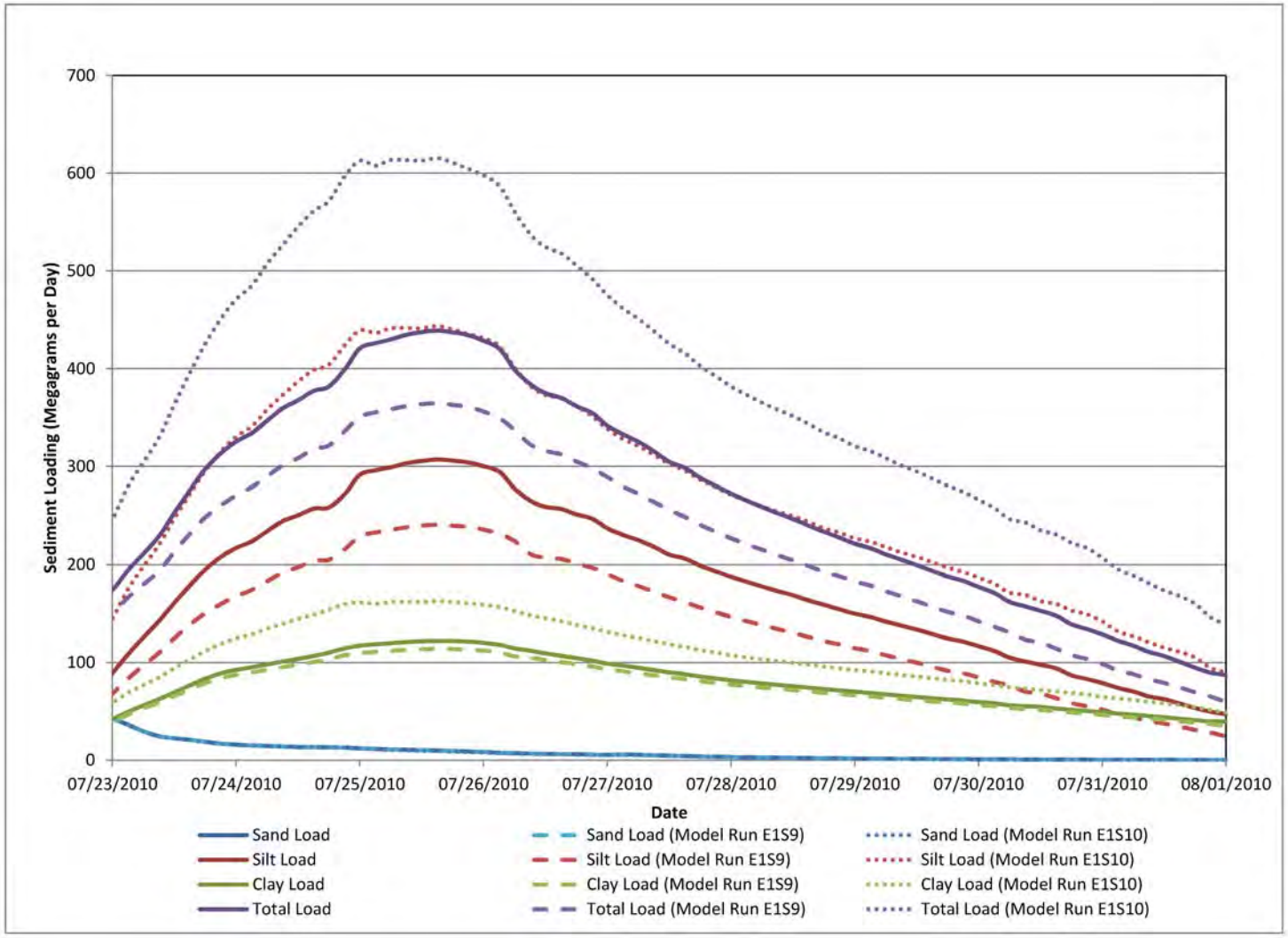
Project #:	106-4186	

FLOODPLAIN: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT KALAMAZOO DAM

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
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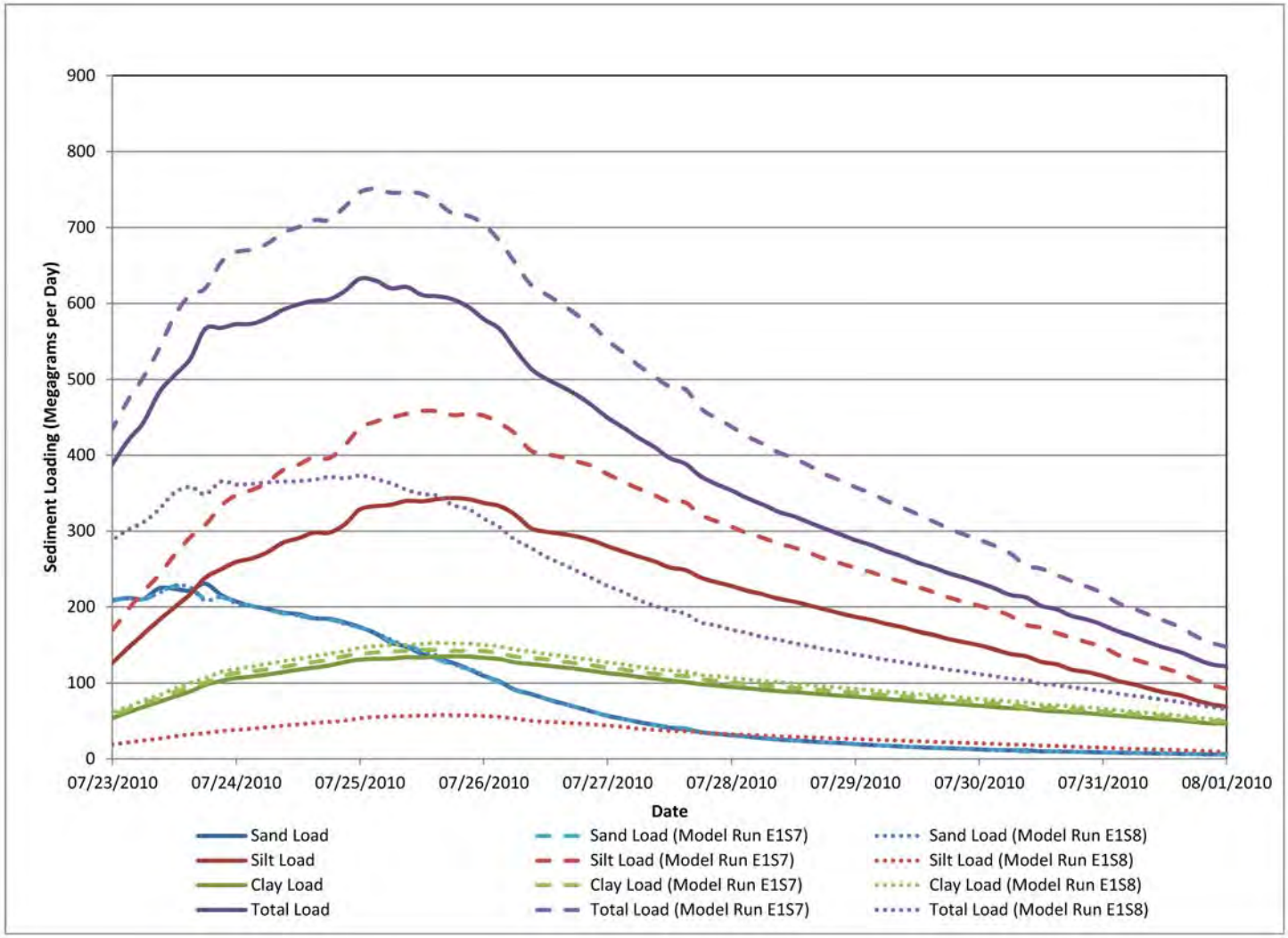
FLOODPLAIN: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT KALAMAZOO DAM

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
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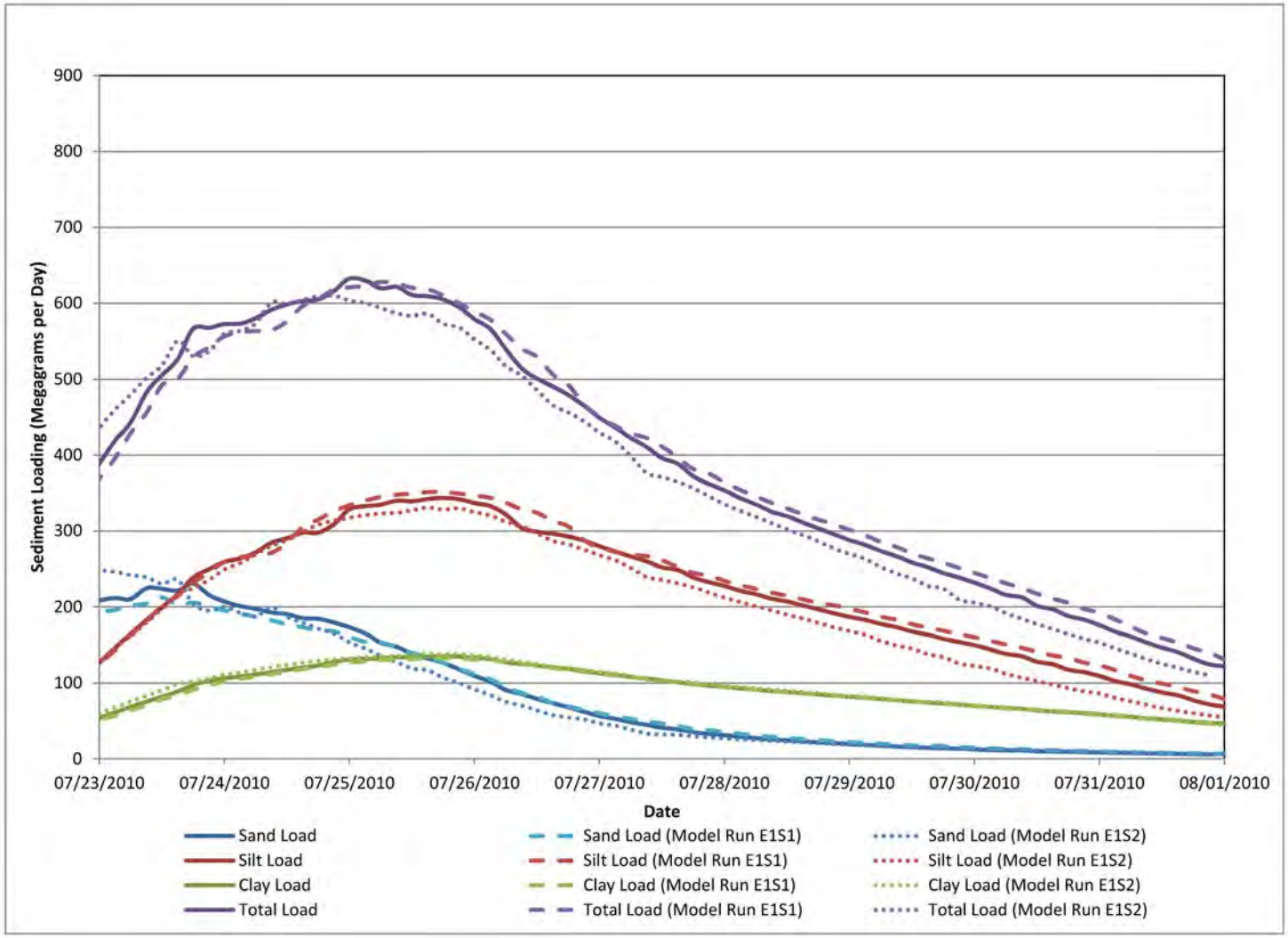
Project #:	106-4186	

FLOODPLAIN: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT KALAMAZOO GAGE

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

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FLOODPLAIN: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT KALAMAZOO GAGE

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

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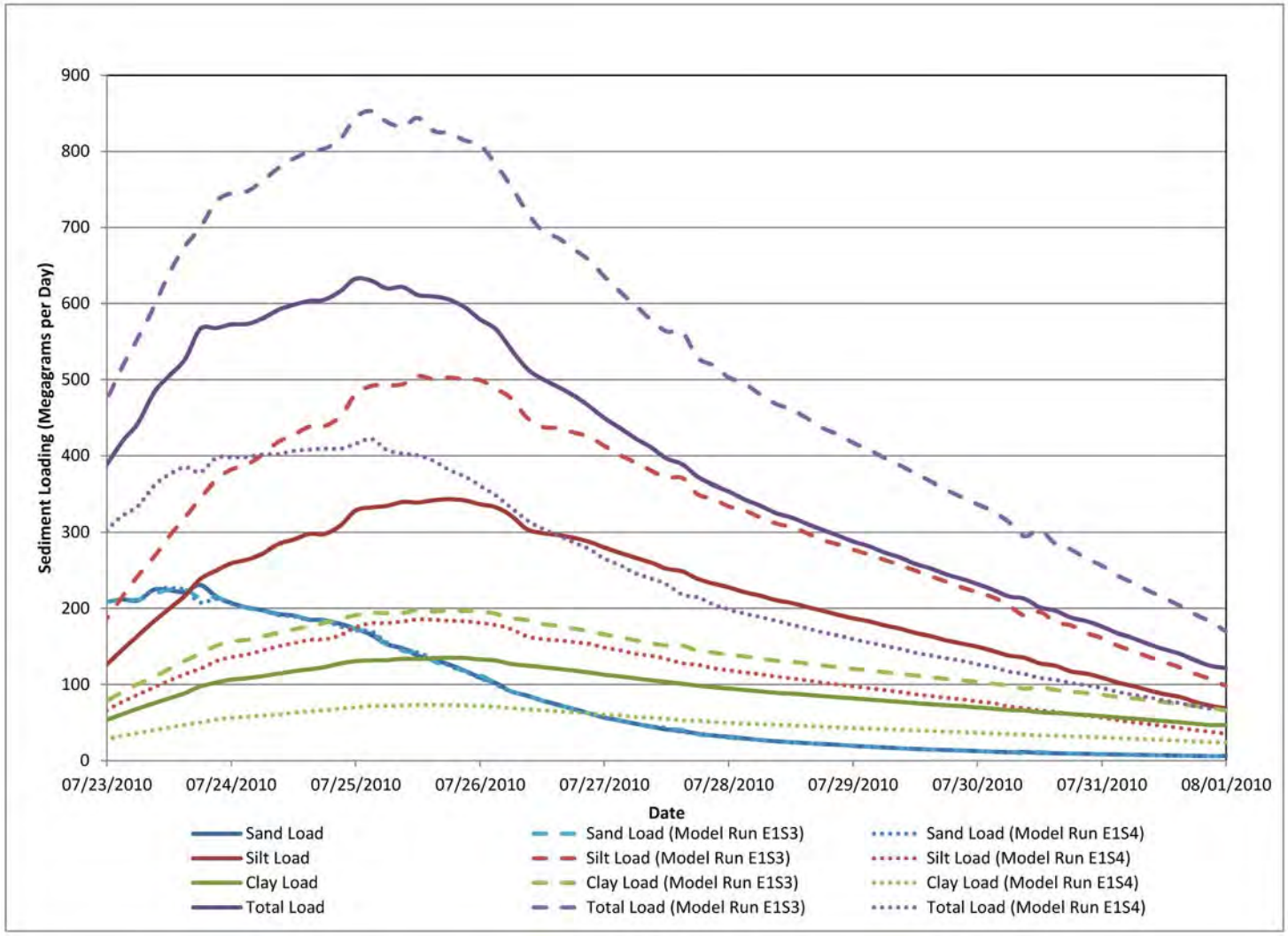

ENBRIDGE

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FLOODPLAIN: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT KALAMAZOO GAGE

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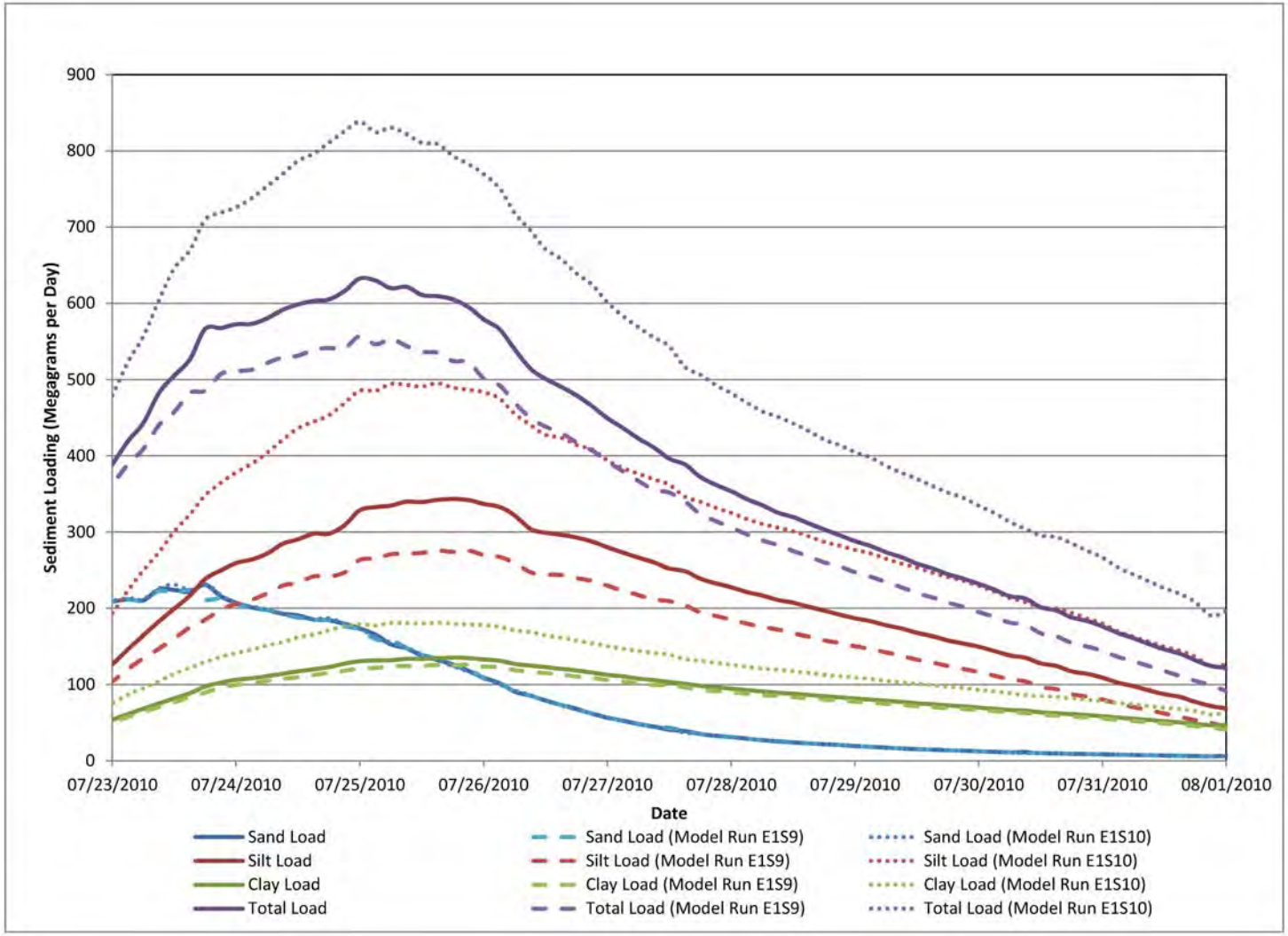

ENBRIDGE

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FLOODPLAIN: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT KALAMAZOO GAGE

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

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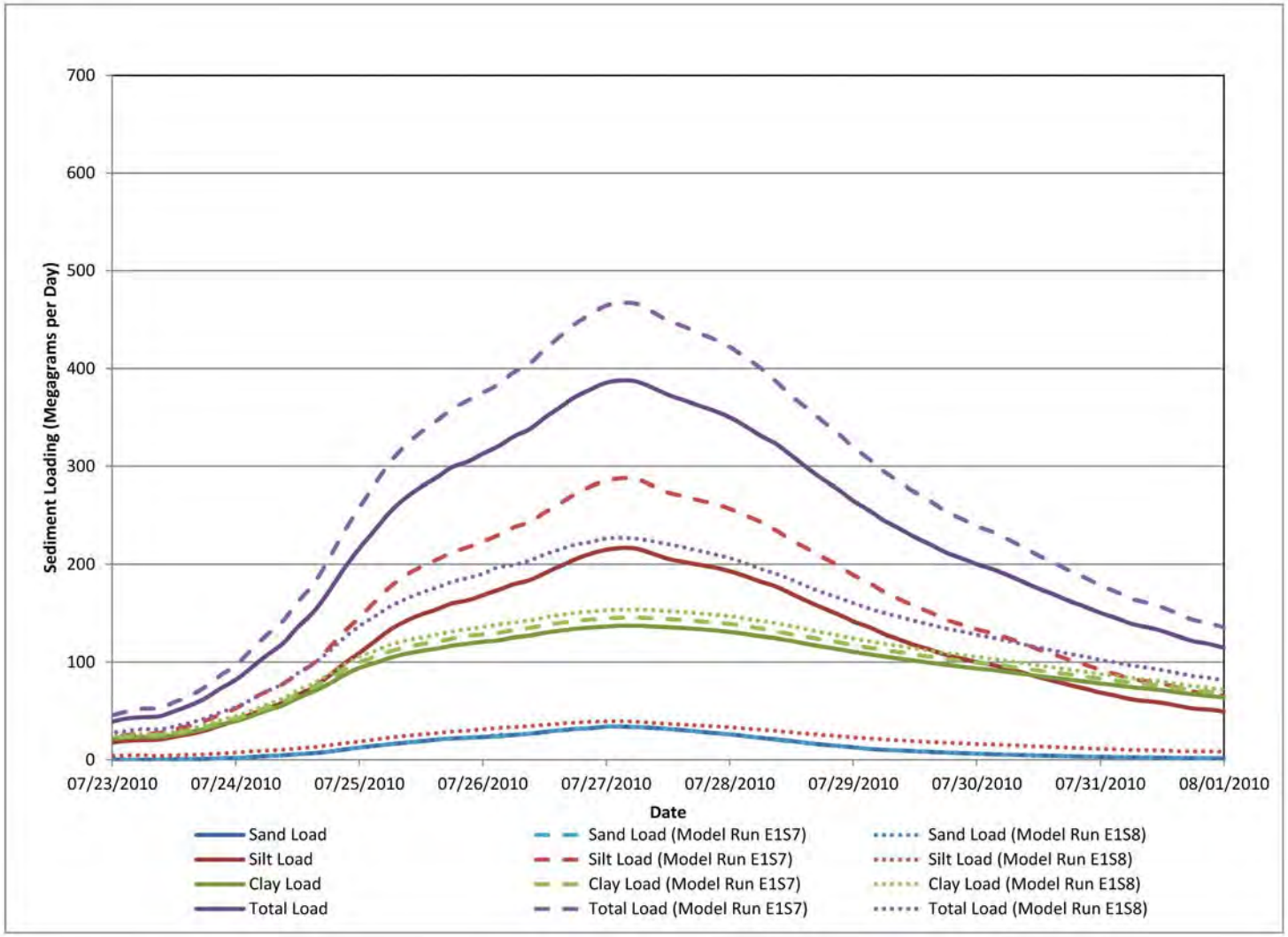


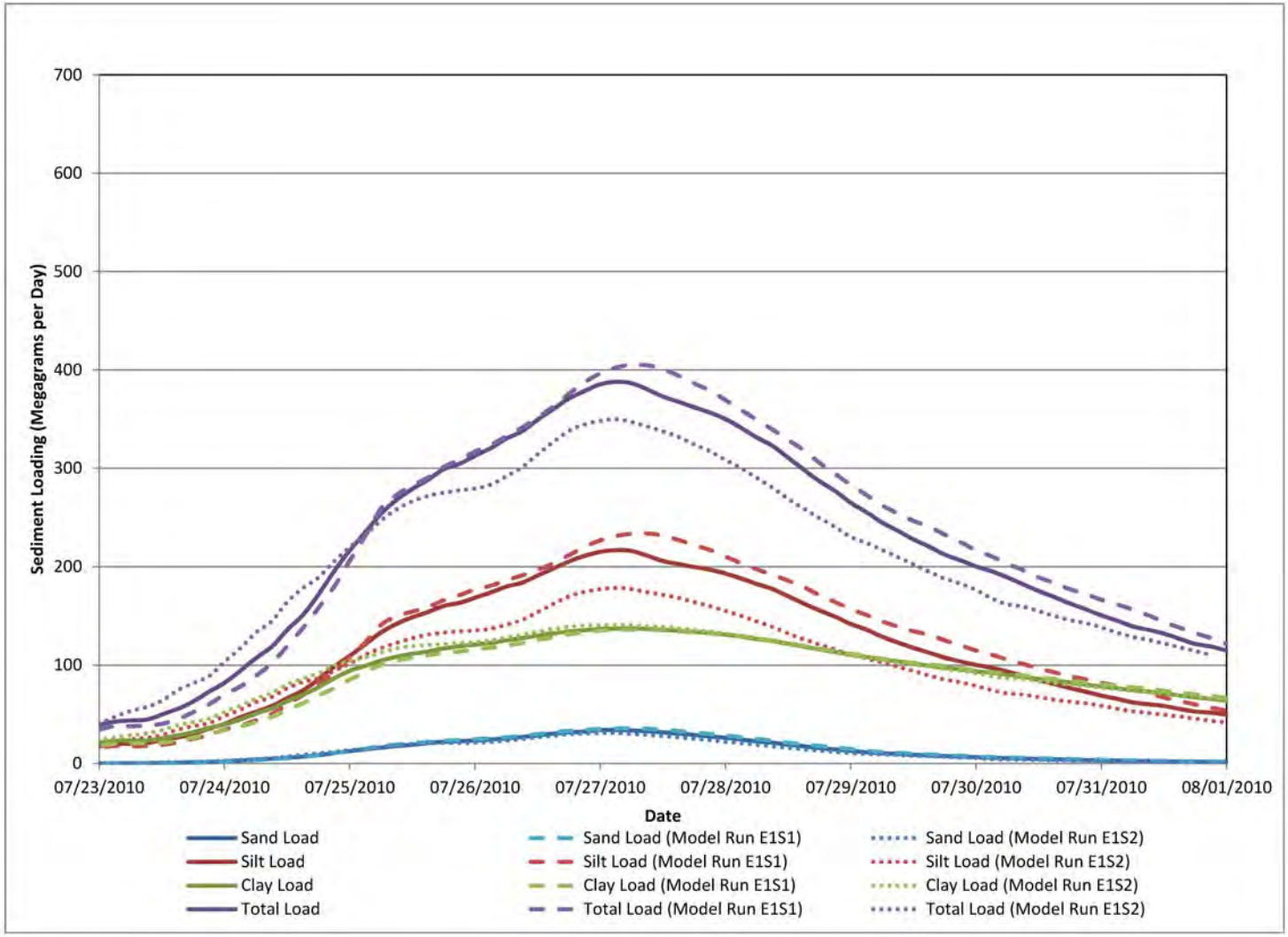
ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT 35TH STREET BRIDGE

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

US EPA ARCHIVE DOCUMENT



ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT 35TH STREET BRIDGE

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

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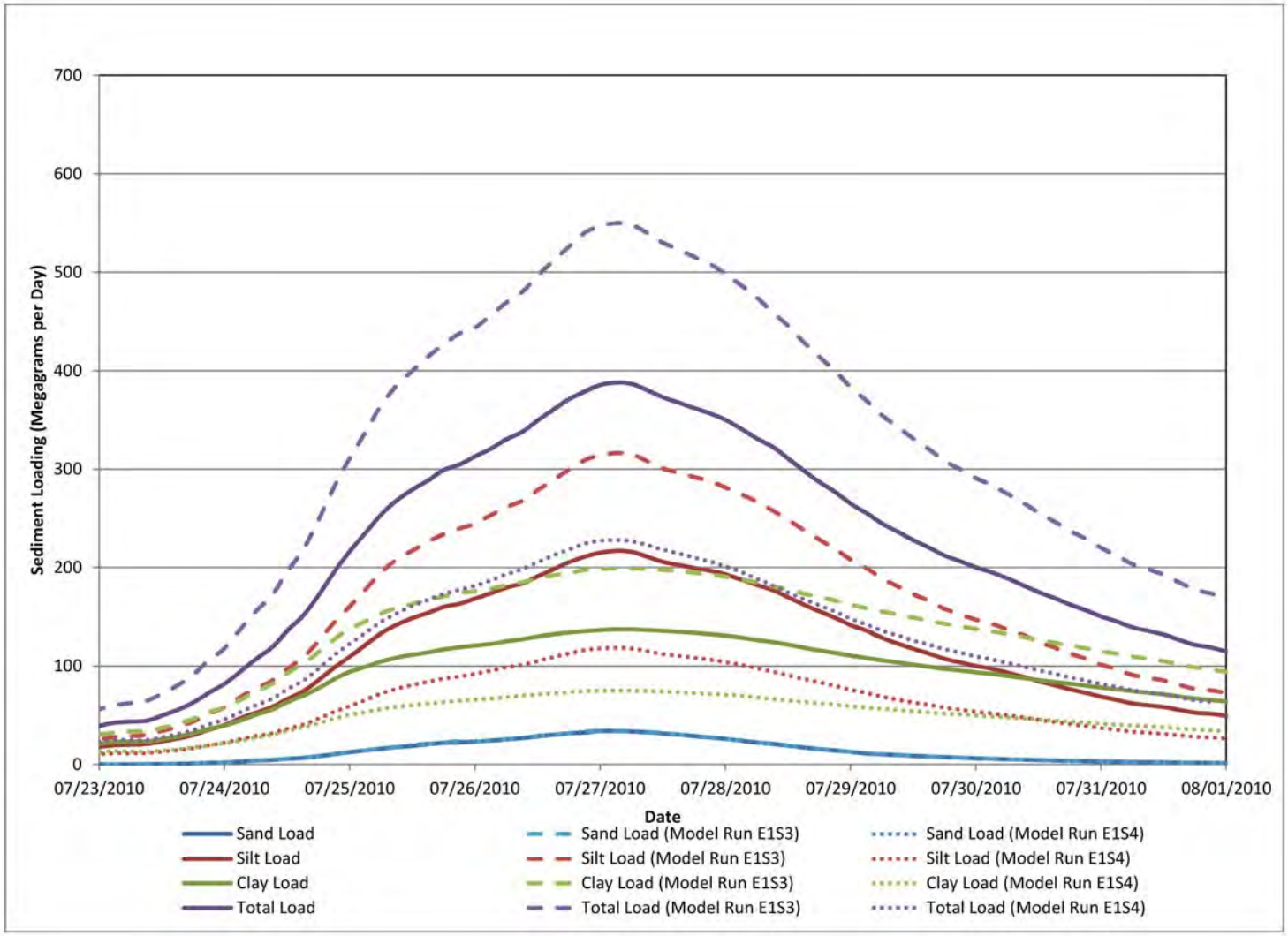

ENBRIDGE

Drawn:	JLH	5/2/2012
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FLOODPLAIN: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT 35TH STREET BRIDGE

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

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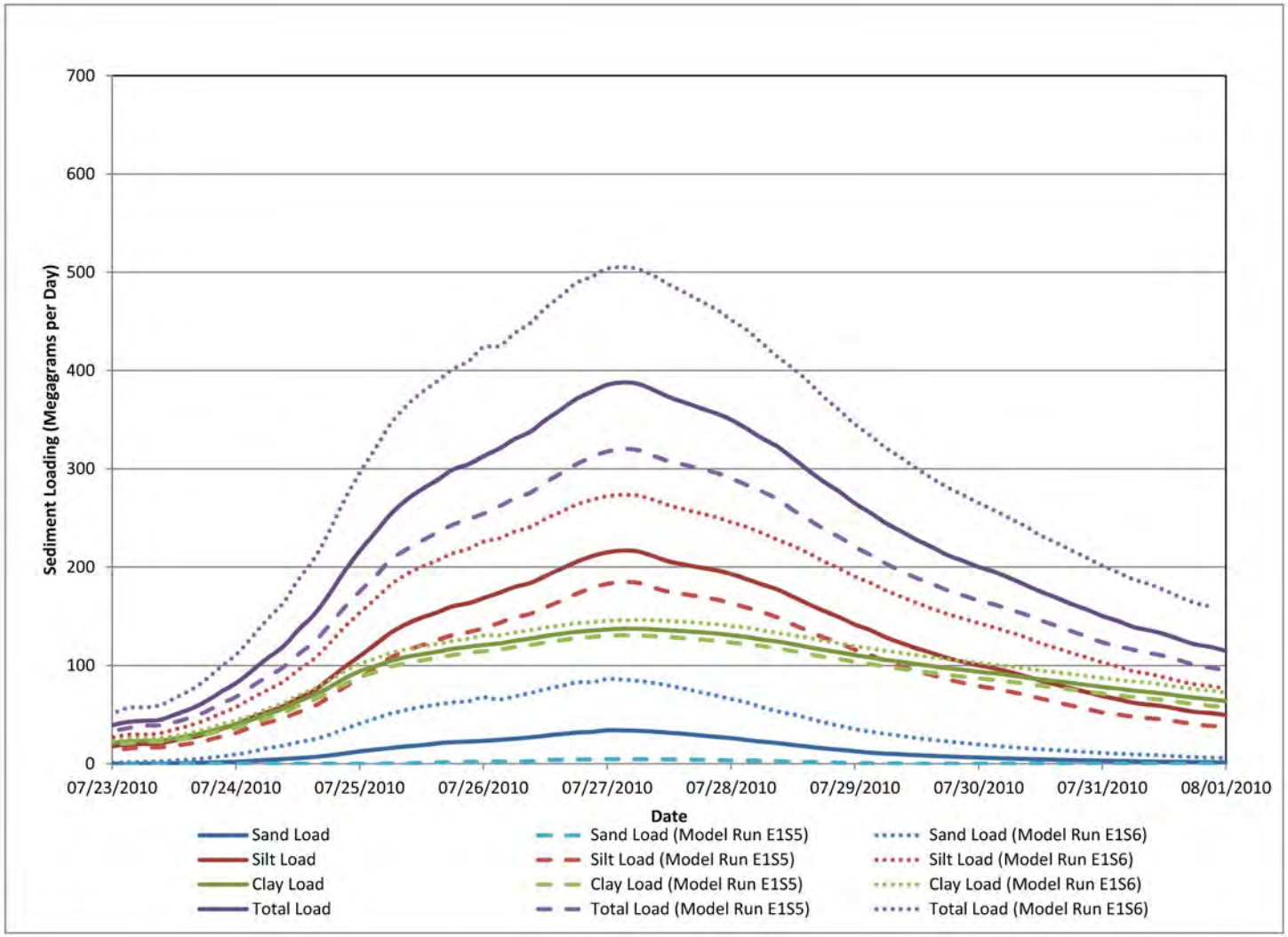

ENBRIDGE

Drawn:	JLH	5/2/2012
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FLOODPLAIN: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT 35TH STREET BRIDGE

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY,
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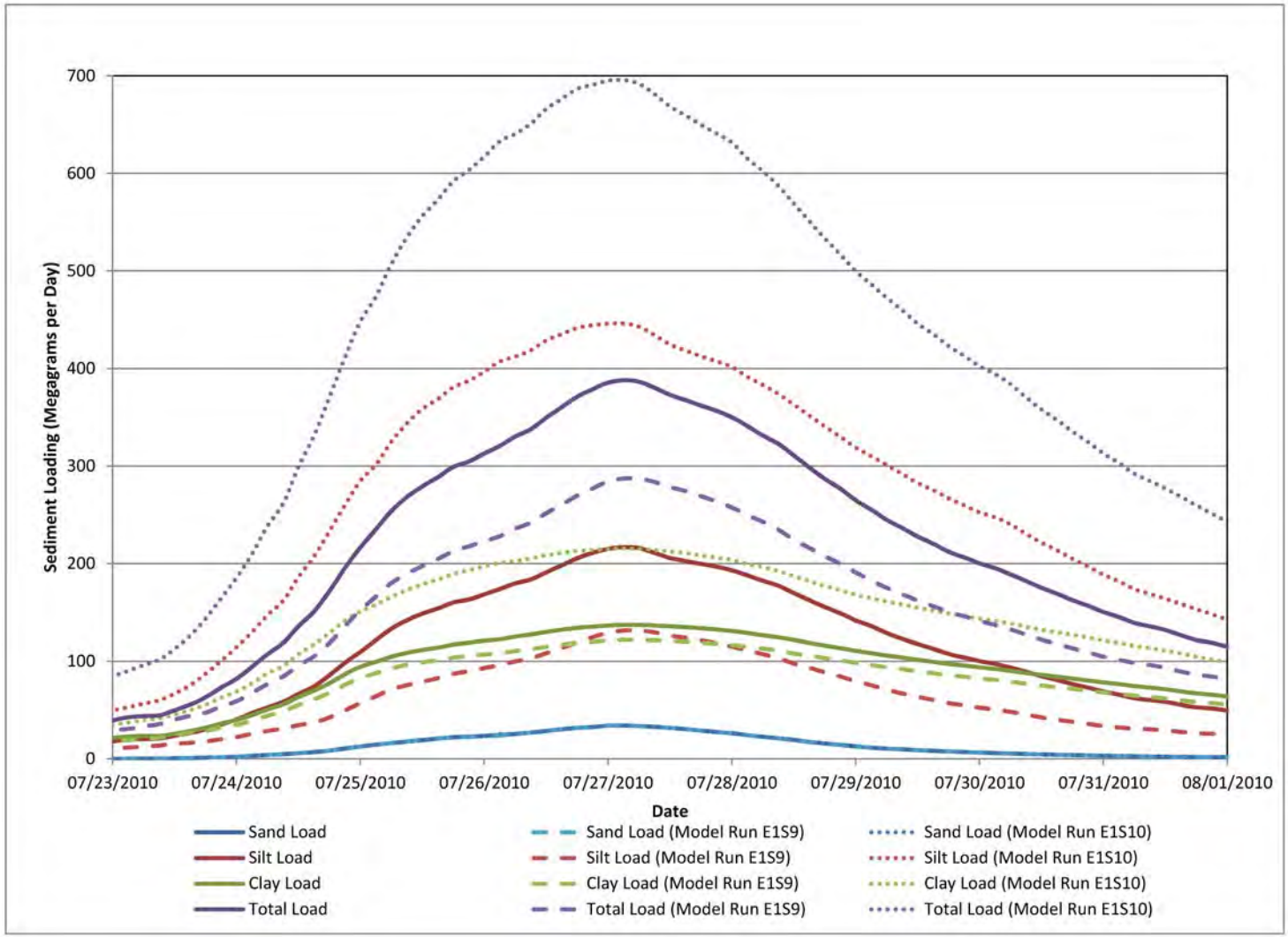
US EPA ARCHIVE DOCUMENT



ENBRIDGE

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FLOODPLAIN: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT 35TH STREET BRIDGE

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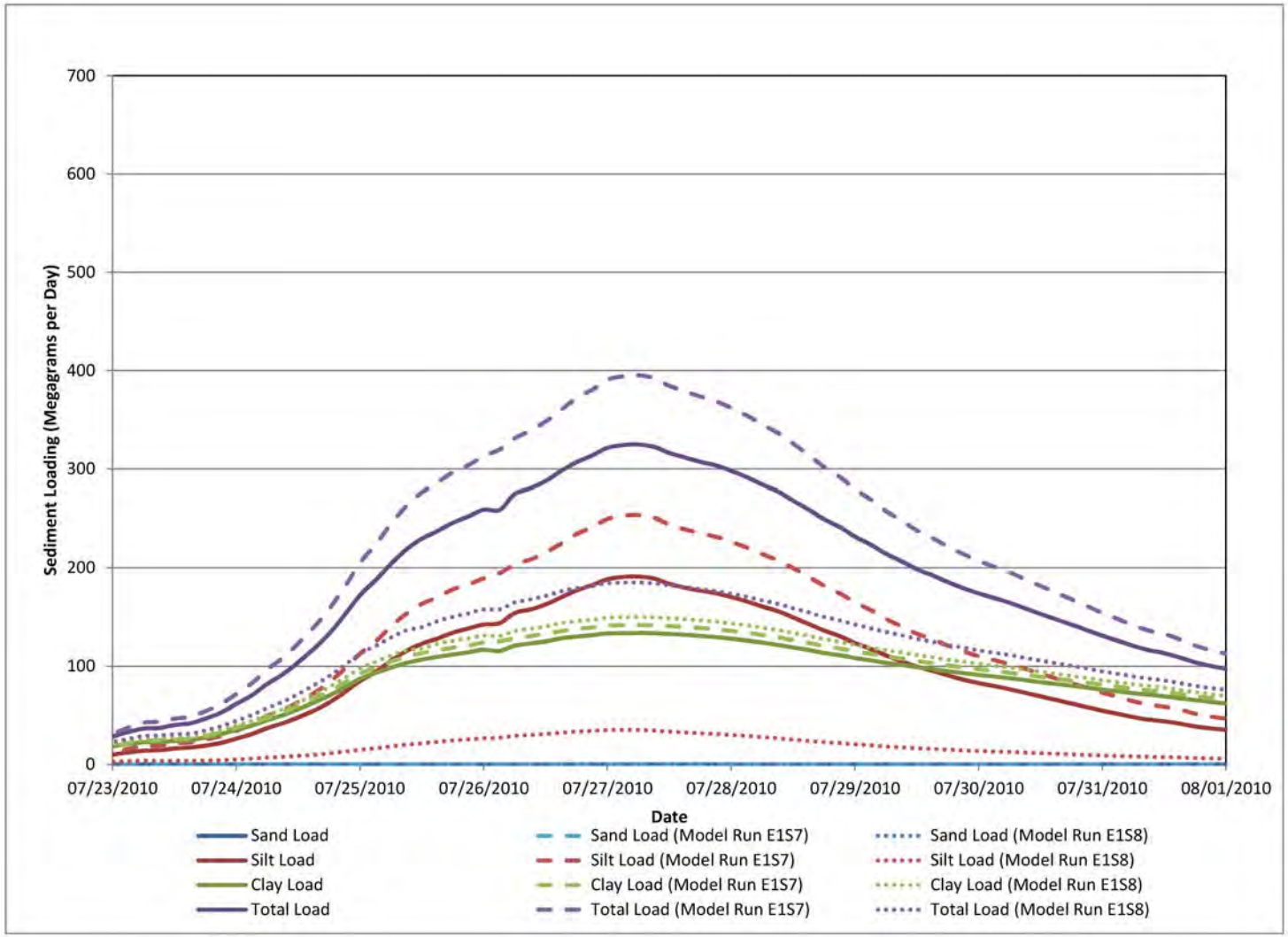

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Footnotes:

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FLOODPLAIN: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT MP 37.75

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

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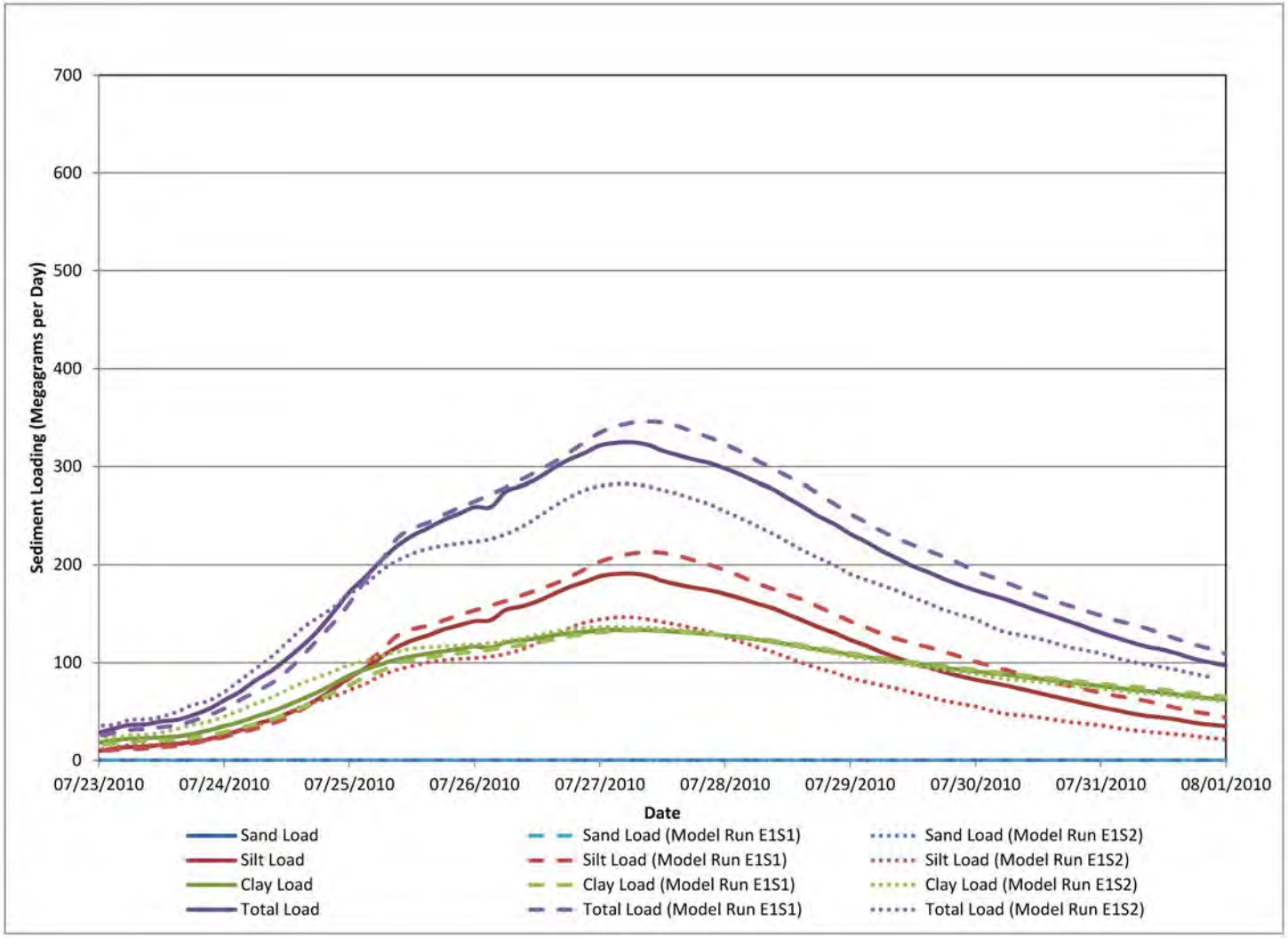

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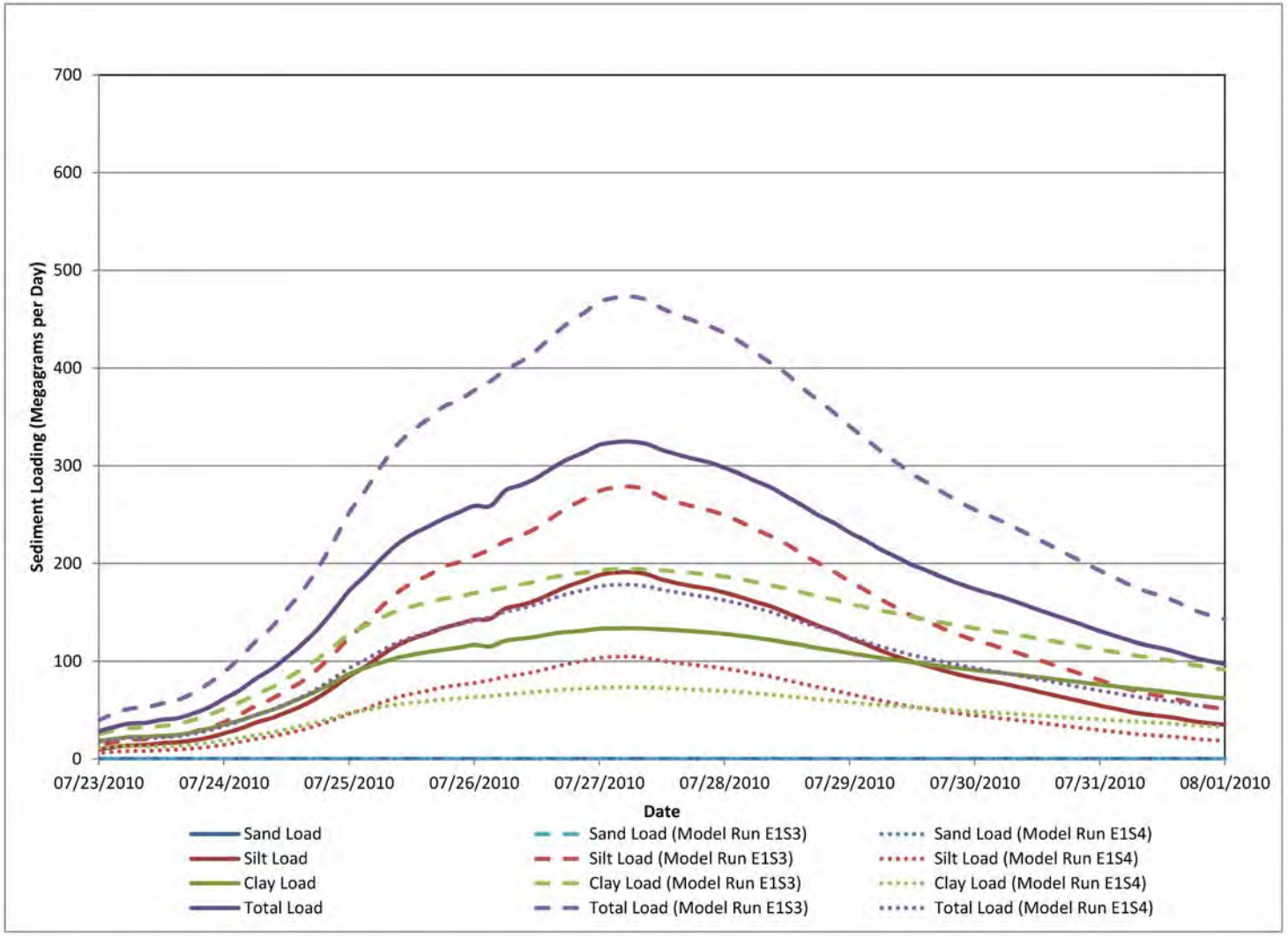

ENBRIDGE

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ENBRIDGE LINE 6B MP 608
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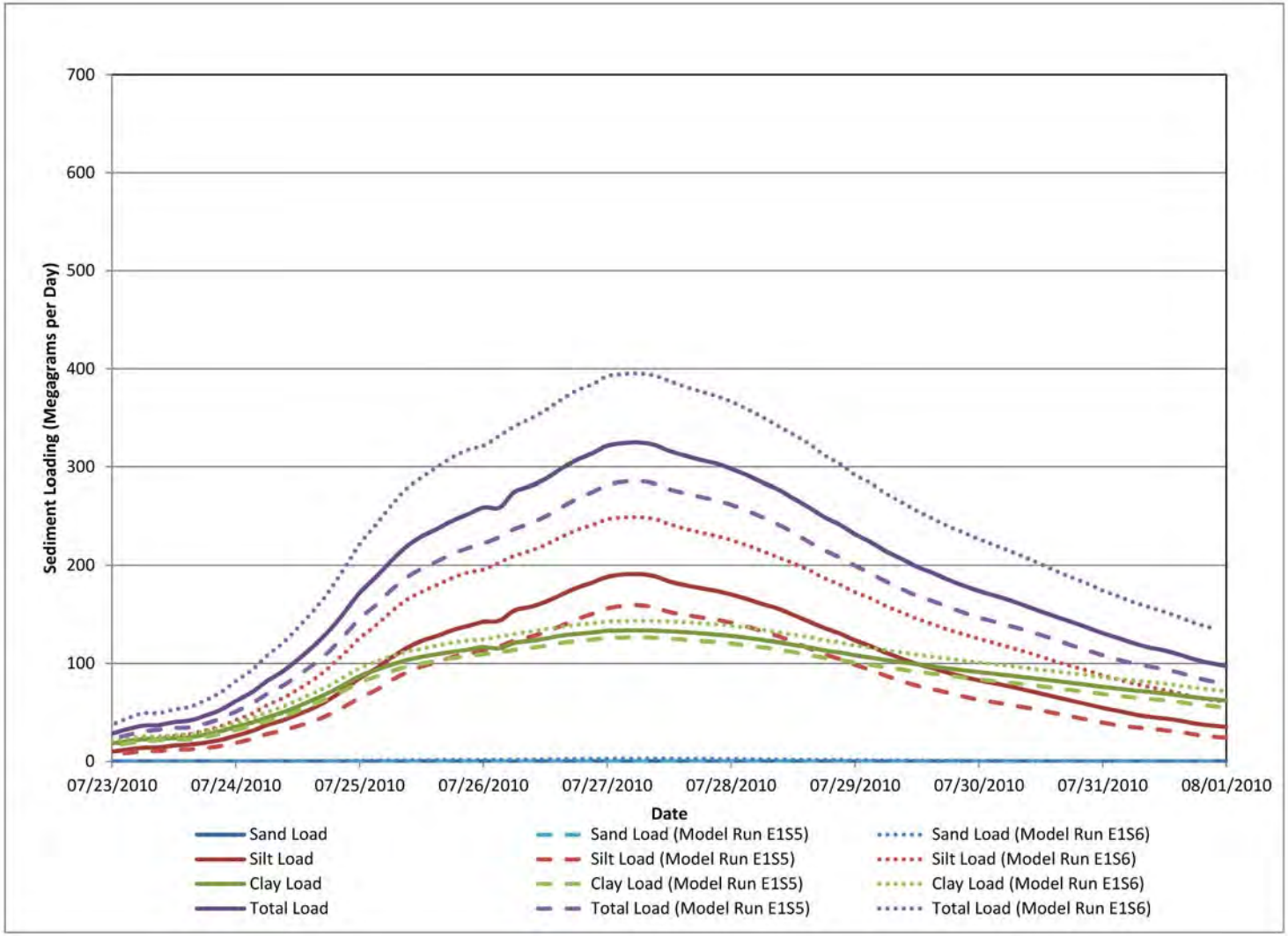

ENBRIDGE

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Footnotes:

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FLOODPLAIN: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT MP 37.75

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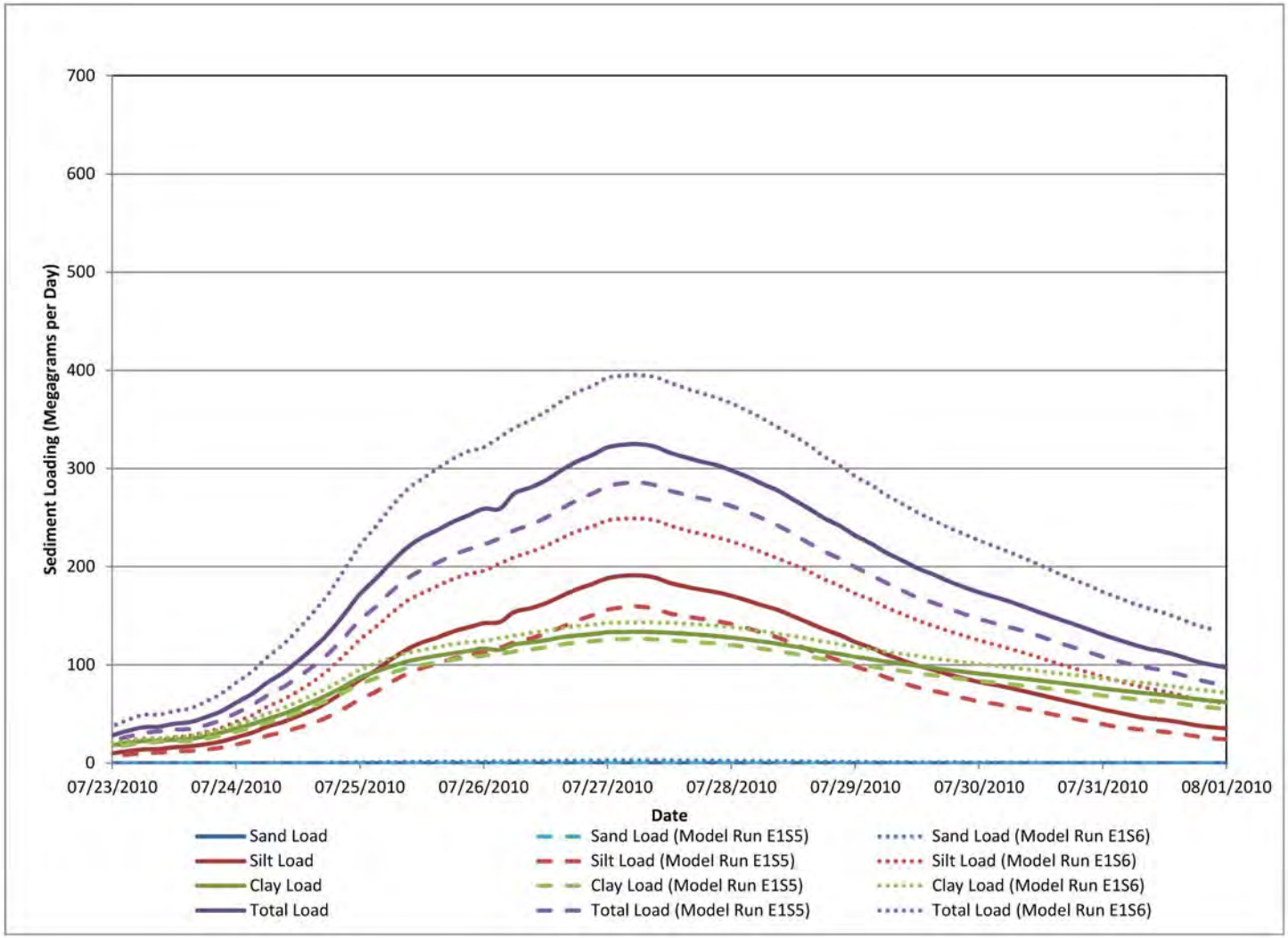

ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

Footnotes:

MP = Mile Post

FLOODPLAIN: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT MP 37.75

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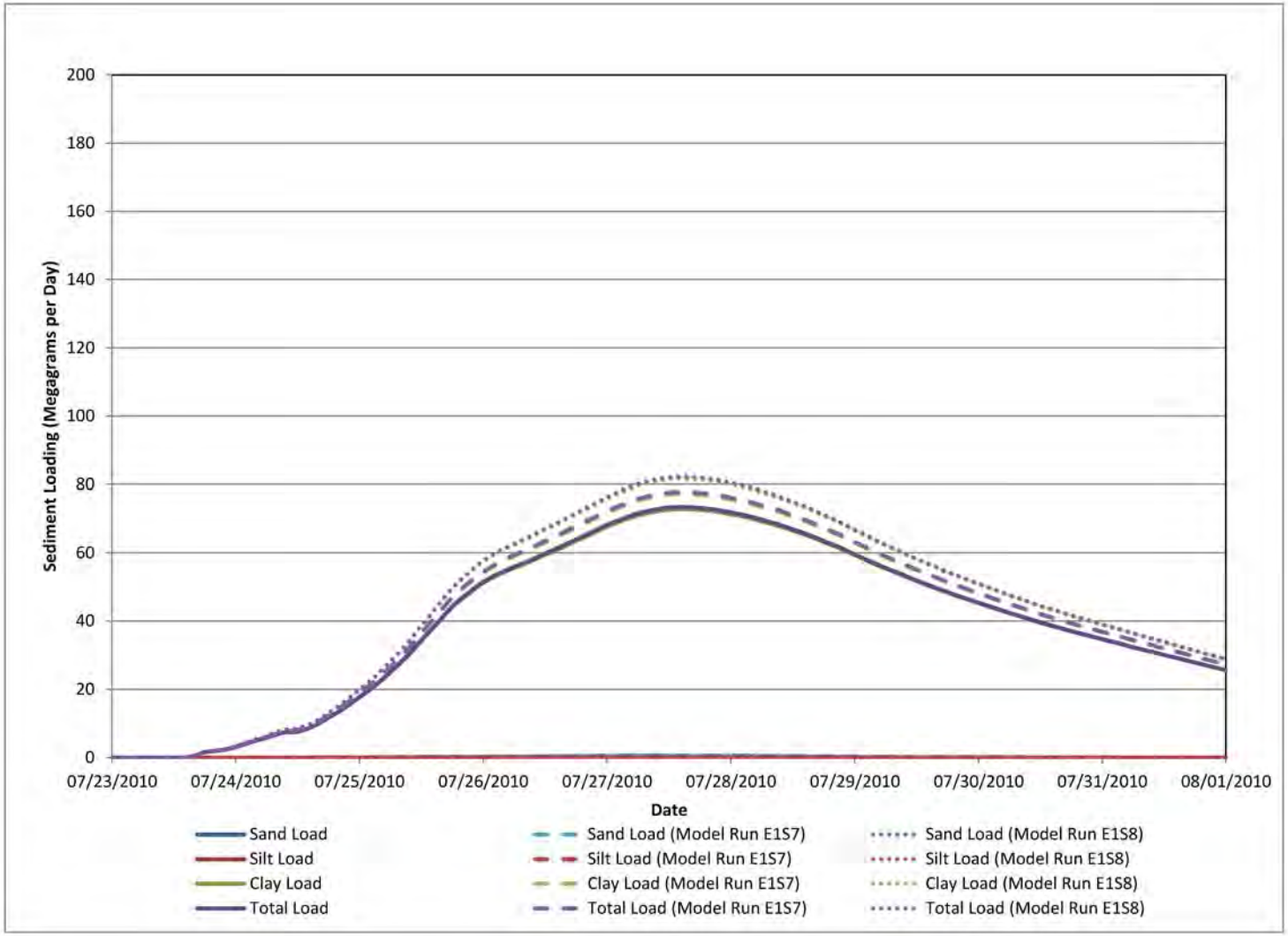

ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

Footnotes:

Total Load = Clay Load

FLOODPLAIN: EFFECT OF PARTICAL SIZE DISTRIBUTION ON SEDIMENT LOADING AT MORROW LAKE DAM

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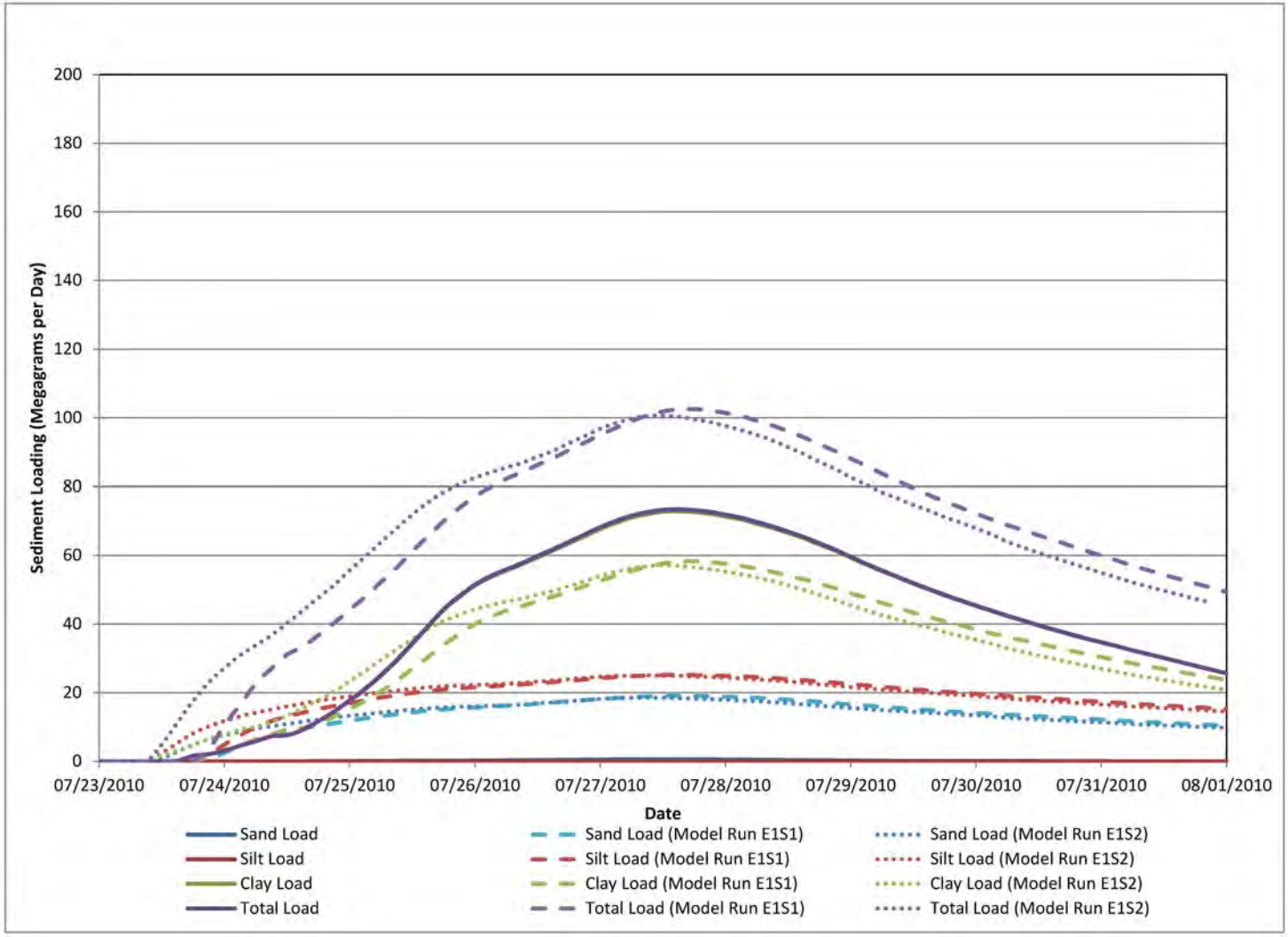

ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF ROUGHNESS ON SEDIMENT LOADING AT MORROW LAKE DAM

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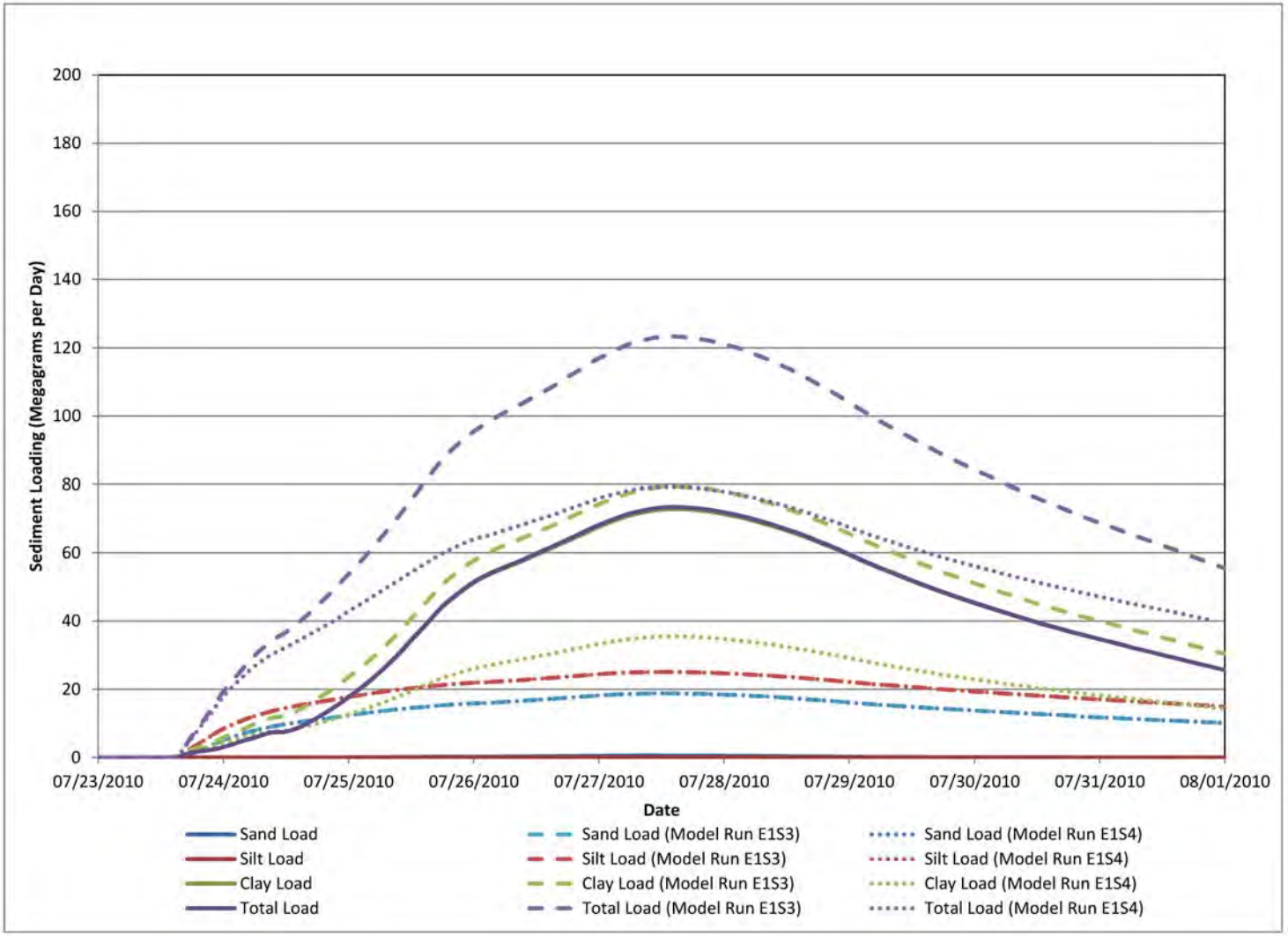

ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF SEDIMENT CONCENTRATION ON SEDIMENT LOADING AT MORROW LAKE DAM

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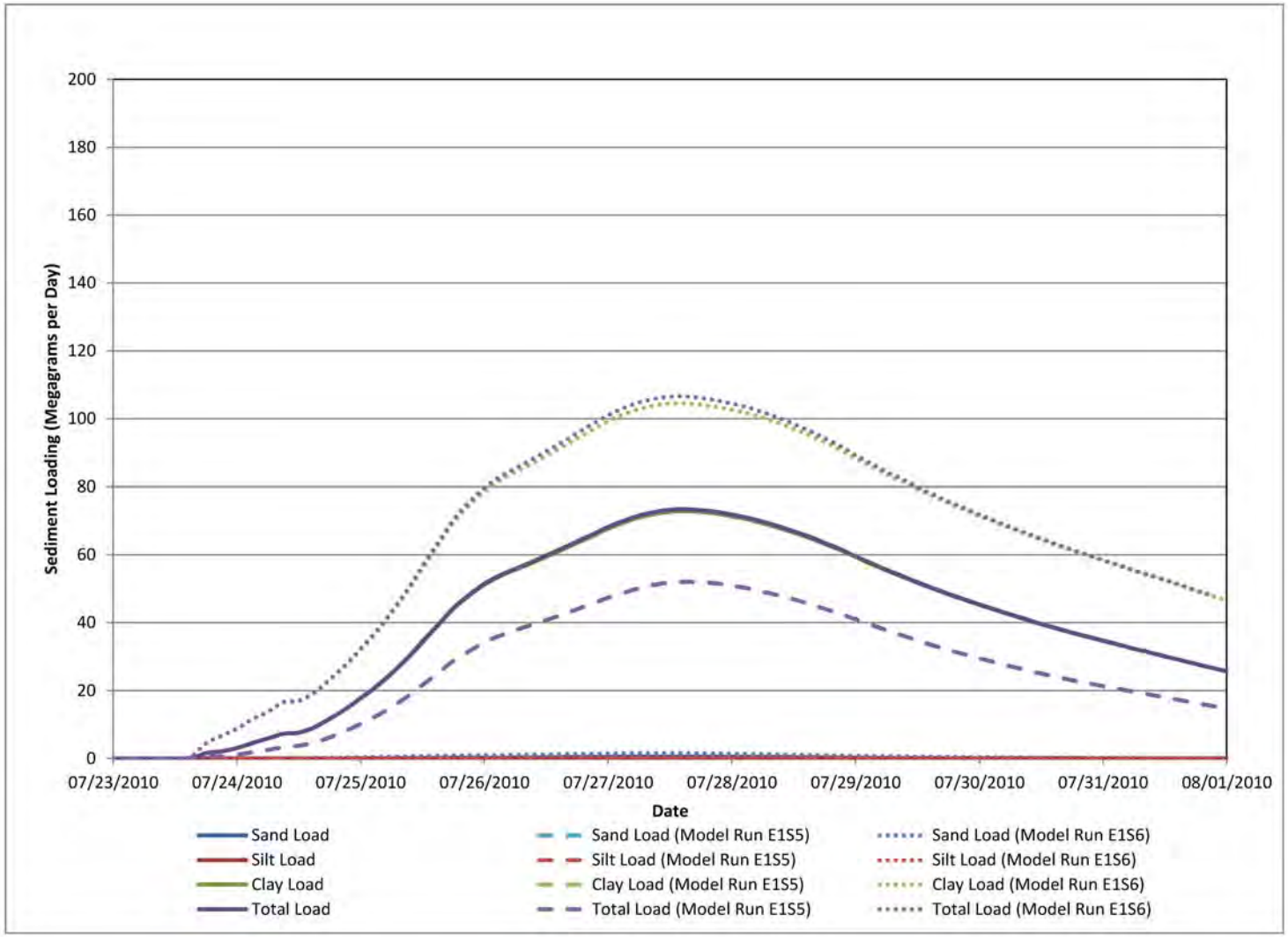

ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

FLOODPLAIN: EFFECT OF SETTLING VELOCITY ON SEDIMENT LOADING AT MORROW LAKE DAM

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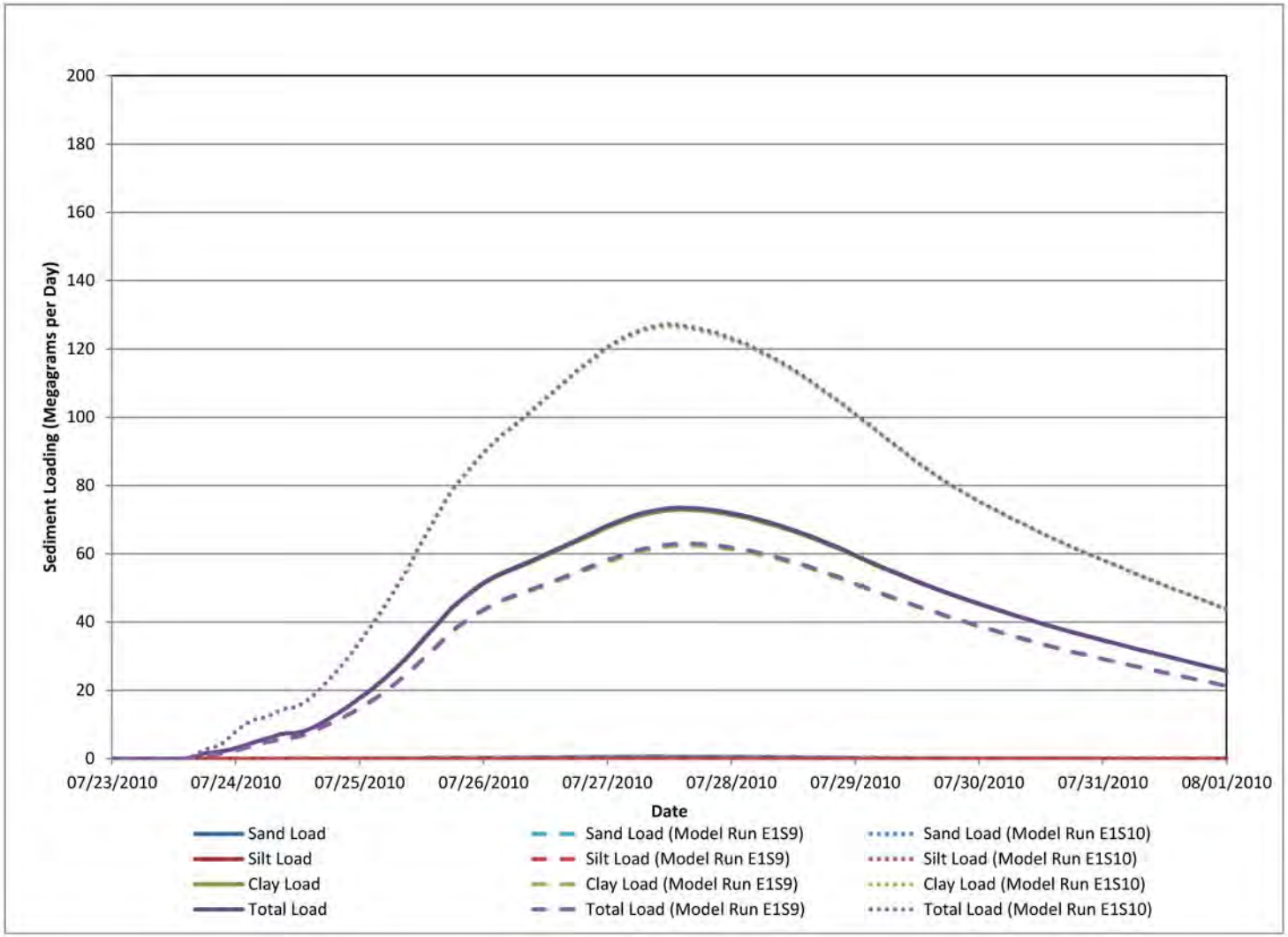

ENBRIDGE

Drawn:	JLH	5/2/2012
Approved:	DBR	5/2/2012
Project #:	106-4186	

Footnotes:

Total Load = Clay Load

FLOODPLAIN: EFFECT OF CRITICAL SHEAR STRESS OF DEPOSITION ON SEDIMENT LOADING AT MORROW LAKE DAM

ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
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Riverine: Simulated Water Surface Elevation on 11/01/2011 (Low Flow Event)

Input Parameter	Parameter Coefficient	MP 2.25 (Feet)	MP 5.35 (Feet)	MP 10.00 (Feet)	MP 15.00 (Feet)	Kalamazoo River Gage Near Battle Creek (Feet)	MP 21.50 (Feet)	MP 27.00 (Feet)	MP 30.00 (Feet)	MP 35.00 (Feet)	MP 38.00 (Feet)
Baseline Model Run	1.00	873.75	868.44	841.50	826.61	803.02	796.52	788.58	784.68	778.08	775.36
Roughness	1.50	873.95	868.57	841.67	826.71	803.22	796.75	788.88	785.01	778.35	775.39
	0.50	873.49	868.24	841.27	826.48	802.79	796.19	788.19	784.32	777.72	775.36
Sediment Concentration	1.50	873.75	868.44	841.50	826.61	803.02	796.52	788.58	784.68	778.08	775.36
	0.50	873.75	868.44	841.50	826.61	803.02	796.49	788.58	784.68	778.08	775.36
Settling Velocity	1.50	873.75	868.44	841.54	826.61	803.05	796.52	788.58	784.71	778.08	775.36
	0.50	873.75	868.44	841.50	826.61	803.02	796.49	788.55	784.68	778.08	775.36
Particle Size Distribution	Maximum Silt	873.75	868.44	841.50	826.61	803.02	796.52	788.58	784.68	778.08	775.36
	Minimum Silt	873.75	868.44	841.50	826.61	803.02	796.52	788.58	784.68	778.08	775.36
Critical Shear Stress of Deposition	1.50	873.75	868.44	841.50	826.61	803.05	796.52	788.58	784.68	778.08	775.36
	0.50	873.75	868.44	841.50	826.61	802.99	796.49	788.55	784.68	778.08	775.36

Floodplain: Simulated Water Surface Elevation on 07/26/2010 (High Flow Event)

Input Parameter	Parameter Coefficient	MP 2.25 (Feet)	MP 5.35 (Feet)	MP 10.00 (Feet)	MP 15.00 (Feet)	Kalamazoo River Gage Near Battle Creek (Feet)	MP 21.50 (Feet)	MP 27.00 (Feet)	MP 30.00 (Feet)	MP 35.00 (Feet)	MP 38.00 (Feet)
Baseline Model Run	1.00	876.38	870.77	843.14	829.89	806.10	800.69	792.29	788.88	781.07	776.38
Roughness	1.50	876.74	870.90	843.31	830.12	806.76	800.82	792.55	789.04	781.33	776.41
	0.50	875.89	870.60	842.85	829.56	805.31	800.49	791.99	788.58	780.58	776.38
Sediment Concentration	1.50	876.38	870.77	843.14	829.89	806.10	800.69	792.29	788.88	781.07	776.41
	0.50	876.38	870.77	843.14	829.89	806.10	800.69	792.29	788.88	781.07	776.41
Settling Velocity	1.50	876.41	870.77	843.14	829.89	806.10	800.69	792.29	788.88	781.07	776.38
	0.50	876.38	870.77	843.14	829.89	806.10	800.69	792.29	788.88	781.04	776.38
Particle Size Distribution	Maximum Silt	876.38	870.77	843.14	829.89	806.14	800.69	792.29	788.88	781.07	776.38
	Minimum Silt	876.38	870.77	843.14	829.89	806.14	800.69	792.29	788.88	781.07	776.38
Critical Shear Stress of Deposition	1.50	876.38	870.77	843.14	829.89	806.10	800.69	792.29	788.88	781.07	776.38
	0.50	876.38	870.77	843.14	829.89	806.10	800.69	792.29	788.88	781.07	776.38

Footnotes:
Maximum Silt=68% Silt
Minimum Silt=5% Silt

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Riverine: Simulated Velocity on 11/01/2011 (Low Flow Event)

Input Parameter	Parameter Coefficient	MP 2.25 (Feet per Second)	MP 5.35 (Feet per Second)	MP 10.00 (Feet per Second)	MP 15.00 (Feet per Second)	Kalamazoo River Gage Near Battle Creek (Feet per Second)	MP 21.50 (Feet per Second)	MP 27.00 (Feet per Second)	MP 30.00 (Feet per Second)	MP 35.00 (Feet per Second)	MP 38.00 (Feet per Second)
Baseline Model Run	1.00	0.92	0.66	1.52	0.60	2.38	0.80	1.82	1.39	0.94	0.30
Roughness	1.50	0.88	0.60	1.45	0.59	2.19	0.76	1.69	1.33	0.89	0.29
	0.50	0.98	0.72	1.68	0.61	2.69	0.87	2.02	1.47	1.00	0.32
Sediment Concentration	1.50	0.92	0.66	1.52	0.60	2.38	0.80	1.82	1.39	0.94	0.30
	0.50	0.92	0.66	1.52	0.60	2.38	0.80	1.82	1.39	0.94	0.30
Settling Velocity	1.50	0.91	0.66	1.52	0.60	2.45	0.80	1.81	1.39	0.93	0.30
	0.50	0.93	0.66	1.53	0.60	2.37	0.81	1.82	1.39	0.94	0.30
Particle Size Distribution	Maximum Silt	0.92	0.66	1.52	0.60	2.38	0.80	1.82	1.39	0.94	0.30
	Minimum Silt	0.92	0.66	1.52	0.60	2.38	0.80	1.82	1.39	0.94	0.30
Critical Shear Stress of Deposition	1.50	0.92	0.66	1.52	0.60	2.38	0.80	1.82	1.39	0.94	0.30
	0.50	0.92	0.66	1.53	0.60	2.45	0.81	1.82	1.39	0.94	0.30

Floodplain: Simulated Velocity on 07/26/2011 (High Flow Event)

Input Parameter	Parameter Coefficient	MP 2.25 (Feet per Second)	MP 5.35 (Feet per Second)	MP 10.00 (Feet per Second)	MP 15.00 (Feet per Second)	Kalamazoo River Gage Near Battle Creek (Feet per Second)	MP 21.50 (Feet per Second)	MP 27.00 (Feet per Second)	MP 30.00 (Feet per Second)	MP 35.00 (Feet per Second)	MP 38.00 (Feet per Second)
Baseline Model Run	1.00	1.95	0.41	1.55	0.82	3.79	1.47	1.07	1.29	1.30	0.48
Roughness	1.50	1.90	0.39	1.42	0.84	3.61	1.51	0.85	1.13	1.23	0.47
	0.50	2.06	0.51	1.75	0.88	4.13	1.43	1.88	1.56	1.41	0.54
Sediment Concentration	1.50	1.95	0.41	1.55	0.82	3.80	1.47	1.07	1.29	1.30	0.48
	0.50	1.95	0.41	1.55	0.82	3.79	1.47	1.07	1.29	1.30	0.48
Settling Velocity	1.50	1.95	0.41	1.55	0.82	3.80	1.47	1.07	1.29	1.30	0.48
	0.50	1.95	0.41	1.55	0.82	3.82	1.47	1.07	1.29	1.30	0.48
Particle Size Distribution	Maximum Silt	1.95	0.41	1.55	0.82	3.82	1.47	1.07	1.29	1.30	0.48
	Minimum Silt	1.95	0.41	1.55	0.82	3.82	1.47	1.07	1.29	1.30	0.48
Critical Shear Stress of Deposition	1.50	1.95	0.41	1.55	0.82	3.81	1.47	1.07	1.29	1.30	0.48
	0.50	1.95	0.41	1.55	0.82	3.79	1.47	1.07	1.29	1.30	0.48

Footnotes:
Maximum Silt=68% Silt
Minimum Silt=5% Silt

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Effect of Roughness on Particle Size Distribution

	Base Model (Model Run A1)									Roughness * 1.5 (Model Run A1S1)									Roughness * 0.5 (Model Run A1S2)								
	Silt			Clay			Sand			Silt			Clay			Sand			Silt			Clay			Sand		
Cross-Section	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)
Ceresco Dam	44.13	44.01	44.39	15.96	15.88	16.00	39.91	39.73	39.99	44.11	43.97	44.37	15.96	15.89	16.00	39.93	39.74	40.04	44.15	44.05	44.31	15.96	15.90	16.00	39.89	39.79	39.94
Kalamazoo Dam	53.20	53.00	53.49	15.94	15.85	16.00	30.86	30.66	31.00	53.13	53.00	53.38	15.96	15.88	16.00	30.91	30.74	31.00	53.27	53.02	53.56	15.92	15.84	15.99	30.81	30.61	30.99
Kalamazoo Gage	41.45	41.41	41.50	17.61	17.60	17.64	40.94	40.86	40.99	41.42	41.36	41.45	17.60	17.58	17.61	40.98	40.94	41.06	41.39	41.35	41.43	17.59	17.57	17.61	41.02	40.96	41.08
35th Street Bridge	56.84	45.90	60.26	14.81	13.97	18.00	28.36	24.00	40.12	56.85	45.93	60.27	14.81	13.98	18.00	28.35	24.00	40.09	56.82	45.88	60.23	14.80	13.96	18.00	28.37	24.00	40.16
MP 37.75	53.89	44.00	68.05	15.94	10.00	18.01	30.17	15.97	38.00	53.89	44.00	68.05	15.94	10.00	18.01	30.18	15.97	38.00	53.89	44.00	68.05	15.94	10.00	18.01	30.17	15.97	38.00
Morrow Lake Dam	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00

Effect of Sediment Concentration on Particle Size Distribution

	Base Model (Model Run A1)									Sediment Concentration* 1.5 (Model Run A1S3)									Sediment Concentration* 0.5 (Model Run A1S4)								
	Silt			Clay			Sand			Silt			Clay			Sand			Silt			Clay			Sand		
Cross-Section	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)
Ceresco Dam	44.13	44.01	44.39	15.96	15.88	16.00	39.91	39.73	39.99	42.34	42.23	42.44	15.30	15.12	15.43	42.36	42.13	42.54	44.06	44.00	44.18	15.98	15.93	16.00	39.96	39.89	40.00
Kalamazoo Dam	53.20	53.00	53.49	15.94	15.85	16.00	30.86	30.66	31.00	52.08	51.56	53.00	15.58	15.25	16.00	32.33	31.00	33.19	53.12	53.00	53.30	15.96	15.91	16.00	30.91	30.79	31.00
Kalamazoo Gage	41.45	41.41	41.50	17.61	17.60	17.64	40.94	40.86	40.99	41.45	41.41	41.50	17.62	17.60	17.64	40.94	40.86	40.99	41.45	41.41	41.50	17.62	17.60	17.64	40.93	40.86	40.99
35th Street Bridge	56.84	45.90	60.26	14.81	13.97	18.00	28.36	24.00	40.12	56.84	45.90	60.26	14.81	13.97	18.00	28.36	24.00	40.12	56.84	45.90	60.26	14.81	13.97	18.00	28.36	24.00	40.12
MP 37.75	53.89	44.00	68.05	15.94	10.00	18.01	30.17	15.97	38.00	53.89	44.00	68.07	15.94	10.00	18.02	30.17	15.95	38.00	53.89	44.00	68.03	15.94	10.00	18.01	30.18	15.98	38.00
Morrow Lake Dam	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	54.60	53.97	55.23	13.17	11.13	15.22	32.23	29.55	34.90	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00

Effect of Settling Velocity on Particle Size Distribution

	Base Model (Model Run A1)									Settling Velocity * 1.5 (Model Run A1S5)									Settling Velocity * 0.5 (Model Run A1S6)								
	Silt			Clay			Sand			Silt			Clay			Sand			Silt			Clay			Sand		
Cross-Section	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)
Ceresco Dam	44.13	44.01	44.39	15.96	15.88	16.00	39.91	39.73	39.99	44.18	44.01	44.53	15.95	15.86	16.00	39.86	39.61	39.99	43.91	43.75	44.11	15.91	15.88	15.94	40.18	40.01	40.34
Kalamazoo Dam	53.20	53.00	53.49	15.94	15.85	16.00	30.86	30.66	31.00	53.25	53.00	53.60	15.93	15.82	16.00	30.83	30.58	31.00	53.09	53.00	53.28	15.95	15.89	16.01	30.97	30.83	31.05
Kalamazoo Gage	41.45	41.41	41.50	17.61	17.60	17.64	40.94	40.86	40.99	41.24	41.13	41.32	17.53	17.48	17.56	41.23	41.12	41.39	41.51	41.47	41.55	17.64	17.62	17.66	40.85	40.79	40.91
35th Street Bridge	56.84	45.90	60.26	14.81	13.97	18.00	28.36	24.00	40.12	56.80	46.00	60.00	14.80	14.00	18.00	28.40	24.00	40.00	56.94	45.99	60.50	14.83	14.00	18.00	28.22	24.00	40.01
MP 37.75	53.89	44.00	68.05	15.94	10.00	18.01	30.17	15.97	38.00	53.89	44.00	68.04	15.94	10.00	18.01	30.17	15.97	38.00	53.89	44.00	68.06	15.94	10.00	18.01	30.17	15.97	38.00
Morrow Lake Dam	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.00	58.00	58.00	14.00	12.00	16.00	28.00	25.99	30.00

Effect of Silt Composition on Particle Size Distribution

	Base Model (Model Run A1)									Maximum Silt (Model Run A1S7)									Minimum Silt (Model Run A1S8)								
	Silt			Clay			Sand			Silt			Clay			Sand			Silt			Clay			Sand		
Cross-Section	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)
Ceresco Dam	44.13	44.01	44.39	15.96	15.88	16.00	39.91	39.73	39.99	44.18	44.01	44.53	15.95	15.84	16.00	39.87	39.63	39.99	44.01	44.00	44.01	16.00	15.99	16.00	40.00	39.99	40.00
Kalamazoo Dam	53.20	53.00	53.49	15.94	15.85	16.00	30.86	30.66	31.00	53.25	53.00	53.62	15.92	15.81	16.00	30.83	30.57	31.00	53.06	53.00	53.15	15.99	15.97	16.00	30.95	30.88	31.00
Kalamazoo Gage	41.45	41.41	41.50	17.61	17.60	17.64	40.94	40.86	40.99	41.45	41.41	41.50	17.62	17.60	17.64	40.93	40.86	40.99	41.44	41.40	41.50	17.61	17.59	17.64	40.95	40.87	41.01
35th Street Bridge	56.84	45.90	60.26	14.81	13.97	18.00	28.36	24.00	40.12	56.84	45.90	60.26	14.81	13.97	18.00	28.36	24.00	40.12	56.84	45.90	60.26	14.81	13.97	18.00	28.36	24.00	40.12
MP 37.75	53.89	44.00	68.05	15.94	10.00	18.01	30.17	15.97	38.00	53.89	44.00	68.07	15.94	10.00	18.01	30.17	15.96	38.00	53.88	43.99	68.01	15.94	10.00	18.01	30.18	15.99	38.00
Morrow Lake Dam	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00

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Effect of Critical Shear Stress of Deposition on Particle Size Distribution

	Base Model (Model Run A1)									Critical Shear Stress *1 .5 (Model Run A1S9)									Critical Shear Stress * 0.5 (Model Run A1S10)								
	Silt			Clay			Sand			Silt			Clay			Sand			Silt			Clay			Sand		
Cross-Section	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)
Ceresco Dam	44.13	44.01	44.39	15.96	15.88	16.00	39.91	39.73	39.99	44.13	44.04	44.27	15.96	15.92	15.99	39.91	39.82	39.96	44.09	44.00	44.27	15.97	15.91	16.00	39.94	39.82	40.00
Kalamazoo Dam	53.20	53.00	53.49	15.94	15.85	16.00	30.86	30.66	31.00	53.14	53.00	53.29	15.96	15.92	16.00	30.90	30.80	31.00	53.17	53.00	53.86	15.94	15.73	16.00	30.88	30.41	31.01
Kalamazoo Gage	41.45	41.41	41.50	17.61	17.60	17.64	40.94	40.86	40.99	41.50	41.44	41.54	17.64	17.61	17.65	40.87	40.81	40.95	41.05	40.85	41.15	17.45	17.36	17.49	41.50	41.36	41.79
35th Street Bridge	56.84	45.90	60.26	14.81	13.97	18.00	28.36	24.00	40.12	56.84	45.90	60.26	14.81	13.97	18.00	28.36	24.00	40.12	56.84	45.90	60.25	14.81	13.97	18.00	28.36	24.00	40.12
MP 37.75	53.89	44.00	68.05	15.94	10.00	18.01	30.17	15.97	38.00	53.89	44.00	68.03	15.94	10.00	18.01	30.18	15.98	38.00	53.90	44.00	68.14	15.94	10.00	18.03	30.16	15.91	38.00
Morrow Lake Dam	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00

Footnotes:
%=Percent
Max=Maximum
Min=Minimum
MP=Mile Post

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Effect of Roughness on Particle Size Distribution

	Base Model (Model Run A1)									Roughness * 1.5 (Model Run A1S1)									Roughness * 0.5 (Model Run A1S2)								
	Silt			Clay			Sand			Silt			Clay			Sand			Silt			Clay			Sand		
Cross-Section	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)
Ceresco Dam	44.00	44.00	44.00	16.00	16.00	16.00	40.00	40.00	40.00	42.79	42.79	42.79	15.56	15.56	15.56	41.65	41.65	41.65	42.28	42.28	42.28	15.37	15.37	15.37	42.34	42.34	42.34
Kalamazoo Dam	53.00	53.00	53.00	16.00	16.00	16.00	31.00	31.00	31.00	53.38	53.37	53.38	16.11	16.11	16.12	30.51	30.50	30.52	53.06	53.00	53.12	16.02	16.00	16.04	30.92	30.85	31.00
Kalamazoo Gage	30.15	15.00	40.72	12.27	5.00	17.30	57.58	41.98	80.00	30.82	15.00	41.52	12.55	5.00	17.65	56.63	40.84	80.00	30.72	15.00	41.37	12.50	5.00	17.58	56.78	41.05	80.00
35th Street Bridge	26.17	15.00	60.00	12.57	5.00	15.00	61.27	26.00	80.00	26.22	15.00	60.56	12.57	5.00	15.02	61.20	25.31	80.00	26.23	15.00	60.75	12.58	5.00	15.10	61.20	25.07	80.00
MP 37.75	34.03	15.00	68.00	10.64	5.00	18.00	55.33	16.00	80.00	34.04	15.00	68.05	10.64	5.00	18.01	55.33	15.96	80.00	34.04	15.00	68.05	10.64	5.00	18.01	55.33	15.96	80.00
Morrow Lake Dam	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	55.38	54.46	56.29	13.40	11.27	15.53	31.23	28.18	34.27	55.07	54.24	55.89	13.32	11.22	15.42	31.62	28.69	34.54

Effect of Sediment Concentration on Particle Size Distribution

	Base Model (Model Run A1)									Sediment Concentration* 1.5 (Model Run A1S3)									Sediment Concentration* 0.5 (Model Run A1S4)								
	Silt			Clay			Sand			Silt			Clay			Sand			Silt			Clay			Sand		
Cross-Section	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)
Ceresco Dam	44.00	44.00	44.00	16.00	16.00	16.00	40.00	40.00	40.00	42.55	42.55	42.55	15.47	15.47	15.47	41.98	41.98	41.98	42.54	42.54	42.54	15.47	15.47	15.47	41.99	41.99	41.99
Kalamazoo Dam	53.00	53.00	53.00	16.00	16.00	16.00	31.00	31.00	31.00	53.23	53.20	53.26	16.07	16.06	16.08	30.70	30.66	30.74	53.23	53.20	53.26	16.07	16.06	16.08	30.70	30.66	30.74
Kalamazoo Gage	30.15	15.00	40.72	12.27	5.00	17.30	57.58	41.98	80.00	30.80	15.00	41.50	12.54	5.00	17.64	56.66	40.87	80.00	30.80	15.00	41.50	12.54	5.00	17.64	56.66	40.87	80.00
35th Street Bridge	26.17	15.00	60.00	12.57	5.00	15.00	61.27	26.00	80.00	26.23	15.00	60.67	12.57	5.00	15.03	61.19	25.18	80.00	26.21	15.00	60.67	12.57	5.00	15.03	61.21	25.18	80.00
MP 37.75	34.03	15.00	68.00	10.64	5.00	18.00	55.33	16.00	80.00	34.04	15.00	68.08	10.64	5.00	18.01	55.32	15.95	80.00	34.03	15.00	68.03	10.64	5.00	18.00	55.33	15.98	80.00
Morrow Lake Dam	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	55.25	54.37	56.12	13.36	11.25	15.48	31.39	28.40	34.38	55.25	54.37	56.12	13.36	11.25	15.48	31.39	28.40	34.38

Effect of Settling Velocity on Particle Size Distribution

	Base Model (Model Run A1)									Settling Velocity * 1.5 (Model Run A1S5)									Settling Velocity * 0.5 (Model Run A1S6)								
	Silt			Clay			Sand			Silt			Clay			Sand			Silt			Clay			Sand		
Cross-Section	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)
Ceresco Dam	44.00	44.00	44.00	16.00	16.00	16.00	40.00	40.00	40.00	43.98	43.98	43.98	15.99	15.99	15.99	40.03	40.03	40.03	44.49	44.49	44.49	16.18	16.18	16.18	39.33	39.33	39.33
Kalamazoo Dam	53.00	53.00	53.00	16.00	16.00	16.00	31.00	31.00	31.00	53.39	53.35	53.43	16.12	16.10	16.13	30.50	30.44	30.55	53.38	53.34	53.42	16.11	16.10	16.13	30.51	30.45	30.56
Kalamazoo Gage	30.15	15.00	40.72	12.27	5.00	17.30	57.58	41.98	80.00	30.60	15.00	41.43	12.46	5.00	17.61	56.94	40.96	80.00	30.84	15.00	41.50	12.56	5.00	17.64	56.60	40.86	80.00
35th Street Bridge	26.17	15.00	60.00	12.57	5.00	15.00	61.27	26.00	80.00	26.20	15.00	60.21	12.57	5.00	15.01	61.23	25.74	80.00	26.25	15.00	60.91	12.58	5.00	15.12	61.18	24.87	80.00
MP 37.75	34.03	15.00	68.00	10.64	5.00	18.00	55.33	16.00	80.00	34.04	15.00	68.05	10.64	5.00	18.01	55.33	15.96	80.00	34.04	15.00	68.06	10.64	5.00	18.00	55.32	15.97	80.00
Morrow Lake Dam	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.32	58.09	58.55	14.09	12.02	16.15	27.59	25.30	29.89

Effect of Silt Composition on Particle Size Distribution

	Base Model (Model Run A1)									Maximum Silt (Model Run A1S7)									Minimum Silt (Model Run A1S8)								
	Silt			Clay			Sand			Silt			Clay			Sand			Silt			Clay			Sand		
Cross-Section	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)	Average (%)	Min (%)	Max (%)
Ceresco Dam	44.00	44.00	44.00	16.00	16.00	16.00	40.00	40.00	40.00	44.22	44.22	44.22	16.08	16.08	16.08	39.70	39.70	39.70	44.22	44.22	44.22	16.08	16.08	16.08	39.70	39.70	39.70
Kalamazoo Dam	53.00	53.00	53.00	16.00	16.00	16.00	31.00	31.00	31.00	53.38	53.34	53.42	16.12	16.10	16.13	30.50	30.45	30.56	53.38	53.34	53.42	16.12	16.10	16.13	30.50	30.45	30.56
Kalamazoo Gage	30.15	15.00	40.72	12.27	5.00	17.30	57.58	41.98	80.00	30.80	15.00	41.50	12.54	5.00	17.64	56.66	40.87	80.00	30.80	15.00	41.50	12.54	5.00	17.64	56.66	40.87	80.00
35th Street Bridge	26.17	15.00	60.00	12.57	5.00	15.00	61.27	26.00	80.00	26.23	15.00	60.66	12.57	5.00	15.03	61.20	25.18	80.00	26.20	15.00	60.66	12.58	5.00	15.03	61.22	25.18	80.00
MP 37.75	34.03	15.00	68.00	10.64	5.00	18.00	55.33	16.00	80.00	34.04	15.00	68.08	10.63	5.00	18.01	55.32	15.95	80.00	34.03	15.00	68.00	10.64	5.00	18.01	55.33	15.99	80.00
Morrow Lake Dam	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.11	57.98	58.23	14.03	12.00	16.06	27.86	25.71	30.02	58.11	57.98	58.23	14.03	12.00	16.06	27.86	25.71	30.02

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Effect of Critical Shear Stress of Deposition on Particle Size Distribution

	Base Model (Model Run A1)									Critical Shear Stress *1 .5 (Model Run A1S9)									Critical Shear Stress * 0.5 (Model Run A1S10)								
	Silt			Clay			Sand			Silt			Clay			Sand			Silt			Clay			Sand		
Cross-Section	**Average (%)**	**Min (%)**	**Max (%)**	**Average (%)**	**Min (%)**	**Max (%)**	**Average (%)**	**Min (%)**	**Max (%)**	**Average (%)**	**Min (%)**	**Max (%)**	**Average (%)**	**Min (%)**	**Max (%)**	**Average (%)**	**Min (%)**	**Max (%)**	**Average (%)**	**Min (%)**	**Max (%)**	**Average (%)**	**Min (%)**	**Max (%)**	**Average (%)**	**Min (%)**	**Max (%)**
Ceresco Dam	44.00	44.00	44.00	16.00	16.00	16.00	40.00	40.00	40.00	44.22	44.22	44.22	16.08	16.08	16.08	39.70	39.70	39.70	44.22	44.22	44.22	16.08	16.08	16.08	39.70	39.70	39.70
Kalamazoo Dam	53.00	53.00	53.00	16.00	16.00	16.00	31.00	31.00	31.00	54.10	54.08	54.11	16.33	16.33	16.34	29.57	29.55	29.59	53.00	53.00	53.00	16.00	16.00	16.00	31.00	31.00	31.00
Kalamazoo Gage	30.15	15.00	40.72	12.27	5.00	17.30	57.58	41.98	80.00	30.87	15.00	41.58	12.57	5.00	17.67	56.57	40.76	80.00	30.44	15.00	41.20	12.39	5.00	17.51	57.17	41.29	80.00
35th Street Bridge	26.17	15.00	60.00	12.57	5.00	15.00	61.27	26.00	80.00	26.22	15.00	60.66	12.57	5.00	15.03	61.20	25.18	80.00	26.22	15.00	60.66	12.57	5.00	15.03	61.21	25.19	80.00
MP 37.75	34.03	15.00	68.00	10.64	5.00	18.00	55.33	16.00	80.00	34.04	15.00	68.03	10.64	5.00	18.01	55.33	15.98	80.00	34.04	15.00	68.11	10.63	5.00	18.01	55.32	15.93	80.00
Morrow Lake Dam	58.00	58.00	58.00	14.00	12.00	16.00	28.00	26.00	30.00	58.11	57.98	58.23	14.03	12.00	16.06	27.86	25.71	30.02	58.11	57.98	58.23	14.03	12.00	16.06	27.86	25.71	30.02

Footnotes:
%=Percent
Max=Maximum
Min=Minimum
MP=Mile Post

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Riverine: Simulated Peak Flow at Cross-Sections on 11/03/2011

Input Parameter	Parameter Coefficient	Ceresco Dam (Cubic Feet per Second)	Kalamazoo Dam (Cubic Feet per Second)	Kalamazoo River Gage Near Battle Creek (Cubic Feet per Second)	35th Street Bridge (Cubic Feet per Second)	MP 37.75 (Cubic Feet per Second)	Morrow Lake Dam (Cubic Feet per Second)
Baseline Model Run	1.00	362.56	448.37	631.39	1021.49	1024.44	1042.35
Roughness	1.50	362.77	448.61	626.73	1025.17	1027.29	1042.35
	0.50	362.60	448.08	626.88	1017.30	1020.31	1034.58
Sediment Concentration	1.50	362.88	448.65	625.18	1022.38	1025.93	1040.94
	0.50	362.60	448.23	624.41	1021.41	1024.07	1038.82
Settling Velocity	1.50	362.92	448.33	623.93	1021.24	1024.04	1038.11
	0.50	362.81	448.44	628.90	1021.37	1024.29	1038.11
Particle Size Distribution	Maximum Silt	362.56	448.23	625.08	1021.39	1024.98	1038.82
	Minimum Silt	362.63	448.23	629.42	1021.43	1024.16	1038.47
Critical Shear Stress of Deposition	1.50	362.74	448.40	622.63	1021.26	1024.84	1038.82
	0.50	362.92	448.44	623.28	1021.64	1024.81	1038.47

Floodplain: Simulated Flow at Cross-Sections on 07/26/2010

Input Parameter	Parameter Coefficient	Ceresco Dam (Cubic Feet per Second)	Kalamazoo Dam (Cubic Feet per Second)	Kalamazoo River Gage Near Battle Creek (Cubic Feet per Second)	35th Street Bridge (Cubic Feet per Second)	MP 37.75 (Cubic Feet per Second)	Morrow Lake Dam (Cubic Feet per Second)
Baseline Model Run	1.00	3286.65	2404.96	2399.94	3174.18	3131.89	3060.32
Roughness	1.50	3293.72	2438.51	2409.35	3150.26	3103.41	3034.54
	0.50	3280.30	2394.02	2351.17	3204.53	3167.08	3095.27
Sediment Concentration	1.50	3287.36	2406.38	2392.80	3183.67	3141.30	3073.38
	0.50	3287.36	2403.55	2403.59	3182.79	3142.52	3072.68
Settling Velocity	1.50	3285.95	2403.90	2401.49	3174.57	3131.85	3061.38
	0.50	3285.24	2405.67	2401.09	3175.52	3135.07	3061.02
Particle Size Distribution	Maximum Silt	3286.65	2404.61	2392.40	3176.24	3136.96	3061.38
	Minimum Silt	3286.65	2406.02	2393.95	3174.56	3131.22	3059.96
Critical Shear Stress of Deposition	1.50	3286.65	2405.32	2390.85	3173.01	3130.60	3060.32
	0.50	3286.65	2405.67	2393.31	3175.04	3133.27	3059.96

Footnotes:
Maximum Silt=68% Silt
Minimum Silt=5% Silt

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Attachment 4

Figures Not Included in Original Document

Model Refinements	Scheduled Completion of Model Analysis and Report*
Set 3D grid cells in select areas	Three weeks
1.5-year flood (2,000 cfs)	One month
2-year flood (2,600 cfs)	One month
25-year flood (4,600 cfs)	One month
Containment strategies	One month
Submerged oil transport as a subset of sediment transport	One month

Footnotes:
*Model analysis and report completion is dependent on completion of field work to supply the model with all necessary inputs.

cfs = cubic feet per second

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