October 1, 2012

Mr. Ralph Dollhopf
Federal OSC and Incident Commander
U.S. EPA, Region 5
Emergency Response Branch
801 Garfield Avenue, #229
Traverse City, MI 49686

Re: Evaluation of Spatial/Temporal Patterns of Submerged Oil at Ceresco, Mill Ponds and the Morrow Lake Delta
Enbridge Line 6B MP 608, Marshall, MI Pipeline Release

Dear Mr. Dollhopf,

An evaluation of the spatial/temporal patterns and migration potential of submerged oil in three impounded sections of the Kalamazoo River affected by the Enbridge Line 6B oil discharge was performed. The three impounded sections evaluated included: 1) upstream of Ceresco Dam; 2) the Mill Ponds; and 3) the Morrow Lake Delta. These three areas contain the majority of known heavy/moderate submerged oil accumulations in the Kalamazoo River system remaining from the Line 6B oil discharge.

The attached evaluation includes a synthesis based on the combination of the following information sources: i) submerged oil assessment and monitoring data for Spring 2012 through Late Summer 2012; ii) selected output results from the two-dimensional hydrodynamic model; and iii) the Net Environmental Benefits Analysis (NEBA) integrated with Tactical Areas.

The attached document represents my synthesis (as a Scientific Support Coordinator) of the applicable opinions and recommendations received from individuals and other technical staff. The individual technical opinions provided to me are based on each person's prior experiences in addressing issues related to oil spill recovery and other environmental assessment/response activities. Opinions expressed by individuals are included within the attached document, or are otherwise documented in supporting documents maintained in the response files. This documentation does not necessarily represent consensus among the individuals of the group. I was present for discussions, or included in written correspondence, regarding the referenced subject matter.

Sincerely,

/s/
Faith Fitzpatrick, Ph. D., P.H., P.G.
Scientific Support Coordinator to the FOSC for Enbridge Line 6B Oil Spill
Research Hydrologist (Fluvial Geomorphology)

Evaluation of Spatial/Temporal Patterns and Migration Potential of Line 6B Submerged Oil within the NEBA/Tactical Areas Framework for Three Impounded Sections of the Kalamazoo River, 2012

Kalamazoo River System
Enbridge Line 6B MP 608 Marshall, MI Pipeline Release
October 1, 2012

Scientific Support Coordinator: Faith Fitzpatrick, Ph.D, P.H., P.G.

Currently available information was assembled to describe and summarize spatial/temporal patterns and migration potential of submerged oil in three impounded sections of the Kalamazoo River: upstream of Ceresco Dam, Mill Ponds in Battle Creek, and Morrow Lake and delta. This information was compiled from the Net Environmental Benefits Analysis (NEBA) integrated with Tactical Areas. Additional assessment/monitoring data and selected outputs from the 2-D Kalamazoo River hydrodynamic model were evaluated within the NEBA/tactical area framework. These three impounded sections of the Kalamazoo River are under consideration by onsite operations staff for submerged oil recovery.

SUMMARY OF NEBA/TACTICAL AREA INTEGRATION

The NEBA relative risk matrix (see August 2012 "NEBA Relative Risk Ranking Conceptual Design" document and appendixes) was integrated with Spring 2012 submerged oil tactical areas previously identified by onsite operations staff to help decision-makers weigh the environmental risks and benefits associated with choices between two basic options: 1) allowing for natural attenuation of Line 6B oil without active oil recovery; or 2) actively recovering remaining submerged oil in the Kalamazoo River system (see August 2012 "Application and Integration of Net Environmental Benefit Analysis (NEBA) with Spring 2012 Tactical Areas" document). This NEBA integration with the 2012 tactical areas resulted in recommendations for each of the tactical areas on the basis of NEBA risk rankings, site-specific oil recovery history, spatial patterns and stability of accumulated submerged oil deposits (relative frequency of heavy, moderate, and light poling points over time), proximity to previously identified sensitive habitats, potential for oil remobilization, distance to nearest potential submerged oil/sediment trap(s), aquatic toxicity results, and number of incidents requiring sheen management.

Submerged oil tactical areas initially were established by Enbridge, MDEQ, and USEPA onsite operations staff by use of Fall 2011 poling reassessment results, oil containment and recovery history, geomorphic setting and habitat, public access, and other monitoring data.

In June 2012, the initial tactical areas were updated with Spring 2012 poling reassessment results; consequently, the number of tactical areas with NEBA recommendations increased from about 143 to 240 primarily because of the occurrence of new locations of heavy/moderate poling points. NEBA recommendations were concurrently formulated for the updated tactical areas through input received from operations staff and opinions received from Science Support Coordination Group (SSCG) individuals. The June 2012 NEBA recommendations for updated tactical areas included one or more of the following:

- Sheen collection
- Monitored natural attenuation
- Increase monitoring frequency
- Evaluate for possible future recovery
- Follow sediment trap monitoring and maintenance plan
- Consider recovery (dredging/hydrovac/hand scraping)
- No action necessary

The June 2012 NEBA recommendations for most of the updated tactical areas were sheen collection/monitored natural attenuation. However, some of the larger tactical areas that remained relatively unchanged or that accumulated more submerged oil over the Winter 2011-12 (i.e. contained more heavy/moderate poling points in the Spring 2012 Reassessment compared to the 2011 LSR or Fall 2011 poling) had NEBA recommendations to increase monitoring frequency and continue to evaluate for possible future recovery.

June 2012 NEBA recommendations for designated sediment traps were to follow sediment trap monitoring and maintenance plans, and either consider recovery (dredging, hydrovac, or hand scraping) or evaluate for possible future recovery. The NEBA conceptual document assumed that sediment traps would require repeated recovery, possibly every 6 months or after a flood. In general, agitation toolbox techniques were not recommended for recovery given the uncertainty associated with potential physical and chemical effects.

June 2012 NEBA recommendations for some tactical areas that were not designated sediment traps, but where submerged oil stayed the same or accumulated over the Winter 2011-12 were to increase monitoring frequency and consider recovery (dredging, hydrovac, or hand scraping) while water levels remained low and the submerged oil was concentrated.

Several of the updated tactical areas had only light or none poling points in the Spring 2012 Reassessment. For these areas, the June 2012 NEBA recommendation was “no action necessary”.

ADDITIONAL INFORMATION FOR EVALUATION OF SPATIAL/TEMPORAL PATTERNS OF SUBMERGED OIL

The recommendations and framework of the June 2012 NEBA/tactical area integration were used in the following evaluation of the spatial/temporal patterns and migration potential of submerged oil for the three impounded sections of the Kalamazoo River over a range of simulated flow conditions for these impoundments.

Assessment/Monitoring Data

Submerged oil poling assessments conducted in the Fall 2011 and Spring 2012 were used in the June 2012 NEBA/tactical area integration. An additional submerged oil poling assessment was performed in August 2012, also known as the 2012 LSR (see 2012 Consolidated Work Plan). The 2012 LSR heavy/moderate submerged oil delineations were completed after the NEBA/tactical area integration was done. In the attachments, submerged oil poling assessment data for Spring 2012 and 2012 LSR were overlaid onto the tactical areas for each of the impounded sections of the Kalamazoo River (except for the Morrow Lake impoundment that had no 2012 LSR data).

The 2012 occurrence of oil sheen and globules documented by the emerging oil management program (sheen tracking master table database) or other operations were considered in the following evaluations.

Selected Hydrodynamic Model Outputs

Outputs from a preliminary 2-dimensional hydrodynamic model constructed by Enbridge (April 2012 version) for the Kalamazoo River were used to evaluate the stability of accumulated submerged oil over different flow conditions. Excerpts of figures from the model calibration report (April 2012) showing the spatial patterns of simulated velocities for three flows are included in the attachments for each of the impounded sections of the Kalamazoo River:

- A fall low flow (September 9, 2010; 467 ft^3/s at the Kalamazoo River at Battle Creek USGS Stream Gauging Station ID 04105500),
- Out-of-bank spring high flow with a recurrence interval of 2 to 5 years (May 28, 2011, 3,390 ft^3/s at the Kalamazoo River at Battle Creek USGS Stream Gauging Station ID 04105500),
- A flood with a recurrence interval of 100 years (6,600 ft^3/s at the Kalamazoo River at Battle Creek USGS Stream Gauging Station ID 04105500).

A majority of submerged oil deposition areas are present where velocities are less than 1 ft/s (Kalamazoo River Hydrodynamic and Sediment Transport Model Report Addendum, May 2012).

A graph of simulated longitudinal suspended sediment loads, compiled from outputs included in the April 2012 version of the model calibration report, for flows on November 3, 2011; May 19, 2011; May 29, 2011; and July 25, 2010 was used to interpret potential storage of submerged oil in the impoundments (Attachment B).

EVALUATION OF SPATIAL/TEMPORAL PATTERNS OF SUBMERGED OIL AND MIGRATION POTENTIAL

The evaluation of spatial/temporal patterns of submerged oil and migration potential in three impounded sections of the Kalamazoo River is described in the following sections. The evaluation includes information collected up to late Summer 2012.

Ceresco Impoundment

The impounded reach of the Kalamazoo River upstream of Ceresco Dam has nine tactical areas with June 2012 NEBA recommendations, totaling approximately 29.5 acres (Attachment A-1). These tactical areas extend from about MP 4.75 to Ceresco Dam, a greater than 1 mile long section of the Kalamazoo River. June 2012 NEBA recommendations for the nine tactical areas are shown in Table 1. Figures showing poling assessment results, NEBA tactical areas, and selected hydrodynamic modeling results (velocity spatial patterns and simulated suspended sediment loads) for the Ceresco Impoundment are included in Attachments A and B.

Table 1. June 2012 integrated NEBA/tactical area recommendations for remaining submerged oil in the Ceresco Impoundment. (Color coding in table and figures in Attachment A indicates NEBA recommendation categories.)

Tactical Area Name	Size (acres)	June 2012 updated recommendation
SO 4.80	0.1	Sheen collection/monitored natural attenuation
SO 4.81	0.1	Sheen collection/monitored natural attenuation
SO 4.84 A	0.1	Sheen collection/monitored natural attenuation
SO 4.84 B	0.1	Sheen collection/monitored natural attenuation
SO 5.15	7.7	Sheen collection, increase monitoring frequency, continue to evaluate for possible recovery
SO 5.84 A	12.3	Follow sediment trap monitoring/maintenance plan and evaluate for possible future recovery

SO 5.84 B	3.4	Follow sediment trap monitoring/maintenance plan and evaluate for possible future recovery
SO 5.84 C	2.3	Follow sediment trap monitoring/maintenance plan, consider recovery (dredging)
SO 5.84 D	3.4	Follow sediment trap monitoring/maintenance plan, consider recovery (dredging)

The most upstream tactical area (SO 4.80) had a NEBA recommendation of "sheen collection/ monitored natural attenuation", which continued to be supported by 2012 LSR results (Attachment A-2 through A-4).

Three (SO 4.81, 4.84A, 4.84B) of the four 0.1-acre tactical areas near the upstream end of the impounded reach in the vicinity of MP 4.75 had NEBA recommendations of "sheen collection/monitored natural attenuation". The 2012 LSR results showed the extent of heavy/moderate submerged oil increasing in these tactical areas and merging with downstream tactical area SO 5.l5 (Attachment A-2 through A-4).

Immediately downstream, tactical area SO 5.15 extends nearly bank to bank and covers 7.7 acres. Because of the high probability of remobilization of the submerged oil during subsequent high flows, with re-deposition and sedimentation risks to downstream areas (see modeling results for velocity distribution in Attachment A-6 through A-8) the NEBA recommendation for this area was "Sheen collection/increase monitoring frequency and continue to evaluate for possible recovery". Consideration was given to the proximity of the sediment trap downstream at SO 5.84C and 5.84D, but model results showed that a large proportion of sediment (and associated submerged oil) would remain in suspension through the constricted channel at the former-railroad embankments and continue over the dam (Attachments A-7 and B). This area required repeated management of sheen and globules through the Spring and Summer 2012 (Attachment A-5). For SO 5.15, the 2012 LSR heavy/moderate submerged oil delineations covered more area than the 2012 Spring Reassessment heavy/moderate delineations (Attachment A-2 through A-4).

Tactical areas SO 5.84A and SO 5.84B were considered by NEBA to be an extension of the Ceresco impoundment's passive sediment trap; therefore, the NEBA recommendation to "follow sediment trap monitoring and maintenance plan and evaluate for future recovery" reflects this. The designated passive sediment trap is downstream of the former-railroad embankment in tactical areas SO 5.84C and 5.84D but tactical areas SO 5.84A and 5.84B were included in the 2012 LSR. Tactical areas SO 5.84A and SO 5.84B are depositional during low flows but are potentially erosional during high flows based on hydrodynamic model outputs (Attachment A-6 through A-8). Parts of both areas required repeated sheen management during the late Summer 2012, similar to SO 5.15. The 2012 LSR heavy/moderate submerged oil delineations cover

approximately 50% of the SO 5.84A and SO 5.84B tactical areas and covered more area than the 2012 Spring Reassessment heavy/moderate delineations (Attachment A-2 to A-4).

Between the former-railroad embankment and Ceresco Dam, the two tactical areas SO 5.84C and SO 5.84D are part of a designated passive sediment trap. NEBA recommendations for these two tactical areas were to follow the sediment trap monitoring and maintenance plan, and consider recovery (dredging). The hydrodynamic model results show that both areas can become erosional during high flows (Attachment A). These areas had repeated sheening and release of oil globules from oiled sediment, especially in SO 5.84D, resulting in sheen and globules flowing over the dam. Residential yards line the north side of SO 5.84C and a canoe portage ramp is located on the south side of SO 5.84D. The 2012 late summer baseline sediment trap monitoring poling results show that additional submerged oil accumulated in SO 5.84C and SO 5.84D (and also in the main channel between these areas) compared to Spring 2012.

Within the Ceresco impoundment, 20.6 acres had heavy/moderate delineations in the Spring 2012 compared to 23.5 acres in late Summer 2012 (Attachment A-2 through A-4).

In addition to the information described above, the following factors were identified in the NEBA process and review of the hydrodynamic model results for consideration for recovery of submerged oil in the Ceresco impoundment:

- It is unlikely that the designated sediment trap at SO 5.84C and SO 5.84D will be able to effectively capture the amount of submerged oil in SO 5.84A, SO 5.84B, and SO 5.15 mobilized during a high-flow event since the lower area of the impoundment is much smaller and the northern half of this reach is in transport or erosional mode during high flows. The submerged oil would likely continue to migrate downstream to be diluted with less- or non-oiled sediment and organic matter coming from upstream sources, tributaries, and channel deposits; and (or) potentially re-accumulated in depositional areas.
- The oiled sediment in the impoundment is likely more erodible following widespread agitation in 2011. Agitation toolbox techniques likely caused decreased roughness and bulk density, increased water content, decreased cohesion, and decreased aquatic vegetation roots and woody debris. These factors increase the likelihood that high-flows will entrain and transport oiled sediment, producing unnaturally high accumulations of fine sediment and burial of substrates in areas downstream of the impoundment.
- If submerged oil is recovered throughout the Ceresco impoundment in a single event, the start time for ecological recovery in tactical areas SO 5.84C and SO 5.84D would be unimpeded by future/periodic submerged oil recovery.

Mill Ponds

The approximately 1-mile long impounded reach of the Kalamazoo River upstream of the Monroe Street Dam (also known as Kalamazoo Dam) in Battle Creek has ten NEBA tactical

areas totaling approximately 24 acres (Attachment C-1). While the majority of the Mill Ponds impoundment is from about MP 14.75 to 15.65 there were tactical areas upstream of MP 14.75 with NEBA recommendations of "increase monitoring frequency and evaluate for possible future recovery". This reach has a more complex geomorphic setting than the Ceresco Impoundment and has tactical areas in the main flowing channel, two large off-channel impoundments (Mill Ponds), a side channel with an enhanced sediment trap (evergreen tree bundles), and backwater areas. NEBA recommendations for the ten tactical areas are shown in Table 2. Figures showing poling assessment results, NEBA tactical areas, and selected hydrodynamic modeling results (velocity spatial patterns and simulated suspended sediment loads) for the Mill Ponds are included in Attachment C.

Table 2. June 2012 integrated NEBA/tactical area recommendations for remaining submerged oil in the Mill Ponds impoundment. (Color coding in table and figures in Attachment C indicates NEBA recommendation categories.)

Tactical Area Name	Size (acres)	June 2012 updated recommendation
SO 14.81	2.28	Follow sediment trap monitoring/maintenance plan and consider recovery using dredging/hydrovac (easy road access), especially in oiled area downstream of trap
SO 14.83	0.06	Sheen collection/monitored natural attenuation
SO 15.10	2.92	Sheen collection, increase monitoring frequency, continue to evaluate for possible future recovery actions
SO 15.23	10.28	Sheen collection, increased monitoring frequency, natural attenuation, possibly no other recovery because of high quality vegetation
SO 15.25	0.04	Sheen collection/monitored natural attenuation
SO 15.35	0.33	Sheen collection/monitored natural attenuation
SO 15.45	0.52	No action necessary
SO 15.56 LDB	0.36	Sheen collection/monitored natural attenuation
SO 15.56 RDB	5.21	Sheen collection, increased monitoring frequency, continue to evaluate for possible future recovery
SO 15.65	2.04	Sheen collection, increased monitoring frequency, continue to evaluate for possible future recovery (dredging/hydrovac)

At the upstream end of the impounded section in the vicinity of the Mill Ponds, the NEBA recommendations for SO 14.81 were to consider recovery of submerged oil in the designated sediment trap using dredging (Table 2). Based on the hydrodynamic model results, the side channel portion of the designated trap likely remains depositional during both low flows and high flows but the downstream portion of the trap is potentially erosional during high flows (Attachment C-6 through C-8). The 2012 late summer sediment trap monitoring poling results showed submerged oil accumulation comparable to Spring 2012. This area required repeated sheen management in the early Summer 2012 near the C5 boat launch.

Continuing downstream, the tactical areas at SO 14.83, SO 15.25, SO 15.35, and SO 15.56 LDB had NEBA recommendations for "sheen collection and monitored natural attenuation". Of these, 15.56 LDB was the only tactical area that had 2012 LSR results, and submerged oil accumulations were comparable to Spring 2012 in this tactical area.

The tactical area SO 15.10 accumulated submerged oil over the Winter 2011-12 that spanned a side channel, backwater, and channel margin along the left descending bank. The NEBA recommendation for this area was to "increase monitoring frequency and continue to evaluate for possible future recovery" (Table 2). Submerged oil accumulations in late Summer 2012 were comparable to Spring 2012. Based on hydrodynamic modeling results, most of the tactical area is depositional during low flows and becomes erosional during high flows, except for the backwater area upstream of the side channel.

The NEBA recommendation for SO 15.23 was to "increase monitoring frequency, natural attenuation, possibly no other recovery because of high quality vegetation". The hydrodynamic model results indicate that this tactical area is depositional during low flow but potentially becomes erosional during high flows (Attachment C-6 through C-8).

For SO 15.56 RDB, the NEBA recommendation was to "increase monitoring frequency and continue evaluation for possible future recovery". Similar to SO 15.23, this tactical area has protected high-quality aquatic vegetation, but the downstream portion accumulated heavy/moderate submerged oil between Spring and late Summer 2012 where it is open to the flowing channel. In addition, the 2012 LSR indicated a new area of heavy/moderate submerged oil between SO 15.56 RDB and SO 15.56 LDB (Attachment C-3 and C-4). The hydrodynamic model results indicate that these tactical areas and the flowing channel between are depositional during low flow (Attachment C-6 through C-8) but potentially become erosional during high flows.

Along the main channel directly opposite the downstream Mill Pond, the tactical area SO 15.45 had a NEBA recommendation that "no action is necessary".

The NEBA recommendation for SO 15.65 was to "increase monitoring frequency and continue to evaluate for possible future recovery (dredging/hydrovac)" (Table 2). Based on hydrodynamic model results, a portion of the area is likely depositional during low flow but the center portion potentially becomes erosional during high flow. Based on 2012 LSR poling this tactical area has no heavy/moderate submerged oil accumulation (Attachment C-3).

The Spring 2012 Reassessment and 2012 LSR in the Mill Ponds impoundment were incomplete because of operational considerations. Nevertheless, general patterns of submerged oil

accumulations in the Mill Ponds were comparable for the Spring 2012 Reassessment and 2012 LSR (Attachment C-2 through C-4).

In addition to the information described above, the following factors were identified in the NEBA process and review of the hydrodynamic model results for consideration for recovery of submerged oil in the Mill Ponds:

- There are no designated sediment traps immediately downstream that could accumulate the submerged oil that potentially could migrate downstream during high flows. The submerged oil would likely continue to migrate through the cement-lined and engineered reaches to become mixed with less- or non-oiled sediment and organic matter coming from Battle Creek or in-channel sources, and (or) re-accumulated in depositional areas.
- The oiled sediment in SO 14.81, SO 15.1, and SO 15.56LDB is likely more erodible following widespread agitation in 2011. Agitation toolbox techniques likely caused decreased roughness and bulk density, increased water content, decreased cohesion, and decreased aquatic vegetation roots and woody debris. These factors increase the likelihood that high flows will entrain and transport oiled sediment, producing unnaturally high accumulations of fine sediment and burial of substrates in areas downstream of the impoundment.
- There is limited trapping efficiency upstream of the dam during high flows, as illustrated by the longitudinal distribution of suspended sediment concentrations in the hydrodynamic model results (Attachment B).

Morrow Lake Impoundment

The Morrow Lake Impoundment extends from approximately the 35th Street Bridge at MP 36.5 to Morrow Dam at MP 39.8 and includes geomorphic settings transitional between riverine and lacustrine. The NEBA tactical area SO 38.40 extends from MP 36.5 to 38.25 and consists of the main depositional areas at the upstream end of Morrow Lake:

- The “delta”--a wide flooded valley with distributary channels, bars, and islands before entering the neck
- The “neck” --narrows between the wide flooded valley and Morrow Lake
- The “fan”-- an advancing depositional zone at the upstream end of Morrow Lake.

NEBA tactical area SO 38.40 covers the entire 316 acres of the Morrow Lake delta, neck, and fan, but excludes the portion of Morrow Lake Impoundment downstream of the fan. Three designated passive sediment traps: Delta A, Delta Z, and 37.75 are included in SO 38.40 (Attachment D-1). The NEBA recommendation recognized the diversity of environments and history of oil accumulation and recovery in this large area and recommended dividing the large area into subareas (Table 3). The NEBA recommendation included “evaluate recovery actions after subarea delineations, follow existing sediment trap monitoring and maintenance plan, for heavy oiled areas consider recovery (dredging)”.

Table 3. June 2012 integrated NEBA/tactical area recommendations for remaining submerged oil in the Morrow Lake impoundment. (Color coding in table and figures in Attachment D indicates NEBA recommendation categories.)

Tactical Area Name	Size (acres)	June 2012 updated recommendation
SO 38.40	316.3	Subdivide into subareas, evaluate recovery actions after subarea delineations, follow existing sediment trap monitoring and maintenance plan, for heavy oiled areas consider recovery (dredging)

The hydrodynamic model results indicate that most of the delta, neck, and fan are depositional during low flow, except for the main channel along the north side of the delta (Attachment D-3 through D-5). During high flows, most of the delta and neck, and the upstream portion of the fan potentially become erosional. Oil accumulations in the vicinity of MP 37.25 to 37.75 have required extensive sheen management and containment booms over the Spring and Summer 2012 (Attachment D-2). A boat ramp located on the north shore near MP 37.75 is used for fishing boats, kayaks, and canoes.

The 2012 LSR was not performed in the delta or neck of the Morrow Lake impoundment; however, tactical area SO 38.4 had 55.5 acres of heavy/moderate delineations in the Spring 2012. For the delta and the neck, multiple monitoring events performed throughout the summer of 2012 indicate comparable submerged oil accumulation with some interim variations. The 2012 LSR indicated heavy/moderate submerged oil accumulations on the fan in the vicinity of the northeast and southeast coves of Morrow Lake.

In addition to the information described above, the following factors were identified in the NEBA process and review of the hydrodynamic model results for consideration for recovery of submerged oil in the Morrow Lake impoundment:

- The delta, neck, and fan are the last accumulation zones before submerged oil reaches downstream areas of Morrow Lake.
- Although the April 2012 version of the hydrodynamic model used a simplified weir design for Morrow Dam (that should be updated with subsurface intakes in the design), results from the hydrodynamic model suggest that there is some trapping efficiency in the upper delta but most of the trapping happens within the lake, and that high flows during the May 2011 event had the capacity to transport submerged oil into the downstream portions of Morrow Lake and past Morrow Dam.
- The oiled sediment in SO 38.40 is likely more erodible following widespread agitation in 2011. Agitation toolbox techniques likely caused decreased roughness and bulk density, increased water content, decreased cohesion, and decreased aquatic vegetation roots and

woody debris. These factors increase the likelihood that high flows will entrain and transport oiled sediment, producing unnaturally high accumulations of fine sediment and burial of substrates in downstream areas of Morrow Lake.

ATTACHMENT A: Supporting Figures for the Ceresco Impoundment

A-1: A map overlay of the NEBA tactical areas.

A-2: A map overlay of the NEBA tactical areas with the Spring 2012 poling point results and delineations for heavy/moderate submerged oil.

A-3: A map overlay of the NEBA tactical areas with the late Summer 2012 (LSR and sediment trap monitoring) poling points and delineations for heavy/moderate submerged oil.

A-4: A map overlay of the NEBA tactical areas with Spring 2012 and late Summer 2012 (LSR and sediment trap monitoring) heavy/moderate submerged oil delineations.

A-5: A map overlay of the Spring 2012 poling point results and delineations for heavy/moderate submerged oil with 2012 emerging oil management results.

A-6: Hydrodynamic model outputs for velocity for September 9, 2010 (low flow).

A-7: Hydrodynamic model outputs for velocity for May 28, 2011 flood.

A-8: Hydrodynamic model outputs for velocity for a 100-yr flood.

ATTACHMENT B: Simulated sediment fluxes at seven locations along the modeled reach of the Kalamazoo River.

ATTACHMENT C: Supporting Figures for the Mill Ponds Impoundment

C-1: A map overlay of the NEBA tactical areas.

C-2: A map overlay of the NEBA tactical areas with the Spring 2012 poling point results and delineations for heavy/moderate submerged oil.

C-3: A map overlay of the NEBA tactical areas with the late Summer 2012 (LSR and sediment trap monitoring) poling points and delineations for heavy/moderate submerged oil.

C-4: A map overlay of the NEBA tactical areas with Spring 2012 and late Summer 2012 (LSR and sediment trap monitoring) heavy/moderate submerged oil delineations.

C-5: A map overlay of the Spring 2012 poling point results and delineations for heavy/moderate submerged oil with 2012 emerging oil management results.

C-6: Hydrodynamic model outputs for velocity for September 9, 2010 (low flow).

C-7: Hydrodynamic model outputs for velocity for May 28, 2011 flood.

C-8: Hydrodynamic model outputs for velocity for a 100-yr flood.

ATTACHMENT D: Supporting figures for Morrow Lake Impoundment

D-1: A map overlay of the NEBA tactical areas with the Spring 2012 poling point results and delineations for heavy/moderate submerged oil.

D-2: A map overlay of the Spring 2012 poling point results and delineations for heavy/moderate submerged oil with 2012 emerging oil management results.

D-3: Hydrodynamic model outputs for velocity for September 9, 2010 (low flow).

D-4: Hydrodynamic model outputs for velocity for May 28, 2011 flood.

D-5: Hydrodynamic model outputs for velocity for a 100-yr flood.

ATTACHMENT A-1

5.75

SO 5.84 C

SO 5.84 D

5.5

SO 5.84 B

5.25

SO 5.84 A

5

SO 5.15

SO 4.84 A

4.75

SO 4.81

SO 4.84 B

SO 4.80

Legend

NEBA/2012 Tactical Area Recommendations

- Sheen collection/monitored natural attenuation
- Sheen collection, increase monitoring frequency, continue to evaluate for possible recovery
- Follow sediment trap monitoring/maintenance plan and evaluate for possible future recovery
- Follow sediment trap monitoring/maintenance plan, consider recovery (dredging)

FOR OFFICIAL USE ONLY

DRAFT

0 200 400 800 Feet

Prepared for:
U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

NEBA/2012 TACTICAL AREAS
CERESCO DAM AREA
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 28, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Ceresco NEBA Maps\Ceresco_NEBA_Tactical_Areas_09282012.mxd

ATTACHMENT A-2

5.75

SO 5.84 C

SO 5.84 D

5.5

SO 5.84 B

5.25

SO 5.84 A

5

SO 5.15

SO 4.84 A

4.75

SO 4.81

SO 4.84 B

SO 4.80

Legend

Spring 2012 Poling Result

SubOil Category

- Heavy
- Moderate
- Light
- None

Spring 2012 Delineations

- Heavy and Moderate Sub-Oil Areas

NEBA/2012 Tactical Area Recommendations

- Sheen collection/monitored natural attenuation
- Sheen collection, increase monitoring frequency, continue to evaluate for possible recovery
- Follow sediment trap monitoring/maintenance plan and evaluate for possible future recovery
- Follow sediment trap monitoring/maintenance plan, consider recovery (dredging)

FOR OFFICIAL USE ONLY

DRAFT

Note: The Data used to create Delineations was obtained from the 2012 Spring and Ceresco Sed-Trap poling results.

0 200 400 800 Feet

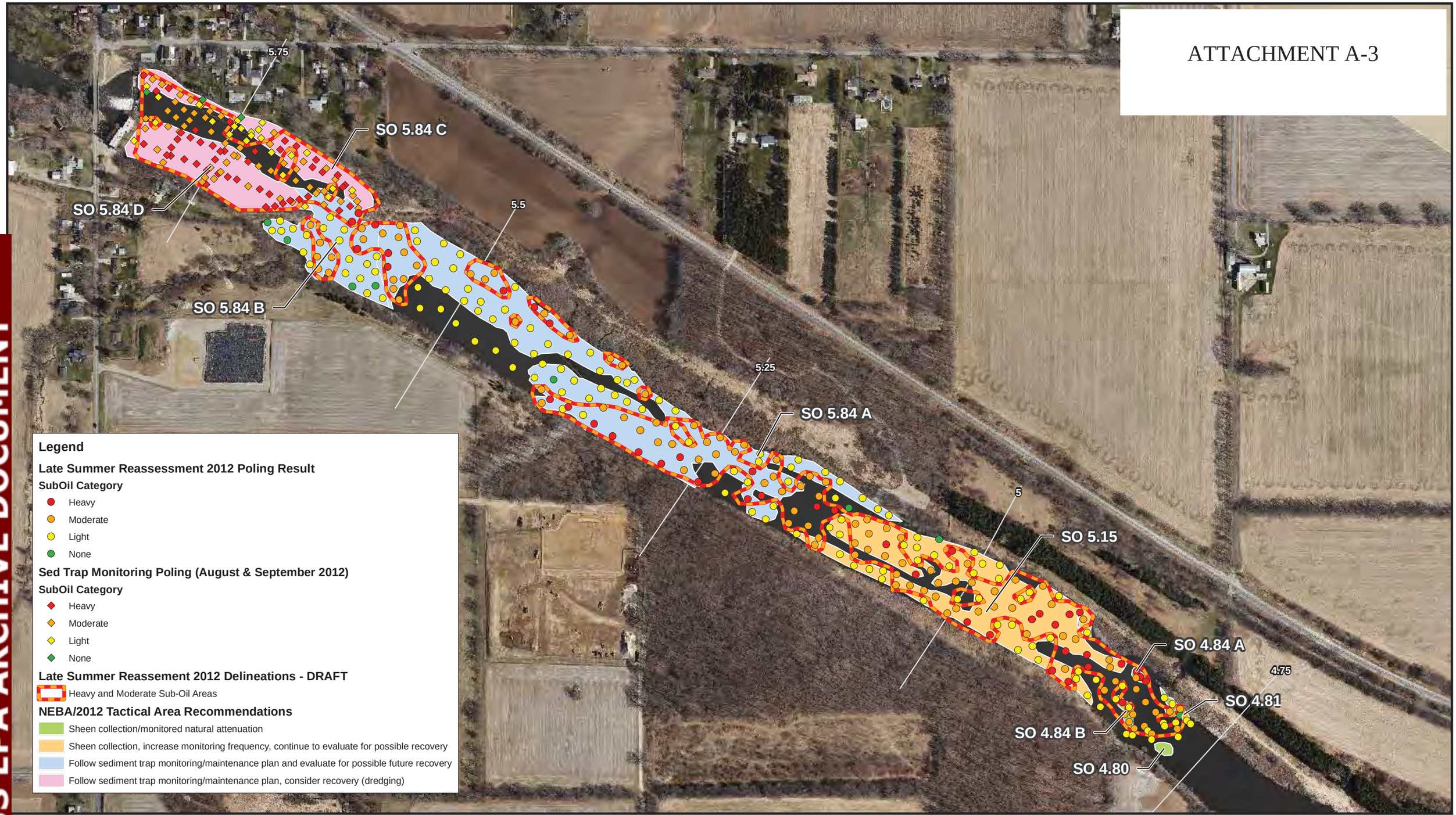
Prepared for:
U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

NEBA/2012 TACTICAL AREAS AND SPRING 2012 POLING RESULTS AND HEAVY\MODERATE DELINEATION AREAS
CERESCO DAM AREA
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 28, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Ceresco NEBA Maps\Ceresco_NEBA_Tactical_Areas_and_Spring_2012_Poling_09282012.mxd

ATTACHMENT A-3



Legend

Late Summer Reassessment 2012 Poling Result

SubOil Category

- Heavy
- Moderate
- Light
- None

Sed Trap Monitoring Poling (August & September 2012)

SubOil Category

- Heavy
- Moderate
- Light
- None

Late Summer Reassement 2012 Delineations - DRAFT

- Heavy and Moderate Sub-Oil Areas

NEBA/2012 Tactical Area Recommendations

- Sheen collection/monitored natural attenuation
- Sheen collection, increase monitoring frequency, continue to evaluate for possible recovery
- Follow sediment trap monitoring/maintenance plan and evaluate for possible future recovery
- Follow sediment trap monitoring/maintenance plan, consider recovery (dredging)

FOR OFFICIAL USE ONLY

DRAFT

Note: The Data used to create Delineations was obtained from the 2012 LSR and Ceresco Sed-Trap poling results.

0 200 400 800 Feet

Prepared for:
U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

NEBA/2012 TACTICAL AREAS AND LATE SUMMER REASSESSMENT
2012 POLING RESULTS AND HEAVY\MODERATE DELINEATION AREAS
CERESCO DAM AREA
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 28, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Ceresco NEBA Maps\Ceresco_NEBA_Tactical_Areas_and_LSR_2012_Poling_09282012.mxd

ATTACHMENT A-4

5.75

SO 5.84 C

SO 5.84 D

5.5

SO 5.84 B

5.25

SO 5.84 A

5

SO 5.15

SO 4.84 A

4.75

SO 4.81

SO 4.84 B

SO 4.80

Legend

Spring 2012 Delineations

Heavy and Moderate Sub-Oil Areas

Late Summer Reassement 2012 Delineations - DRAFT

Heavy and Moderate Sub-Oil Areas

NEBA/2012 Tactical Area Recommendations

Sheen collection/monitored natural attenuation

Sheen collection, increase monitoring frequency, continue to evaluate for possible recovery

Follow sediment trap monitoring/maintenance plan and evaluate for possible future recovery

Follow sediment trap monitoring/maintenance plan, consider recovery (dredging)

FOR OFFICIAL USE ONLY

DRAFT

Note: The Data used to create Delineations was obtained from the 2012 SPRING & LSR and Ceresco Sed-Trap poling results.

0 200 400 800 Feet

Prepared for:
U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

NEBA/2012 TACTICAL AREAS AND 2012 HEAVY\MODERATE DELINEATION AREAS
CERESCO DAM AREA
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 28, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Ceresco NEBA Maps\Ceresco_NEBA_Tactical_Areas_and_SPRING_LSR_2012_Delineation_09282012.mxd

ATTACHMENT A-5

5.75

5.5

5.25

5

4.75

Legend

Spring 2012 Poling Result

SubOil Category

- Heavy
- Moderate
- Light
- None

Spring 2012 Delineations

- Heavy and Moderate Sub-Oil Areas

Ceresco Sheen Observations

- Sheen Observed

FOR OFFICIAL USE ONLY

DRAFT

Note: The Data used to create Delineations was obtained from the 2012 Spring and Ceresco Sed-Trap poling results.

0 200 400 800 Feet

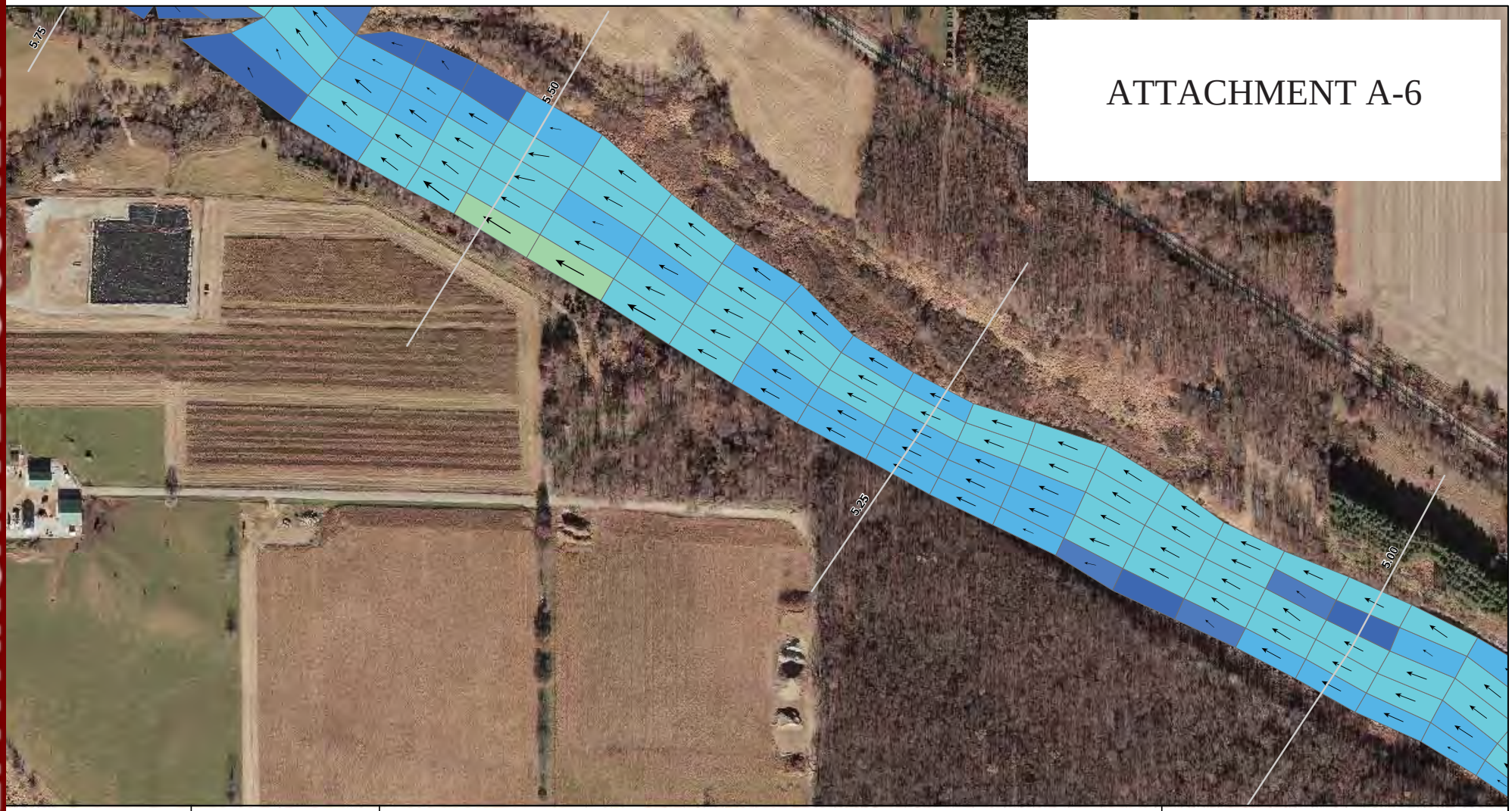
Prepared for:
U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

SHEEN AREAS AND SPRING 2012
POLING RESULTS AND HEAVY\MODERATE DELINEATION AREAS
CERESCO DAM AREA
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 28, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Ceresco NEBA Maps\Ceresco_Sheen_and_Spring_2012_Poling_09282012.mxd

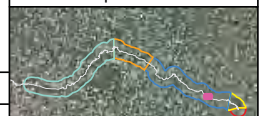
ATTACHMENT A-6



ENBRIDGE

Drawn:	BRS	3/23/2012
Approved:	DBR	3/23/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - September 9, 2010

- < 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

Quarter Mile Grid Segment

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

Kalamazoo River near Battle Creek USGS gage daily average discharge: 467 cfs

N

0 125 250 500
Scale in Feet

RIVERINE GRID: VELOCITY
SEPTEMBER 9, 2010

MP 04.90 - MP 05.65

SHEET 5 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_Sep9_2010.mxd

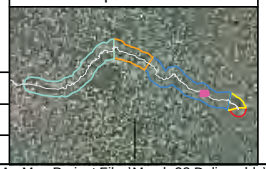
Aerial Photography Date: November 2011

ATTACHMENT A-6 - CONTINUED

ENBRIDGE

Drawn:	BRS	3/23/2012
Approved:	DBR	3/23/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - September 9, 2010

- < 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

Quarter Mile Grid Segment

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

Kalamazoo River near Battle Creek USGS gage daily average discharge: 467 cfs

N

0 125 250 500
Scale in Feet

RIVERINE GRID: VELOCITY
SEPTEMBER 9, 2010

MP 05.65 - MP 06.30

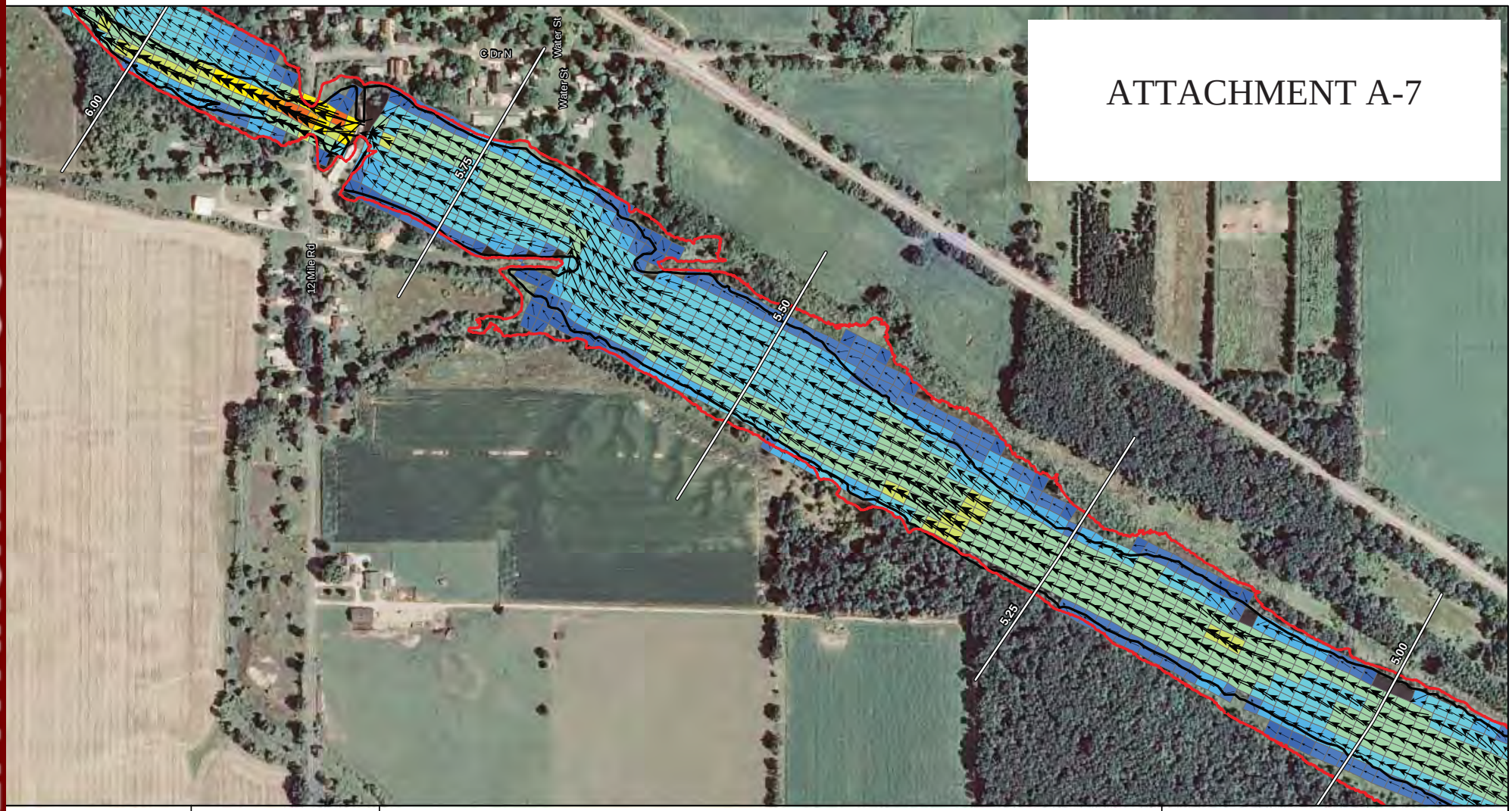
SHEET 6 OF 56

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_Sep9_2010.mxd

Aerial Photography Date: November 2011

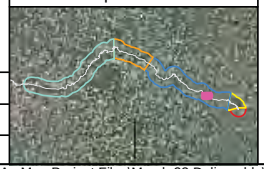
ATTACHMENT A-7



ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

Kalamazoo River near Battle Creek USGS gage daily average discharge: 3,390 cfs

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

N

0 175 350 700
Scale in Feet

FLOODPLAIN GRID: VELOCITY
MAY 28, 2011

MP 04.98 - MP 06.03

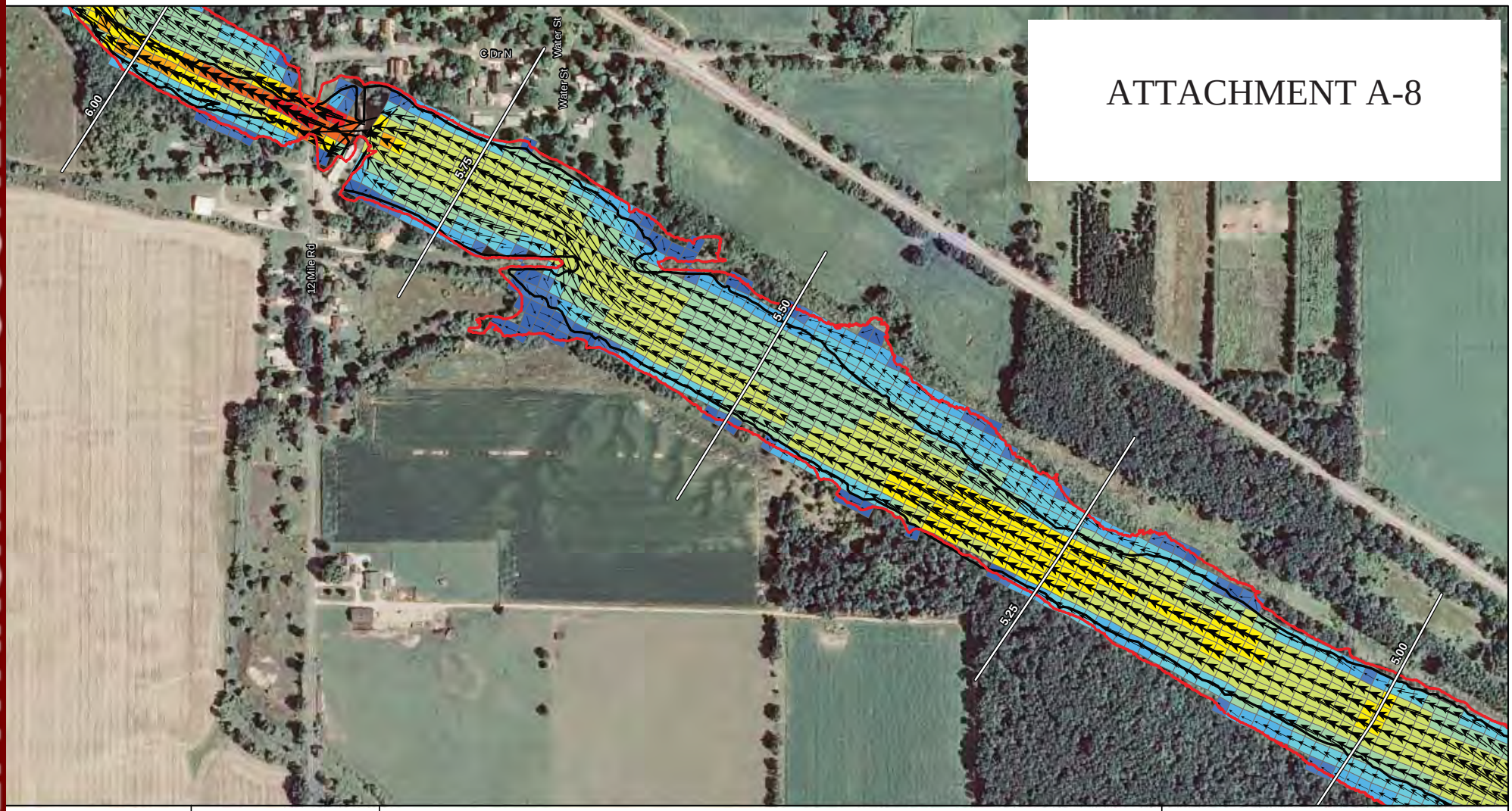
SHEET 4 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Floodplain_Velocity_May28_2011.mxd

Aerial Photography Date: July & August 2009

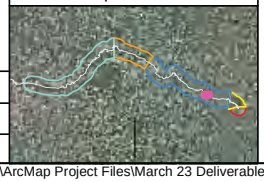
ATTACHMENT A-8



ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

ft/sec = Feet Per Second

N

0 175 350 700

Scale in Feet

FLOODPLAIN GRID: VELOCITY
100-YEAR FLOOD

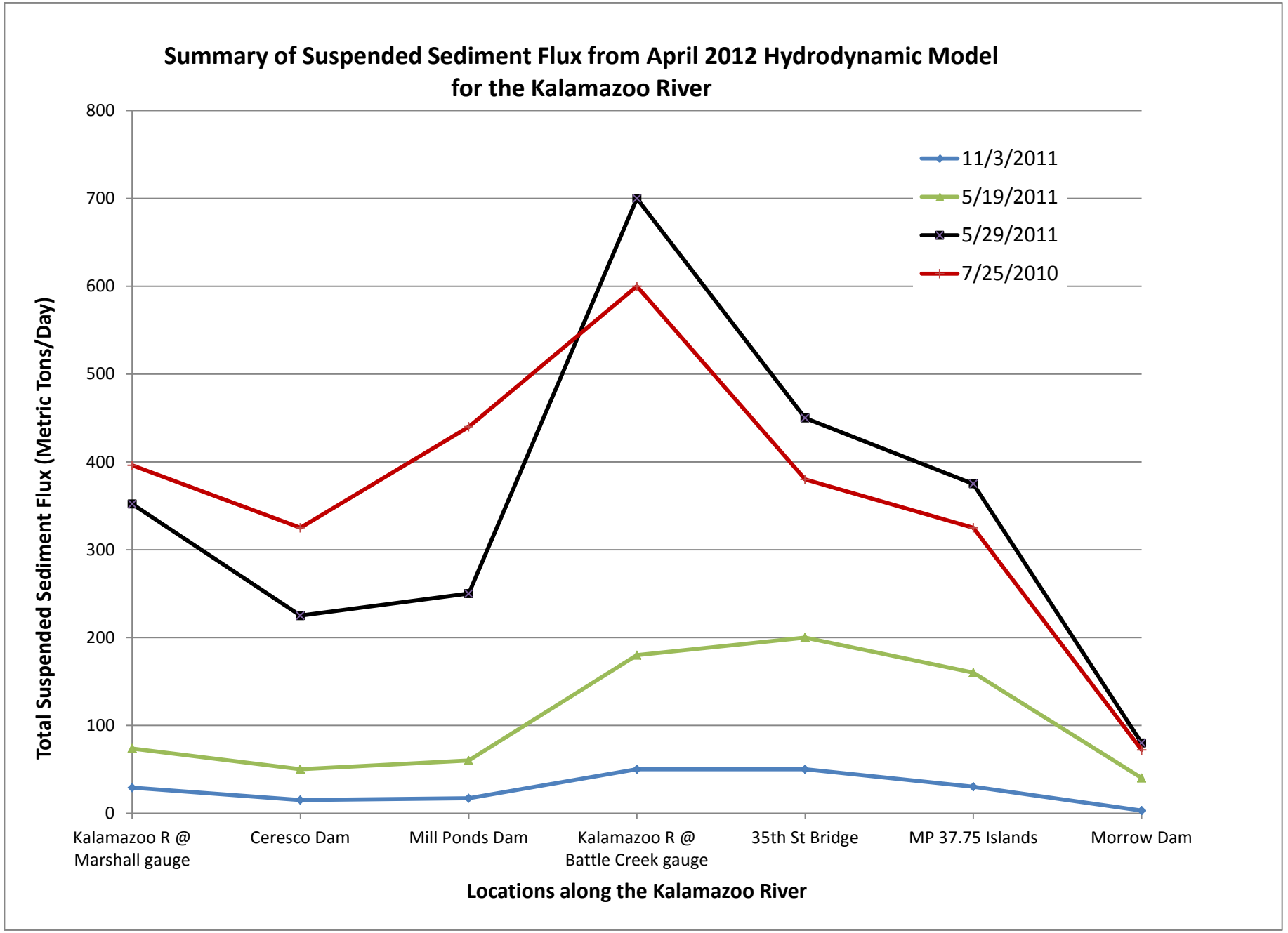
MP 04.98 - MP 06.03

SHEET 4 OF 45

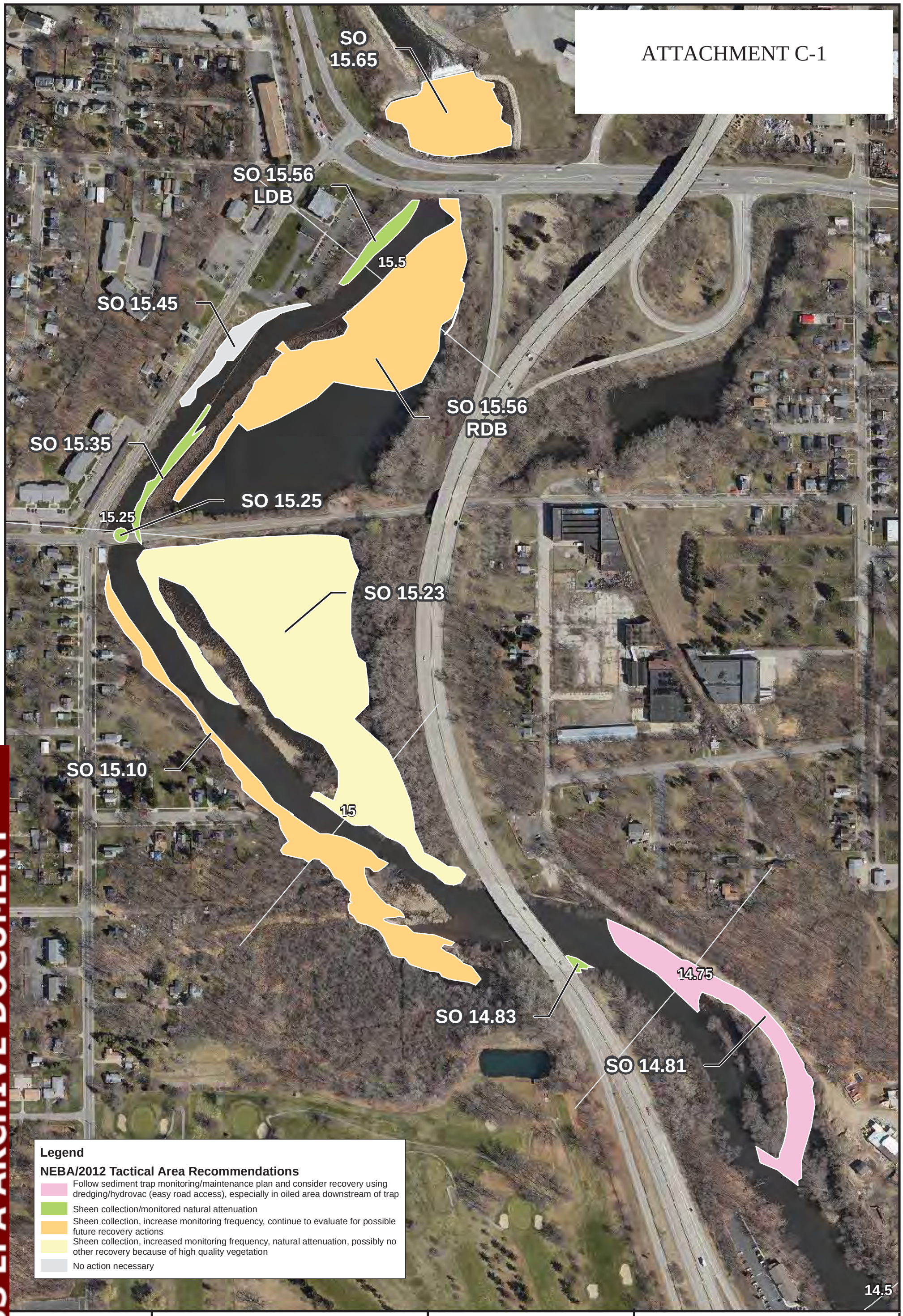
ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Floodplain_Velocity_100yr.mxd

Aerial Photography Date: July & August 2009



ATTACHMENT C-1



FOR OFFICIAL USE ONLY

DRAFT

N W E S

0 150 300 600 Feet

Prepared for: U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

NEBA/2012 TACTICAL AREAS
MILL POND
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 28, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Mill Pond NEBA Maps\Mill_Pond_NEBA_Tactical_Areas_09282012.mxd

ATTACHMENT C-2

SO 15.65

SO 15.56 LDB

15.5

SO 15.45

SO 15.56 RDB

SO 15.35

SO 15.25

15.25

SO 15.23

SO 15.10

15

14.75

SO 14.83

SO 14.81

14.5

Legend

Spring 2012 Poling Result

SubOil Category

- Heavy
- Moderate
- Light
- None

Spring 2012 Delineations

- Heavy and Moderate Sub-Oil Areas

NEBA/2012 Tactical Area Recommendations

- Follow sediment trap monitoring/maintenance plan and consider recovery using dredging/hydrovac (easy road access), especially in oiled area downstream of trap
- Sheen collection/monitored natural attenuation
- Sheen collection, increase monitoring frequency, continue to evaluate for possible future recovery actions
- Sheen collection, increased monitoring frequency, natural attenuation, possibly no other recovery because of high quality vegetation
- No action necessary

FOR OFFICIAL USE ONLY

DRAFT

Note: The Data used to create Delineations was obtained from the 2012 Spring and Mill Pond Sed-Trap poling results.

N W E S

0 150 300 600 Feet

Prepared for: U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

NEBA/2012 TACTICAL AREAS AND SPRING 2012 POLING RESULTS AND HEAVY\MODERATE DELINEATION AREAS
MILL POND
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 28, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Mill Pond NEBA Maps\Mill_Pond_NEBA_Tactical_Areas_and_Spring_2012_09282012.mxd

ATTACHMENT C-3

SO 15.65

SO 15.56 LDB

15.5

SO 15.45

SO 15.56 RDB

SO 15.35

SO 15.25

15.25

SO 15.23

SO 15.10

15

14.75

SO 14.83

SO 14.81

14.5

Legend

Late Summer Reassessment 2012 Poling Result

SubOil Category

- Heavy
- Moderate
- Light
- None

Sed Trap Monitoring Poling (August & September 2012)

SubOil Category

- Heavy
- Moderate
- Light
- None

Late Summer Reassement 2012 Delineations - DRAFT

- Heavy and Moderate Sub-Oil Areas

NEBA/2012 Tactical Area Recommendations

- Follow sediment trap monitoring/maintenance plan and consider recovery using dredging/hydrovac (easy road access), especially in oiled area downstream of trap
- Sheen collection/monitored natural attenuation
- Sheen collection, increase monitoring frequency, continue to evaluate for possible future recovery actions
- Sheen collection, increased monitoring frequency, natural attenuation, possibly no other recovery because of high quality vegetation
- No action necessary

FOR OFFICIAL USE ONLY

DRAFT

Note: The Data used to create Delineations was obtained from the 2012 LSR and Mill Pond Sed-Trap poling results.

N W E S

0 150 300 600 Feet

Prepared for: U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

NEBA/2012 TACTICAL AREAS AND LATE SUMMER REASSESSMENT 2012 POLING RESULTS AND HEAVY\MODERATE DELINEATION AREAS
MILL POND
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 27, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Mill Pond NEBA Maps\Mill_Pond_NEBA_Tactical_Areas_and_LSR_2012_09282012.mxd

ATTACHMENT C-4

SO 15.65

SO 15.56 LDB

15.5

SO 15.45

SO 15.56 RDB

SO 15.35

SO 15.25

15.25

SO 15.23

SO 15.10

15

14.75

SO 14.83

SO 14.81

14.5

Legend

Spring 2012 Delineations

Heavy and Moderate Sub-Oil Areas

Late Summer Reassement 2012 Delineations - DRAFT

Heavy and Moderate Sub-Oil Areas

NEBA/2012 Tactical Area Recommendations

- Follow sediment trap monitoring/maintenance plan and consider recovery using dredging/hydrovac (easy road access), especially in oiled area downstream of trap
- Sheen collection/monitored natural attenuation
- Sheen collection, increase monitoring frequency, continue to evaluate for possible future recovery actions
- Sheen collection, increased monitoring frequency, natural attenuation, possibly no other recovery because of high quality vegetation
- No action necessary

FOR OFFICIAL USE ONLY

DRAFT

NNote: The Data used to create Delineations was obtained from the 2012 SPRING & LSR and Mill Pond Sed-Trap poling results.

N W E S

0 150 300 600 Feet

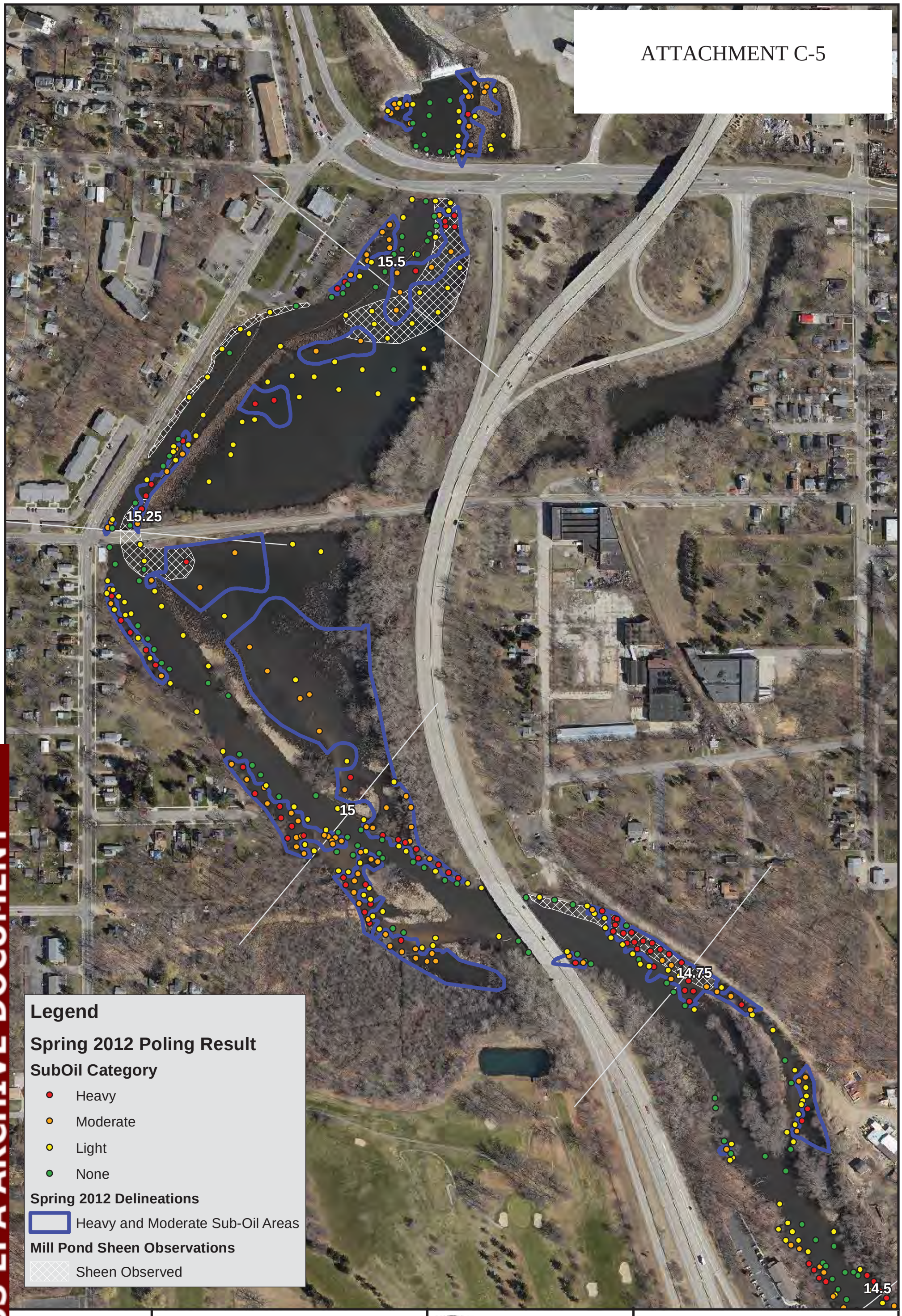
Prepared for: U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

NEBA/2012 TACTICAL AREAS AND 2012 HEAVY\MODERATE DELINEATION AREAS
MILL POND
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 26, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Mill Pond NEBA Maps\Mill_Pond_NEBA_Tactical_Areas_and_SPRING_LSR_2012_09282012.mxd

ATTACHMENT C-5



FOR OFFICIAL USE ONLY

DRAFT

Note: The Data used to create Delineations was obtained from the 2012 Spring and Mill Pond Sed-Trap poling results.

N W E S

0 150 300 600 Feet

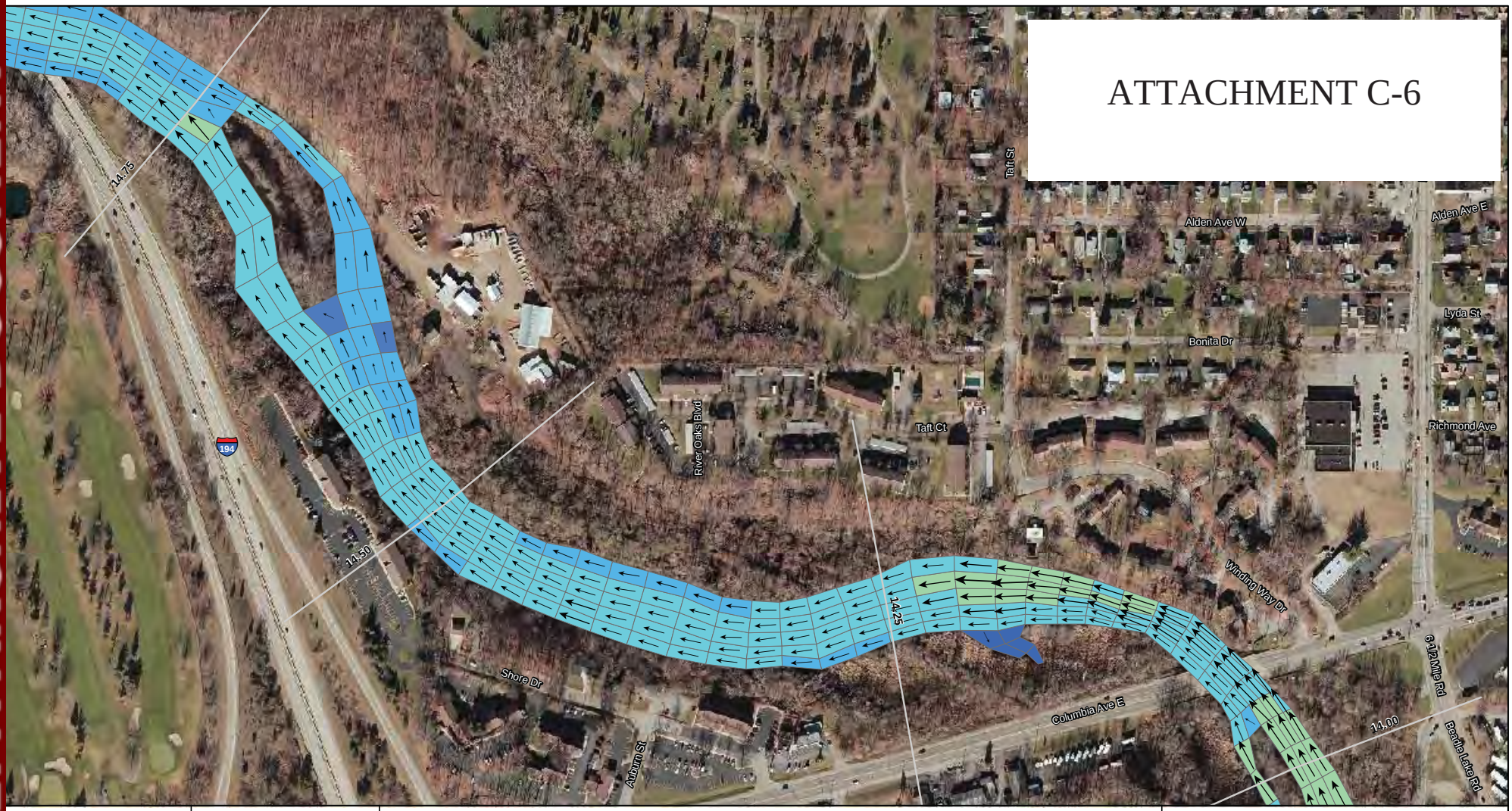
Prepared for: U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

SHEEN AREAS AND SPRING 2012 POLING RESULTS AND HEAVY\MODERATE DELINEATION AREAS
MILL POND
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 28, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Mill Pond NEBA Maps\Mill_Pond_Sheen_and_Spring_2012_09282012.mxd

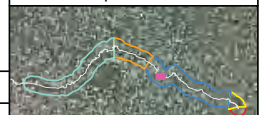
ATTACHMENT C-6



ENBRIDGE

Drawn:	BRS	3/23/2012
Approved:	DBR	3/23/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - September 9, 2010

- < 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

Quarter Mile Grid Segment

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

Kalamazoo River near Battle Creek USGS gage daily average discharge: 467 cfs

N

0 125 250 500
Scale in Feet

RIVERINE GRID: VELOCITY
SEPTEMBER 9, 2010

MP 14.00 - MP 14.85

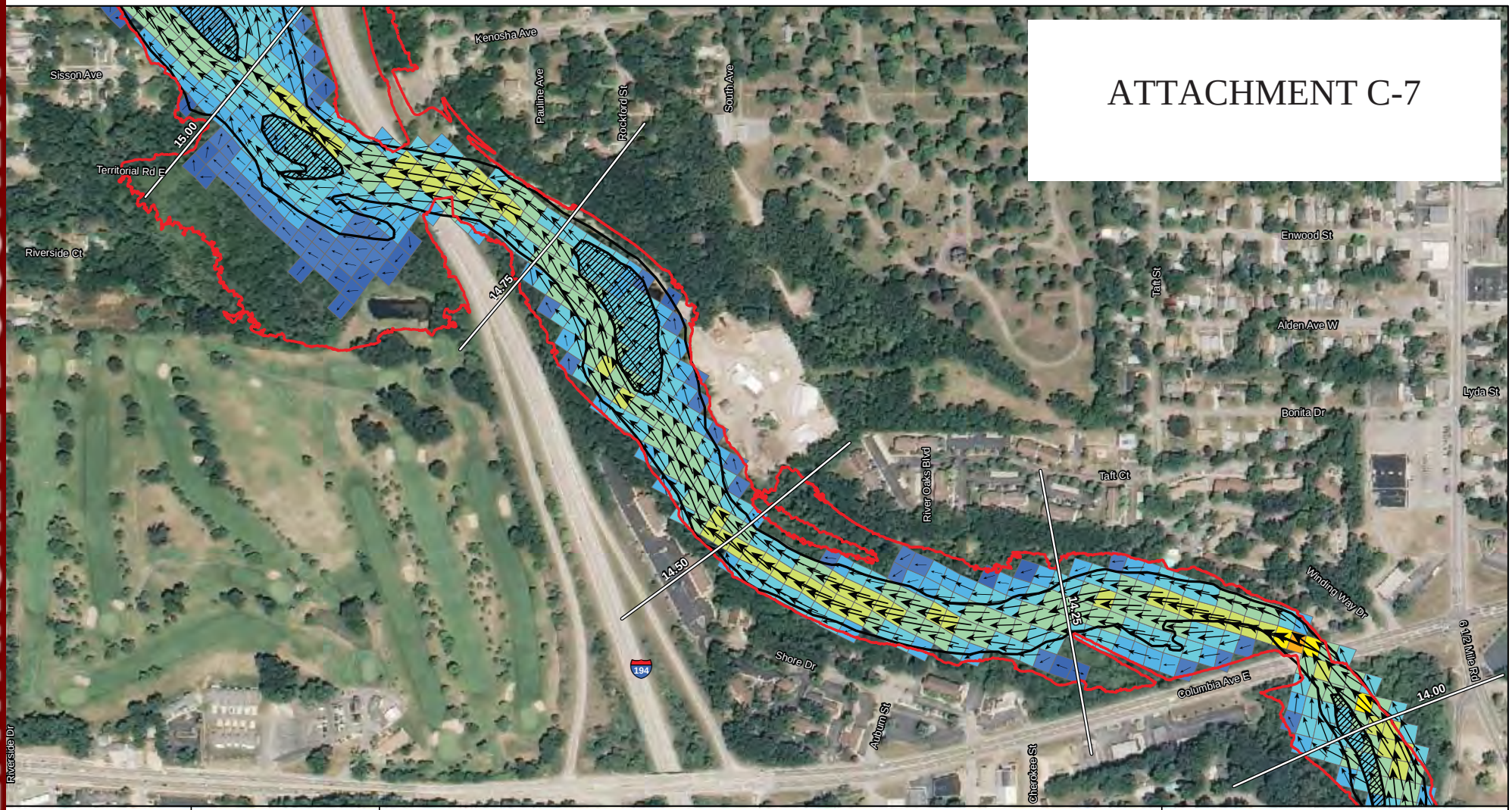
SHEET 17 OF 56

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_Sep9_2010.mxd

Aerial Photography Date: November 2011

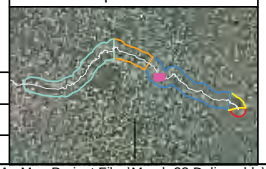
ATTACHMENT C-7



ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

Kalamazoo River near Battle Creek USGS gage daily average discharge: 3,390 cfs

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

N

0 175 350 700
Scale in Feet

FLOODPLAIN GRID: VELOCITY
MAY 28, 2011

MP 14.00 - MP 15.05

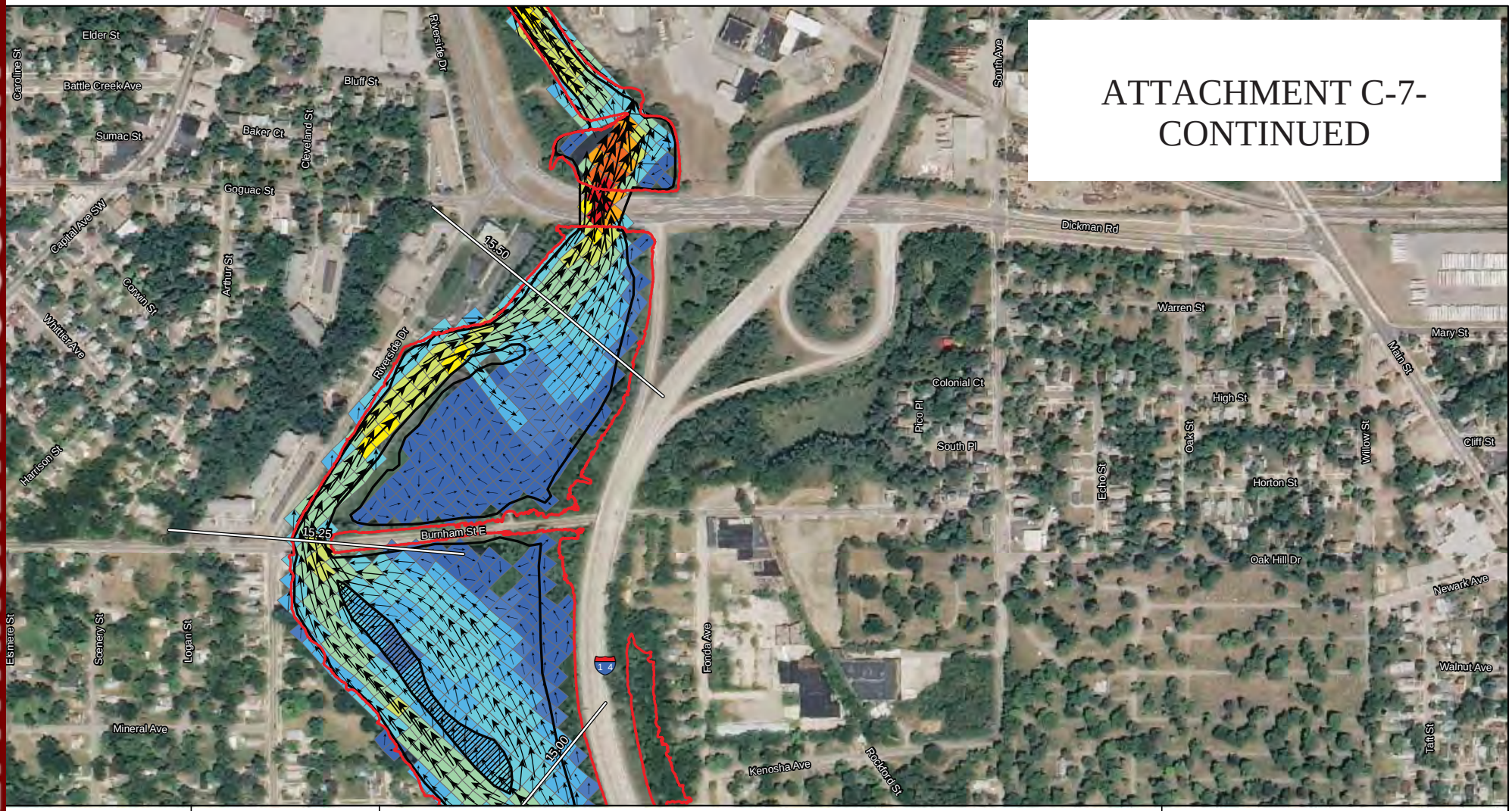
SHEET 13 OF 45

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

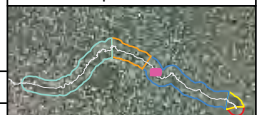
X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Floodplain_Velocity_May28_2011.mxd

Aerial Photography Date: July & August 2009

ATTACHMENT C-7- CONTINUED



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
- Quarter Mile Grid Segment

Kalamazoo River near Battle Creek USGS gage daily average discharge: 3,390 cfs

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

N

0 175 350 700
Scale in Feet

FLOODPLAIN GRID: VELOCITY
MAY 28, 2011

MP 15.05 - MP 15.71

SHEET 14 OF 45

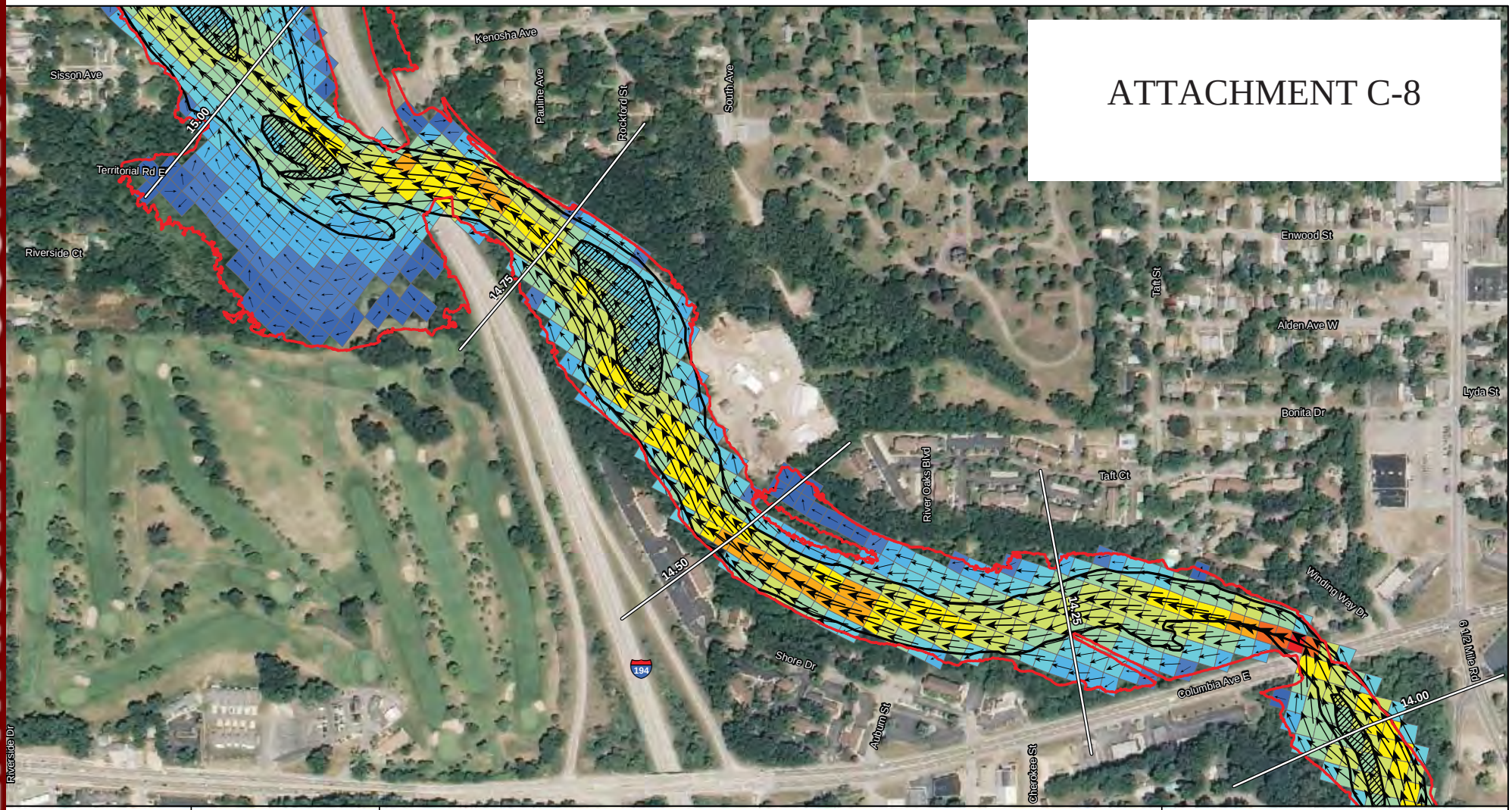
ENBRIDGE LINE 6B MP 608
MARSHALL, MI PIPELINE RELEASE
ENBRIDGE ENERGY, LIMITED PARTNERSHIP

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
Project #:	106-4186

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Floodplain_Velocity_May28_2011.mxd

Aerial Photography Date: July & August 2009

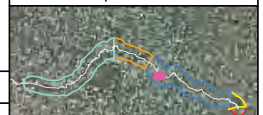
ATTACHMENT C-8



ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

ft/sec = Feet Per Second

N

0 175 350 700

Scale in Feet

FLOODPLAIN GRID: VELOCITY
100-YEAR FLOOD
MP 14.00 - MP 15.05

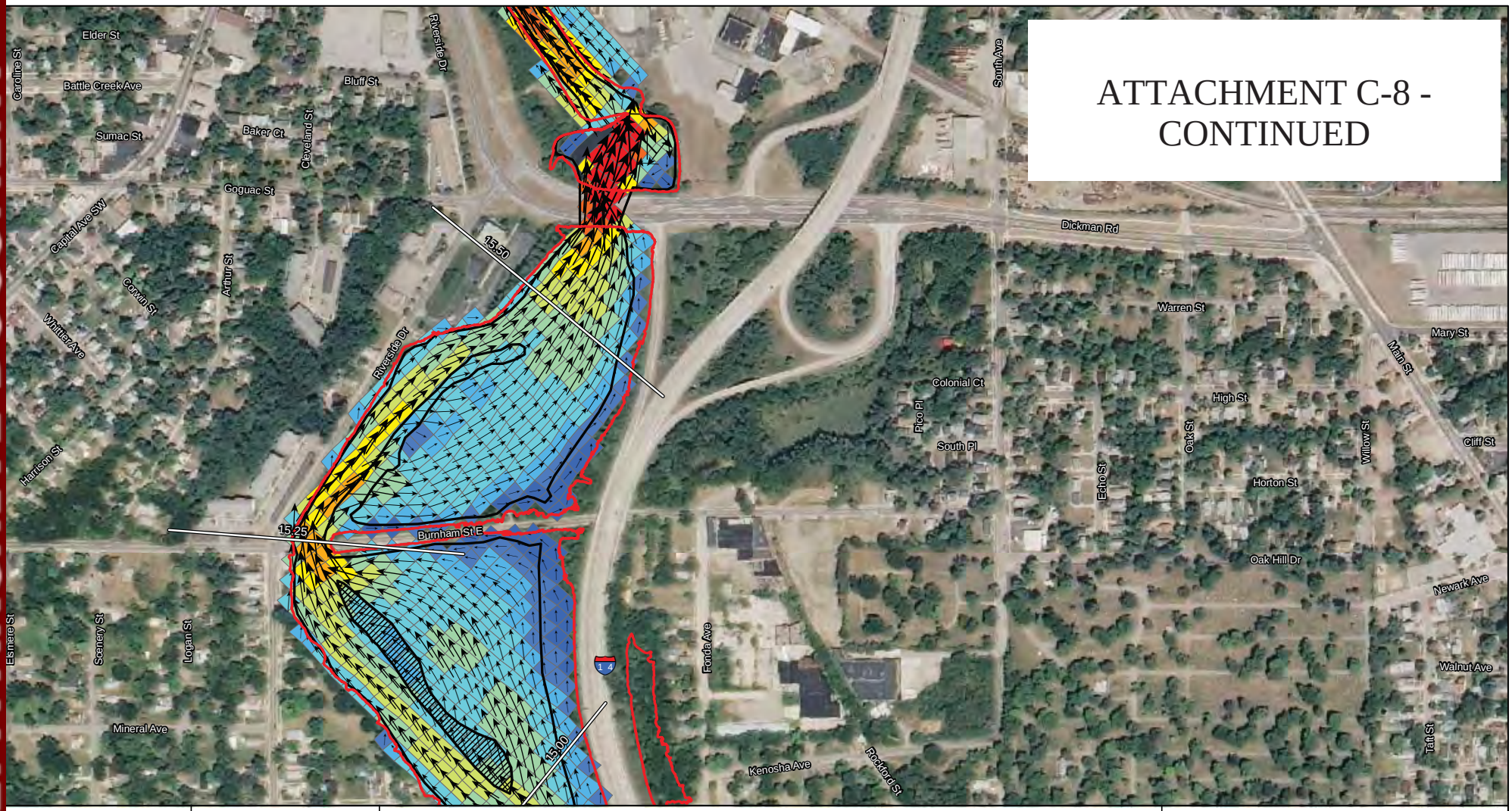
SHEET 13 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Floodplain_Velocity_100yr.mxd

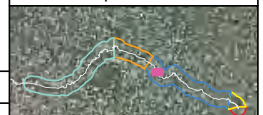
Aerial Photography Date: July & August 2009

ATTACHMENT C-8 - CONTINUED



Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

ft/sec = Feet Per Second

N

0 175 350 700

Scale in Feet

FLOODPLAIN GRID: VELOCITY
100-YEAR FLOOD

MP 15.05 - MP 15.71

SHEET 14 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Floodplain_Velocity_100yr.mxd

Aerial Photography Date: July & August 2009

ATTACHMENT D-1

38.25
38
SO 38.40
37.75
37.5
37.25
37
36.75
36.5

Legend

Spring 2012 Poling Result

SubOil Category

- Heavy
- Moderate
- Light
- None

2012 Spring Reassessment

- Heavy and Moderate Sub-Oil Areas

NEBA/2012 Tactical Area Recommendations

- Subdivide into subareas, evaluate recovery actions after subarea delineations, follow existing sediment trap monitoring and maintenance plan, for heavy oiled areas consider recovery (dredging)

FOR OFFICIAL USE ONLY

DRAFT

N
W E
S

0 325 650 1,300 Feet

Prepared for:
U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

NEBA/2012 TACTICAL AREA
MORROW LAKE DELTA
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 28, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Morrow Lake Delta NEBA Maps\Morrow_Lake_Delta_NEBA_Tactical_Areas_09282012.mxd

ATTACHMENT D-2

38.25
38
37.75
37.5
37.25
37
36.75
36.5

Legend

Spring 2012 Poling Result

SubOil Category

- Heavy
- Moderate
- Light
- None

2012 Spring Reassessment

Heavy and Moderate Sub-Oil Areas

Morrow Lake Delta Sheen Observations

Sheen Observed

FOR OFFICIAL USE ONLY

DRAFT

0 325 650 1,300 Feet

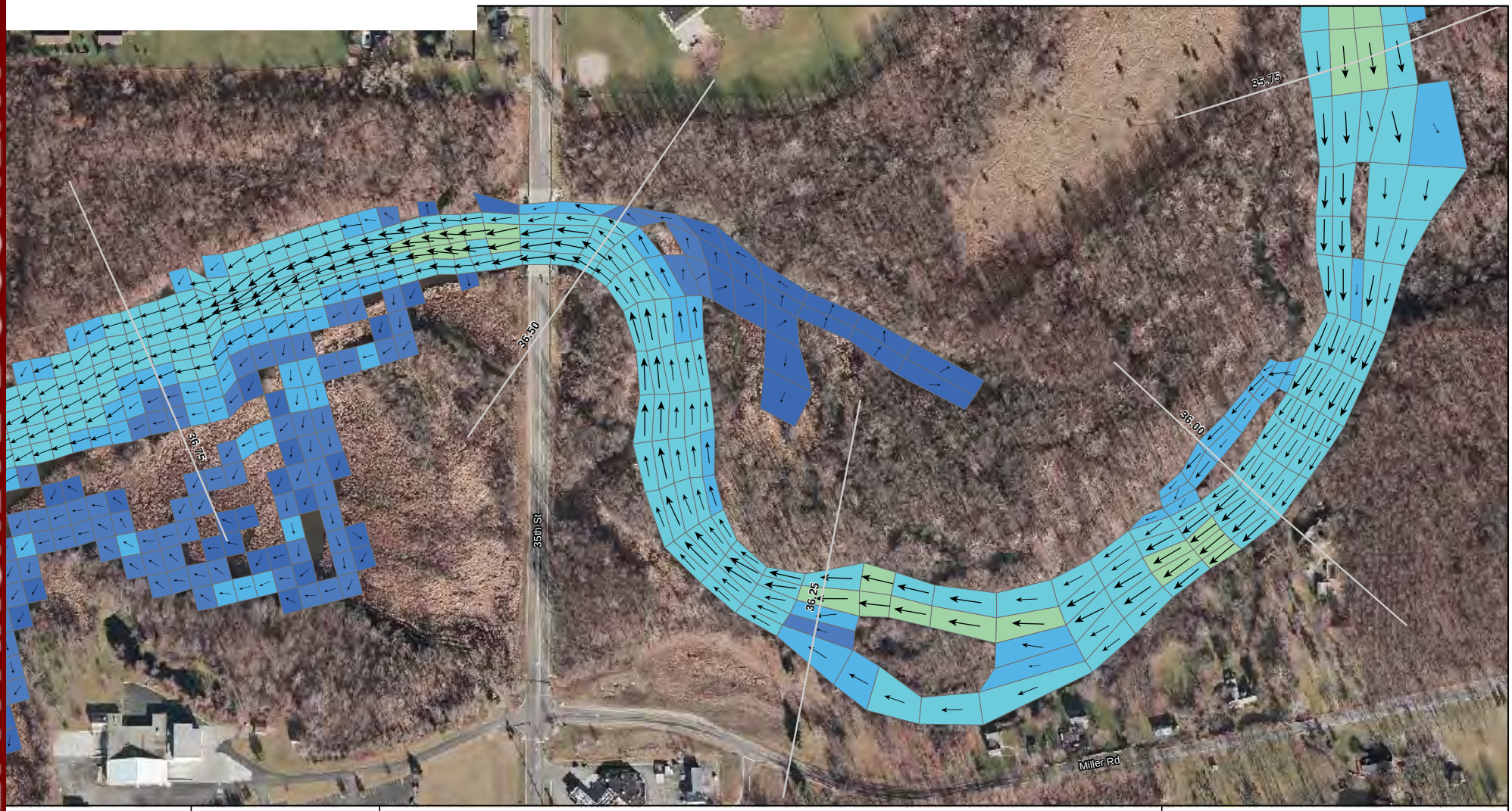
Prepared for:
U.S. EPA REGION V
Contract No.: EP-S5-06-04
TDD: S05-0005-1007-030
DCN: 1154-4D-AHMS

Prepared by:
WESTON SOLUTIONS, INC.
2501 Jolly Road, Suite 100
Okemos, MI

SHEEN AREA AND SPRING 2012 POLING RESULTS AND HEAVY\MODERATE DELINEATION AREAS
MORROW LAKE DELTA
MARSHALL, MI PIPELINE RELEASE
KALAMAZOO RIVER, MI
CREATED: SEPTEMBER 28, 2012

Path: F:\Logistics\GIS_Data\Marshall_Oil_ER\GIS\MXD\20120928\Morrow Lake Delta NEBA Maps\Morrow_Lake_Delta_Sheen_09282012.mxd

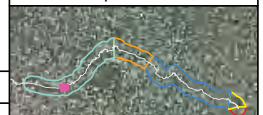
ATTACHMENT D-3



ENBRIDGE

Drawn:	BRS	3/23/2012
Approved:	DBR	3/23/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - September 9, 2010

- < 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

Quarter Mile Grid Segment

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

Kalamazoo River near Battle Creek USGS gage daily average discharge: 467 cfs

N

0 125 250 500
Scale in Feet

RIVERINE GRID: VELOCITY
SEPTEMBER 9, 2010

MP 35.75 - MP 36.80

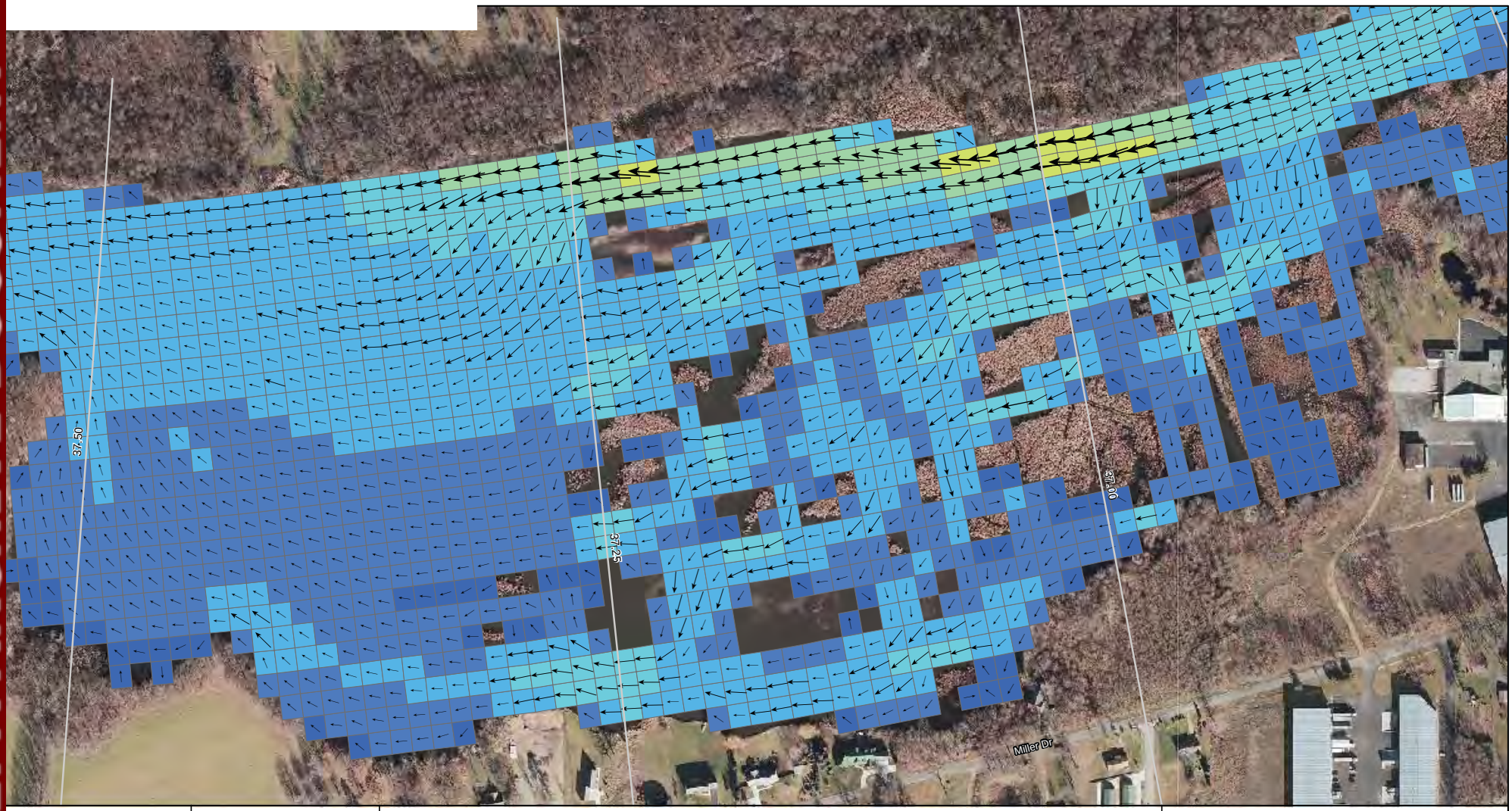
SHEET 47 OF 56

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_Sep9_2010.mxd

Aerial Photography Date: November 2011

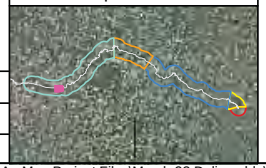
ATTACHMENT D-3 - CONTINUED



ENBRIDGE

Drawn:	BRS	3/23/2012
Approved:	DBR	3/23/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - September 9, 2010

- < 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

Quarter Mile Grid Segment

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

Kalamazoo River near Battle Creek USGS gage daily average discharge: 467 cfs

N

0 125 250 500
Scale in Feet

RIVERINE GRID: VELOCITY
SEPTEMBER 9, 2010

MP 36.80 - MP 37.55

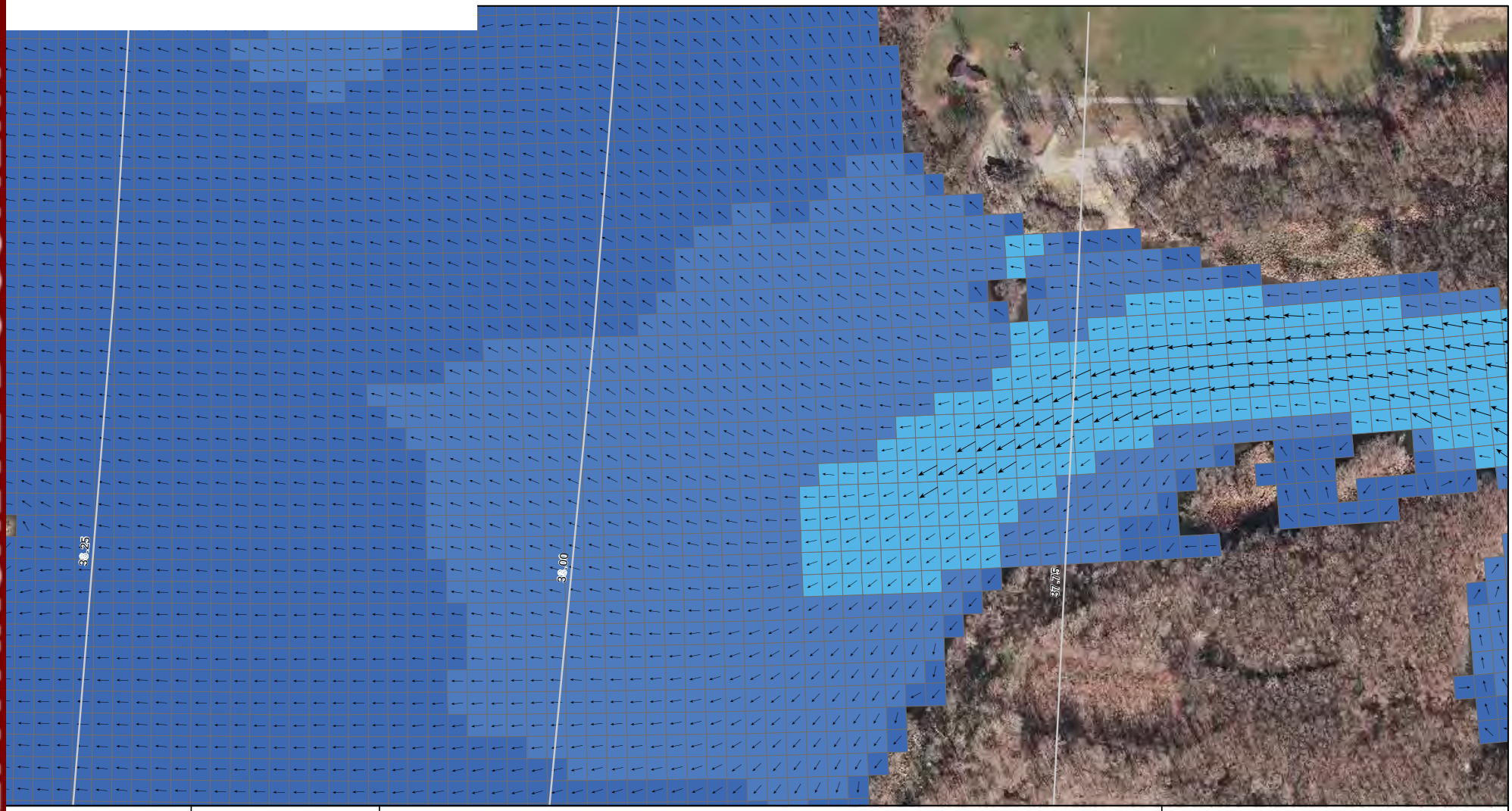
SHEET 48 OF 56

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_Sep9_2010.mxd

Aerial Photography Date: November 2011

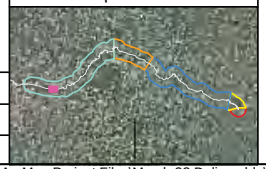
ATTACHMENT D-3 - CONTINUED



ENBRIDGE

Drawn:	BRS	3/23/2012
Approved:	DBR	3/23/2012
Project #:	106-4186	

Map Location



Legend

Velocity (ft/sec) - September 9, 2010

- < 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

Quarter Mile Grid Segment

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

Kalamazoo River near Battle Creek USGS gage daily average discharge: 467 cfs

N

0 125 250 500
Scale in Feet

RIVERINE GRID: VELOCITY
SEPTEMBER 9, 2010

MP 37.55 - MP 38.30

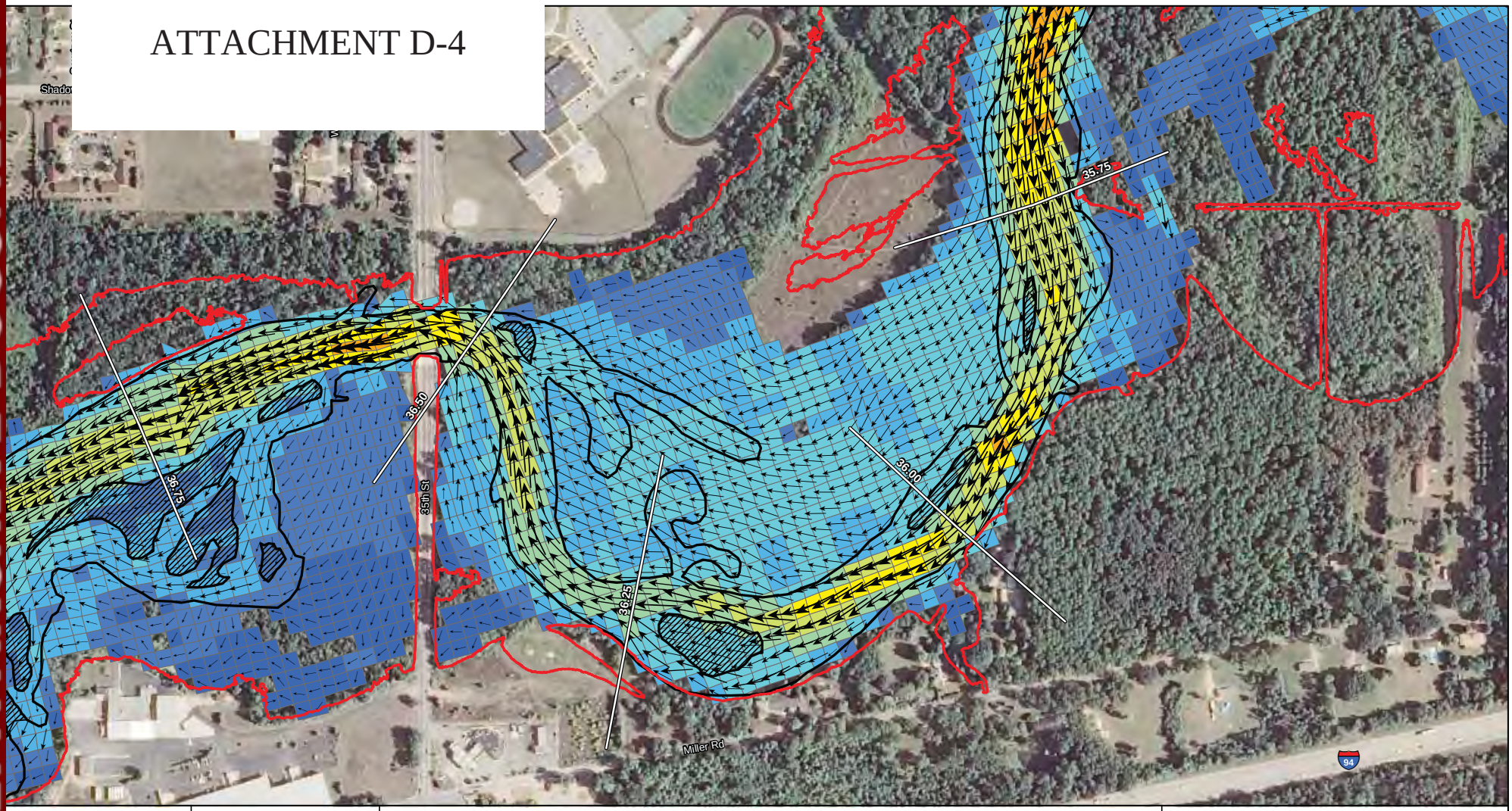
SHEET 49 OF 56

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_Sep9_2010.mxd

Aerial Photography Date: November 2011

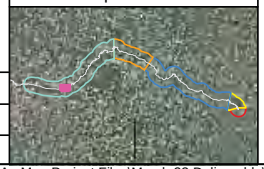
ATTACHMENT D-4



ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

Kalamazoo River near Battle Creek USGS gage daily average discharge: 3,390 cfs

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

N

0 175 350 700
Scale in Feet

FLOODPLAIN GRID: VELOCITY
MAY 28, 2011

MP 35.75 - MP 36.75

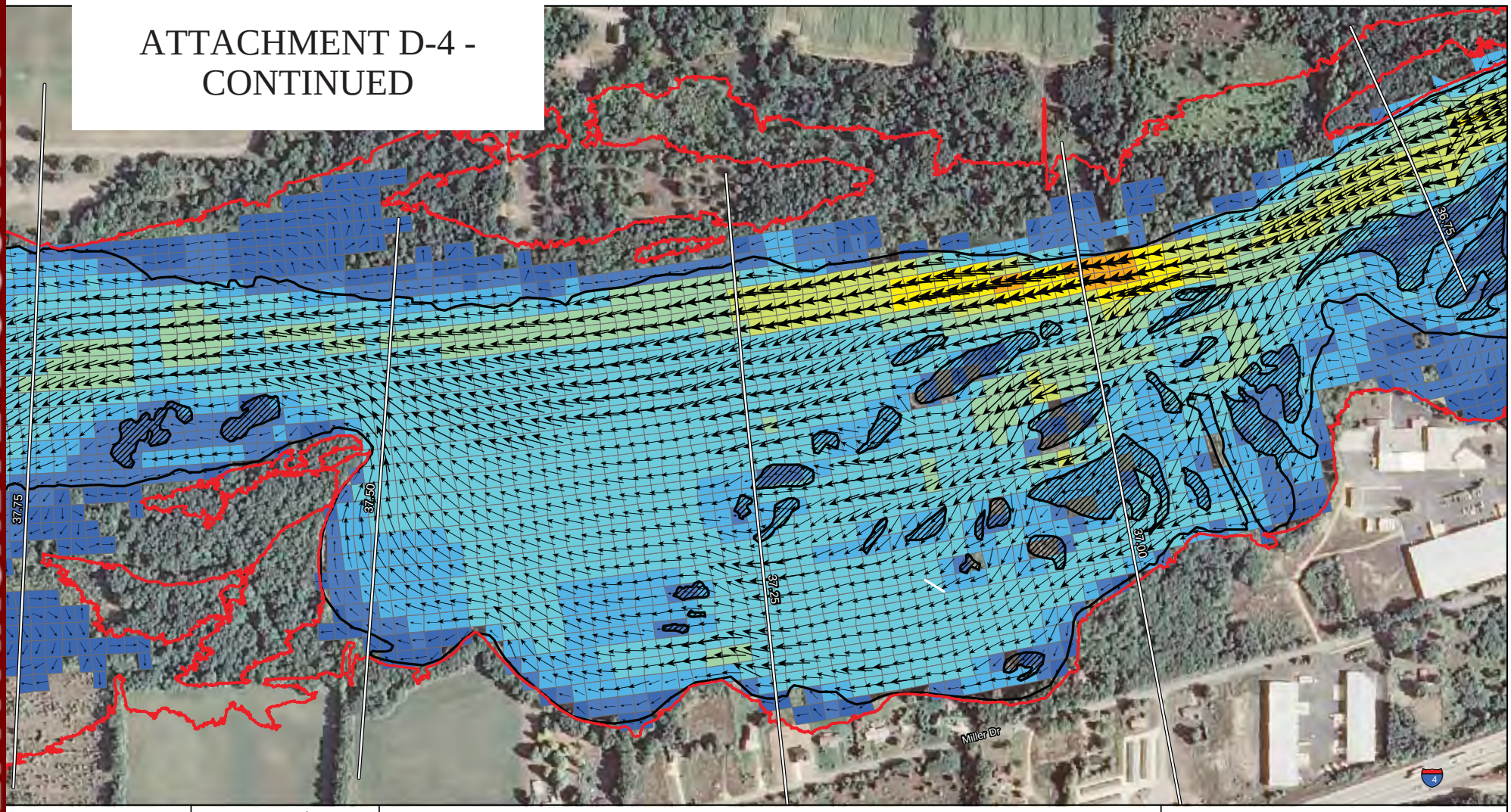
SHEET 40 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Floodplain_Velocity_May28_2011.mxd

Aerial Photography Date: July & August 2009

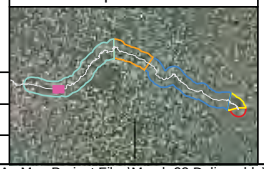
ATTACHMENT D-4 - CONTINUED



ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

Kalamazoo River near Battle Creek USGS gage daily average discharge: 3,390 cfs

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

N

0 175 350 700
Scale in Feet

FLOODPLAIN GRID: VELOCITY
MAY 28, 2011

MP 36.75 - MP 37.75

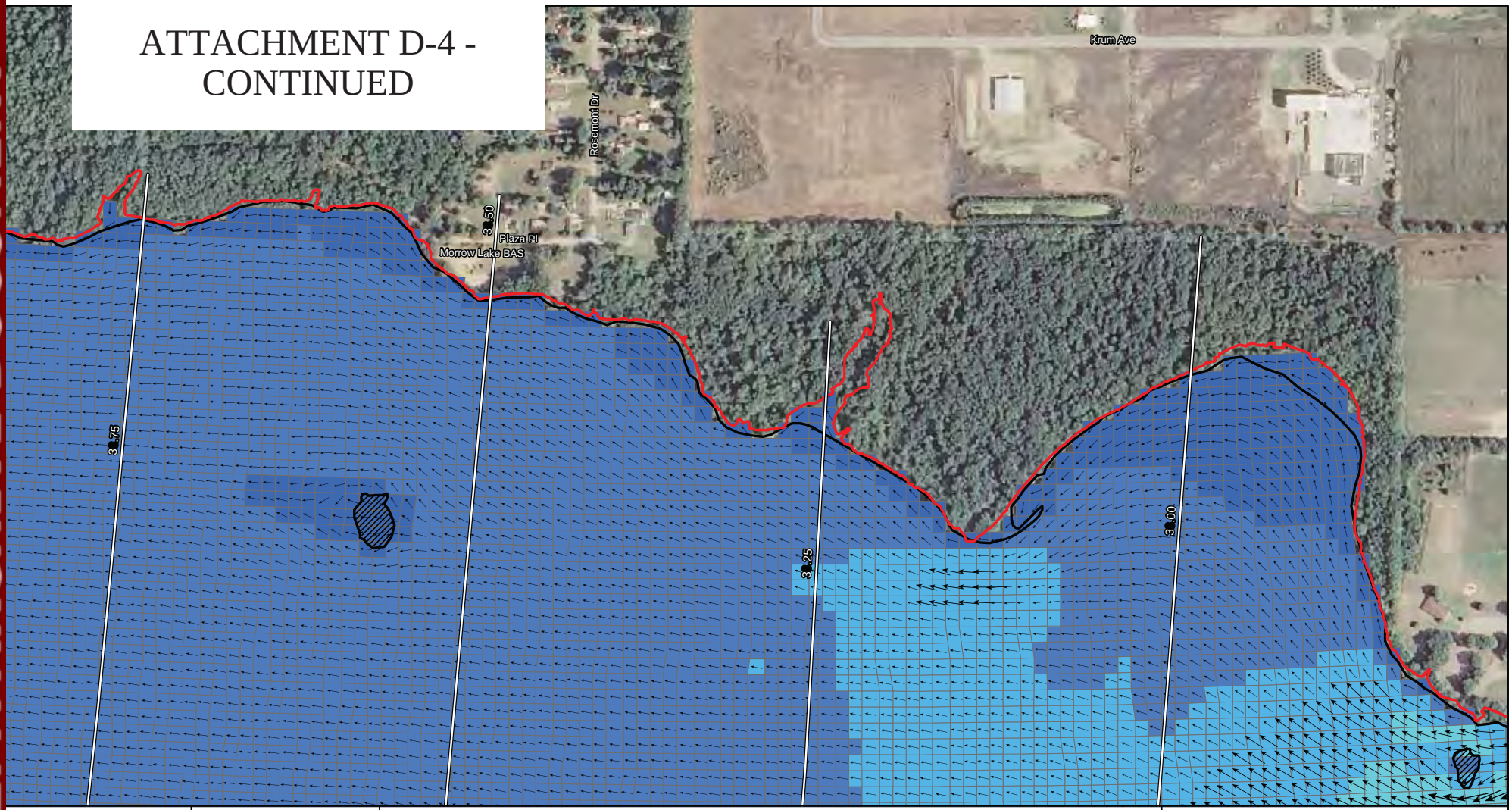
SHEET 41 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Floodplain_Velocity_May28_2011.mxd

Aerial Photography Date: July & August 2009

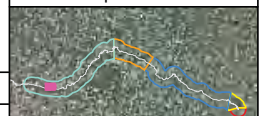
ATTACHMENT D-4 - CONTINUED



ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

Kalamazoo River near Battle Creek USGS gage daily average discharge: 3,390 cfs

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

N

0 175 350 700
Scale in Feet

FLOODPLAIN GRID: VELOCITY
MAY 28, 2011

MP 37.75N - MP 38.80N

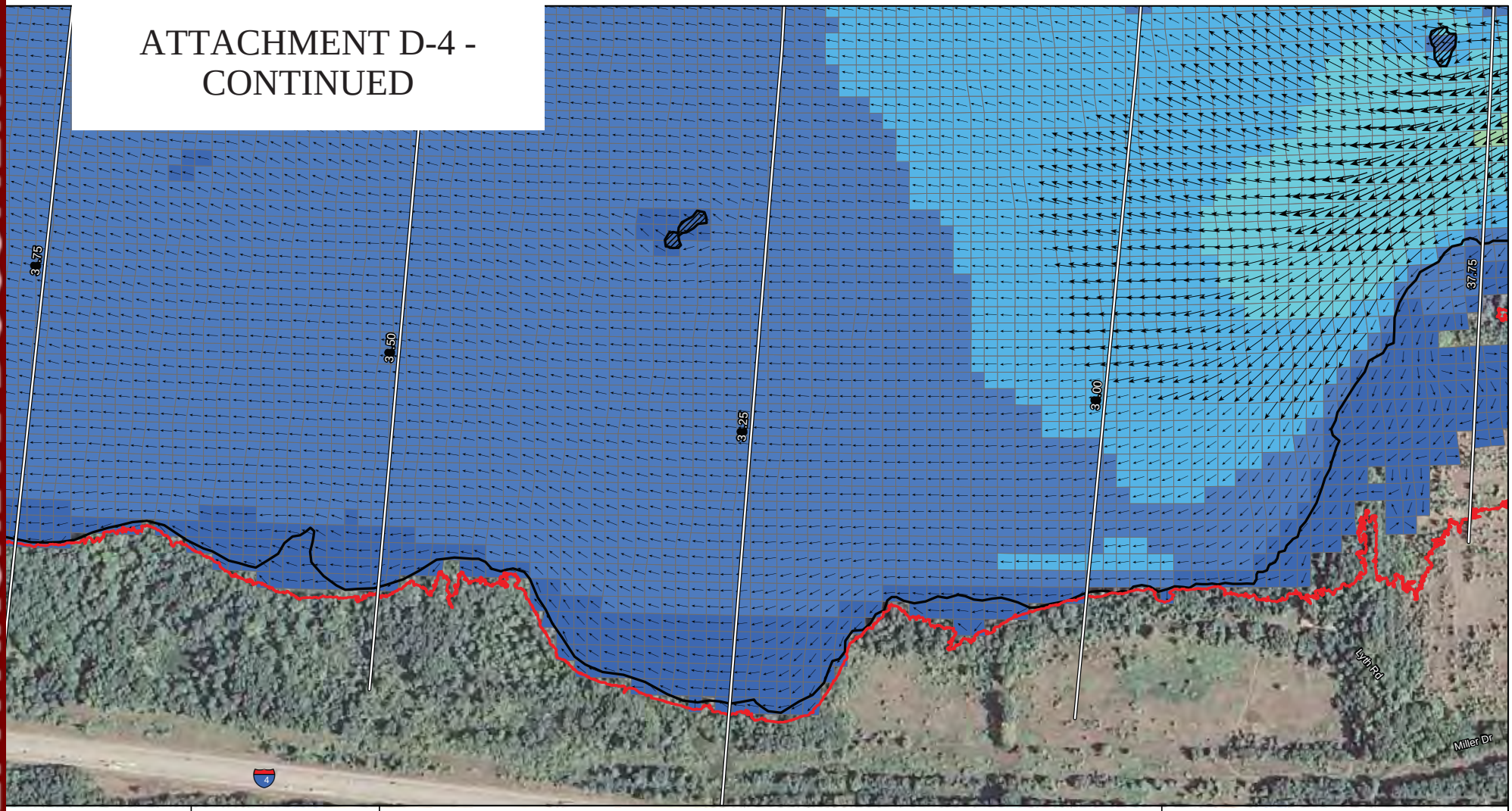
SHEET 42 OF 45

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

X:\Hydrodynamic Model Data Transfer\ArcMap Project Files\March 23 Deliverable\Floodplain_Velocity_May28_2011.mxd

Aerial Photography Date: July & August 2009

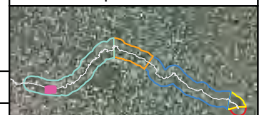
ATTACHMENT D-4 - CONTINUED



ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

Kalamazoo River near Battle Creek USGS gage daily average discharge: 3,390 cfs

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

N

0 175 350 700
Scale in Feet

FLOODPLAIN GRID: VELOCITY
MAY 28, 2011

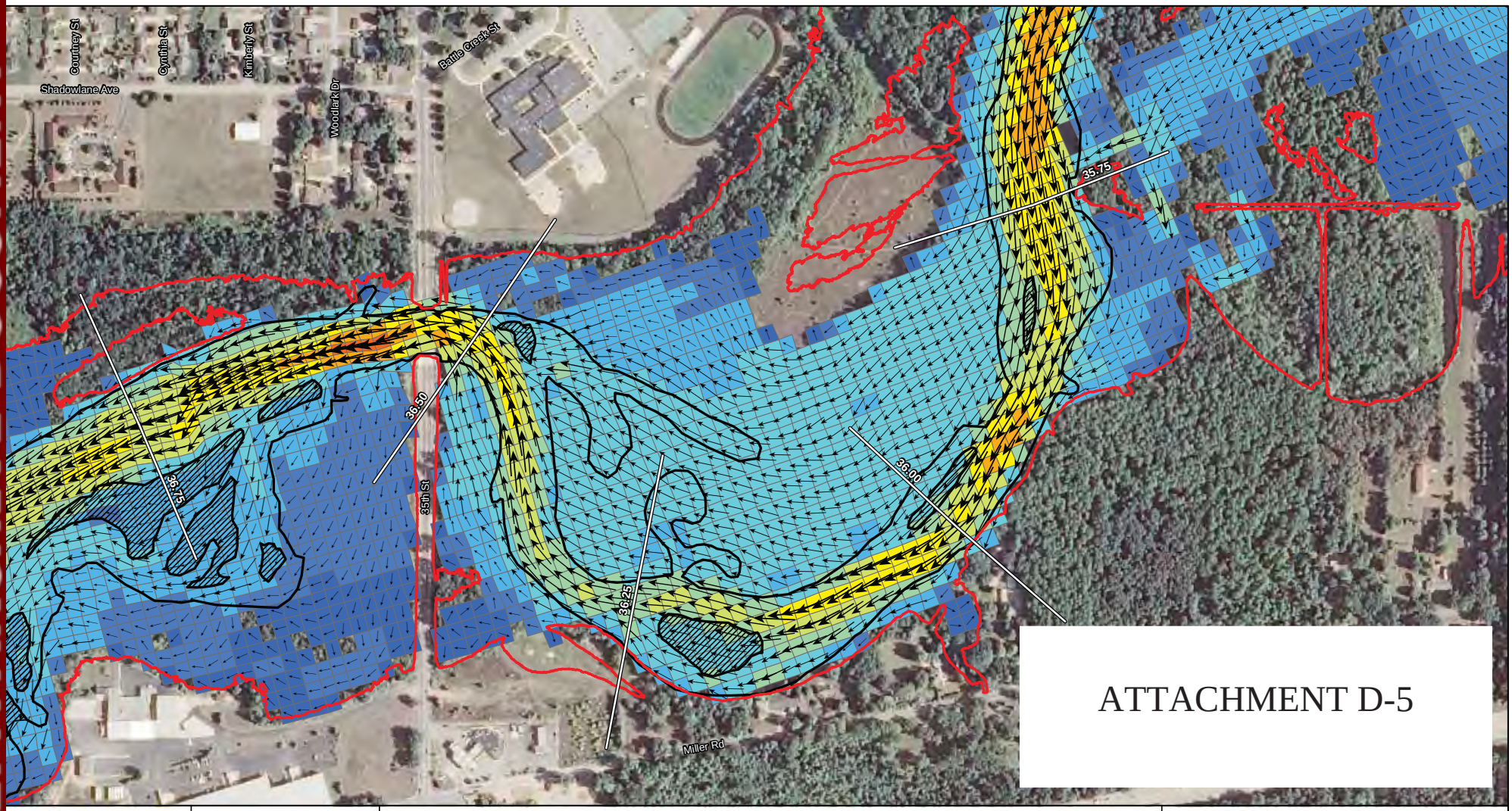
MP 37.75S - MP 38.80S

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\March 23 Deliverable\Floodplain_Velocity_May28_2011.mxd

Aerial Photography Date: July & August 2009

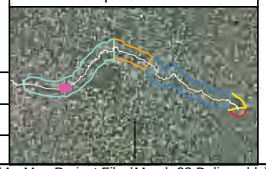


ATTACHMENT D-5

ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

ft/sec = Feet Per Second

N

0 175 350 700

Scale in Feet

FLOODPLAIN GRID: VELOCITY
100-YEAR FLOOD

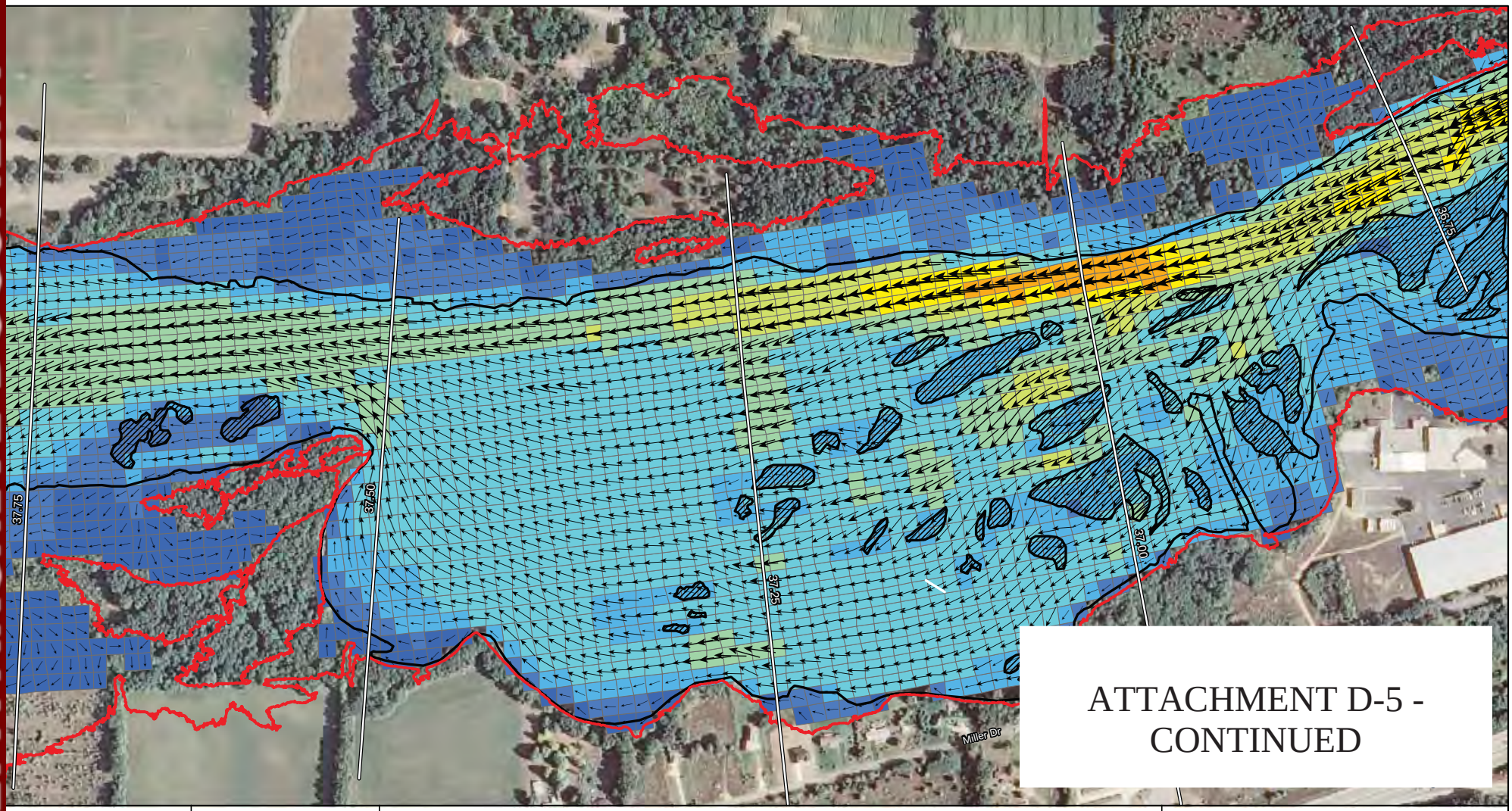
MP 35.75 - MP 36.75

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\March 23 Deliverable\Floodplain_Velocity_100yr.mxd

Aerial Photography Date: July & August 2009

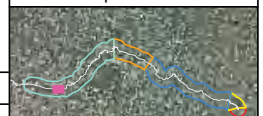


ATTACHMENT D-5 - CONTINUED

ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

ft/sec = Feet Per Second

N

0 175 350 700

Scale in Feet

FLOODPLAIN GRID: VELOCITY
100-YEAR FLOOD

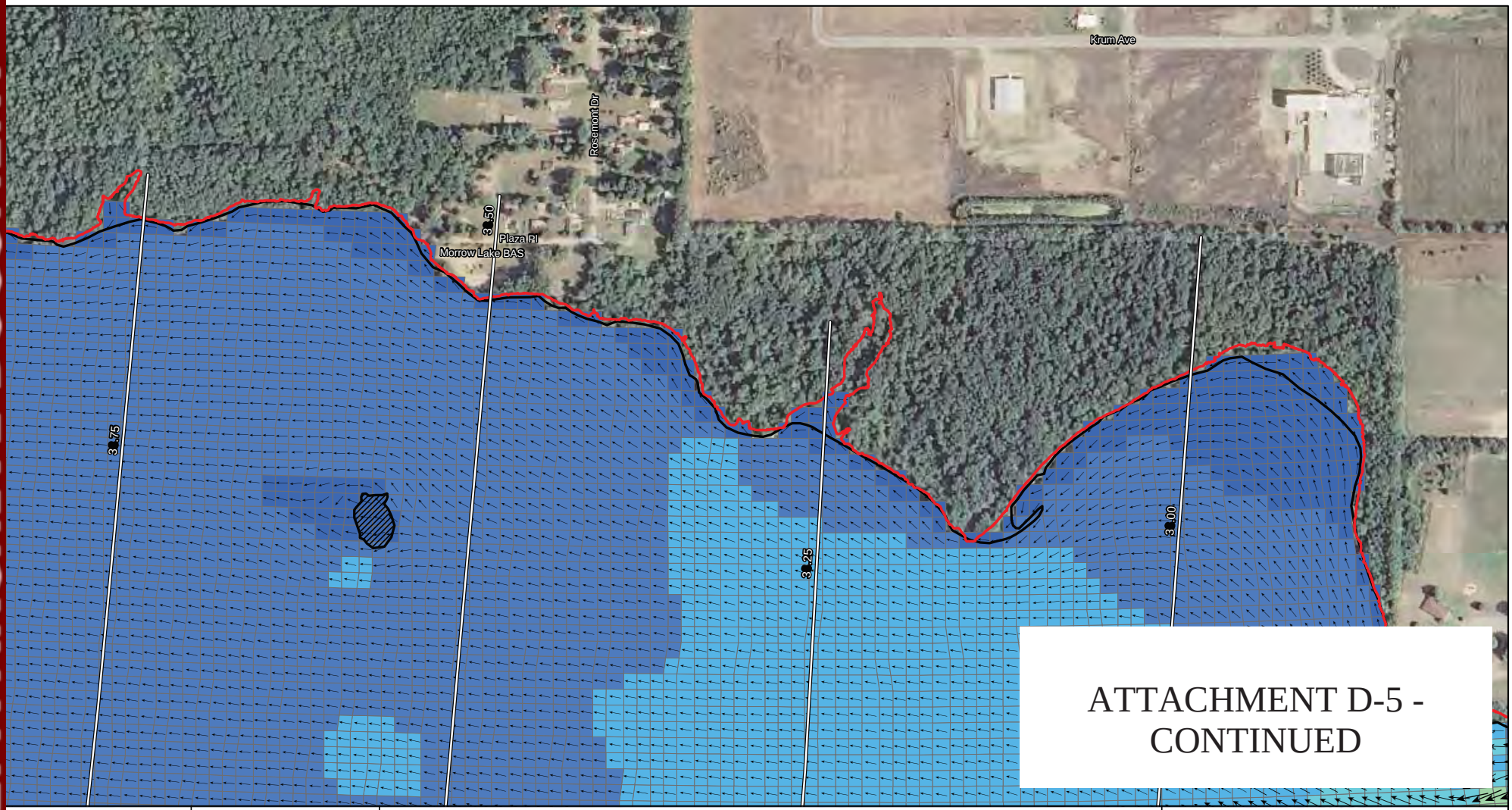
MP 36.75 - MP 37.75

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\March 23 Deliverable\Floodplain_Velocity_100yr.mxd

Aerial Photography Date: July & August 2009

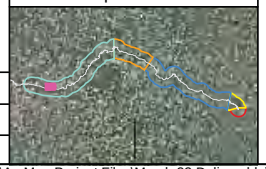


ATTACHMENT D-5 - CONTINUED

ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

ft/sec = Feet Per Second

N

0 175 350 700
Scale in Feet

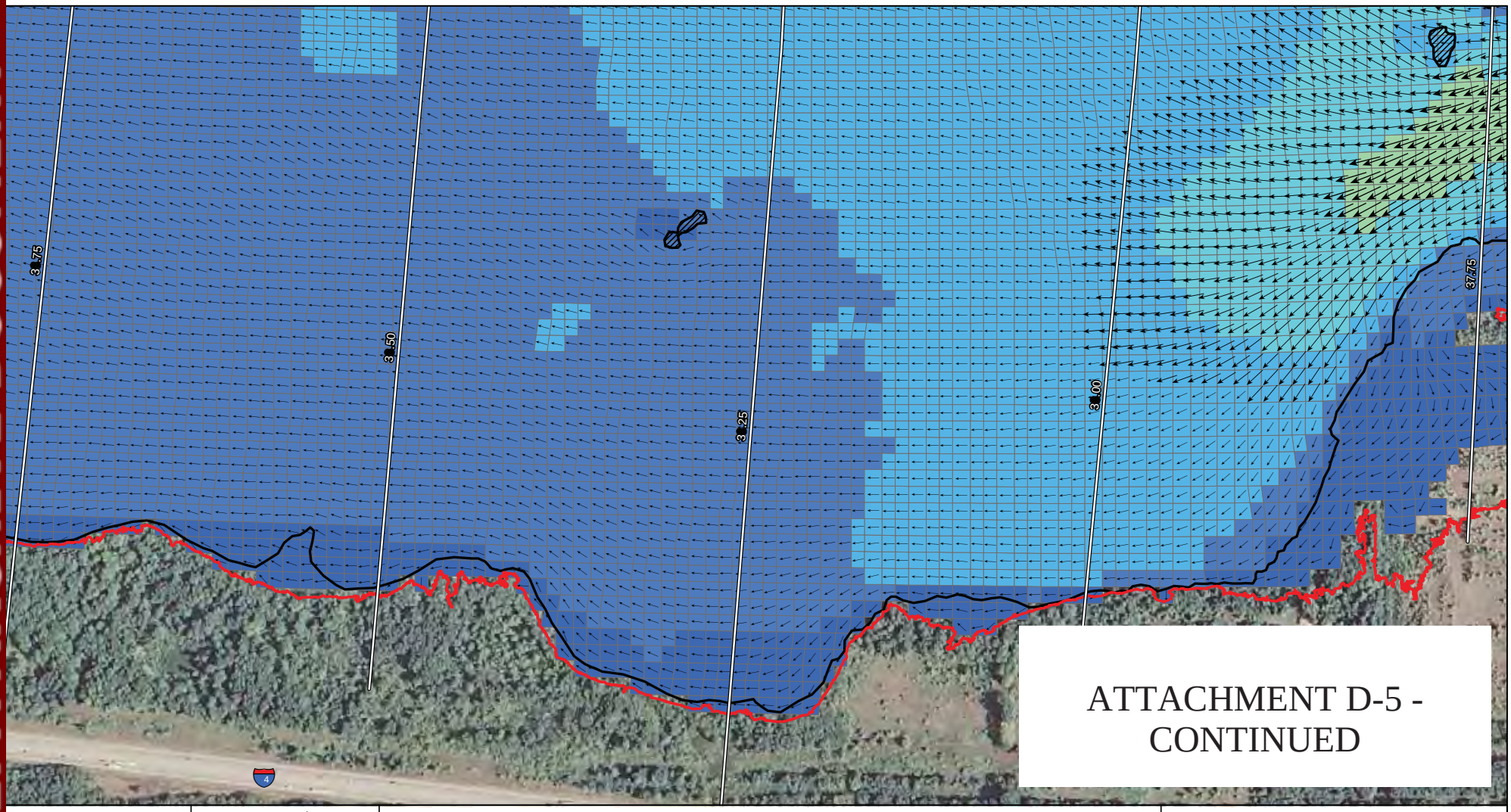
FLOODPLAIN GRID: VELOCITY
100-YEAR FLOOD
MP 37.75N - MP 38.80N

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\March 23 Deliverable\Floodplain_Velocity_100yr.mxd

Aerial Photography Date: July & August 2009

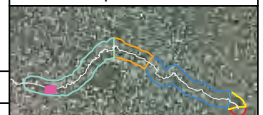


ATTACHMENT D-5 - CONTINUED

ENBRIDGE

Drawn:	BRS 3/23/2012
Approved:	DBR 3/23/2012
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
- Quarter Mile Grid Segment

ft/sec = Feet Per Second

N

0 175 350 700

Scale in Feet

FLOODPLAIN GRID: VELOCITY
100-YEAR FLOOD

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\March 23 Deliverable\Floodplain_Velocity_100yr.mxd

Aerial Photography Date: July & August 2009