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Enbridge Line 5

Straits of Mackinac, MI

Biota Investigation Work Plan

Final Report

Enbridge Energy, Limited Partnership

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LIST OF ACRONYMS

ANOVA	Analysis of variance
AOI	Area of interest
APB	Acid producing bacteria
BIWP	Biota Investigation Work Plan
CP	Cathodic Protection
CSE	Copper Sulfate Electrode
Enbridge	Enbridge Energy, Limited Partnership
EPA	Environmental Protection Agency
ILI	In-line Inspection
mV	Millivolt
ROV	Remotely Operated Vehicle (Camera)
SRB	Sulfate-reducing bacteria
USACE	United States Army Corps of Engineers
VIV	Vortex induced vibration

DEFINITIONS

Area(s) of Interest

An Area of Interest is a part of the pipeline where, based on visual inspection, (i) the normal (local) Biota is unexpectedly absent or (ii) there is evidence of possible coating damage (e.g. Dislodged Coating and/or potential Holiday). Disturbed Areas (see definition below) are not Areas of Interest as the lack of Biota can be attributed to past maintenance and monitoring activities.

Biota

Animals and plants living around and on the pipelines through the Straits (e.g. mussels, periphyton, algae, microbes, etc.)

Calcareous Deposit

A layer consisting of calcium carbonate and other salts deposited on the surface. When the surface is cathodically polarized by cathodic protection, this layer is the result of the increased pH adjacent to the protected surface. This layer functions as a barrier against the corrosive environment, leading to a decrease in cathodic protection current demand and more persistent chemical polarization of the pipe surface.

Disturbed Area

An area on the pipeline where past maintenance and monitoring activities resulted in the removal of Biota but does not represent damage to the pipe coating.

Dislodged Coating

An area on the pipeline where, based on visual inspection, the outer wrap of the coating appears to have been dislodged or removed without exposure of the pipe steel.

Holidays

An area on the pipeline where there is a discontinuity in the coating that exposes the pipe steel to the environment.

Undisturbed Area

An area on the pipeline where there is no evidence of any loss of Biota (or pipe coating).

1.0 Summary

This report presents the findings of the Enbridge Energy, Limited Partnership (Enbridge) investigation into the potential impact of Biota living on and around the two 20-inch diameter pipelines ("Dual Pipelines") that span the Straits of Mackinac ("Straits"). The investigation of potential Biota impacts was undertaken pursuant to paragraph 69 of the Consent Decree entered between Enbridge (including related Enbridge entities) and the U.S Government in Case 1:16-cv-00914, ECF No. 14 filed 05/23/17 W.D. Mich). The work was performed in accordance with Enbridge's Biota Investigation Work Plan ("BIWP") that was approved by the United States Environmental Protection Agency ("EPA") on June 13, 2017. The BIWP is set forth at Appendix A to this report. Appendices B and C to this report set forth addenda to the BIWP. Key findings of this report include:

- Accumulation of mussels and other Biota on the pipelines at the Straits of Mackinac have NOT impacted the integrity of the pipelines' coating or the underlying metal, including areas where coating is damaged or missing;
- The presence of mussels and other Biota on the pipelines at the Straits of Mackinac is NOT creating a corrosive environment at the pipe's surface, nor are they increasing the local levels of bacteria over background levels in the environment; and,
- The mass, volume and texture of biomass is NOT threatening the integrity of either of the Dual Pipelines, including at areas where the pipelines are suspended above the floor of the Straits.

The findings of this investigation suggest that the Biota does not impair or threaten to impair the Dual Pipelines. Further, as indicated in the Engineering Stress Analysis attached as Appendix H to this report, the Biota may have a beneficial effect by reducing VIV concerns.

2.0 Introduction to Biota Work Plan

2.1 Objective

The BIWP collected and analyzed field data (samples and measurements) from and near the Dual Pipelines. Through the data collected and the assessments performed, the effect of the Biota on the Dual Pipelines has been determined.

This report, including the summary of data collected and assessments performed, is intended to fulfill the requirements of Paragraph 69.c of the Consent Decree. Paragraph 69.c requires that Enbridge submit to EPA for approval a final report within 60 days of completion of Enbridge's investigation under the BIWP.

2.2 Background – Related Work Activities in the Straits

2.2.1 2014 Biota Assessment

In late 2014, unrelated to the Consent Decree, an assessment into mussel attachment to the Dual Pipelines was undertaken by Enbridge. This assessment is publically-available and consisted of a literature review followed by the collection and analysis of mussels from the Dual Pipelines [1]. The assessment focused on identifying the dominant mussel populations (i.e., zebra or quagga). It was determined that the mussel communities on the Dual Pipelines were primarily quagga mussels and were attaching to the pipelines in single layers. One coating sample was analyzed for mussel byssal threads and no penetration into the coating was observed.

2.2.2 Biota Investigation Work Plan

Enbridge's BIWP investigation addresses the following specific requirements set forth in paragraph 69.a. These assessments, which have been numbered in this document for consistent referencing, are listed below:

- Assessment 1: "…..assess whether the accumulation of mussels and other Biota have impacted the integrity of the pipelines' coating or the underlying metal, including areas where there are openings or "holidays" in the pipeline coating."
- Assessment 2: "…..evaluate whether the mussels and other Biota are creating a corrosive environment by, among other things, fostering the growth of anaerobic sulfate-reducing bacteria ("SRB") that may cause metal loss."
- Assessment 3: "…..evaluate whether mussels and other Biota are introducing features that may threaten the integrity of either of the Dual Pipelines due to the weight of such

biomass or the pressure caused by current or ice movement around such biomass in areas where the pipelines are suspended above the floor of the Straits."

Proposed locations for surveying and obtaining aquatic Biota samples were determined based upon video-photography from 2014 and 2016 coupled with a literature review of limnological information on the Straits. Based on the visually observable Biota, four distinct zones (depth range) were identified (see Table 1).

The BIWP included provisions for multiple sample locations per zone on each of the Dual Pipelines for principal Biota analysis (characterization, size, mass, bacteria), and additional areas of interest were included to address locations of possible coating damage. Table 2 contains the summary of coating inspection dive locations.

The BIWP (see Appendix A) was approved by the EPA on June 13, 2017. Crews were mobilized in August 2017, and all subsequent analyses were completed by February 28, 2018. This report summarizes all collected data and provides analysis to fulfill the Consent Decree requirements.

Enbridge was supported by several contractors in the completion of this work. Brief descriptions of the role for each of the major contractors are as follows:

- Ballard Marine Construction (BMC) – Dive Manager, Biota Sample Collection by divers, support staff
- Durocher Marine (Durocher) – Tow Barge operation and crane operation
- WSP – BIWP development and implementation, logistics
- GEI – Biologists supporting Biota sampling and performing biological analysis

In addition, the Consent Decree provides for retention of an independent third party (ITP) to verify Enbridge's compliance with the requirements of the Decree, including the BIWP. ITP personnel were on-board the work barge and involved with oversight of all sampling activities under the BIWP.

2.2.2.1 Amendments to the Original Work Scope

Details of the various amendments and reasons for those amendments can be found in the BIWP Addendum A and B, which are attached to this document as Appendices B and C, respectively. The following highlights three specific changes described in these documents.

Enbridge added two (2) additional sites to be reviewed in response to coating damage caused by dive barge operation on August 26, 2017 during execution of the BIWP. The barge anchor hooked an abandoned communication cable, which was subsequently dragged across the East Pipeline. Inspection data from these additional sites are included in this report.

Enbridge engaged an additional consultant to perform microscopy on coating samples obtained from the Dual Pipelines to better address Assessment #1.

Addendum B was submitted to the EPA on December 8, 2017 and was neither approved nor disapproved by EPA. Addendum B advised that Enbridge needed to undertake additional bacteria testing using qPCR ('quantitative polymerase chain reaction') to evaluate the microbiological samples to better address Assessment #2. Additionally, opportunistic samples of sediment from the lake bottom were collected to establish levels of endemic bacteria in the Straits. Data generated from this work is discussed in Section 4.4.

3.0 Assessment #1: Biota Impact on Pipeline Coating and Underlying Metal

Crews were mobilized in August of 2017 to inspect the coating on the Dual Pipelines by using work barges, divers, support teams, and underwater ROV equipped with cameras, which provided live feed and recordings to technicians on-board the support barges. In 2017, a total of 23 coating inspection locations (i.e., 18 Areas of Interest (AOI) and 5 additional sites) associated with the BIWP have been examined by divers to gather information regarding the condition of the coating, to collect cathodic protection readings at holidays, and to examine, characterize and sample Biota present on the pipelines.

3.1 Coating Inspection

Refer to Appendix D to this report for the coating inspection forms associated with this study. As noted in Table 2**Error! Reference source not found.**, bare metal (0.01 ft.^{2}) was identified by diver inspection at EAS-1. Sites EAS-3 and EAS-4 were not included in the original BIWP submitted to the EPA. These two locations were added to the Work Plan due to the mechanical damage caused to the coating by a communication cable during the execution of the 2017 BIWP. The bare metal at EAS-3 and EAS-4 comprises 99.6 % (2.57 ft.^{2}) of the total bare metal as-found at the BIWP locations.

In addition, calcareous deposits were observed at six (6) of the BIWP locations as shown in Table 2. Calcareous deposits are known in pipeline and other industries to be a byproduct of the cathodic protection of steel surfaces in marine environments. A representative photograph of a calcareous deposit is shown in Figure 1. The deposits are a demonstration that the cathodic protection current is effectively protecting the steel and, as the deposit builds, it serves as an additional protective layer on the steel.

Calcareous deposits discovered as part of the BIWP were removed to confirm the condition of the pipe beneath them (see Sections 3.3 and 3.4). Table 3 shows the summary of BIWP coating repairs at all identified bare metal locations. As previously reported to the EPA on December 19, 2017, coating repairs were completed at all BIWP locations with exception of EAS-4 (1.64 ft^2), which will be repaired in 2018.

3.2 Biota Impact on Coating

3.2.1 Coating Thickness Measurements

All the AOI locations identified in the BIWP were inspected and the coating thickness readings were measured to assess the condition of the coating. In total, 360 coating thickness readings were obtained during the diver inspections at the AOI locations. More than a third of these measurements were collected at the feature of interest at each dive, to represent areas where the normal (local) Biota is unexpectedly absent or there is evidence of possible coating damage (e.g. dislodged coating and/or potential holiday). Another set of measurements were obtained in close proximity to these features (i.e., undisturbed area within 2 inches), to characterize gradation in coating condition between the AOI and adjacent coating. A final set of coating measurements were obtained from each dive location at an undisturbed areas at least 5 feet from the AOI, and these were used to characterize 'typical undamaged coating' on that pipe joint. The coating thickness measurements are summarized in Table 4 and are based on the information from the inspection forms in Appendix D. The average coating thickness along with the 99% confidence intervals were found to be comparable between the measurement locations:

- Area of Interest: 125 ± 6 mils,
- Undisturbed Area within 2 inches: 122 ± 8 mils, and
- Undisturbed Area at 5 feet: 118 ± 6 mils

Error! Reference source not found. shows the distribution of the thickness measurements and provides a visual comparison between the three measurement locations. The measurements collected from the BIWP suggest that the majority of the AOI locations have intact coating and are not Dislodged Coating or Holidays. As mentioned in Section 3.1, three (3) dive sites presented exposed metal in the as-found condition (EAS 1, EAS-3 and EAS-4). EAS-3 and EAS-4 were created by abrasion that occurred when an abandoned communications cable was hooked by a dive barge anchor on August 26, 2017, during execution of the BIWP. EAS-1 presented a small coating defect with bare metal observed, as well as areas covered by a calcareous deposit.

3.2.2 Visual Examination of Coating

A substantial amount of Biota was removed from the pipe surface in the course of the BIWP. In general, the Biota could be easily dislodged using the diver's gloved hands. No visually detectable coating damage was observed before or after the Biota clearing activities.

Sampling of dislodged outer wrap of the coating was performed at five (5) locations. Microscopic examination of selected samples demonstrated that the mussels byssal filaments adhere firmly to the exterior surface of the coating and do not penetrate into the coating itself (refer to Appendix F for the detailed analysis completed by GEI Consultants).

3.3 Visual Inspection for Corrosion Metal Loss

No external corrosion metal loss was observed by the divers at any of the locations inspected. Moreover, it was confirmed by direct diver inspection that no corrosion metal loss had occurred at any location where the calcareous deposits were removed and bare pipe revealed, including the circumferential weld location at EAS-1. The results of the diver's observations are consistent with historical inline inspection ("ILI") results. The most recent ILI was conducted in 2017 and an additional ILI tool run is scheduled for early 2018. The 2017 results provide evidence that corrosion is being effectively managed through the combination of the protective coating, cathodic protection, and associated integrity management activities.

3.4 Pipe Wall Thickness Measurements

Separate and independent of the BIWP, pipe wall thickness measurements were taken at various locations on the Dual Pipelines. In 2017, a total of 348 measurements were taken at coating repair locations after cleaning the area of any adherent material.

An underwater ultrasonic thickness ("UT") gauge was utilized to measure the pipe wall thicknesses. The average of the pipe wall thickness measurements was 0.814 ± 0.023 inches (99% confidence level). The minimum wall thickness measurement was 0.754 inches, well above the American Petroleum Institute API 5L Specification for Line Pipe minimum acceptance, which states that the wall thickness tolerances for 0.812 inch (nominal thickness) seamless pipe is from 0.711 to 0.934 inches. The pipe wall thicknesses exceeds both the original version of API 5L used for design and construction, as well as the current (more stringent) version of API 5L. Figure 3 provides a summary of the Line 5 wall thickness variation for the East and West segments and evidences that the wall thickness variation is within the tolerances stated in the API 5L Specification for Line Pipe. These results are consistent with the results obtained by the in-line inspection tool.

3.5 Cathodic Protection Measurements

3.5.1 Background

CP is an electrochemical method of preventing corrosion of metal structures exposed to aqueous environments. CP is a well-established process that has been used to protect pipelines in soil and water for over 100 years. While it is possible to meet the objective of preventing corrosion using CP or coating systems singly, it is more effective and reliable to use them together. The coating system provides a primary barrier between the steel and the environment and also substantially reduces the amount of metal requiring CP – making the application of cathodic protection simpler and more efficient. The CP systems are installed to ensure that corrosion is prevented where there are imperfections in the coating system which may have been caused during construction or subsequent events. The Dual Pipelines were designed to be protected using both an external coating system and cathodic protection. The enamel corrosion barrier applied to the dual pipelines was the best available at the time of construction and is viewed to be an effective corrosion barrier still by today's standards [2].

Enbridge monitors and maintains the CP system protecting the Dual Pipelines through the Straits in accordance with industry best practices and regulatory requirements. Routine monitoring activities presently include annual collection and evaluation of pipe-to-soil potential measurements on each side of the Straits, and continuous remote monitoring of the Enbridge owned impressed current sources affecting the dual pipelines. Over time and as the need arises, the current output of the CP systems are adjusted to maintain protection levels; and the consumable anode beds are upgraded when needed.

3.5.2 Calcareous Deposits

Calcareous deposits are a well-known byproduct of CP in scaling water and soil environments. Such deposits form when application of CP drive electrochemical reactions at the pipe surface that increase the alkalinity of the structure-environment interface. The increase of pH is both a result of the CP current, and the cause of chemical polarization that is observed during structure-to-soil potential surveys [3].

Corrosion rates for carbon steel are significantly reduced at pH values associated with the application of effective CP and the development of calcium and magnesium carbonate at the pipe surface. This is further substantiated through the ILI results and direct diver observations that indicate no external metal loss anomalies in Dual Pipelines.

3.5.3 Cathodic Protection Findings

A total of 382 pipe-to-water CP measurements were recorded during the BIWP. Enbridge employed a criterion of -600mV CSE as an initial indicator of possible bare metal. This criterion was established in consideration of the guidance provided in the Polatrak CP Gun operating manual, the half-cell potential difference between Ag-AgCl and CSE reference cells, and dive logistics.

These measurements are evaluated in consideration of other CP readings in the area when making the determination of metal exposure. Summary results from each site, including major findings where applicable, are presented in Table 5: Summary of CP Measurements from BIWP. The full complement of CP data including detailed discussion of each dive's readings is provided in Appendix E.

Cathodic protection potentials recorded during the BIWP dive inspections generally exhibited substantial availability of cathodic protection current – as indicated by current applied 'ON' CP readings. The average of all 'ON' readings was -1328 mV CSE, which is approximately 700mV more electronegative than the expected native potential of steel in freshwater. Moderate to high levels of cathodic polarization were also observed in the majority of data – as indicated by the current interrupted 'OFF' CP readings. The average of all 'OFF' readings was -940 mV CSE, which exceeds the requirements of industry best practice [4] and applicable regulations [5].

The WAS-1 dive site was one of the earliest investigations where substantial calcareous deposit accumulation was observed. Additional CP readings were obtained prior to deposit removal to establish cathodic protection levels in the as-found (undisturbed) condition. This was accomplished by applying substantial force and a grinding action between the CP gun tip to penetrate the deposit and obtain the metal contact necessary to obtain CP potential measurements. These data indicated a reduction in cathodic protection levels of nearly 100mV after the deposits were removed. This underscores the protective nature of the intact deposits and highlights the advantage of keeping such deposits intact during future CP surveys. It is also noted that the divers detected no corrosion metal loss at any dive; this demonstrates that the cathodic protection being received by the Dual Pipelines has been entirely successful at preventing external corrosion metal loss and that Biota have not affected the pipe surface including at areas where there are openings in the pipe coating.

3.5.4 Correlation of CP Readings with ILI Data

Neither Enbridge's most recent metal loss ILI nor the Cathodic Protection Current Mapping (CPCM) ILI identified any corrosion features or cathodic protection anomalies for correlating with the underwater CP readings obtained during the diver investigations as part of section 3.2.1 of the BIWP.

3.6 Assessment #1 Conclusions

Coating samples obtained from the Dual Pipelines indicate that the Biota, including the mussels, are simply attached to the surface of the coating and are not impacting the coating integrity or performance. Pipe observations and data collected during the BIWP indicate that any external coating damage is unrelated to the Biota.

The Dual Pipelines are free of detectable metal loss based on the most recent ILI and the BIWP diver examinations. The absence of external corrosion metal loss at coating defects demonstrates that the Biota are not affecting the integrity of the exposed metal and that the cathodic protection applied to the pipelines is effective. The absence of detectable metal loss using ILI further confirms that the Biota are not affecting the integrity of the underlying pipe metal through the coating.

There is no evidence to suggest that the presence of mussels and other Biota are affecting the integrity of the pipeline coating or underlying metal (including at coating defects or holidays).

4.0 Assessment #2: Biota Impact on Corrosion Threat

Assessment #2 requires that Enbridge address the question of whether Biota '… are creating a corrosive environment…'. As discussed in Section 3.0, no external corrosion metal loss has been identified on either of the Dual Pipelines through the Straits of Mackinac by ILI, diver observation, or manual wall thickness measurements.

This section explores whether microorganisms attached to the coating protecting the pipe are more, less, or equivalently populous to the macro environment in the Straits and to determine if the mussels have the potential to create a uniquely corrosive environment at the pipe coating.

4.1 Background

Biota samples were obtained at seven (7) locations in accordance with the EPA-approved BIWP. In addition, opportunistic sampling of Biota was performed at nine (9) additional locations.

4.2 Direct Attachment of Biota to Pipe Metal

Although there was an abundance of Biota (mussels, periphyton) observed on the external surface of the pipe coating, no incidences of direct metal attachment was observed. This observation suggests that the cathodic protection system may render the pipe metal surface inhospitable to Biota attachment.

4.3 Presence/Absence Bacteria Testing

84 samples were evaluated for SRB and APB populations using the Biosan Laboratories culturing test kits. GEI Consultants was retained by Enbridge to conduct and interpret these test results (see full report in Appendix F).

According to the BioSan culture interpretation rubric, "Strong" levels of APB acid production and "Heavy" amounts of SRB sulphate reducer growth were observed at every BIWP dive site. Similarly, a sample of white deposit and an opportunistic sample of Dislodged Coating found near the Dual Pipelines also indicated "Strong" APB production and "Heavy" SRB sulphate reducer growth. This data indicates that the environment in the Straits is conducive to formation of sessile (stationary) biofilms containing these organisms.

However, it was also noted that bacterial cultures prepared from equipment blanks (controls), tap water, lake water, and distilled water also produced high levels of APB (ranging from "Moderate" to "Strong"). Email communication between BioSan and GEI on September 13th, 2017, noted that "…positive APB results can be observed in water that may contain microorganisms and that

common environmental organisms such as Bacillus can produce a large amount of acid. One of these organisms in 100 ml has the potential to produce a color change in our Sani-Check APB Test Kit in 1-2 days. This is why the interpretation chart is based on the amount of acid production and not the amount of APB. Not all APB produce the same amount of acid."

In order to explore this issue further, GEI engaged a company specializing in bacteria identification and enumeration using genetic analysis by quantitative polymerase chain reaction (qPCR).

4.4 qPCR Genetic Bacterial Enumeration

Microbial Insights performed qPCR testing of alcohol preserved Biota samples. The "Census™" Analysis specifically targets a variety of APB and SRB organisms associated with biodegradation of environmental pollutants (many of which utilize similar metabolic pathways as bacteria associated with microbiologically influenced corrosion). These test results are discussed in detail in the enclosed GEI report (Appendix F),

In addition to pipe surface Biota testing, this series of tests included lake bed sediment for comparison of sessile populations and to address whether the Biota on the pipe are uniquely active.

Based on Microbial Insights database of over 40,000 natural environments, the presence of APB and SRB in the samples collected from the Dual Pipelines generally falls within typical ranges (the middle two quartiles of the database). In comparison to lake water, the bacteria on surfaces where Biota was attached to the pipe coating is several orders of magnitude more abundant. This is a typical relationship between planktonic (swimming) and sessile (surface attached) biofilms. However, the population of bacteria in lake bed sediment was an order of magnitude higher than the pipe surface attached Biota, indicating that the presence of Biota are not creating a more hospitable environment for bacteria on the pipe surface relative to the surrounding lake bed sediment.

4.5 Assessment #2 Conclusions

The presence of Biota on the Dual Pipelines combined with the observed absence of external corrosion metal loss through any form of inspection (ILI or dive) on the Dual Pipelines demonstrates that the Biota attached to the pipe coating have not created a corrosive environment at the pipe surface.

Biota samples collected and analyzed during the BIWP indicate that populations of bacteria associated with Biota at the surface of the pipe are lower than the level of bacteria found in bottom sediment samples representing the macro environment in the Straits.

There is no evidence that the presence of Biota (mussels and periphyton) is creating a more hospitable environment for microorganisms that could impact corrosion of metal.

5.0 Assessment #3: Biota Impact on Structural Integrity of Dual Pipelines

5.1 Introduction to the Structural Integrity Analysis

To support the BIWP, Kiefner and Associates (Kiefner) was retained to perform a structural integrity analysis to evaluate whether mussels and other Biota are introducing features that may threaten the integrity of either of the Dual pipelines in areas where the pipelines are suspended above the floor of the Straits (spans). In performing the stress analysis of the spans, Kiefner referred to ASME B31.4 [6] Chapter IX "Offshore Liquid Pipeline Systems" to determine the allowable stress limit of the free spans. In performing the vortex induced vibration (VIV) assessment of the spans, Kiefner referred to the methodology in the June, 2017 edition of DNV-RP-F105 [7] Free Spanning Pipelines. To ensure a conservative assessment, VIV avoidance criteria was used to evaluate the maximum span length including suitable safety factors where VIV would not occur. The Biota data collected by the BIWP was used in the stress analysis and VIV assessment.

Sensitivity analysis on the Biota thickness was also performed to study the effect of Biota mass on the stress and VIV. In addition, the pipeline weight (with varying products, natural gas liquid and light crude), internal pressure, pipeline diameter and wall thickness, pipe steel grade and pipe coating were also included in the stress and VIV assessments.

5.2 Biota Mass Density and Thickness

The potential for Biota encrustation to impact the structural integrity of the Dual Pipelines was addressed in part by evaluating the increase in cross sectional area. Pipe circumference measurements (over Biota, and again after Biota was removed) were evaluated to determine typical encrustation thickness within the different depth range zones (see Table 1) for use in analysis of forces imparted by moving water current.

Based on the lab testing results, the average (mean) thickness of Biota was calculated at these sites using the circumference measurements and ranged from ~0.45" – 1.00" (1.15 – 2.53 cm) thick. For zones B, C, and D, the average (mean) thickness of Biota ranged from ~0.45" – 0.716" (1.15 – 1.82 cm). For the purposes of the structural analysis, Biota thicknesses up to 6" were studied (with 1" used as the maximum from measured biota thickness).

The Biota mass density used in the analysis was 1350 kg/m^3 (about 1.35 times denser than water) per DNV-RP-C205-2014 [8].

5.3 Engineering Analysis Results

According to the Kiefner report, thickness of Biota affects the results in two ways: first it increases the drag force; and second it increases pipe weight. A comparison between the longitudinal stresses for pipe with no biota and the longitudinal stresses for pipe with 6-inch thick biota shows that the differences are insignificant relative to the material specified minimum yield strength (SMYS). At water velocities equal to or less than 3.44 ft/sec (the extreme water velocity determined by Kiefner to have a 1% annual probability of exceedance) the difference in the longitudinal stress due to Biota thickness is less than 1% SMYS. The insensitivity of the longitudinal stress to Biota thickness is because the longitudinal stress is dominated by the compression from the differential temperature and bending stress from the pipe and product weight."

The Kiefner report further states, "Water velocity, along with the span length, are the two primary factors which control stresses in the free span from gravity and drag forces, as well as the VIV characteristics of the pipeline". Note that the drag forces are equivalent to the pressure caused by the current.

Kiefner calculated the maximum span lengths for single span case based on the avoidance criteria for cross flow and inline VIV per DNVGL-RP-F105 [7]. Modal finite element analysis (FEA) approach was used to assess continuous span cases. Based on the assessment, with two or more continuous spans, the pipelines may potentially violate the inline avoidance criterion, while they meet the cross flow avoidance criterion. Based on Kiefner Inline fatigue assessments conducted for assessing 100-year cumulative fatigue damage for continuous spans, the 100-year cumulative fatigue damage in the pipelines was negligible for one through four continuous spans, each 75 feet long. An increase in the number of spans is not expected to change the results significantly because the frequency of vibration becomes insensitive to the number of span beyond four. In addition to meeting all easement requirements, the lengths of all existing spans in the Straits are less than the maximum span lengths calculated by Kiefner. Furthermore, Enbridge will install additional anchors in 2018 which will further reduce the span lengths. Therefore, the Kiefner study is conservative.

The sensitivity analysis contained within the Kiefner report shows the effect of several parameters. Variations in Biota thickness up to 6 inches on multiple continuous spans created by installing screw anchor supports are not expected to affect the stresses by more than 5% SMYS. Biota was also found to lower the vibration frequency of the pipelines by increasing their mass. However, the effect of a reduction in the frequency was more or less offset by the increase in VIV onset velocity. Overall, the Keifner study concluded that Biota thickness of up to 6 inches did not affect the maximum span length in terms of VIV avoidance. As noted in Section 5.2 of this report, the maximum Biota thickness at the studied sites was no more than 1 inch.

Kiefner also considered the potential impact of ice on the biota mass and the pipeline at areas of free spans. Given that the exposed portions of the pipeline are deeper than 65 feet, and ice buildup in the Straits does not exceed 65 feet, Kiefner concluded that ice is not considered to be a threat to the exposed pipelines in the Straits crossing.

According to the Kiefner report, the presence of Biota is expected to reduce the likelihood and intensity of VIV because of the uneven and non-uniform surface texture. In order for VIV lock-in to occur vortices should shed at the same frequency along a significant portion of the pipeline as determined by the mode shape of a participating vibration. Unevenness of the pipe surface is expected to make this much less likely as compared to a smooth pipe, first because it causes turbulence which tends to make the shedding aperiodic, and second because the conditions of the pipe surface vary along the length, making it less likely that vortices shed in harmony along a long portion of the pipelines. However, since the effect of surface roughness due to Biota is difficult to quantify, it was ignored in the assessment.

5.4 Assessment #3 Conclusions

Kiefner's analysis of the impact of Biota on the structural integrity demonstrated that the thickness and weight of the biomass are not significant factors impacting the integrity of the Dual Pipelines.

For single span cases, spans with length equal to or shorter than 87 feet with up to 6-inch biota will not experience VIV when exposed to the extreme water velocity.

For continuous span (multiple consecutive spans) cases, negligible fatigue damage is anticipated where individual free span length is limited to 75 feet with up to 6-inch biota.

The presence of Biota is expected to reduce the likelihood and intensity of VIV because of the uneven and non-uniform surface texture. This was not quantified in the assessment, but the effect can be considered as an added safety factor to the assessment results.

6.0 Conclusions

The following conclusions have been reached based on the BIWP assessments performed:

- Assessment #1: The accumulation of mussels and/or other Biota are not causing coating deterioration or other harmful effects to the Dual Pipelines. The mussels byssal filaments adhere tenaciously to the surface of the coating, but no coating penetration was found. Average coating thickness measurements for the AOI, Undisturbed Area (< 2 in), and Undisturbed (> 5 ft) were 125 ± 6 mils, 122 ± 8 mils, and 118 ± 6 mils, respectively. The Biota is only attaching itself to the outer layer of the coating without damaging it.
- Assessment #2: The accumulation of mussels and/or other Biota are not creating a corrosive environment by, among other things, fostering the growth of anaerobic SRB that may cause metal loss. SRB and APB field testing showed uniform indications of the bacteria on the various surfaces tested whether or not Biota was present. The presence of the bacteria, regardless of the source, represents a risk factor for microbiologically influenced corrosion. However, this risk factor is adequately mitigated by the external coating and CP system installed on the pipe. The lack of external corrosion indicates that the pipe itself is not experiencing a corrosive environment.
- Assessment #3: In the areas where the pipelines are suspended above the lake floor, the structural integrity assessment shows that the presence of Biota on the Dual Pipelines has little impact on maximum span lengths (considering operating loads, drag forces, buoyant weight, and VIV). Furthermore, the assessment also showed that with the current span lengths and water flow rates, VIV is not expected to have any adverse effects on the structural integrity of the pipelines. Mussels and other Biota are not introducing features that may threaten the integrity of either of the Dual Pipelines due to the weight of such biomass or the pressure caused by current or ice movement around such biomass in areas where the pipelines are suspended above the floor of the Straits.

7.0 References

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7. DNV.GL-RP-F105, "Free spanning pipelines," DNV.GL, June 2017.

8. DNV-RP-C205, "Environmental Conditions and Environmental Loads," DNV.GL, April 2014.

Tables

Table 1: Biota Zoning Characteristics

Designation	Depth Range	Periphyton	Quagga Mussels
Zone A	50-100 ft	Most abundant	Present
Zone B	100-150 ft	Moderately abundant	Moderately abundant
Zone C	150-200 ft	Sparse	Most abundant
Zone D	<200 ft	Negligible	Abundant

Table 2: Diver Inspection Results at BIWP Locations

Location	Longitude	Latitude	Description	Area of Bare Metal As-Found (ft^2)	Area of Bare Metal Created by Calcareous Deposit Removal (ft^2)	Area of Calcareous Deposit remaining (ft^2)
EAOI-1	[redacted]		Area of Interest	-	0.03	-
EAOI-2			Area of Interest	-	-	-
EAOI-3			Area of Interest	-	-	-
EAOI-4			Area of Interest	-	-	-
EAOI-5			Area of Interest	-	0.01	-
EAOI-6			Area of Interest	-	-	-
EAOI-7			Area of Interest	-	6.18	-
EAOI-8			Area of Interest	-	-	-
EAOI-9			Area of Interest	-	-	-
EAOI-10			Area of Interest	-	-	-
EAOI-11			Area of Interest	-	-	-
EAS-1			Additional Site	0.01	0.88	-
EAS-2			Additional Site	-	0.14	-
EAS-3			Additional Site	0.93	-	-
EAS-4			Additional Site	1.64	-	-
WAOI-1			Area of Interest	-	-	-
WAOI-2			Area of Interest	-	-	-
WAOI-3			Area of Interest	-	-	-
WAOI-4			Area of Interest	-	-	-
WAOI-5			Area of Interest	-	-	-
WAOI-6			Area of Interest	-	-	-
WAOI-7			Area of Interest	-	-	-
WAS-1			Additional Site	-	0.40	-

Table 3: Summary of BIWP Coating Repairs at Bare Metal Locations

Location	Coating Repairs Completed	Area Of Bare Metal Remaining (ft^2)
EAOI-1	Yes	0
EAOI-5	Yes	0
EAOI-7	Yes	0
EAS-1	Yes	0
EAS-2	Yes	0
EAS-3	Yes	0
EAS-4	To be completed 2018	1.64
WAS-1	Yes	0
	Total	1.64

Note: Data is extracted from coating repair forms included in Appendix G.

Table 4. Summary of the Coating Thickness Measurements at Areas of Interest

Coating Thickness (mil)																			
Area of Interest							Undisturbed Area (> 5 ft)							Undisturbed Area (< 2 in)					
126	109	131	119	105	136		119	128	141	120	115	116		123	119	110	100	135	123
115	135	120	105	100	135		105	120	105	100	110	130		95	130	110	105	130	130
83	112	190	84	89	120		90	108	124	110	104	88		210	120	225	88	95	116
160	180	115	180	180	125		84	115	125	100	110	100		180	170	115	170	100	104
205	202	115	94	105	96		72	105	75	80	115	115		215	103	140	180	175	115
110	120	140	105	90	125		105	110	110	115	100	110		105	100	110	94	105	100
84	155	160	160	160	170		70	85	90	90	115	155		84	80	160	85	120	105
115	150	105	105	105	110		110	110	90	100	100	100		105	125	98	95	95	100
105	100	110	70	105	125		100	72	105	115	105	115		74	115	100	88	90	98
125	120	120	140	140	125		110	125	120	115	105	110		125	135	125	110	95	125
125	135	135	125	140	125		125	135	100	115	115	140		120	94	105	145	125	115
130	110	105	145	94	105		135	105	105	130	130	110		130	120	100	72	115	100
130	120	160	130	125	145		125	135	139	120	100	136		122	120	135	120	130	135
159	166	190	111	104	135		160	190	110	114	100	126		160	200	120	106	109	113
140	130	115	125	140	120		110	115	105	94	100	95		115	115	100	135	115	148
95	85	95	115	115	110		120	120	115	145	125	140		80	105	120	140	110	125
89	105	94	115	125	120		100	105	115	105	120	130		95	99	94	125	135	145
120	190	180	125	125	125		195	190	200	140	105	115		190	200	185	135	130	135
210	72	105	78	120	96		150	125	130	200	190	220		125	115	130	200	66	74
110	105	125	134	104	119														
135	105	105	145	120	105														
135	160	140	105	125	145														

Note: Data is extracted from coating inspection forms included in Appendix D.

Table 5: Summary of CP Measurements from BIWP

Location	CP Measurement (-mV vs. CSE)			Date (DD/MM/YY)	Comments
	ON_{avg}	OFF_{avg}	OFF_{min}		
WAS-1	1358	885	836	09/22/2017	'ON' readings indicate available CP current, average 'OFF' reading indicates full protection.
EAS-1	1535	1019	945	10/06/2017	Full protection observed
EAS-2	-	-	-	-	No valid CP readings were obtained as insufficient bare metal existed.
EAS-3	841	806	783	08/29/2017	'ON' readings indicate available CP current. Note that this large area of exposed metal was created ~3 days prior to these measurements being taken which is insufficient time for buildup of calcareous deposit or ultimate CP protection levels to mature.
EAS-4	961	865	844	08/30/2017	'ON' readings indicate available CP current, average 'OFF' reading indicates full protection. Note that this large area of exposed metal was created ~4 days prior to these measurements being taken which is insufficient time for buildup of calcareous deposit or ultimate CP protection levels to mature.
EAOI-1	-	-	-	-	No valid CP readings were obtained as insufficient bare metal existed.
EAOI-5	-	-	-	-	No valid CP readings were obtained as insufficient bare metal existed.
EAOI-7	1365	1082	903	10/12/2017 10/13/2017	'ON' readings indicate available CP current, 'OFF' reading indicates full protection.

Figures

Figure 1: Photograph showing a calcareous deposit at EAS-2.

Note: The average thickness of the calcareous deposit and adjacent enamel coating was 0.12 and 0.13 inches, respectively.

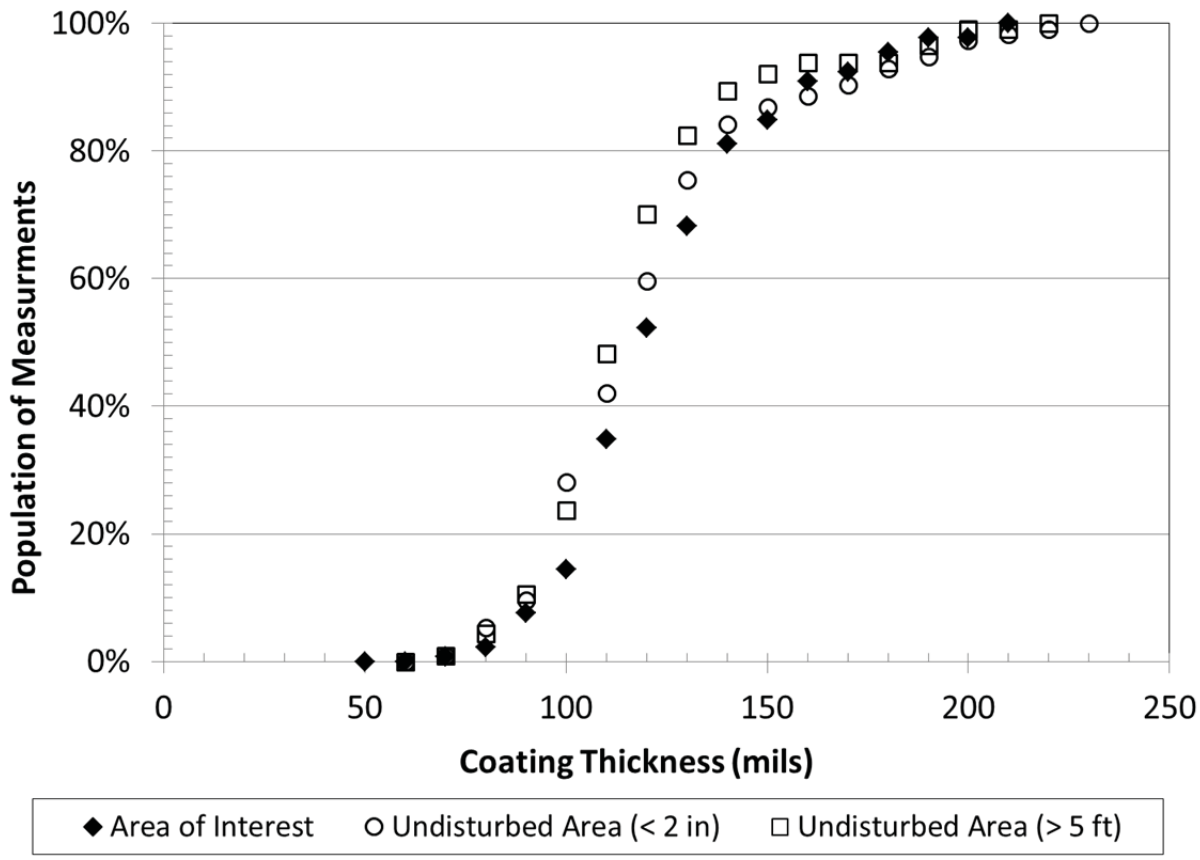

Figure 2: Distribution plot of the percentage of measurements at various coating thicknesses.

Average measurements for the Area of Interest, Undisturbed Area (< 2 in), and Undisturbed (> 5 ft) were 125 ± 6 mils, 122 ± 8 mils, and 118 ± 6 mils, respectively.

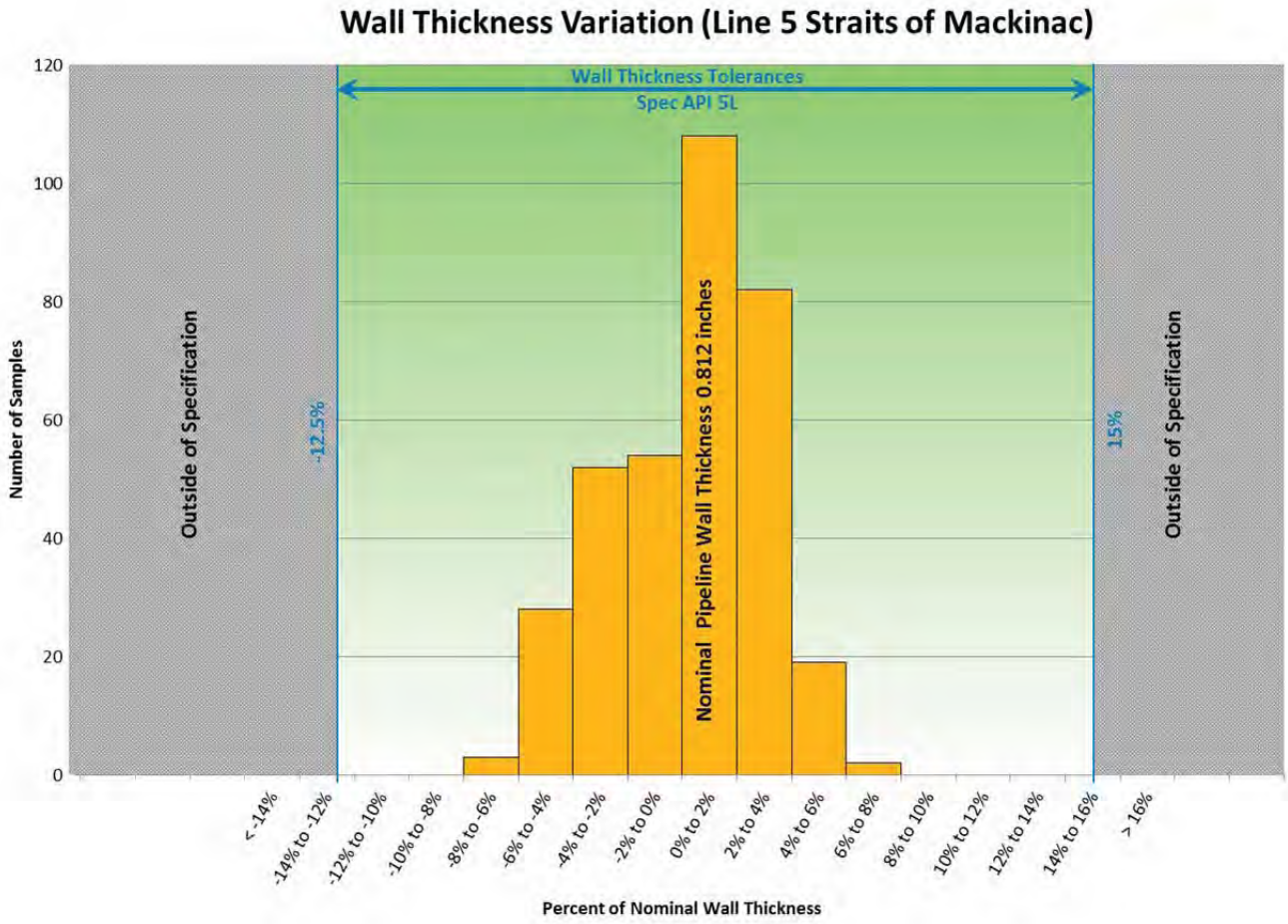

Figure 3: Pipe wall thickness distribution at 2017 coating repair locations.

Appendix A: Biota Investigation Work Plan (Rev. 2)

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Enbridge Line 5

Straits of Mackinac, MI

Biota Investigation Work Plan

Enbridge Energy, Limited Partnership

Revision 2: May 18, 2017

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ENBRIDGE

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Table 1: Biota sample sites: East and West pipelines

APPENDICES

Appendix A. Bibliography
Appendix B. Level of Mussel Colonization Reference Cards
Appendix C. Standard Operating Procedures

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LIST OF ACRONYMS

ANOVA	Analysis of variance
APB	Acid producing bacteria
CP	Cathodic Protection
CPDM	Cathodic Protection Data Management
Enbridge	Enbridge Energy, Limited Partnership
mV	Millivolt
SRB	Sulfate-reducing bacteria
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VIV	Vortex induced vibration

DEFINITIONS

Area(s) of Interest

An Area of Interest is a part of the pipeline where, based on visual inspection, (i) the normal (local) Biota is unexpectedly absent or (ii) there is evidence of possible coating damage (e.g., Dislodged Coating and/or potential Holiday). Disturbed Areas (see definition below) are not Areas of Interest as the lack of Biota can be attributed to past maintenance and monitoring activities.

Biota

Animals and plants living around and on the pipelines through the Straits (e.g. mussels, periphyton, algae, microbes)

Dislodged Coating

An area on the pipeline where, based on visual inspection, the outer wrap of the coating appears to have been dislodged or removed without exposure of the pipe steel.

Disturbed Area

An area on the pipeline where past maintenance and monitoring activities resulted in the removal of Biota but does not represent damage to the pipe coating.

Holidays

An area on the pipeline where there is a discontinuity in the coating that exposes the pipe steel to the environment.

Undisturbed Area

An area on the pipeline where there is no evidence of any loss of Biota (or pipe coating).

1.0 Introduction

Enbridge Energy, Limited Partnership (Enbridge) will be required by federal consent decree (Case 1:16-cv-00914, ECF No. 3 filed 07/20/16), once the decree is entered, to conduct measures to prevent spills in the Straits of Mackinac (Subsection VII.E of the consent decree). The consent decree contains requirements specifically focused on the two 20-inch diameter pipelines ("Dual Pipelines") that span the Straits of Mackinac ("Straits") as part of Enbridge's' Lakehead System Line 5 pipeline ("Line 5").

Per the consent decree, Enbridge must conduct an investigation ("Biota investigation") to assess whether any of the Biota found on the pipeline impact the integrity of the Dual Pipelines. Prior to undertaking that effort, Enbridge must submit to the United States Environmental Protection Agency ("USEPA") for approval, a proposed plan for the Biota investigation described in Subparagraph 69.a. This document details Enbridge's plan for a Biota investigation that will satisfy requirements of the consent decree listed in Subparagraph 69.a. Enbridge anticipates the information obtained from this investigation will complement the information gathered during integrity monitoring activities already undertaken by the company.

2.0 Consent Decree Requirements

The consent decree includes three requirements ("assessments") that must be part of Enbridge's Biota investigation. Those assessments are listed below and associated efforts presented herein are designed to provide information to address the requirements in the consent decree. The assessments were not numbered in the consent decree but have been numbered in this document for consistency in referencing the assessments.

- Assessment 1: "…..assess whether the accumulation of mussels and other Biota have impacted the integrity of the pipelines' coating or the underlying metal, including areas where there are openings or "holidays" in the pipeline coating."

- Assessment 2: "…..evaluate whether the mussels and other Biota are creating a corrosive environment by, among other things, fostering the growth of anaerobic sulfate-reducing bacteria ("SRB") that may cause metal loss."

- Assessment 3: "…..evaluate whether mussels and other Biota are introducing features that may threaten the integrity of either of the Dual Pipelines due to the weight of such biomass or the pressure caused by current or ice movement around such biomass in areas where the pipelines are suspended above the floor of the Straits."

3.0 Methods

Prior to development and submittal of this Biota Investigation Work Plan ("Plan"), Enbridge conducted literature searches and reviews of key topics and issues to aid in identifying, developing, and proposing use of appropriate methodologies, assessments, and analyses that could best address the requirements of the consent decree. Additional scoping efforts included assessing video-photography of the Dual Pipelines from 2014 and 2016 and overlaying pertinent pipeline and resource data. Those preliminary efforts have facilitated development of this Plan. Opportunistic testing of techniques and methodologies will enable subsequent sampling and monitoring efforts to be more effective.

3.1 Literature Searches

Literature searches and reviews included, but were not limited to, limnological data of the Straits, physical and chemical features of aquatic Biota previously observed on the pipelines, field data collection methodologies, cathodic protection, and SRB. Appendix A provides a bibliography of the literature reviewed.

3.2 Coating Inspections

In order to address Assessments 1 and 2 of the Consent Decree, this plan incorporates pipeline coating tests, inspection and documentation at Areas of Interest. A total of 18 representative Areas of Interest[1] were selected for the coating inspection – 11 on the East Pipeline and 7 on the West Pipeline. These 18 sites were identified during the video surveys and selected based on their appearance, distribution through the four limnologic zones, and proximity to other dive locations (e.g., locations where screw anchors will be installed in 2017). Visual criteria used to select these sites include: (1) the normal (local) Biota is unexpectedly

[1] In previous versions of this Plan, these Areas of Interest were variously referred to as "holidays", "dislodged coating' and 'delaminations' – and this inconsistency in terminology has led to confusion. Until diver examinations are completed per this study, the exact nature of these features is unknown. It is for this reason that Enbridge has selected them for direct examination.

absent (and the disruption is not consistent with Biota removal caused by past maintenance and monitoring activities) or (2) there is evidence of possible coating damage.

The locations of the 18 Areas of Interest are identified in Figures 1, 2 and 3. These Areas of Interest will be inspected to establish the condition of the pipe and coating (i.e., Disturbed Area, Dislodged Coating or Holiday), measure the size of the area, report the presence of corrosion and, if present, determine cathodic protection levels at Holidays. Seven (7) of the 18 Areas of Interest shown in these Figures also coincide with locations at which Biota sampling will be conducted to address Assessment 3 of the Consent Decree (described later in Section 3.3 and Table 1).

Thickness readings of the coating will also be measured using an underwater, ultrasonic thickness gauge to assess the condition of the coating. Biota, if present, will be removed prior to the coating thickness measurements. As shown in Figure 4 and described below, the thickness measurements will be collected at each (i) Area of Interest and (ii) at the Undisturbed Areas adjacent to the Area of Interest.

i. **Area of Interest:** Three thickness measurements shall be taken at equal distances downstream from the center of the Area of Interest as close to as possible to the 9, 12, and 3 o'clock positions around the pipe, respectively. Three thickness measurements shall be taken upstream from the center of the Area of Interest as close as possible to the 9, 12, and 3 o'clock positions, respectively. If the Area of Interest exceeds 6 square feet, additional thickness measurements shall be taken at a frequency of 3 measurements (9, 12, and 3 o'clock positions) for every additional 6 square feet.

ii. **Undisturbed Area**:

   a. <u>Within two inches of the Area of Interest (as determined by the diver).</u> Three thickness measurements shall be taken at equal distances downstream from the Area of Interest as close to as possible to the 9, 12, and 3 o'clock positions, respectively. Three additional thickness measurements shall be taken at equal distances upstream from the Area of Interest as close to as possible to the 9, 12, and 3 o'clock positions, respectively.

   b. <u>At least five (5) feet from the Area of Interest (as determined by the diver).</u> Three thickness measurements shall be taken at equal distances downstream

from the Area of Interest as close to as possible to the 9, 12, and 3 o'clock positions, respectively. Three (3) thickness measurements shall be taken at equal distances upstream from the Area of Interest as close as possible to the 9, 12, and 3 o'clock positions, respectively.

In addition to the 18 Areas of Interest, three (3) additional sites have been identified by the Enbridge marine contractor as being valuable to investigate further. The locations of these areas are identified as "Additional Site" in Figures 1, 2, and 3. These sites will be investigated using the same protocol described above for the 18 Areas of Interest. CP measurements (Section 3.2.1) and Biota sampling (Section 3.5.3.2) will be taken if Holidays are found.

3.2.1 Cathodic Protection Evaluation

Cathodic protection readings will be taken at each Holiday area that may be found. The diver will utilize a hand-held bathycorrommeter dual element probe, specifically a REDACTED [redacted] that is a product of REDACTED [redacted], Houston, Texas, for those measurements.

Three potential measurements shall be taken at any Holiday area that may be found to evaluate levels of cathodic protection. The video camera attached to the diver shall assist in recording the measurements obtained from the REDACTED [redacted] and in providing visual observations of the Holiday area. Readings will not be taken of any coated portions of the pipe since the REDACTED [redacted] requires a metal contact to obtain a reading.

Data collected during this investigation will be evaluated by one of Enbridge NACE Accredited CP Specialists prior to incorporation into Enbridge's Cathodic Protection Data Management (CPDM) system as a unique survey. Data collected during this evaluation will be correlated with the most recent cathodic protection in-line inspection results.

3.3 Biota Study Zones and Sampling Locations

Proposed locations for surveying and obtaining aquatic Biota samples were determined based upon a wide range of information. Primary factors included video-photography from 2014 and 2016 coupled with a literature review of limnological information on the Straits. Assessment of underwater video determined that within both the northern and southern shallow water zones where the pipeline was visible (not buried beneath the bottom substrates) there was a mixture of submergent aquatic vegetation, algae, periphyton, and mussels. As the

Dual Pipelines extended into deeper water, the density of filamentous algae and macrophytes diminished, and the density of mussels increased. The approximate "break point/depth" where vegetation began to diminish occurred between water depths of 100 to 120 feet. This depth and reduction in plant growth correlates with expected euphotic zones for Lake Michigan which range from approximately 60 to 100 foot water depths (Lake Access 2016).

Underwater video-photography provided useful information in identifying general types of aquatic Biota present and changes in composition and density of that aquatic Biota at various depths and locations on and around the pipes. Figures 5 and 6 summarize qualitative observations made of the aquatic Biota on the east and west pipelines, respectively, using 2014 and 2016 video-photography. A review of 2016 video-photography for both pipelines indicated that the composition and density of Biota along both pipelines were similar to one another, and that findings presented were representative of both pipelines (Enbridge, 2016).

Using the video-photography information, four zones were established based upon physical, limnological, and biological features associated with various water depths of the Straits across both the Dual Pipelines. Figure 1 shows the location of the four zones across the east and west pipelines. The four zones for the east and west pipelines and a basic description relative to each are provided below:

- Zone A – 50- to 100-foot water depth; periphyton most abundant; mussels present
    - There is a Zone A at the northern and southern ends of each of the Dual Pipelines.
- Zone B – 100- to 150-foot water depth; periphyton moderate, mussels moderate.
    - There is a Zone B at the northern and southern ends of each of the Dual Pipelines.
- Zone C – 150- to 200-foot water depth; periphyton sparse, mussels most abundant
    - There is a Zone C at the northern and southern ends of each of the Dual Pipelines.
- Zone D – Over 200-foot water depth; mussels abundant
    - There is only one Zone D as it represents the deepest zone of each of the Dual Pipelines.

As shown in Figure 1, starting from the North Bank of the Straits, each pipeline passes through zones A, B, and C before reaching the deepest zone (D), and then through C, B, and A before passing out of the Straits via the South Bank.

In order to address Assessment 3 of the Consent Decree, Biota will be collected at two (2) sampling sites from each limnologic zone on each pipeline (see Figure 1). This approach will result in eight (8) sampling sites on each pipeline with four (4) sampling sites within each zone. A primary focus of this Biota sampling is to establish mass and volume of the Biota, which will be used in calculations to assess the forces acting on the pipelines. The level of effort being conducted within each zone provides for evaluation of variability among surveys, samples, and measurements taken within each zone. Details of these surveys, sampling, and measurements are discussed further in Section 3.5. If a Holiday is found, Biota sampling will follow methods described in Section 3.5.4.

The proposed Biota sampling locations within each zone also included locations with suspended and non-suspended pipe, areas of expected elevated water currents, and Areas of Interest, and took into account dive logistics. Areas where pipe was suspended above the bottom of the lake were selected over areas where the pipe was partially buried in the lake bottom to enable surveys, measurements and sampling to occur around the full diameter of the pipe.

3.4 Biota Sampling Field Testing

Specific Biota sampling protocol described below will be field tested prior to collecting Biota samples from the Dual Pipelines. Field testing will be conducted in another location of Lake Michigan through a series of shallow water dives to ensure the methods described below can be safely executed by the diver while maintaining data/sample integrity. These dives will test the effective use of diver communication and video techniques to ensure adequate communication with the biologist on the barge during sample observation and collection. Field testing will also ensure effective communication between the diver and biologist on providing randomly generated numbers which the diver will use to move up-current to randomly generated sampling locations (when not at a specific Area of Interest), where and how to collect samples, take measurements and readings, and in transferring of samples to the water

surface (dive boat). Any changes to the protocols to increase safety, communication, and/or integrity of the data collection will be provided to the USEPA for approval prior to conducting the described work within the Straits.

3.5 Biota Surveys, Measurements, and Sampling

In evaluating appropriate sampling methods to use, literature searches and reviews provided few articles or studies where Biota samples were being collected from deep freshwater structures for analysis. Many of the references were from marine environments and were associated with saltwater corrosion issues and/or aquatic Biota that are not present in the freshwater of the Straits (Castaneda and Benetton, 2008; Duperron, 2010; Moura et al., 2013). The overall paucity of references dealing with Biota collection in deep freshwater environments necessitated adapting sampling methodologies and principles utilized in marine environments for use in the Straits (Gale and Thompson, 1975; Hicks and Oster, 2012; Kikuchi et al., 2006; Purcell, 1996; Purcell and Bellwood, 2001; Water Research Foundation, 2015).

Based upon discussions with marine contractors who have conducted maintenance related activities for Line 5, a professional diver will be required to perform the proposed visual survey, data collection, and sampling tasks given that pipeline sampling locations range from approximately 65 to over 225 feet below the water surface of the Straits. Surveying, data collection, and sampling methods were selected to address the requirements of the consent decree while also being manageable by a diver operating at those extreme depths using gloves and necessary safety gear. The conditions also require that the size and number of sampling containers be kept at a minimum while still maintaining the integrity of the samples and not impacting subsequent testing and analysis.

Each diver will be equipped with a video camera so that visual surveys and data collection activities can be observed and directed (as necessary) by surface staff to ensure data is being collected accurately and scientifically. Field data and Biota samples will be obtained as effectively and efficiently as possible, while also adhering to safety and time constraints imposed from working in various water depths and underwater currents associated with the Straits. Dive times will be limited to approximately 30 minutes or less when operating at depths greater than 120 feet.

Enbridge (2016) identified that the apparent density of mussels and other Biota on the Dual Pipelines varied based upon water depth and past maintenance and monitoring activities. In some areas, past maintenance and monitoring activities have disturbed or removed the normal local amount of Biota, such sites would be poor choices for addressing Assessment 3. Should a Biota site coincide with an area where Biota has been previously disturbed (Disturbed Area), the diver is directed to relocate a maximum of 100 linear feet to reach an area of undisturbed Biota (Undisturbed Area). If all areas in that 100-linear-foot span have been disturbed by past monitoring activities, the samples shall be taken within the Disturbed Area (as it represents existing and representative conditions of that site). This location selection criterion applies to all survey and sampling activities outlined below.

3.5.1 Visual Biota Surveys

At the 16 Biota sampling sites, video-photography will be used to provide a visual record of the Biota associated with various sections of the Dual Pipelines, the general appearance/condition of the Dual Pipelines, and to document the field sampling process. Prior to collecting samples, a slow pan view of the sampling site will be taken.

The slow pan view will enable qualitative characterization of the relative level of mussel colonization on the pipe (i.e., heavy, moderate, sparse, or none). In addition, multiple layers of Biota, if present, will be noted in areas where samples are to be collected. The divers, in communication with a biologist, will also be trained with reference cards to identify the relative level of mussel colonization. The reference cards to be used are included in Appendix B. The slow pan or other video-photography footage obtained throughout the sampling dive may also provide data on the presence of fish species or macroinvertebrates that may be utilizing the pipelines for habitat (e.g., feeding and cover sites). Where positive identifications can be made by the diver or biologist(s) reviewing the video-photography, the data will be recorded to the lowest possible taxa.

Special attention will be given to any areas where Biota have been disturbed and Areas of Interest. Those areas will be closely inspected by the diver(s) allowing for additional video footage to be collected of those areas for further review.

3.5.2 Biota Measurements

To avoid potential bias, upon arrival at one of the 16 Biota sampling locations the diver will receive a randomly- generated number (ranging from 1 - 100 feet) from a person on board the boat. The diver will then proceed into the current (or to the north) that given distance and commence Biota measurements.

Once the diver has arrived at the random location, the thickness of Biota on the pipelines will be determined. The circumference of the pipeline will be measured at three locations with a flexible tape measure. Once that measurement has been recorded, a “clean pipe” circumference measurement should be taken in the same location as the previous measurement. To do that, the diver should gently, but comprehensively, remove all attached material (mussels, periphyton, etc.) from the pipeline and re-measure the circumference. A combination of a narrow plastic putty knife and nylon scrub brush will be used to remove attached material. The process will be repeated at two additional locations that are approximately three feet and six feet up-current from the initial location. That information will be useful in calculating point estimates of Biota thickness at those specific locations on the pipeline. It is important to note that circumference measurements can only be taken at locations where the pipelines are elevated off the lake bed (i.e., not partially or fully-buried).

3.5.3 Biota Sampling

Biota samples will be taken up-current of the Biota measurements (Section 3.5.2 Biota Measurements). Taking these samples up-current of the Biota measurements will minimize disturbances, turbidity, and any possible sample impacts or biases to the Biota sampling. Collection of Biota from the Dual Pipelines will include all Biota attached to or surrounding the pipelines, including mussels, macrophytes, periphyton, biofilm, etc. Biota will be collected in accordance with the protocol outlined below with the intent of collecting complete samples with little to no loss of Biota. Biota will be evaluated and analyzed as presented in Section 4.0 Analysis.

Prior to collection of Biota samples, sampling containers (pre-labeled with a unique sample identification number [ID]) will be held in front of the video camera so that the sampling location and associated unique sample ID(s) can be documented.

Once the Biota sampling site has been identified (up-current or north of the Biota measurements), a set of paired samples will be taken from every designated location on or around the pipe. Biota samples will be collected using a container similar to that used by Purcell (1996). The sampling containers for the Biota samples need to enclose a fixed surface area on the pipe to enable quantification (number of mussels per square inch) of the total surface area sampled at each site. At this time, it is expected the containers will enclose approximately 10 to 16 square inches (Figure 7).

The containers will be compact so divers can effectively transport numerous containers, handle, and use them at depth within their limited dive times. The containers will be pre-filled with lake water to ensure neutral or negative buoyancy. Prototype containers and proposed collection protocol (described below) will be field tested, and refined if necessary, prior to Biota sampling on the Dual Pipelines.

The Biota sampling container will consist of a four (4) inch diameter circular plastic pipe, synthetic nylon screen (e.g., bolt cloth-Nitex), end caps, and water pressure release valve (i.e., vent) with a screw-in end cap (Figure 7). One end of the sampling container will be affixed with screen, end cap, and vent and the other end will be open for collection of the Biota sample. The end caps for the container and vent will be tethered to the sampling container to prevent loss of end caps during the collection process. A thin, flexible blade, such as a plastic putty knife, will be slid in between the wall of the pipeline and the sampling container to dislodge Biota from the pipeline up into the container. The dislodged material will be captured inside the sampling container. Mussels that are outside of the sampling container will not be included in the sample unless the majority of the length of the mussel is within the interior portions of the container. The blade will be used to push mussels into the interior of the sampling container or to pull them out from the container (where the majority of the mussel is outside of the container). At that point, the sampling container will be carefully removed from the pipeline ensuring that the blade is held against the open end of the sampling container to minimize sample loss. The diver will place the end cap on the blade then slowly remove the blade so that the end cap can be pushed on to the open end of the container. The small vent will allow water to escape, yet retain material scraped off the pipeline due to the screen inside the upper part of the container. The container will be returned to the surface and the sample extracted and placed into storage bags as described in Section 3.5.4 Sampling Handling and Preparation. The final sampling container and method used to collect Biota samples, as part of

implementing this Plan, is expected to undergo additional modifications and refinements to those currently presented. Containers and protocol will be field tested and any subsequent improvements to the containers and methods will be made to increase the divers' ability to handle and maintain the integrity of the samples being collected (i.e., minimize sample loss and obtain samples from a defined area).

At the sixteen (16) Biota sampling locations shown in Figure 1, Biota samples will be collected following the protocols described above. Samples will be taken from four different positions on the pipelines (top, both sides, and the bottom). A set of two samples will be taken from each of the four (4) positions for a total of eight (8) sampling containers per sampling location (Figure 8). Spacing of the paired set of samples will be as close to one another as possible but without adversely affecting the integrity of the sample locations or the collected sample. Samples will not be collected from the bottom of the pipeline if it is not accessible due to safety hazards or because the bottom is in contact with the lake bed. The paired samples will be numbered as belonging to either Set 1 or Set 2. Half of the samples (one from each pipeline position) will be used to obtain Biota community data (e.g., mussel count) described in Section 4.1 Biota Counts/Densities/Weight and the other half will be used for testing for the presence or absence of SRB or acid producing bacteria ("APB") as described in Section 4.2 Presence/Absence Bacteria Testing. Set 1 or Set 2 will be randomly assigned (coin flip or random number generator) for either SRB/APB testing or to be sent to the ecological lab for Biota community data.

As discussed above, a stratified sampling design has been selected based on the visual observations of Biota on the Dual Pipelines and the establishment of four zones. The zones represent varying degrees of biomass accumulation that correlate to water depth, depending on the development of the periphyton/macrophyte and mussel assemblage, including microbial biofilm development. The zones also represent potential differences in biomass accumulation depending on whether the zone is on the north or south side of the Straits.

One sample site has been established in each zone with the exception of Zone D where two sample sites have been established. This provides for eight (8) sample sites for the east and west pipelines for a total of 16 sample sites across the Dual Pipelines (Figures 1-3). Biotic samples will be collected from the Undisturbed Areas to examine the extent to which the biomass of the plant-microbial biofilm layer or mussel layer vary with respect to location

around the pipe. The data will be graphically displayed to identify potential patterns in biomass accumulation by different zones and by different positions around each pipeline. The total biomass and individual biomass components (e.g., plant-biofilm biomass or quagga biomass) for each stratum will be analyzed using a mixed model analysis of variance (ANOVA) to examine whether there are differences in the biomass with respect to zones or position on the pipeline. Further comparisons may prove to be meaningful if statistical differences are noted.

3.5.3.1 Biota Sampling at Areas of Interest

A total of seven (7) representative locations were selected for the Biota sampling at Areas of Interest – 3 on the East Pipeline and 4 on the West Pipeline. The locations of the seven (7) areas of interest that will be sampled are identified in Figures 1 – 3. Biota samples will be collected following the protocols described above (3.5.3). Collection of samples will commence at the down-current location first (i.e., diver facing into the current) to minimize disturbances, turbidity, and any possible sample impacts. A set of two samples will be taken from the Area of Interest and another set of two samples will be taken outside of the Area of Interest at the same position on the pipe. That will yield a total of four (4) samples per sampling location. One of the two Area of Interest samples will be used to obtain Biota community data as described in Section 4.1 Biota Counts/Densities/Weight and the other for testing for SRB and APB as described in Section 4.2 Presence/Absence Bacteria Testing.

The sampling design of the Areas of Interest has been structured to provide paired biomass data to evaluate whether these areas provide a more desirable/suitable area for periphyton-microbial biofilm development or quagga mussel attachment when compared to immediately adjacent coated area (see Figure 9). Results of Area of Interest sampling will provide insight as to whether the accumulation of mussels or other Biota have impacted the integrity of the pipeline. The biomass data will be graphically displayed to identify potential patterns in biomass accumulation at these Areas of Interest, and determine whether statistical differences in biomass accumulation exist in those areas where the coating has been disturbed.

3.5.3.2 Biota Sampling at Any Holiday Found

Currently there are no known Holidays on the pipeline. However, Biota will be sampled from any Area of Interest that is found to be a Holiday. A set of two samples will be taken from within the Holiday and two samples outside of the Holiday (at the same position on the pipe as

the Holiday area samples [Figure 9]). That will yield a total of four samples per sampling location. One of two samples taken from the Holiday and non-Holiday area will be used to obtain Biota community data as described in Section 4.1 Biota Counts/Densities/Weight and the other for SRB and APB testing as described in Section 4.2 Presence/Absence Bacteria Testing.

The sampling design of the Holidays has been structured to provide paired biomass data to evaluate whether these areas provide a more desirable/suitable area for periphyton-microbial biofilm development or quagga mussel attachment when compared to immediately adjacent coated area (see Figure 9). Results of sampling of any Holiday found will provide insight as to whether the accumulation of mussels or other Biota have the potential to impact the integrity of the pipeline. The biomass data will be graphically displayed to identify potential patterns in biomass accumulation at these Areas of Interest, and will be used to determine whether statistical differences in biomass accumulation exist in those areas where the coating has been disturbed.

3.5.3.3 Additional/Opportunistic Sampling

If Dislodged Coatings are found along the lake floor or, at the discretion of the diver, are easily removed from the pipe without affecting the integrity of the glass inner wrap and enamel coating, their location shall be first surveyed, inclusive of its surroundings, using a slow pan view of the site. The sample and any attached Biota shall be carefully bagged and sealed in a bag with a unique sample ID. The location and sample depth of where the sample was collected will be recorded by the field sampling team. Upon collection of the Dislodged Coating, the pipeline shall be visually inspected by the diver to identify the source of the Dislodged Coating if possible. If Dislodged Coating samples are found, they will be evaluated for biologically-induced impacts to the coating as indicated in Section 4.3 Coating Integrity Testing.

3.5.4 Sample Handling and Preparation

Sampling containers will be returned to the surface upon completion of the dive and grouped according to laboratory. All biological material will then be transferred from each sampling container into individual plastic storage bags (Ziploc® or Whirl-Pak®, one bag per sampling container). Transferring of the samples from the containers to the storage bags will be conducted by experienced staff using sterilized stainless steel instruments (e.g., long-handled

spatula). Remaining material will be washed from the container into the storage bags using wash bottles filled with lake water. Bags will be labeled with information such as the pipe, zone, sampling, and pipe position site numbers clearly visible. Representative photographs will be taken of this process.

Samples will be transported on ice to a secure laboratory or office facility near the Straits. Bacteria presence/absence testing (see Section 4.2) will be conducted at the secure facility. Sample handling and chain-of-custody procedures can be found in Appendix C.

4.0 Analysis

Experienced aquatic biologists will review all of the underwater video-photography taken of the Dual Pipelines, with respect to sampling sites and their surrounding habitats to assist in the identification of larger macrophytes and fish species that may be attached to or utilizing the Dual Pipelines (and which are unlikely to be captured within the Biota sampling containers). Review of the video-photography can assist in identifying apparent visual differences in colonization rates or densities of mussels or other Biota on the Dual Pipelines at various depths and locations around the pipe. Qualitative characterization of the relative level of mussel colonization on the pipe (i.e., heavy, moderate, sparse, or none as shown in Appendix B) will be made using the video-photography, recorded, and potentially used in conjunction with the lab analyses.

Those observations may be beneficial and substantiated by the lab analyses of the Biota samples sent to an ecological laboratory. Comparison of video-photography of specific areas from previous and subsequent years, where locations can be confirmed, will be evaluated for differences in colonization rates or densities, especially in areas where maintenance and inspection activities removed mussels from the upper surface of the pipe.

As noted in Section 3.5 Biota Surveys, Measurements, and Sampling, Biota samples will be collected in pairs to enable analysis of multiple parameters from the same location without having to collect and subdivide larger samples, which can increase the risk of contamination and loss of sample integrity.

One Biota sample from each of the four locations sampled around the pipe (or one Biota sample from each of the two locations if sampled at a Holiday) will be sent to an ecological laboratory for evaluation of Biota composition and physical metrics of the Biota present. Experienced staff will conduct tests for the presence or absence of SRB and APB on the set of Biota samples that were not randomly selected to be sent to the lab for Biota analysis. Dislodged Coating samples will also be sent to the ecological lab for evaluation of attached Biota.

4.1 Biota Counts/Densities/Weight

The ecological laboratory will qualitatively evaluate and separate out the larger Biota (i.e., mussels) from the smaller Biota. At the present time, Biota is expected to be divided into four (4) general categories: plant matter (macrophytes and algae), mussels, benthic macroinvertebrates, and biofilm (microscopic organisms and undiscernible gelatinous material). All Biota will be identified or keyed out to its lowest practicable taxa.

The ecological laboratory will obtain dry and wet weights of mussels using standard laboratory procedures for obtaining these masses, similar to those used by United States Army Corps of Engineers (USACE,1993; Wilson et al., 2006). Mussels will be enumerated and their shells measured. Shell measurements will be used to assist in determining the number of generations (i.e., age structure) of mussels present at each of the sampling locations. Mussels are consumed by some fish species, particularly round gobies (*Neogobius melanostomus*) (French and Jude, 2001; Wilson et al., 2006), and overt signs of mussel predation such as active feeding and high abundance of round gobies will be documented.

The ecological laboratory will obtain collective dry and wet weights of the remaining Biota using standard laboratory procedures similar to those used by USACE (1993). The total mass of all aquatic Biota will be obtained by adding together the weights of the mussels and the remaining non-mussel Biota.

4.2 Presence/Absence Bacteria Testing

Staff will utilize BioSan Laboratories SRB and APB test kits for evaluating Biota samples taken from the one set of samples collected from the various sides of the pipe, Dislodged Coatings, areas adjacent to Dislodged Coatings, and any Dislodged Coating for the presence or absence of SRB and APB. Approximately 5 grams or less of biofilm/periphyton will be removed from the appropriate sample bag(s) and placed it into a test kit. Additional information related to SRB/APB test kit use can be found in Appendix C.

The SRB test kits contain tubes of culture media specifically formulated to promote the growth of anaerobic SRB. SRBs are organisms which reduce sulfate to sulfide in the absence of oxygen. The most common organisms of that type associated with accelerated corrosion and industrial environments are found in the genera *Desulfovibrio* and *Desulfotomaculum*. When

sulfide is liberated, it reacts with iron in the tubed culture medium to form iron sulfide, a black precipitate. The degree to which the test kit medium blackens, along with the length of time it takes to change color, allows for an estimated count of sulfate reducers to be made. Test kits include sample applicators that allows for the evaluation of both liquids and surfaces.

The APB test kit is a simple and rapid test for the detection and enumeration of APB with results in 24 hours when strong acid producers are present. That semi-quantitative system contains tubes of culture media specifically formulated to promote the growth of APB. One culture tube equals one test and no syringes are needed. Similar to the SRB test kits, applicators are included to allow for the evaluation of both liquids and surfaces. When acid is liberated, it reacts with the tubed culture medium and changes the color from red to yellow. The length of time it takes to change color allows for an estimated count of acid producing bacteria to be made.

4.3 Coating Integrity Testing

In addition to the coating inspection in Section 3.2, Enbridge will also retrieve representative samples of Dislodged Coating from the bottom of the Straits when available. The intent of this work is to confirm the overall thickness of the coating and determine the penetration depth of various types of Biota into the coating. The overall coating thickness and penetration depths will be measured by cross-sectional microscopy. Biota samples will also be tested for SRB and APB in accordance with Section 4.2.

4.4 Engineering Stress Analysis

An additional analysis will be conducted and will include additional inputs from the Biota Investigation. The intent of the augmented analysis will be to determine how sensitive both stress and vortex induced vibration (VIV) assessments are to variability in the pipeline as a result of Biota. The inputs into this engineering analysis from the Plan will include; Biota mass, Biota size, and corresponding effect on drag force and effective diameter.

In addition to the Plan variables, the variables normally considered for stress and VIV assessments include pipeline weight (with varying products), internal pressure, span length, pipeline wall thickness, grade, diameter, coating type/thickness and water velocities. For the stress analysis, the methodology used will involve varying the input parameters within a finite element model to determine the effects of varying the weight, span length, pressure and

buoyancy on the pipe stress. For VIV assessments, both the increase in diameter due to Biota presence, as well as the increase in pipe mass will be assessed utilizing finite element analysis to calculate nodal frequencies and span lengths and closed formed solutions to determine VIV limits.

This assessment will require at least 12 weeks to complete once the Biota variable data has been provided to the engineering consultant.

5.0 Quality Assurance/Quality Control

Robust quality assurance/quality control measures will be instituted to ensure the integrity of samples and measurements generated during the Biota investigation (see also Appendix C). Those measures will include, but are not limited to:

- Project organization: the Project Manager, subcontractors, and all parties taking part in this effort will be identified and their roles articulated prior to commencing efforts. Planning and coordination calls and/or meetings will take place with divers, members of the integrity team, biologists, etc., to ensure the proper execution of sampling and data collection protocol.
- Proper training: The divers used on this project will be Operator Qualified (OQ) for coating thickness measurements and cathodic protection readings.
- All instruments will be calibrated according to manufacturer's recommendations.
- Field sampling review: the location of zones, sampling sites, and pipe positions where samples are to be collected will be reviewed prior to undertaking any field sampling efforts.
- Video-photography and audio communication (between divers and personnel on boats) will be utilized to ensure proper documentation of conditions and sampling requirements.
- Sample handling: biological samples (e.g., biofilm, periphyton, mussels, etc.) collected during the course of the investigation will be handled and preserved using proper techniques to ensure sample integrity.
    - Methods currently include the removal and washing of all Biota from the sampling containers into plastic storage bags using a flexible blade and wash bottles.
- Documentation and records: field notes, chain-of-custody documents, laboratory reports, etc., will be compiled and saved at secure locations in hard copy and/or electronic form.
    - Chain-of-custody files will be utilized to track the custody of samples throughout collection, transfer/shipment of samples to analytical labs, etc. Pertinent information such as the dates, times, and persons handling samples will be recorded to ensure that chain-of-custody is properly documented.

- Data validation: Data generated through the course of these efforts will be routinely evaluated for accuracy, precision, representativeness, and completeness.
- Reporting: Reports and project deliverables will be edited, reviewed, and finalized prior to submittal.

6.0 Schedule and Deliverables

Enbridge shall implement the Plan in accordance with the schedule described below, predicated upon USEPA's approval of the Plan in June 2017. If USEPA approval is not granted by this date, logistical requirements, seasonal limitations, and biological growing season considerations will necessitate moving field sampling efforts to 2018.

- June 2017: Refinement and opportunistic testing of sampling methodologies, lab analyses, and statistical tests of any preliminary data.
- July 2017 → September 2017: Visual and Biota surveys and sampling of Biota on Dual Pipelines.
    - Representative samples of the aquatic Biota attaching to and/or surrounding the Dual Pipelines are best obtained later in the growing season since macrophytes, algae, and periphyton will not fully establish until later in the growing season when water temperatures are highest (July-September, [NOAA, 2016]).
    - Representative samples of mussels can be obtained at any time of the year but late summer is recommended given mussels would be at their greatest size (Schneider, 1992), which would enable more accurate maximum mass estimations.
- August 2017 → December 2017: Lab and engineering stress analysis.
    - Discussions with the ecological laboratory and Enbridge integrity indicate that 12 weeks are needed to process the large volume of Biota samples for analysis.
    - A pipeline structural engineering firm will also require 12 weeks to complete an engineering stress analysis of the Biota with respect to the integrity of the pipelines suspended above the floor at the Straits.
- December 2017 → February 2018: Data analysis.
- March 2018: Submittal of Final Report.
    - Submitted within 60 days of completion of field and lab analyses.

Implementation of this Plan, inclusive of its literature reviews, visual surveys, Biota measurements, Biota sampling and lab analyses, chemical and biological activities, and levels of cathodic protection will aide in answering the assessments presented in Section 2.0 Consent Decree Requirements. To achieve compliance with the consent decree, Enbridge

will implement this Plan in accordance with the schedules presented above. As part of the Plan the following deliverables will be provided to USEPA, within the specified timeframes, as follows:

- No later than 60 days after the completion of field and lab analyses associated with implementing this Plan, Enbridge shall submit a final report to USEPA for review and approval, describing the findings and results of the investigation.
    - In the event that the investigation finds that mussels and other Biota have impaired, or threaten to impair, the Dual Pipelines, Enbridge shall supplement its final report with a proposed work plan to address such impairments, together with a proposed schedule for completing such work.
        - The supplement shall be submitted within 60 days of submittal of the final report to USEPA.

7.0 Workforce

Key personnel currently proposed for implementation of this Plan include the following:

Enbridge Energy, Limited Partnership

- [redacted] Senior Manager Environment U.S. Operations
- [redacted] Senior Integrity Engineer

Leggette, Brashears, and Graham, Inc. (LBG)

- REDACTED P.E., Civil Engineer, Leggette, Brashears & Graham, Inc, Hancock, Michigan
- REDACTED P.E., Environmental Engineer, Leggette, Brashears & Graham, Inc, Wetmore, Michigan

GEI Consultants of Michigan, P.C.

- REDACTED Sr. Aquatic Biologist, Traverse City, Michigan
- REDACTED Aquatic Ecotoxicologist, Lansing, Michigan

GEI Consultants, Inc.

- REDACTED, Aquatic Ecologist / Limnologist, Denver, Colorado
- REDACTED Ecological Laboratory Manager, Denver, Colorado

Ballard Marine

- REDACTED Project/Operations Manager

Kiefner and Associates Inc.

- REDACTED Principal Engineer, Manager-Stress Analysis, Columbus, Ohio

Key personnel, Contractors and Consultants maybe changed as needed to facilitate completion of this investigation plan as outlined in Section 6.0 Schedules and Deliverables.

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FIGURES

Figure 1 – General profile view of east and west pipelines and associated zones
Figure 2 – Profile view of sampling zones and sites for the east pipeline
Figure 3 – Profile view of sampling zones and sites for the west pipeline
Figure 4 – Layout of Thickness Measurements at Areas of Interest
Figure 5 – Qualitative assessment of the Biota across the east pipeline
Figure 6 – Qualitative assessment of the Biota across the west pipeline
Figure 7 – Biotic sampler
Figure 8 – Layout at Undisturbed Area with Biota Sampling
Figure 9 – Layout at Area of Interest with Biota Sampling

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DATE: 5/16/17	FIGURE 1: GENERAL PROFILE VIEW OF EAST AND WEST PIPELINE AND ASSOCIATED ZONES Sources: Topographic imagery from ArcGIS Online. Topographic Data from Ballard Marine Construction	ENBRIDGE®

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FIGURE 2
PROFILE VIEW OF SAMPLING ZONES AND SITES FOR THE EAST PIPELINE

Legend

Topographic Profile
Lake Bottom Profile
Pipeline Profile
Water Level Indicator
1+256 Station ID
E-20 Span ID
Natural Touch Down
Grout Bag
Existing Anchor Location
Proposed Anchor Location
Additional Site
Area of Interest
S Sample Site of 6-8 Samples Around the Pipe
B Biota Sample Site at Area of Interest

ENBRIDGE

Drawn: LBG 5/16/2017	Approved: LBG 5/16/2017	Project #: Straits, MI	Name: g2Eenbstraits0[redacted]

Sources: Topographic imagery from ArcGIS Online. Topographic Data from Ballard Marine Construction.
Notes: Aquatic Observations are approximate. Area of Interest Locations and 2016 Anchor Locations are not survey grade data [redacted]

FIGURE 3
PROFILE VIEW OF SAMPLING ZONES AND SITES FOR THE WEST PIPELINE

Legend

	Trajectory Profile	●	Sites Of Interest
	Sampling Zone	●	Sampling Sites Location
	Spoils Pile	●	Sediment Sites
	Wind Line Marker	●	Small Stream
	Pipeline	●	Wetlands Affected Wetlands Pipeline
	Spoil	●	Sampling Sites Location

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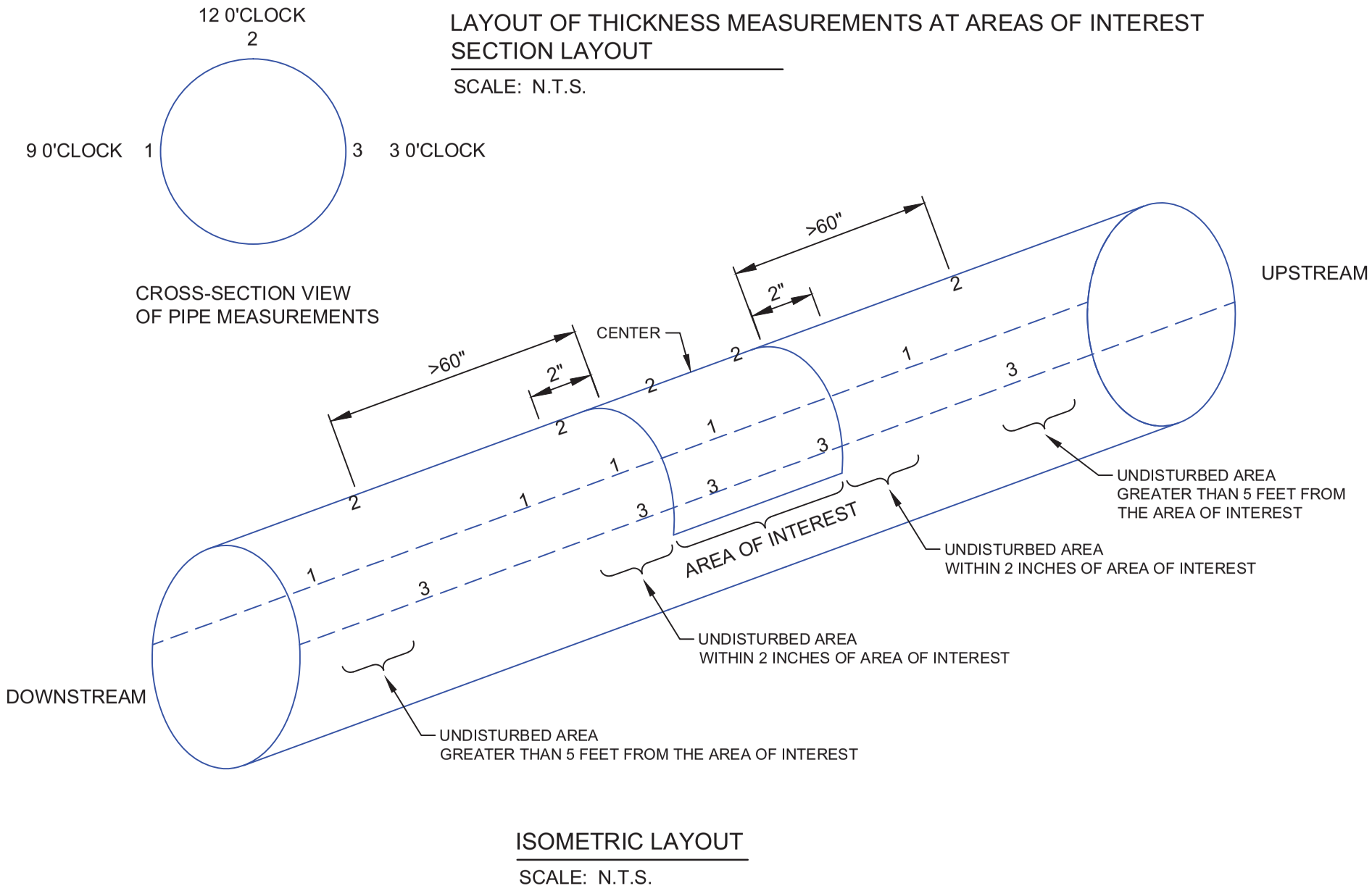

DATE: 5/11/2017	FIGURE 4: LAYOUT OF THICKNESS MEASUREMENTS AT AREA OF INTEREST	ENBRIDGE

FIGURE 5
QUALITATIVE ASSESSMENT OF THE BIOTA
ACROSS THE EAST PIPELINE

Legend

- Topographic Profile
- Lakeshore Profile
- Pipeline Profile
- Water Level Variation
- Bedrock
- Sand/Silt

ENBRIDGE

Source: Enbridge Pipeline Inc. Lakeshore Pipeline Inc. Enbridge Pipeline Inc. Lakeshore Pipeline Inc.
Data Sources: Enbridge Pipeline Inc. Lakeshore Pipeline Inc. Enbridge Pipeline Inc. Lakeshore Pipeline Inc.
Date: 2011-07-01 Time: 11:00 AM
Filename: Enbridge Pipeline Inc. Lakeshore Pipeline Inc. Enbridge Pipeline Inc. Lakeshore Pipeline Inc.

FIGURE 6
QUALITATIVE ASSESSMENT OF THE BIOTA ACROSS THE WEST PIPELINE

Legend:

- Topographic Profile
- Lacustrine Fields
- Fluvial Fields
- Rivers and Streams
- Wetlands
- Bluffs

ENBRIDGE

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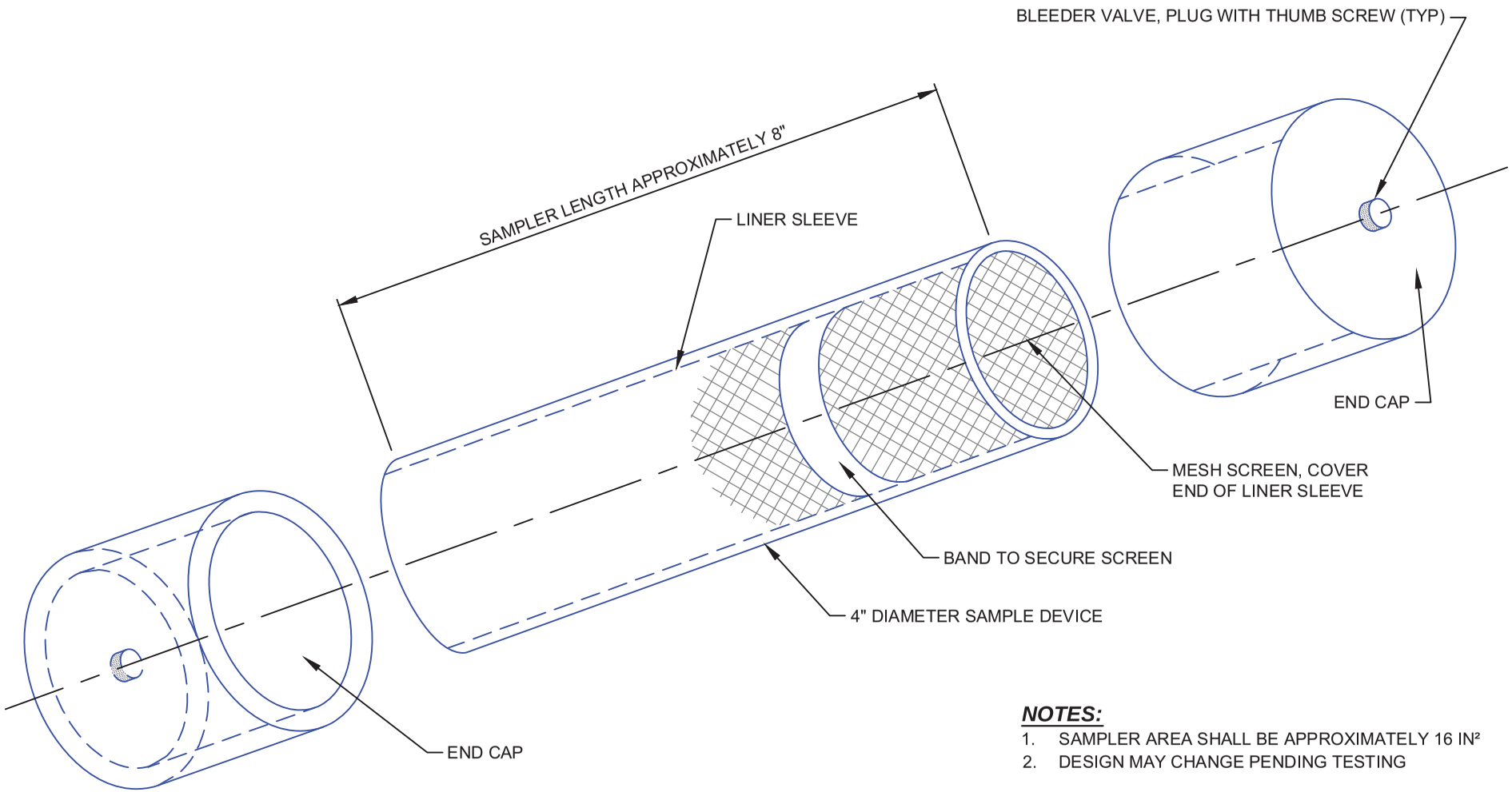

NOTES:

1. SAMPLER AREA SHALL BE APPROXIMATELY 16 IN²
2. DESIGN MAY CHANGE PENDING TESTING

BIOTIC SAMPLER ISOMETRIC VIEW

SCALE: N.T.S.

DATE: 5/17/2017	FIGURE 7: BIOTIC SAMPLER	ENBRIDGE

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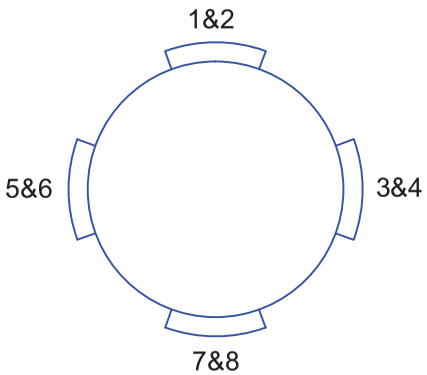
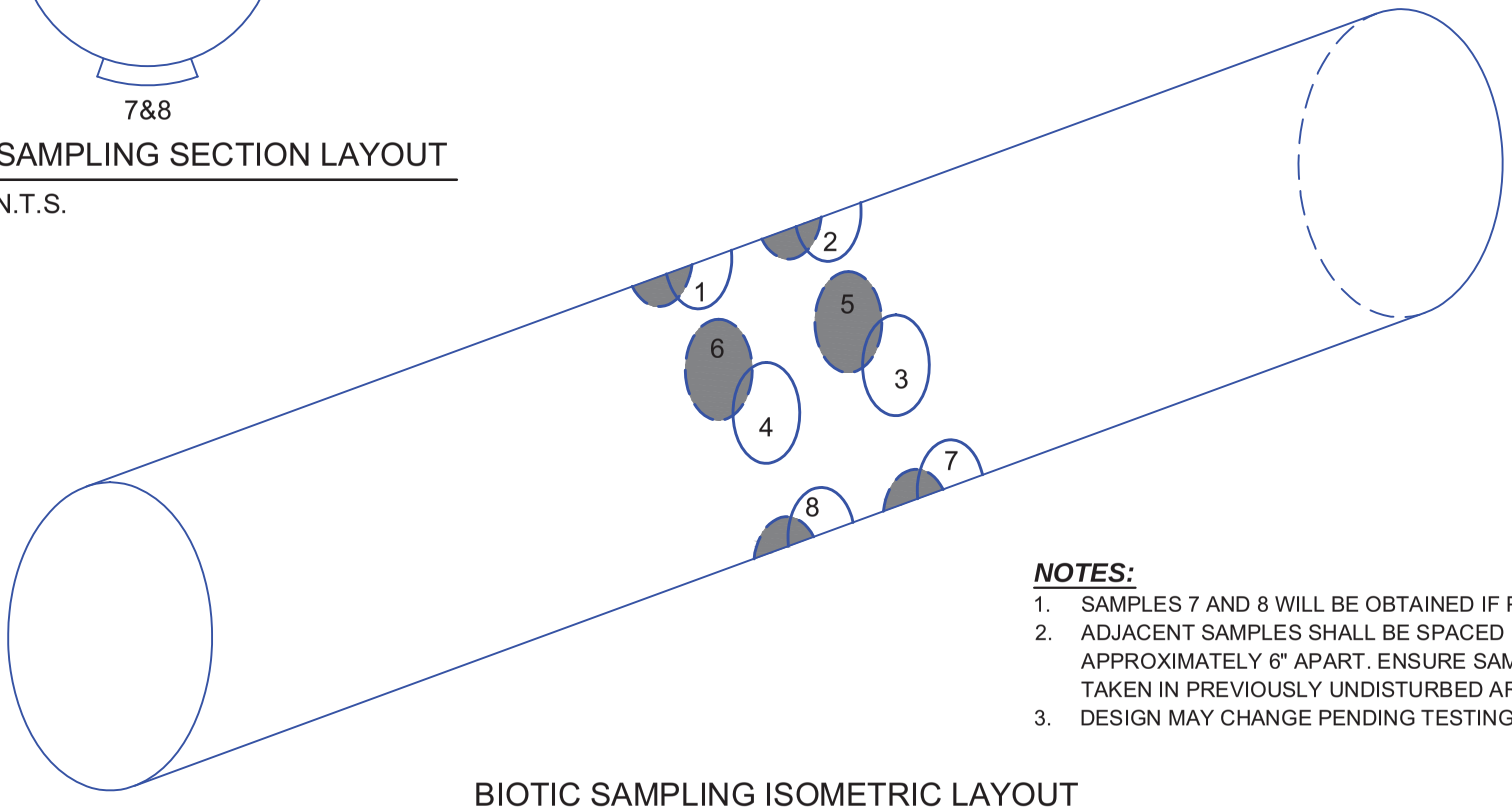


BIOTIC SAMPLING SECTION LAYOUT

SCALE: N.T.S.



NOTES:

1. SAMPLES 7 AND 8 WILL BE OBTAINED IF POSSIBLE.
2. ADJACENT SAMPLES SHALL BE SPACED APPROXIMATELY 6" APART. ENSURE SAMPLES ARE TAKEN IN PREVIOUSLY UNDISTURBED AREAS.
3. DESIGN MAY CHANGE PENDING TESTING

BIOTIC SAMPLING ISOMETRIC LAYOUT

SCALE: N.T.S.

DATE: 5/11/2017	FIGURE 8: LAYOUT AT UNDISTURBED AREA WITH BIOTA SAMPLING	ENBRIDGE

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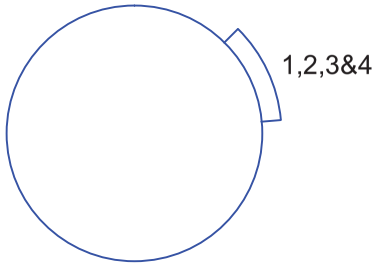
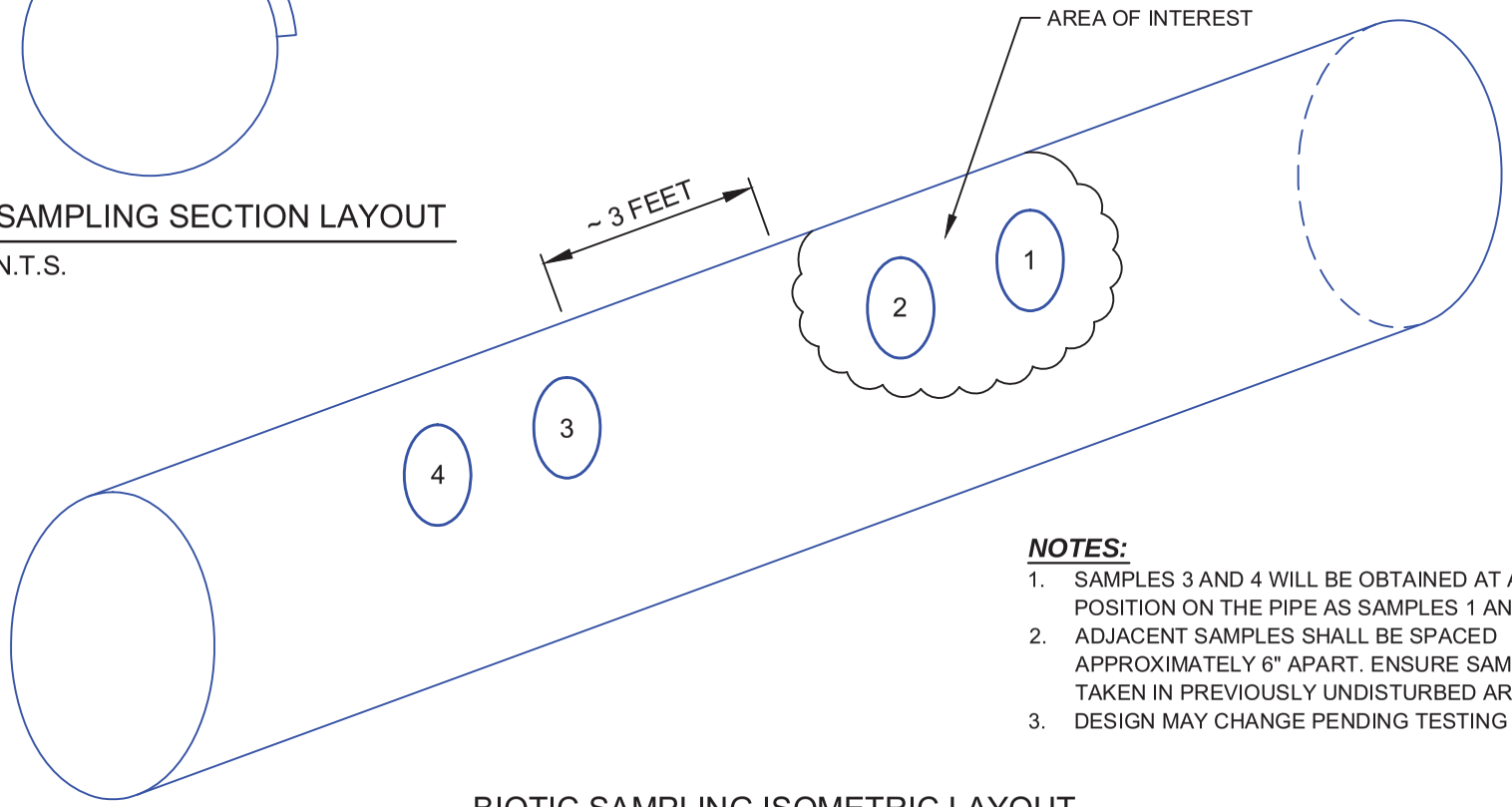


BIOTIC SAMPLING SECTION LAYOUT

SCALE: N.T.S.



NOTES:

1. SAMPLES 3 AND 4 WILL BE OBTAINED AT A SIMILAR POSITION ON THE PIPE AS SAMPLES 1 AND 2.
2. ADJACENT SAMPLES SHALL BE SPACED APPROXIMATELY 6" APART. ENSURE SAMPLES ARE TAKEN IN PREVIOUSLY UNDISTURBED AREAS.
3. DESIGN MAY CHANGE PENDING TESTING

BIOTIC SAMPLING ISOMETRIC LAYOUT

SCALE: N.T.S.

DATE: 5/11/2017	FIGURE 9: LAYOUT AT AREA OF INTEREST WITH BIOTA SAMPLING	ENBRIDGE

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TABLES

Table 1: Biota sample sites: East and West pipelines

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Table 1. Biota sample sites: East and West pipelines

East Pipeline - Biota sample sites

Zone	Water depth (ft)[1]	Proposed Biota sampling sites[2]	Description of Biota sampling sites	Total number of Biota samples[3]	Total number of Biota samples at area of interest[4]
A (north)	50-100	1	Equidistant between E07 and E65B	6-8	-
B (north)	100-150	1	North of E-05B	6-8	-
C (north)	150-200	1	Area of Interest south of E01B-B	6-8	4
D	>200	1	Area of Interest north of E76A/B	6-8	4
D	>200	1	E10	6-8	-
C (south)	150-200	1	E16	6-8	-
B (south)	100-150	1	South of E-61A	6-8	-
A (south)	50-100	1	Area of Interest south of 34A	6-8	4

West Pipeline - Biota sample sites

Zone	Water depth (ft)[1]	Proposed Biota sampling sites[2]	Description of Biota sampling sites	Total number of Biota samples[3]	Total number of Biota samples at area of interest[4]
A (north)	50-100	1	W65B	6-8	-
B (north)	100-150	1	W61A	6-8	-
C (north)	150-200	1	W58B	6-8	-
D	>200	1	Area of Interest near W54A	6-8	4
D	>200	1	Area of Interest near W72A	6-8	-
C (south)	150-200	1	Area of Interest north of W-70B	6-8	4
B (south)	100-150	1	Area of Interest south of W35B North	6-8	4
A (south)	50-100	1	Area of Interest south of W10	6-8	4

[1] Pipelines buried to water depth of approximately 65 feet

[2] One site per zone, sampling immediately adjacent to Area of Interest when possible

[3] Six samples/site if pipeline bottom not accessible; eight samples/site otherwise

[4] Paired sampling: two samples in area of interest, two samples immediately adjacent area of interest

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APPENDICES

Appendix A – Bibliography

(Includes literature cited and other documents preliminarily reviewed)

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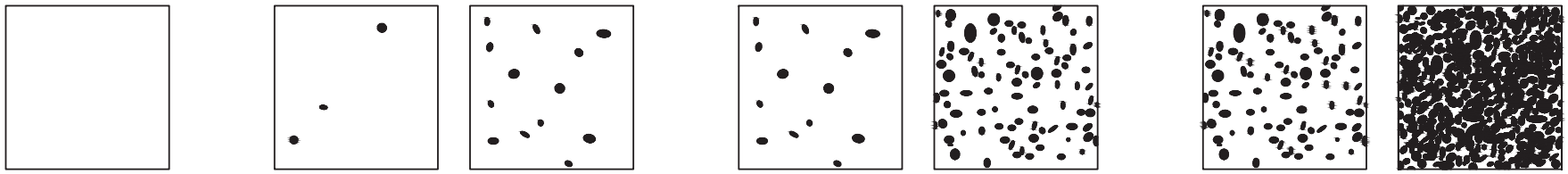

<10% = SPARSE

10-<50% = MODERATE

50-100% = HEAVY

DATE: 5/16/2017	APPENDIX B: LEVEL OF MUSSEL COLONIZATION REFERENCE CARDS	ENBRIDGE

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STANDARD OPERATING PROCEDURE

Field Notebook

---

1. Objective

Describe methods for documentation of field activities.

Documentation of site activities is a crucial part of the field investigation process. The field notebook serves as the record of field activities performed or observed during the project. It provides a factual basis for preparing field observation reports, if required, and reports to clients and regulatory agencies. Example field notes are provided in Attachment A.

2. Execution

- Use a separate all-weather bound notebook for each site/location/project number. Spiral notebooks should not be used because pages can be easily removed.
- Write neatly using black or blue pen, preferably a waterproof pen. Use of pencil is also acceptable only with approval of the project manager, such as in but not limited to, certain field conditions [e.g., cold or wet weather].
- Write the project name, project number, book number (i.e., 1 of 3), and date on the front cover. On the inside cover, identify the project name, project number, and "Return Book To:" the office address of the project manager.
- Number all of the pages of the field book starting with the first entry.
- Record activities as they occur. Record only facts and observations, regardless of whether they appear to be relevant at that time.
- Identify conditions or events that could affect/impede your ability to observe conditions (e.g. snow-covered ground surface, inability to access areas of interest).
- Neatly cross out mistakes using a single line and initial them. Erasures are not permitted.
    - If an error is made on an entry in the field notebook, the individual who made the entry should make the corrections. The corrections must be initialed and dated by the person making the correction.
- Sign or initial and date the bottom of every page with an entry if the project requires such documentation.
- Place a diagonal line through unused portions of a page.
- Record the following information upon each arrival at the site:
    - Date/time/weather.
    - Personnel.
    - Purpose of visit/daily objectives.
    - People (client, contractor, landowners, etc.) present upon arrival at site.

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- Record the following information during the course of the day:
  - Conversations with contractors/subcontractors, clients, visitors, professional staff, landowners (site or abutters). If possible, record complete names, titles, and affiliations.
  - Time of arrival and departure of individuals.
  - Activities as they occur.

- Additional examples of observations to record may include and are not limited to:
  - Type and quantity of monitoring well construction materials used.
  - Use of field data sheets or electronic logging equipment (e.g. boring logs, monitoring well sampling logs, etc.).
  - Ambient air monitoring data.
  - Field equipment calibration information.
  - Locations and descriptions of sampling points.
  - Contractor/Subcontractor progress.
  - Sample media (soil, sediment, groundwater, etc.).
  - Sample collection method.
  - Number and volume of sample(s) collected and sample bottle preservatives used.
  - Sample identification number (s) and date and time of sample collection.
  - Approximate volume of groundwater removed before sampling.
  - Any field observations made such as pH, temperature, turbidity, conductivity, water level, etc.
  - References for maps and photographs of the sampling site(s).
  - Information pertaining to sample documentation: bottle lot numbers/ dates, method of sample shipments, chain-of custody record numbers, and overnight shipping numbers.
  - Surveying data (including sketches with north arrows).
  - Changes in weather.
  - Rationale for critical field decisions.
  - Recommendations made to the client representative and/or Project Manager(s).
  - Site sketch of conditions at the end of the day.
  - Summary of work completed/work remaining.
  - Allow time at the end of the day to complete entries in the notebook.

3. Attachments

Attachment A - Example Field Notes

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Attachment A – Example Field Notes

Start of each day includes:
- **Date**
- **Project Number**
- **People on site**
- **Purpose of Work**
- **Weather Conditions**

Each page is numbered

7/7/01 1/2

GEI: J. SMITH
ONSITE: 0845
OFFSITE: 1020
WEATHER: SUNNY, 70°F

PURPOSE:
1) GAUGE MONITORING WELLS FOR NAPL.
2) REMOVE NAPL FROM MONITORING WELLS IF DETECTED.

DEPTH TO WATER (▽), DEPTH TO BOTTOM (DTB), AND DEPTH TO NAPL WERE GAUGED IN WELLS USING AN OIL/WATER INTERFACE PROBE.

MW301B
▽ - 3.68'
DTB - 26.52'
Depth to NAPL - ND

JLS 7/7/01

2/2

MW309B
▽ - 11.35'
DTB - 28.77'
Depth to NAPL - ND. Strong naphthalene odor.

MW308
▽ - 4.42'
DTB - 6.81'
Depth to NAPL - ND

MW302B JLS 7/7/01
▽ - ~~8.60'~~ 8.59'
DTB - 28.81'
Depth to NAPL - 27.58'
(1.23 ft NAPL)

REMOVED APPROX. 1 GAL NAPL and 1 GAL OF WATER FROM MW302B USING PERISTALTIC PUMP. TRANSFERRED NAPL/WATER MIXTURE TO DESIGNATED DRUM ON-SITE

OFFSITE: 1020
JLS 7/7/01

Errors are single line crossed out and initialed

Blank Space crossed out and initialed

Bottom of each page signed and dated

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STANDARD OPERATING PROCEDURE

Photo Documentation

---

1. Objective

Describe methods to document and retain photographic records.

Keeping a record of photographs taken is crucial to their validity as a representation of existing conditions.

2. Execution

- Photographs of a site, individual samples, or other observations should be taken using a digital camera.
- Set the camera to record the time and date for each photograph.
- All photographic records, along with the following information, should be recorded in the field notebook (SOP FD-001).
    - If applicable, the compass direction describing the direction the photograph was taken (e.g. looking southeast). This may not apply to photographs of individual samples.
    - Brief description of what the photograph is intended to show.
- The field notebook should note who took the photographs.
- The photographs should be electronically backed up on a computer or other data storage device.
- If photographs will be used in a report, memo, or letter, they should be placed on a photograph record template and the relevant information describing the photograph should be inserted into the caption section for each photograph.

3. Limitations

- Some clients and regulatory agencies require photographs of every subsurface soil sample collected. These photographs typically include a “whiteboard” which indicates the site, the boring ID, and the depth of the sample, while logging details are recorded in the field notebook. Under these circumstances, it is not necessary to include compass directions or descriptions.

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STANDARD OPERATING PROCEDURE

Sample Handling

1. Objective

Describe appropriate environmental sample handling procedures.

The procedures include collection and transport of environmental samples to a laboratory for chemical analysis. Appropriate sample handling should ensure that samples are properly:

- labeled and documented;
- preserved;
- packaged; and
- transported

2. Execution

- Prior to mobilizing to the field, select a shipper or arrange for a courier for sample delivery to the laboratory. If using a shipper (i.e., FedEx or UPS) determine the time constraints for pickup requests, the location and hours of the nearest shipping office, and any size/weight restrictions.
- A waterproof or permanent ink pen should be used for all labels. The label should have an adhesive backing and be placed on the jar or bottle, not on the cap. In addition, clear packing tape can be placed over the sample label to secure it to the bottle as moisture from the samples can loosen the label adhesive.
- Record the following information on the label and in the field notebook (See SOPs FD-001 and FD-003):
    - Project number
    - Sample identification (i.e. MW-201 or SS-2)
    - Date and time (military time) of collection
    - Sampler's initials
    - Analysis methods
    - Preservative, if present
- Pre-preserved laboratory jars are preferable and should be used whenever practicable. If sample jars are not pre-preserved, add preservative as appropriate.
- At each sampling location, samples should be collected in order of volatility, most volatile first. Samples collected for volatile analysis should be placed in sample containers immediately upon retrieval of the sample.
- Aqueous samples for volatile analysis should be collected without air bubbles.
- The collection and preservation method of soil samples for volatile analysis may depend on project, client, or state regulatory requirements. Check with your Project Manager and/or SOPs SM-001 and SM-002 where appropriate.

- Care must be taken to avoid getting soils on the threads of sample jars, which can cause a faulty seal.
- If compositing samples in the field, specify the basis for composite (i.e. volume, weight, spoon recovery, etc.) and record in the field book the procedure for compositing the sample.
- Once samples have been collected and labeled, place samples in a cooler with sufficient bagged ice or freezer packs (blue ice) (if allowed) to chill samples to 4°C. If using ice, use double-bagged ice.
- Complete the chain-of-custody (COC) (SOP FD-003).
- If transporting the samples by way of a shipper:
    i. The sample cooler should have water drains securely sealed with duct tape, both on the inside and outside of the cooler.
    ii. Place a layer of packing material on the bottom of the cooler as a cushion.
    iii. Individually wrap each sample bottle with bubble packing or suitable packing material and place the wrapped bottles upright in the cooler with sufficient packing material between samples to avoid breakage.
    iv. Methanol preserved samples for volatiles analysis should be packed so they remain upright with the soil completely covered by the methanol during transport.
    v. Place a layer of packing material on top of the sample bottles.
    vi. Place bagged ice or freezer packs on top of the packing material. Fill the remaining space in the cooler with packing material to eliminate the possibility of vertical movement of samples.
    vii. Place the completed and signed chain-of-custody form in a sealable plastic bag and place on top of the packing material in the cooler, or tape it to the inside lid of the cooler.
    viii. Fill out the appropriate shipping or courier forms and attach to the top or handle of the cooler. If necessary, place the proper shipping labels on the cooler. Have the courier sign the COC form (or write pickup by FEDEX, UPS, etc. with date and time). Place a signed and dated custody seal on the cooler.
- All samples should be submitted to the laboratory as soon as possible. In many cases, same day shipping will be required by the client or the project manager. Be clear on this before beginning the field work.
- A copy of the waybills should be kept by the field supervisor to track shipments if necessary.

3. Limitations

- If samples are shipped on a Friday, call the laboratory ahead of time to confirm that personnel will be at the laboratory to receive and log-in the samples.
- During warm weather, make sure to use plenty of ice in the shipping container.

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- Field personnel should be aware of analyses which have short hold times and schedule sampling events and shipping accordingly. Shipment of samples for analyses with short hold times must be arranged for in advance. Refer to the project work plan, quality assurance project plan, or state/federal regulations for holding time and preservative information. Contact the laboratory ahead of time when shipping samples with short hold time to ensure the lab is prepared for these analyses.
- For glassware containing preservatives (e.g., HCl, HNO_3), take care not to overfill the container, thus flushing the preservative out of the bottle.
- Never composite samples for VOCs in the field. Collect individual aliquots and direct the laboratory to perform compositing, if needed.
- Collection of aqueous samples should not be performed over the opening of a monitoring well. Preservatives from overfilling, a marker pen or other objects could fall into the well.
- If the recharge volume for a monitoring well is low, completely fill all volatile vials and then collect the minimum sample volume required for each remaining analysis.
- During subsurface soil sampling, if the recovery from the split-spoon sample is inadequate, if appropriate, resample the bottom of the borehole to obtain proper sample volume.
- Laboratories will homogenize and test the contents of the sample container, unless directed otherwise. Samples should not contain rocks, twigs, leaves, etc… unless these materials are of interest.

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STANDARD OPERATING PROCEDURE

Sample Management and Chain of Custody

1. Objective

Describe methods to label sample containers, manage the samples, and prepare Chain of Custody documentation for the samples. Sample transport is also addressed.

2. Project Setup

When setting up a sampling event, inform the recipients of the samples (laboratories) and recipients of laboratory results (data group and project managers). Discuss with the laboratory the sampling media, turnaround times, and reporting limits for appropriate regulatory criteria for the site. Include the data group on correspondence so that turnaround times, data validation, and project deliverable schedules can be tracked successfully.

- Laboratory - Number of samples, analyses needed: bottle orders and holding times, turnaround times needed, reporting limits needed for regulatory criteria.
- Data group - Number of samples, analyses requested, turnaround times and reporting limits requested, data validation needed, regulatory criteria to use for tabulating results, deliverables needed, and project name and number.
- Schedule - Inform the laboratory and Data Group of schedule delays, changes to analyses, and expediting.

3. Sampling Execution

- Review the work plan prior to sampling to determine the following:
  - Sample matrix and sampling method.
  - Required analysis and sample volumes.
  - Sample container type and preservative requirements.
  - Required analysis methods and/or report formats.
  - The turnaround time required by the project.
  - If the data will be sent directly from the laboratory to the data validator, Project Manager, or Data Group.
  - Holding time restrictions for sampling media and analytical methods.
  - Sample naming convention used for this project site.
- Sample labels should be filled out using a waterproof or permanent marker or pen. Required information includes:
  - Sample ID.
  - Date and time of sample collection.
  - Project number.
  - Sample preservatives.
  - Sampler's initials.
  - Laboratory analytical methods.

- Place the label on the jar or bottle, not on the cap. Sample custody begins at this time.
- Record the above information in the field notebook.
- Individually wrap sample jars with packing material, if needed. Place samples in a cooler with bagged ice or freezer packs (blue ice) immediately after collection. Add sufficient ice or freezer packs to cool samples to approximately 4°C.

- Complete a chain of custody (COC) for the samples as described below. Laboratory COCs may be used as long as they contain fields for all required sample information as described in Section 2.1.

3.1. Chain-of-Custody (COC) Completion

- Fill out COC neatly and in permanent ink. Alternatively, an Excel version of the COC is available and can be filled out electronically.
- Certain analyses (i.e. air analysis by TO-15) require specialized, laboratory issued COCs. Make sure any specialized COCs are available before sample collection.
- Record the project name and number, the sampler's name(s) and the state where the samples were collected.
- For each sample, enter the sample identification number, date and time (military time) collected, the number of sample containers, and any additional information to fulfill project, client or regulatory requirements.
- Record the type of analysis (including laboratory method; e.g. EPA-SW846 Method XX) requested and the preservative (if appropriate) in the vertical boxes.
- Field duplicates should be anonymous to the laboratory, but must be recorded for use by the Data Group. To keep track of this information, link the field duplicate with the proper sample in the field notebook. If required by the Project Manager or Data Group, also document this information on or attach a note to a copy of the COC.
- Trip blanks for large sites should be named similar to the samples they are collected with so that there are not two of the same sample name for the same site. For example, "OU1TB-122509" and "OU3TB-122509" would avoid any mistakes.
- Strike incorrect entries on the COC with a single line, followed by the initials of the person making the correction, the date, and the correct entry.
- When sample custody is ready to be relinquished, complete the bottom of the form with date and time (military time) and signatures of relinquisher and receiver of samples as indicated. The sample collector is always the first signature while the analytical laboratory is the final signature. Theoretically, all individuals handling the samples between collection and laboratory should sign the form; however, if a common carrier (i.e., Federal Express, UPS) is used for shipping, the carrier must be identified in the 'Received by' box on the

COC. If the sampler hand delivers the samples to the laboratory, the received box must be signed by the laboratory.

- If the samples are placed in a designated secure area (e.g. sample fridge), note this location in the "Received by" box on the COC.
- Single sheet and triplicate COCs are utilized. If using the triplicate COCs (white, yellow, and pink copies), the pink copy should be retained by the sampling personnel and provided to the Data Group for proper filing. The white and yellow copies should accompany the samples to the laboratory.
- If you are using the single sheet COC, make a copy of the COC after it has been signed by the lab courier and forward it to the Data Group.
- Prior to sample shipment by common carrier, the COC must be placed inside the cooler in a Ziplock bag or other watertight package.
- If a common carrier such as FedEx is used to transport the samples to the laboratory, include the carrier tracking number and identify the carrier in the "Received by" box on the COC.
- If a courier is used to transport samples to the laboratory the courier signs the COC in the "Received by" box.
- Place a custody seal on the cooler if shipping via common carrier.
- Transport samples to the laboratory as soon as possible. It is preferable to transport the samples directly to the laboratory from the field. Samples brought back to the office for storage prior to submission to the laboratory must be kept cold (4° C).
- Unused sampling containers/media that are sent back to the lab should be included on a separate COC.

4. Limitations

- Keep the number of people involved in handling samples to a minimum.
- Where practical, only allow people associated with the project to handle the samples.
- Always document the transfer of samples from one person to another on the COC.
- The COC should always accompany the samples.
- Give samples positive identification at all times that is legible and written with waterproof or permanent ink.
- When sending samples via a common carrier, use one COC per package.
- Where practical, avoid sending samples from more than one site with separate COCs in a single package.

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SANICHECK® APB

Field Test Kit for Detecting Acid Producing Bacteria (APB)

INSTRUCTIONS

1. Disinfect hands with an alcohol wipe before handling any of the test kit components.
2. Open one Agar Tube and place screw cap side up on a clean, dry surface.
3. Remove sterile Sample Applicator Swab from the envelope (do not touch the swab side).
4. Insert Sample Applicator Swab into the liquid sample for approximately 10 seconds. For solid samples, use the Sample Applicator directly to swab the surface.
5. Transfer Sample Applicator into the Agar Tube by inserting it slowly into the agar to reach the bottom of the tube.
6. Slowly and carefully remove Sample Applicator from the Agar Tube. Discard used Sample Applicator.
7. Replace screw cap on Agar Tube.
8. Incubate samples for 1-5 days at 30°C.
9. Examine tubes daily for color change.
   - Color change from **red to yellow** in the Agar Tube indicates acid production. Note: any portion of the Agar Tube turning yellow indicates acid production.
   - Strong acid producers even at very low numbers can change the color overnight.
   - Slow acid producers require longer time for color change development depending on the type and number of acid producers present in the sample.
   - Visually check Agar Tubes daily for color change from red to yellow.
   - Use the evaluation chart provided below to estimate the amount of acid production due to the growth of acid producing bacteria.

Evaluation Chart for Acid Production
due to the Growth of Acid Producing Bacteria

Appearance of Yellow	Acid Production
Day 1 – Day 2	Strong
Day 3 – Day 4	Medium
Day 5	Weak

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SANI-CHECK® SRB

Test System for Counting Sulfate Reducing Bacteria

DESCRIPTION OF TEST

Anaerobic sulfate reducing bacteria are ubiquitous in the environment. They are found in secondary oil recovery effluents, estuarine waters, deep wells, cooling waters, metalworking fluids, water-based hydraulic fluids, and petroleum based products that in some way become contaminated with water. During their growth they are responsible for fouling, objectionable hydrogen sulfide odors, corrosion of metals, and pitting of concrete. It is essential that these organisms be monitored and controlled to prevent damage caused by their metabolic activities.

SANI—CHECK SRB are tubes of culture media that is specifically formulated to promote the growth of anaerobic sulfate reducing bacteria. The medium contains reducing agents that maintain a low oxidation reduction potential and thus allows for maximal growth. When the organisms grow in this medium, sulfate is reduced to sulfide and a black precipitate of iron sulfide is formed. The degree of blackening through the medium is directly proportional to the amount of sulfate reducer growth.

SANI-CHECK SRB is designed to be used in areas where little or no formal laboratory facilities are available. Everything needed to perform 25 tests is enclosed including: 25 SANI-CHECK SRB tubes, 25 identification labels, 25 applicators, one bottle mineral oil 15 (mil), one sample vial with cap, one alligator clip, and one instruction sheet.

Collection of Sample

Oily Sample
Microorganisms are unable to grow in the absence of water. In contaminated oil/water systems, the organisms will be found at the interface and in the water layer. Therefore, it is important that sampling be done from these locations. A sample vial is included with SANI-CHECK SRB. The vial should be filled with a freshly collected sample that has only a minimal oil layer on its surface. Excess oil can be skimmed from the surface of the sample with the enclosed dropper.

Water and Other Sample
No special sampling precautions are necessary. The sample may be tested using the provided vial or any other suitable container.

DIRECTIONS FOR USE

1. Open a SANI-CHECK SRB tube by peeling off the protective seal and removing the cap. Grip an applicator with the alligator clip and insert applicator into liquid sample. Immerse for approximately 5 seconds, withdraw, and drain excess fluid by running applicator along the inner lip of vial or other sample container. (Dry surfaces may be sampled by pre-wetting the applicator with tap water and swabbing a representative portion of the test area.)
2. Holding applicator with clip, insert into tube of agar, taking care to center it as much as possible. Push the applicator into the tube until it is about even with the surface of the agar.
3. Add 2-3 drops of mineral oil to the tube.
4. For Best results, place tube in any location where the temperature will be close (within 5 degrees) to that of the environment which it was taken.
5. Observe the tube regularly for results and compare to the chart below.

	Sulfate Reducers/ml*				
Days of Incubation:	1	2	3	4	5
TUBE APPEARANCE					
completely black	$\geq 10^6$	$\geq 10^5$	$\geq 10^4$	$\geq 10^3$	$\geq 10^2$
narrow zone of black around applicator center .	$\geq 10^5$	$\geq 10^4$	$\geq 10^3$	$\geq 10^2$	$\geq 10^1$
no reaction	$< 10^5$	$< 10^4$	$< 10^3$	$< 10^2$	$< 10^1$

*Figures shown have been calculated by Biosan Laboratories using anaerobic plate counts and a pure culture of *Desulfovibrio desulfuricans* (ATCC #7757)

≥ greater than or equal to
< less than

Interpretation of Quantitative Results

Sulfate Reducers/ml	Interpretation
10^5 (100,000) or more/ml	Heavy
10^3-10^4 (1,000-10,000)/ml	Moderate
10^2-10^3 (100-1,000)/ml	Low
10^1-10^2 (10-100)/ml	Very Low
10^1 (10) or less/ml	Generally Insignificant

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Appendix B: Biota Work Plan - Addendum A

Biota Investigation Work Plan: Addendum A

The following amendments to procedures set forth in the Biota Investigation Work Plan (Work Plan) were approved by the EPA via emails on August 11, August 15, August 16, and August 21, 2017.

Section 3.2 Coating Inspections

Revision to Work Plan:

An Elcometer magnetic coating gauge will be used to measure the thickness of the coating. The effective range of the Elcometer magnetic coating thickness gauge is from 25mils (thousandths of an inch) to 250mils. Where the thickness of the coating is greater than 250mils, the reading at that point will be recorded as “greater than 250mils”. Where a reading of less than 25mils is obtained, the Polatrak Cathodic Protection (CP) tool will be used to determine whether a CP measurement is possible at this location. The Polatrak tool requires a direct metal-to-metal contact between the tip of the Polatrak tool and exterior wall of the pipe. If definitive CP readings are obtained the area will be considered a Holiday and the requirements in the Work Plan for a Holiday will be followed. If definitive CP readings are not obtained, the coating thickness at this point will be recorded as greater than 0 but less than 25mils.

Rationale for Change:

Due to potential difficulties using Ultrasonic Testing (UT) to determine coating thickness on bituminous coating underwater, the project team has identified an alternative means to measure the coating thickness. An Elcometer magnetic coating gauge will be used to measure the thickness of the coating instead of UT as outlined in Revision 2 of the Work Plan.

Section 3.5.2 Biota Measurements

Revision to Work Plan

To avoid potential bias, upon ROV arrival at a Biota sampling locations not pre-defined as an Area of Interest, the crew will generate a randomly- generated number (ranging from 1 - 100 feet). The ROV will then proceed into the current (or to the north) that given distance and the diver will be lowered to the ROV location to commence Biota measurements.

Rationale for Change:

The purpose of this change is to use the time required to travel the randomly-generated distance at the surface, rather than at depths where the diver has a limited amount of time to be submerged and complete the work.

Section 3.5.3 Biota Sampling

Revision to Work Plan

In addition to placing the biota on ice after recovering the samples, ethanol will also be applied to the samples to comply with DNR permitting, which requires euthanization of invasive species such as quagga and/or zebra mussels.

One of the paired samples will be considered a “Biota” sample, which will be submitted to the GEI ecological laboratory for analysis. The other sample from each pair is considered a “Bacterial” sample, in which the sample will be evaluated APB and SRB “test kits” manufactured by Biosan Laboratories for analysis “in the field.” The remainder of the “Bacterial” sample will be submitted to the Microbial Insights laboratory for storage. Mussels will be removed from the sample prior to submission to Microbial Insights as biofilm/periphyton is the target substrate for storage, rather than mussels. Ethanol will only be applied to the “Biota” sample and will not need to be applied to the “bacterial” samples.

Rationale for Change:

Addition of detail to the Work Plan due to DNR permit requirements.

Section 3.5.3.1 Biota Sampling at Areas of Interest

Revision to Work Plan

A total of seven (7) representative locations are selected for the Biota sampling at Areas of Interest – 3 on the East pipeline and 4 on the West pipeline. Paired sampling at the Area of Interest will occur. Following this, a number between10-30 will be randomly-selected. The diver will move up current (or whichever direction is safest for the diver if the current is perpendicular to the pipelines) that many feet to arrive at the randomly-selected position and biota sampling (6-8 samples around the pipeline) will occur at this location.

Rationale for Change:

The purpose of this change is to ensure that biota sampling is conducted at randomly-selected sites while minimizing the extent to which a diver is required to walk along the lake bed. Randomly-selecting a number between10-30 is within the range a diver can safely walk without using up too much bottom time.

Section 3.5.3.2 Biota Sampling at Any Holiday Found

Revision to Work Plan

Once the Remote Operated Vehicle identifies the Area of Interest at which various measurements will be taken, the diver on first approaching the pipe will collect four biota samples as identified in Figure 9 of the BIWP. If it is determined that there are no Holidays at the Area of Interest, the Biota samples that were collected will be properly disposed of per MDNR permit requirements. If, however, a Holiday is found at the Area of Interest the Biota samples taken from that location will be retained and analyzed as described in the Work Plan.

Rationale for Change:

This change is suggested as it is not possible to determine if any holidays might exist in the coating before the surface of the pipe is cleaned prior to undertaking the work described in the BIWP. If in the process of cleaning the pipe to take the various measurements as described Section 3.2 a Holiday is identified that would require the diver to then take such Biota samples. However in the process of cleaning the pipe as well as moving around the pipe silt and other materials are stirred up. By collecting Biota samples first it will minimize any extraneous silt or other materials being collected in these samples versus collecting the Biota samples after the pipe is cleaned.

Figures 1, 2, and 3

Revision to Work Plan

The following table with the approximate (+/-50ft) Global Positioning System (GPS) locations of each Area of Interest and Additional Site will be used by the general contractor to successfully locate the previously identified Areas of Interest and Additional Sites. The locations of Areas of Interest and Additional Sites shown on Figures 1, 2 and 3 of the Work Plan (Revision 2: May 18, 2017) are schematic representations only and not to be used for specifically locating the sites.

Actuals	Location		Description
	Latitude	Longitude	
Between E-74 & E-71	REDACTED [redacted]		Area of Interest
Between E-77 & E-26			Area of Interest
Between E-24 & E-25			Area of Interest
E-30			Area of Interest
E-35			Area of Interest
Between E-33 & E-34B			Area of Interest
E-39			Area of Interest
Near E-48			Area of Interest

Actuals	Location		Description
	Latitude	Longitude	
Near E-70	REDACTED [redacted]		Area of Interest
Between E-02 & E76			Area of Interest
E-01B-B			Area of Interest
Between W-10 & W-11			Area of Interest
W-12A			Area of Interest
Between W-15 & W-16			Area of Interest
W-35			Area of Interest
W-70			Area of Interest
W-68			Area of Interest
Between W-56 & W-54			Area of Interest
E-74			Additional Site
E-72			Additional Site
W-68A			Additional Site

Rationale for Change:

Figures 1, 2 and 3 included in the test plan were provided to show the general locations for all Areas of Interest and Additional Sites. After performing initial dives, it was determined that some of the marked locations in the figures of the Areas of Interest and Additional Sites did not fully correlate with the listed pipe spans. The table with the approximate (+/-50ft) Global Positioning System (GPS) locations of each Area of Interest and Additional Site is being provided to supplement and correct Figures 1, 2 and 3 of the Biota Investigation Work Plan (Revision 2: May 18, 2017). The GPS coordinates listed will be used by the general contractor to successfully locate the previously identified Areas of Interest and Additional Sites.

Figure 7

Revision to Work Plan

The lid and shape of the sample apparatus outlined in Figure 7 may be modified.

Rationale for Change:

To preserve the sample integrity during the sample collection activities.

Appendix C: Biota Work Plan - Addendum B

Biota Investigation Work Plan: Addendum B

Background and Rationale for this Addendum

The bacteria testing using the BioSan equipment conducted in accordance with the BIWP (Section 4.2) included testing on non-biota sample "blanks" (e.g. tap water), some of which showed unexpected levels of culturable bacteria. These results bring into question the sensitivity of the full test result data set regarding bacteria levels. As such, Enbridge, in consultation with external environmental experts, wishes to conduct additional sampling and testing in order to obtain more reliable and useful test results. The scope of this additional work for the BIWP (Section 4.2) is described below:

Additional Sampling and Testing of Lake Water and Bottom Sediments, and Genetic Bacterial Enumeration of Previously Collected Samples

The collection of additional bacterial samples (lake water and bottom sediment) will help establish background levels of bacteria, and will provide additional context to the biota samples collected from the Line 5 dual pipelines. Water and bottom sediments will be collected in conjunction with on-going barge operations. Integration logistics between barge operations and these additional sampling efforts are being developed with maintenance operations. As such, specific sampling locations and depths for water and sediment will be predicated by the barge work locations. Water and sediment samples will be collected at each site as described in the next section.
Additionally, genetic bacterial analysis (quantitative polymerase chain reaction – qPCR) will be performed on both the new samples as well as the preserved biota samples from the original BIWP. In contrast with the BioSan culturing technique that may inconsistently incubate different bacterial strains, qPCR allows a more refined discrimination of bacterial population *as it existed* in the native environment. This can more precisely enumerate bacterial strains.

Water Sampling

Water samples will be collected at near surface (~ two feet of depth), approximate mid-depth, and near bottom for a total of three (3) water samples per location. Bottom water samples will be collected using a Niskin sampler (as with previous bottom water samples). All other water samples will be collected using a Van Dorn sampler. Samples will be shipped overnight to Microbial Insights for DNA extraction, qPCR testing and storage.

Bottom sediments sampling

Sediment samples will be collected from the lake bed. Samples will be collected in pairs, adjacent to each other, to provide replicate data. The sampling technique will be finalized based on feedback from Ballard Marine; it is expected that sediment sampling containers will be developed using PVC pipe or lexan-type tubing similar to systems used for sediment coring. Sediment would be sampled to a depth of approximately two inches. Sediment samples will be shipped overnight to Microbial Insights for DNA extraction, qPCR testing and storage. Greater sediment depth may need to be sampled pending confirmation on sediment volume requirements for all lab work.

APB and SRB field testing

BioSan APB and SRB field test kits will be used on each water and sediment sample following BioSan test kit protocol. APB and SRB blanks will also be generated (in duplicate) daily at the rate of no less than one set of blanks per ten investigative water or sediment samples. Types of blanks will include, but not limited to, equipment blanks (Van Dorn and Niskin samplers, sediment sampling equipment, etc.), and water blanks (i.e., distilled). Decontamination procedures recommended by Microbial Insights are consistent with those employed during the initial sampling effort (i.e., wash with non-phosphate detergent followed by rinse with distilled water). Microbial Insights advised an ethanol rinse may be beneficial for additional decontamination (i.e., wash with non-phosphate detergent, rinse with distilled water, rinse with ethanol, rinse with distilled water). This will be added to the decontamination process for equipment blanks.

Field documentation

Efforts will be documented to the same level as that of biota sampling efforts. Field data sheets will be utilized for each sample site, all samples will be photographed with time-stamp, and a field notebook will be maintained to document all efforts. It is anticipated that a daily field log would be transmitted to Leggette, Brashears, and Graham, Inc. and Enbridge on a daily basis.

Results reporting

Data generated through these efforts shall be evaluated and summarized. Summaries will include, but not limited to, figures depicting sediment sampling and water sampling locations, and the associated results from the APB/SRB test kits and qPCR testing. This information will be included in the BIWP report.

Appendix D: Coating Inspection Reports

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/08/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-1	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

Coating Condition	☒ Disturbed Area ☐Dislodged Coating ☐Holiday ☐Other	**Size of anomaly (ft^2):**	9.17 (3'4" X 2'9")
Feature 1	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☒Other	**Size of anomaly (ft^2):**	0.01 (1" X1")
Feature 2	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☒Other	**Size of anomaly (ft^2):**	0.01 (1" X1.5")
Feature 3	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☒Other	**Size of anomaly (ft^2):**	0.01 (1" X1")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☐Other	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	6 o'clock (pipe resting on lake bed)

Comments/Issues/Discussion

EAOI-1 E-01B-B is an area of disturbed biota and contains three areas of white deposit within a 6" X 1.5" area on the top of the pipe (12 o'clock).

DFT measurements indicate normal coating thickness through the entire area inspected.

CP measurements taken with the Polatrak CP gun through the white deposit areas deviated slightly from reference 'open water' measurements, but they were not sufficiently electronegative to indicate contact with Line 5 pipe metal.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/08/17	Frame(HH:MM:SS)	9:01:01	Date:	09/08/17	Frame(HH:MM:SS)	12:07:06

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
North End #1	115	105	110
#2	150	125	110
#3	105	98	90
South End #4	105	95	100
#5	105	95	100
#6	110	100	100
Average Thickness	115	103	101

Additional Coating Thickness Inspection Data (A/R)

	Centerline of AOI at 12, 3, and 9 o'clock	
Top	105	
West	125	
East	110	

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) (note: holiday could not be confirmed)					
CP Reading #1 (mV) (feature 1)	-234 -281	CP Reading #2 (mV) (feature 2)	-440 -316	CP Reading #3 (mV) (feature 3)	-320 -260
Temperature (°F)	45	DFT at Feature (mil)	N/R	DFT Adjacent to Features (mil) (features 1, 2, and 3 respectively)	130, 145, 140

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/08/17	Frame(HH:MM:SS)	12:07:06	Date:		Frame(HH:MM:SS)	

Note: CP readings at this feature were recorded with the probe of Polatrak CP gun pressed firmly into the white substance coating the pipe. These readings were more electronegative than the 'open water' CP readings (-198mV / -170mV), but are not consistent with Line 5 pipe metal contact – indicating that the presence of a resistive coating on the pipe surface.

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ENBRIDGE

External Pipeline Inspection Form for L5 Straits of Mackinac

General Information			
Date:	08/26/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-2	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results			
General Area	☒ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	4.52 (1'5.5" X 3.1')
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	6:00

ments/Issues/Discussion

EAOI-2 is between E-02A and E-76B

Minimum DFT thickness recorded was 70 mils, so no CP measurements were obtained.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	08/26/17	Frame(HH:MM:SS)	08:54:11	Date:	08/26/17	Frame(HH:MM:SS)	08:59:19

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	70	88	115
#2	105	90	105
#3	125	98	115
North End #4	105	74	100
#5	100	115	72
#6	110	100	105
Average Thickness	103	94	102

Additional Coating Thickness Inspection Data (A/R)

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

General Information			
Date:	08/30/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-3	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	4[redacted]

External Pipe Coating Inspection Results			
General Area	☐ Disturbed Area ☒Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	3.69 (18" X 29.5")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	5:00 – 7:00

Comments/Issues/Discussion

EAOI-3 Near E-70

Outer wrap is disloged at 12:00

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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[redacted]

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	08/30/17	Frame(HH:MM:SS)	01:22:23	Date:	08/30/17	Frame(HH:MM:SS)	01:22:23

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
North End #1	125	125	110
#2	120	135	125
#3	120	125	120
South End #4	140	110	115
#5	140	95	105
#6	125	125	110
Average Thickness	128	119	114

Additional Coating Thickness Inspection Data (A/R)

[redacted]

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	08/30/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-4	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☒ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	4.12 (1.6' X 2.9')
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	3-9 o'clock

Comments/Issues/Discussion

EAOI-4 is near E-48

Minimum DFT thickness recorded was 94 mils, so no CP measurements were obtained.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	08/30/17	Frame(HH:MM:SS)	14:51:00	Date:	08/30/17	Frame(HH:MM:SS)	16:07:12

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	125	145	115
#2	140	125	115
#3	125	115	140
North End #4	125	120	125
#5	135	94	135
#6	135	105	100
Average Thickness	131	117	121

Additional Coating Thickness Inspection Data (A/R)

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/06/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-5	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

Coating Condition	☒ Disturbed Area ☐Dislodged Coating ☐Holiday ☐Other	**Size of anomaly (ft^2):**	23.29 (6'6"x3'7")
Feature 1	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☒Other	**Size of anomaly (ft^2):**	0.01 (1" X1")
Feature 2	☐ Disturbed Area ☒Dislodged Coating ☐Holiday ☐Other	**Size of anomaly (ft^2):**	0.01 (1" x 2")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☐Other	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☐Other	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	N/A (pipe is suspended)

Comments/Issues/Discussion

EAOI-5 E-39 is an area of disturbed biota and contains one area of white deposit approximately the size of a quarter located near the top of the pipe (at 12 o'clock). The white deposit is located adjacent to a coated circumferential seam weld in the pipe.

DFT measurements indicate normal coating thickness through the entire area inspected, with slightly thinner coating adjacent to the white deposit.

CP measurements taken with the Polatrak CP gun through the white deposit areas deviated slightly from reference 'open water' measurements, but they were not sufficiently electronegative to indicate contact with Line 5 pipe metal.

Part of the white deposit broke away during the CP readings without exposing bare metal.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/06/17	Frame(HH:MM:SS)	14:45:12	Date:	09/06/17	Frame(HH:MM:SS)	14:47:47

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
North End #1	145	72	130
#2	94	115	130
#3	105	100	110
South End #4	130	130	135
#5	110	120	105
#6	105	100	105
Average Thickness	119	106	119

Additional Coating Thickness Inspection Data (A/R)* (see note below)

	16” from South End	34” from South End	52” from South End
West	135	145	145
Top	105	105	120
East	105	125	105

Note: An area of dislodged outer wrap was identified 2.5’ from the south end of the AOI. Coating thickness in this area was 100 mil.

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Cathodic Protection and Coating Measurements (if Holiday is found) (note: holiday could not be confirmed)							
CP Reading #1 (mV) (feature 1)	-391 -326	CP Reading #2 (mV)	N/R	CP Reading #3 (mV)	N/R		
Temperature (°F)	50	DFT at Feature (mil)	N/R	DFT Adjacent to Features (mil)	82,72,78,78		

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/06/17	Frame(HH:MM:SS)	14:47:47	Date:		Frame(HH:MM:SS)	

Note: CP readings at this feature were recorded with the probe of Polatrak CP gun pressed firmly into the white substance coating the pipe. These readings were more electronegative than the 'open water' CP readings (-101mV / -061mV), but are not consistent with Line 5 pipe metal contact – indicating that the presence of a resistive coating on the pipe surface.

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/05/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	E-AOI-6	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☐ Disturbed Area ☒Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	3.17 (1'7"x2')
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☒YES ☐NO		**Lake floor location wrt pipe:**	3-9 o'clock

Comments/Issues/Discussion

EAOI-6 is between E-33 and E-34B

Minimum DFT thickness recorded was 100 mils, so no CP measurements were obtained.

Opportunistic sampling of dislodged outer wrap was performed (found laying on lake floor).

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/05/17	Frame(HH:MM:SS)	14:00:07	Date:	09/05/17	Frame(HH:MM:SS)	14:00:14

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	130	120	120
#2	125	130	100
#3	145	135	136
North End #4	130	122	125
#5	120	120	135
#6	160	135	139
Average Thickness	135	127	125

Additional Coating Thickness Inspection Data (A/R)

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/05/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-7	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

Coating Condition	☒ Disturbed Area ☐Dislodged Coating ☐Holiday ☐Other	**Size of anomaly (ft^2):**	7.08 (2'5" X 2'10")
Feature 1	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☒Other	**Size of anomaly (ft^2):**	0.04 (3" X2")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☐Other	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☐Other	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☐Other	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	N/A (pipe is suspended)

Comments/Issues/Discussion

EAOI-7 is located in Span E-35. This area of disturbed biota contains one area of white deposit.

DFT measurements indicate normal coating thickness through the entire area inspected, with slightly thinner coating adjacent to the white deposit.

The Polatrak CP gun was used to test for coating holiday through the white deposit, but valid CP measurements could not be obtained. This indicates the presence of a resistive or isolating coating on the pipe surface.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/05/17	Frame(HH:MM:SS)	12:24:13	Date:	09/05/17	Frame(HH:MM:SS)	12:23:58

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	111	106	114
#2	104	109	100
#3	135	113	126
North End #4	159	160	160
#5	166	200	190
#6	190	120	110
Average Thickness	144	134	133

Additional Coating Thickness Inspection Data (A/R)* (see note below)

	Centerline of AOI	Adjacent to white substance	
	134	63	
	104	75	
	119	95	

CP gun was pressed firmly into the white deposit, but valid CP readings could not be obtained.

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information			
Date:	10/13/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-7	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results				
1A	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.23 (1'1"x2½")
1B	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.19 (1'2"x2")
1C	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.01 (1"x1½")
1D	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.92 (1'7"x7")
1E	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.67 (2'x4")
1F	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.19 (6"x4½")
1G	☐ Disturbed Area ☐Holiday	☐Dislodged Coating ☒Other	**Size of anomaly (ft^2):**	0.07 (4"x2½")
1H	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.003 (¾"x¾")
1I	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	1.33 (16"x1')
1J	☐ Disturbed Area ☐Holiday	☐Dislodged Coating ☒Other	**Size of anomaly (ft^2):**	0.59 (10"x8½")
1K	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.002 (¾"x½")
1L	☐ Disturbed Area ☐Holiday	☐Dislodged Coating ☒Other	**Size of anomaly (ft^2):**	1.04 (15"x10")
1M	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.44 (16"X4")
1N	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.28 (16"X2½")
1O	☐ Disturbed Area ☒Holiday	☐Dislodged Coating ☐Other	**Size of anomaly (ft^2):**	0.17 (12"X2")
Corrosion present:	☐YES	☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor:	☐YES	☒NO	**Lake floor location wrt pipe:**	N/A (pipe is suspended)

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Comments/Issues/Discussion

EAOI-7 is located in Span E-35.

Features 1G, 1J, 1L are classified as 'other' (DFT >25, no valid metal contact CP readings).

Features 1K, 1M are classified as 'holidays' based on diver observation. However, DFT readings were >25mils and no valid CP readings could be obtained.

All other features are classified as holidays, and have valid CP readings indicated metal contact with pipe.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/05/17	Frame(HH:MM:SS)	12:24:13	Date:		Frame(HH:MM:SS)	

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	10/06/2017	**Next Calibration Due:**	10/06/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
North End #1	78	200	200
#2	120	66	190
#3	96	74	220
South End #4	210	125	150
#5	72	115	125
#6	105	130	130
Average Thickness	113	118	169

Additional Coating Thickness Inspection Data (A/R)* (see note below)

	Centerline of AOI	Adjacent to white substance	

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1A							
CP Reading #1 (mV)	-1235 -1238	CP Reading #2 (mV)	-1223 -1269	CP Reading #3 (mV)	-1206 -1195		
Temperature (°F)	62	DFT at Holiday (mil)	<25	DFT Adjacent to Holiday (mil)	100, 250, 109		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	10:08:23	Date:		Frame(HH:MM:SS)	

Average CP ‘OFF’ reading: -869mV.

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1B							
CP Reading #1 (mV)	-1185 -1196	CP Reading #2 (mV)	-1281 -1277	CP Reading #3 (mV)	-1278 -1279		
Temperature (°F)	54	DFT at Holiday (mil)	<25	DFT Adjacent to Holiday (mil)	135, 102, 126		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	10:12:48	Date:		Frame(HH:MM:SS)	

Average CP ‘OFF’ reading: -903mV.

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1C							
CP Reading #1 (mV)	-1511 -1528	CP Reading #2 (mV)	-1485 -1511	CP Reading #3 (mV)	-1505 -1515		
Temperature (°F)	54	DFT at Holiday (mil)	48	DFT Adjacent to Holiday (mil)	78,76,79		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	10:19:27	Date:		Frame(HH:MM:SS)	

Average CP 'OFF' reading: -1112mV

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1D							
CP Reading #1 (mV)	-1359 -1370	CP Reading #2 (mV)	-1355 -1367	CP Reading #3 (mV)	-1365 -1373		
Temperature (°F)	54	DFT at Holiday (mil)	37	DFT Adjacent to Holiday (mil)	71,106,42		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	10:22:32	Date:		Frame(HH:MM:SS)	

Average CP ‘Off’ reading:-1078mV

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1E							
CP Reading #1 (mV)	-1174 -1187	CP Reading #2 (mV)	-1205 -1214	CP Reading #3 (mV)	-1186 -1087		
Temperature (°F)	54	DFT at Holiday (mil)	42	DFT Adjacent to Holiday (mil)	99,88,94		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	10:28:51	Date:		Frame(HH:MM:SS)	

Average CP ‘OFF’ reading: -917mV

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1F							
CP Reading #1 (mV)	-1568 -1570	CP Reading #2 (mV)	-1561 -1570	CP Reading #3 (mV)	-1552 -1558		
Temperature (°F)	55	DFT at Holiday (mil)	<25	DFT Adjacent to Holiday (mil)	96,88,121		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	10:30:30	Date:		Frame(HH:MM:SS)	

Average CP 'OFF' reading: -1127mV

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Feature 1G							
CP Reading #1 (mV)	-272 -254	CP Reading #2 (mV)	-227 -184	CP Reading #3 (mV)	-251 -248		
Temperature (°F)	55	DFT at Feature (mil)	68	DFT Adjacent to Feature (mil)	66, 120, 105		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	11:05:27	Date:		Frame(HH:MM:SS)	

No bare metal was observed. DFT readings>25 mils. Valid CP readings could not be obtained (no pipe metal could be contacted).

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1H							
CP Reading #1 (mV)	-1577 -1571	CP Reading #2 (mV)	-1562 -1547	CP Reading #3 (mV)	-1575 -1559		
Temperature (°F)	55	DFT at Holiday (mil)	65	DFT Adjacent to Holiday (mil)	115, 115, 94		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	11:07:53	Date:		Frame(HH:MM:SS)	

Average CP ‘OFF’ reading: -1073mV

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1l							
CP Reading #1 (mV)	-1486 -1468	CP Reading #2 (mV)	-1551 -1508	CP Reading #3 (mV)	-1524 -1517		
Temperature (°F)	59	DFT at Holiday (mil)	<25	DFT Adjacent to Holiday (mil)	115,125,86		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	11:21:24	Date:		Frame(HH:MM:SS)	

Average CP ‘OFF’ reading: -1053mV

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Feature 1J							
CP Reading #1 (mV)	-270 -290	CP Reading #2 (mV)	-252 -273	CP Reading #3 (mV)	-401 -349		
Temperature (°F)	55	DFT at Feature (mil)	51	DFT Adjacent to Feature (mil)	94, 94, 135		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	11:59:33	Date:		Frame(HH:MM:SS)	

No bare metal was observed. DFT readings>25 mils. Valid CP readings could not be obtained (no pipe metal could be contacted).

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1K							
CP Reading #1 (mV)	-311 -282	CP Reading #2 (mV)	-276 -258	CP Reading #3 (mV)	-276 -261		
Temperature (°F)	55	DFT at Holiday (mil)	47	DFT Adjacent to Holiday (mil)	94, 88, 112		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	12:01:27	Date:		Frame(HH:MM:SS)	

NB: Diver observed bare metal (holiday) from visual examination, but Polartrak gun could not be positioned to take valid reading. DFT of 47 mils at feature suggests the bare metal area is very small in relation to the apparent visual feature. Recorded CP readings 1, 2, and 3 indicate no metal contact (open water readings) which are not valid pipe potential.

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Feature 1L							
CP Reading #1 (mV)	-278 -265	CP Reading #2 (mV)	-267 -252	CP Reading #3 (mV)	-280 -259		
Temperature (°F)	54	DFT at Feature (mil)	88	DFT Adjacent to Feature (mil)	88, 94, 98		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	12:01:59	Date:		Frame(HH:MM:SS)	

No bare metal was observed. DFT readings>25 mils. Valid CP readings could not be obtained (no pipe metal could be contacted).

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1M							
CP Reading #1 (mV)	-434 -429	CP Reading #2 (mV)	-407 -403	CP Reading #3 (mV)	-446 -416		
Temperature (°F)	55	DFT at Holiday (mil)	71	DFT Adjacent to Holiday (mil)	84, 83, 104		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	12:03:45	Date:		Frame(HH:MM:SS)	

NB: Diver observed bare metal (holiday) from visual examination, but Polartrak gun could not be positioned to take valid reading. DFT of 71 mils at feature suggests the bare metal area is very small in relation to the apparent visual feature. Recorded CP readings 1, 2, and 3 indicate no metal contact (open water readings) which are not valid pipe potential.

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1N							
CP Reading #1 (mV)	-1436 -1430	CP Reading #2 (mV)	-1025 -1043	CP Reading #3 (mV)	-1401 -1406		
Temperature (°F)	59	DFT at Holiday (mil)	29	DFT Adjacent to Holiday (mil)	115, 116, 72		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	12:05:18	Date:		Frame(HH:MM:SS)	

Average CP 'OFF' reading: -913mV. Note that CP reading #2 may have been affected by surface contact resistance between Polatrack gun and pipe steel.

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1O							
CP Reading #1 (mV)	-1291 -1302	CP Reading #2 (mV)	-1466 -1459	CP Reading #3 (mV)	-1212 -1218		
Temperature (°F)	59	DFT at Holiday (mil)	29	DFT Adjacent to Holiday (mil)	78,120,96		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/12/17	Frame(HH:MM:SS)	12:05:59	Date:		Frame(HH:MM:SS)	

Average CP ‘OFF’ reading: -970mV

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/06/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-8	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☒ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	3.67 (1'10"x2')
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	N/A (pipe is suspended)

Comments/Issues/Discussion

EAOI-8 is in Span E-30

Minimum DFT thickness recorded was 94 mils, so no CP measurements were obtained.

Diver identified the outer layer as being loose.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/06/17	Frame(HH:MM:SS)	08:56:29	Date:	09/06/17	Frame(HH:MM:SS)	09:45:37

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	125	135	94
#2	140	115	100
#3	120	145	95
North End #4	140	115	110
#5	130	115	115
#6	115	100	105
Average Thickness	128	120	103

Additional Coating Thickness Inspection Data (A/R)

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/06/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-9	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☐ Disturbed Area ☒Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	0.71 (1'5"x6")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☒YES ☐NO		**Lake floor location wrt pipe:**	2-9 o'clock

Comments/Issues/Discussion

EAOI-9 is between E-24 and E-25

Minimum DFT thickness recorded was 80 mils, so no CP measurements were obtained.

Opportunistic sampling of coating and banding was recovered from the lake floor beside the pipe.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/06/17	Frame(HH:MM:SS)	11:13:28	Date:	09/06/17	Frame(HH:MM:SS)	11:13:33

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	115	140	145
#2	115	110	125
#3	110	125	140
North End #4	95	80	120
#5	85	105	120
#6	95	120	115
Average Thickness	102	113	127

Additional Coating Thickness Inspection Data (A/R)

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/06/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-10	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☐ Disturbed Area ☒Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	8.83 (4'5"x2')
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	1-11 o'clock

Comments/Issues/Discussion

EAOI-10 between E-77 and E-26

The diver described what appeared to be a 'scratch in the coating @ 12:00. However, DFT thickness readings in this area were 95 mils, indicating intact coating. Minimum DFT thickness recorded was 89 mils, so no CP measurements were obtained.

Diver observed 'bands' in the lake bed at this AOI.

A loose piece of outerwrap was recovered and brought to surface.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/06/17	Frame(HH:MM:SS)	12:26:44	Date:	09/06/17	Frame(HH:MM:SS)	12:27:34

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	115	125	105
#2	125	135	120
#3	120	145	130
North End #4	89	95	100
#5	105	99	105
#6	94	94	115
Average Thickness	108	115	112

Additional Coating Thickness Inspection Data (A/R)

		C/L of AOI, close as possible to 12 o'clock	
		135	
		160	
		140	

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	08/24/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAOI-11	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☐ Disturbed Area ☒Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	0.02 (1.3" x 1.9")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	2-10 o'clock

Comments/Issues/Discussion

EAOI-11 is between E-74 and E-71

Minimum DFT thickness recorded was 105 mils, so no CP measurements were obtained.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	08/24/17	Frame(HH:MM:SS)	17:05:42	Date:	08/24/17	Frame(HH:MM:SS)	15:50:39

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	125	135	140
#2	125	130	105
#3	125	135	115
North End #4	120	190	195
#5	190	200	190
#6	180	185	200
Average Thickness	144	162	157

Additional Coating Thickness Inspection Data (A/R)

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

General Information			
Date:	10/06/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAS-1	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results			
1B 12:00	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.02 (1”x 3-1/2”)
1C 9:00	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.01 (1”x1-1/2”)
1D 7:00	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.50 (1-1/2”x4’)
1E 6:00	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.32 (1-1/2”x2’7”)
1F 9:00	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.03 (1-1/4”x3”)
Corrosion present:	☐YES ☒NO (see note 1)	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	In span 10-18”

Comments/Issues/Discussion

EAS-1 within span of E-72.

1B and 1C are on a girth weld (Same GW)

(1) Dive video shows an area of discoloration beneath coating (upon removal of dislodged coating by the diver). Inspection of pipe after wire brushing did not reveal metal loss.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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[redacted]

Visual Inspection (General Coating Condition)							
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:		Frame(HH:MM:SS)		Date:		Frame(HH:MM:SS)	

Coating Gauge Information			
Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	09/15/2017	**Next Calibration Due:**	09/15/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data			
Thickness Measure (mil)	**Area of Interest**	**Undisturbed Area (< 2 in.)**	**Undisturbed Area (> 5 ft.)**
South #1	N/A	N/A	N/A
#2	N/A	N/A	N/A
#3	N/A	N/A	N/A
#4	N/A	N/A	N/A
#5	N/A	N/A	N/A
#6	N/A	N/A	N/A
Average Thickness			

Additional Coating Thickness Inspection Data (A/R)			

[redacted]

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1B							
CP Reading #1 (mV)	-1616 -1606	CP Reading #2 (mV)	-1394 -1418	CP Reading #3 (mV)	-1390 -1407		
Temperature (°F)	56	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	160,190,105		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/06/17	Frame(HH:MM:SS)	11:19:42	Date:		Frame(HH:MM:SS)	

NB: CP Readings #2 and #3 are suspected to be impacted by contact resistance (some coating or other resistive material between probe tip and pipe metal).

Alternatively, the ~200mV variation might be attributable to rectifier interruption during these measurements (consistent with Holidays 1B, 1D, and 1F; while 1E's only valid CP readings are in the range of -1400mV CSE).

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1C							
CP Reading #1 (mV)	-1569 -1578	CP Reading #2 (mV)	-956 -998	CP Reading #3 (mV)	-945 -960		
Temperature (°F)	56	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	110,72,120		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/06/17	Frame(HH:MM:SS)	11:24:38	Date:		Frame(HH:MM:SS)	

NB: CP Readings #2 and #3 are suspected to be impacted by contact resistance (some coating or other resistive material between probe tip and pipe metal).

The only valid CP readings from this holiday are similar in magnitude to the most electronegative readings from Holidays 1B, 1C, and 1F)

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1D							
CP Reading #1 (mV)	-1133 -1496	CP Reading #2 (mV)	-1437 -1439	CP Reading #3 (mV)	-1471 -1460		
Temperature (°F)	56	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	170, 160, 135		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/06/17	Frame(HH:MM:SS)	11:28:50	Date:		Frame(HH:MM:SS)	

NB: CP Readings #1 (top) is suspected to be impacted by contact resistance (this may be caused by slight movement of probe tip in between top and bottom readings).

Alternatively, the ~300-350mV variation might be attributable to rectifier interruption during these measurements (this is slightly greater than the variations observed at Holidays 1B, and 1F; while 1E's only valid CP readings are in the range of -1400mV CSE).

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1E							
CP Reading #1 (mV)	-600 -591	CP Reading #2 (mV)	-530 -501	CP Reading #3 (mV)	-1406 -1403		
Temperature (°F)	56	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	198, 98, 120		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/06/17	Frame(HH:MM:SS)	11:34:57	Date:		Frame(HH:MM:SS)	

NB: CP Readings #1 and #2 are suspected to be impacted by contact resistance (some coating or other resistive material between probe tip and pipe metal).

The only valid CP readings at this holiday is consistent with some of the readings from other holidays at this location.

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1F							
CP Reading #1 (mV)	-1669 -1674	CP Reading #2 (mV)	-1478 -1494	CP Reading #3 (mV)	-1478 -1494		
Temperature (°F)	56	DFT at Holiday (mil)	85	DFT Adjacent to Holiday (mil)	130, 130, 125		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	10/06/17	Frame(HH:MM:SS)	11:35:09	Date:		Frame(HH:MM:SS)	

NB: CP Readings #2 and #3 are suspected to be impacted by contact resistance (some coating or other resistive material between probe tip and pipe metal).

Alternatively, the ~200mV variation might be attributable to rectifier interruption during these measurements (consistent with Holidays 1B, 1D, and 1F; while 1E's only valid CP readings are in the range of -1400mV CSE).

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	08/15/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAS-1	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☒ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	48.84 (46'x 1.74')
Holiday 1	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.01 (3.0"x0.5")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	N/A (pipe is suspended)

Comments/Issues/Discussion

EAS-1 within span of E-72. Total span is 46' long, within the areas of 10:00 and 2:00.
South End Lat: [redacted] long [redacted]
North End Lat: [redacted]
Center Line listed in general information above.

One (1) feature with DFT measurements below the minimum resolvable thickness of gauge was found. The Polatrak CP gun was used to confirm the existence of bare metal:

Holiday 1 presented average CP reading of -1680mV CSE (holiday confirmed). Holiday found in coating at coordinates Lat: [redacted] Long: [redacted]

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	8/15/17	Frame(HH:MM:SS)	09:26:36	Date:	8/15/17	Frame(HH:MM:SS)	09:27:04

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
North End #1	115	125	130
#2	109	135	130
#3	115	136	140
South End #4	120	145	140
#5	120	128	130
#6	101	130	134
Average Thickness	113	133	134

Additional Coating Thickness Inspection Data (A/R)

	Close as possible to 9 o'clock	Close as possible to 12 o'clock	Close as possible to 2 o'clock
North End	104	120	122
---	104	115	118
South End	130	130	140

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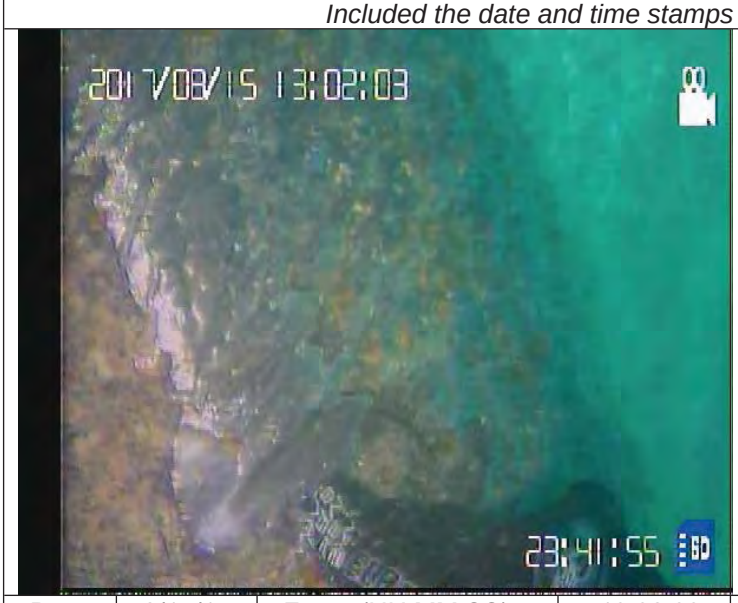
ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1							
CP Reading #1 (mV)	-1676 -1683	CP Reading #2 (mV)	-1674 -1681	CP Reading #3 (mV)	-1690 -1674		
Temperature (°F)	NR	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	96, 94, 95		

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.



Date:	8/15/17	Frame(HH:MM:SS)	13:02:03	Date:	8/15/17	Frame(HH:MM:SS)	13:05:42

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ENBRIDGE

External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	08/24/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAS-2	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

Coating Condition	☐ Disturbed Area ☐Dislodged Coating ☐Holiday ☒Other	**Size of anomaly (ft^2):**	0.14 (2.5" x 8")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	N/A (pipe is suspended)

Comments/Issues/Discussion

EAS-2 is within span of E-74.

DFT measurements indicate normal coating thickness through majority of area, with one small area of slightly reduced thickness, which may indicate possible dislodgement of outer wrap. This could not be confirmed due to the presence of a white deposit.

The Polatrak CP gun was used to check for coating holiday through the white deposit. CP measurements could not be obtained, indicating the corrosion barrier coating is intact.

It is recommended to revisit this site to destructively remove the white deposit and inspect the coating condition beneath it. This should be performed during the recoating project so that any resulting coating damage can be repaired.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	8/24/17	Frame(HH:MM:SS)	14:11:12	Date:	8/24/17	Frame(HH:MM:SS)	14:38:33

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
North End #1	135	130	115
#2	140	130	115
#3	110	140	120
South End #4	117	119	125
#5	130	94	130
#6	70	150	135
Average Thickness	117	127	121

Additional Coating Thickness Inspection Data (A/R)

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) (note: holiday could not be confirmed)							
CP Reading #1 (mV) See note (below)	-261 -291	CP Reading #2 (mV)	N/R	CP Reading #3 (mV)	N/R		
Temperature (°F)	NR	DFT at Feature (mil)	≥ 70 avg.117	DFT Adjacent to Feature (mil)	≥ 94 avg.127		

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	8/24/17	Frame(HH:MM:SS)	14:11:12	Date:	8/24/17	Frame(HH:MM:SS)	14:38:33

Note: CP readings at this feature were recorded with the probe of Polatrak CP gun pressed firmly through the white substance covering the pipe. These readings were identical to 'open water' CP readings, which were recorded with the CP gun probe close to (but not touching) the pipe.

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

General Information			
Date:	08/29/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAS-3	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results			
Coating Condition	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.93 (8”x1.4’)
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor:	☐YES ☒NO	**Lake floor location wrt pipe:**	Pipe suspended

Comments/Issues/Discussion

East Additional Site #3 (South of E-22).

DFT measurements at the feature are below the minimum resolvable thickness of gauge.
The Polatrak CP gun was used to confirm the existence of bare metal:

Holiday 1 presented average CP reading of -848mV CSE (holiday confirmed).

No external corrosion was detected by dive team.

[redacted]

[redacted]

Enbridge Representative/ Inspector Signature

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition and Holiday 1)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	8/29/17	Frame(HH:MM:SS)	10:35:09	Date:	8/29/17	Frame(HH:MM:SS)	10:35:44

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
North End #1	105	85	130
#2	≤25	120	120
#3	115	115	130
South End #4	≤25	80	100
#5	≤25	80	100
#6	≤25	125	105
Average Thickness		101	114

Additional Coating Thickness Inspection Data (A/R)

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1							
CP Reading #1 (mV)	-852 -886	CP Reading #2 (mV)	-804 -842	CP Reading #3 (mV)	-834 -875		
Temperature (°F)	44	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	80, 80, 125		

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	8/29/17	Frame(HH:MM:SS)	10:35:09	Date:	8/29/17	Frame(HH:MM:SS)	10:35:44

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

General Information			
Date:	08/30/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	EAS-4	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results			
General Area	☒ Disturbed Area Coating ☐Dislodged ☐Holiday	**Size of anomaly (ft^2):**	3.0 (1'6" X 2')
Holiday 1	☐ Disturbed Area Coating ☐Dislodged ☒Holiday	**Size of anomaly (ft^2):**	0.53 (7" X 11")
Holiday 2	☐ Disturbed Area Coating ☐Dislodged ☒Holiday	**Size of anomaly (ft^2):**	1.11 (1'4" X 10")
	☐ Disturbed Area Coating ☐Dislodged ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area Coating ☐Dislodged ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☐YES ☒ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	Pipe buried

Comments/Issues/Discussion

East Additional Site #4.

Two (2) features with DFT measurements below the minimum resolvable thickness of gauge were found. The Polatrak CP gun was used to confirm the existence of bare metal:
Holiday 1 presented average CP reading of -963mV CSE (holiday confirmed).
Holiday 2 presented average CP reading of -958mV CSE (holiday confirmed).

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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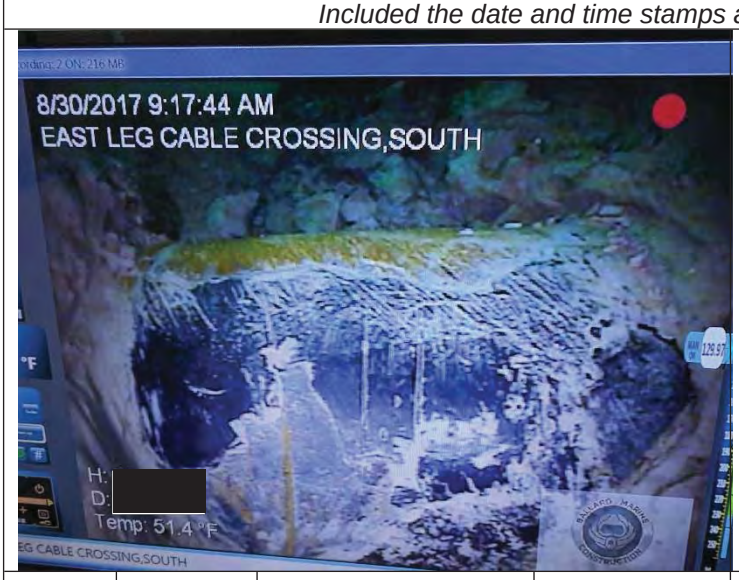
ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition, Holidays 1 and 2)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video sdurveillance.



Date:	8/30/17	Frame(HH:MM:SS)	09:17:44	Date:	8/30/17	Frame(HH:MM:SS)	08:55:25

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
North End #1	≤25	N/R (see note, below)	N/R
#2	≤25	N/R	N/R
#3	≤25	N/R	N/R
South End #4	≤25	N/R	N/R
#5	≤25	N/R	N/R
#6	≤25	N/R	N/R
Average Thickness			

Additional Coating Thickness Inspection Data (A/R)

Note: coating thickness in undisturbed areas around the cable rub could not be obtained due to the presence of silt and soil (lake bed). The pipe is below the level of the lake bed. See Holiday 1 and Holiday 2 *'DFT thicknesses adjacent to the Holidays'* for representative coating thickness in the area.

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1							
CP Reading #1 (mV)	-955 -991	CP Reading #2 (mV)	-938 -965	CP Reading #3 (mV)	-951 -979		
Temperature (°F)	44	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	96, 84, 100, 135		

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	8/30/17	Frame(HH:MM:SS)	8:58:31

Date:	8/30/17	Frame(HH:MM:SS)	9:17:40

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 2							
CP Reading #1 (mV)	-981 -1012	CP Reading #2 (mV)	-907 -933	CP Reading #3 (mV)	-944 -974		
Temperature (°F)	44	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	105, 140, 76, 95, 84		

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	8/30/17	Frame(HH:MM:SS)	10:03:31

Date:	8/30/17	Frame(HH:MM:SS)	10:14:55

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/07/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	WAOI-1	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☒ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	1.65 (1'2"x1'5")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☒YES ☐NO		**Lake floor location wrt pipe:**	6 o clock

Comments/Issues/Discussion

WAOI-1 is South of span W-54

Minimum DFT thickness recorded was 100 mils, so no CP measurements were obtained.

A coating-like material (12" X 16.75", 3 mm thick) was found leaning against the east side of the pipe and was brought to surface.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/07/17	Frame(HH:MM:SS)	08:55:54	Date:	09/07/17	Frame(HH:MM:SS)	10:54:37

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	119	100	120
#2	105	135	115
#3	136	123	116
North End #4	126	123	119
#5	109	119	128
#6	131	110	141
Average Thickness	121	118	123

Additional Coating Thickness Inspection Data (A/R)

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/07/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	WAOI-2	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☒ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	5.0 (5'x1')
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	N/A (pipe is suspended)

Comments/Issues/Discussion

WAOI-2 is in span W-68A

Minimum DFT thickness recorded was 95 mils, so no CP measurements were obtained.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/07/17	Frame(HH:MM:SS)	14:39:54	Date:	09/07/17	Frame(HH:MM:SS)	16:06:16

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	105	105	100
#2	100	130	110
#3	135	130	130
North End #4	115	95	105
#5	135	130	120
#6	120	110	105
Average Thickness	118	116	112

Additional Coating Thickness Inspection Data (A/R)

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	08/26/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	WAOI-3	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☐ Disturbed Area ☒Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	3.84 (1 .2' X 3.2')
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	N/A (pipe is suspended)

Comments/Issues/Discussion

WAOI-3 is in span W-70

Minimum DFT thickness recorded was 83 mils, so no CP measurements were obtained.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	08/26/17	Frame(HH:MM:SS)	12:54:10	Date:	08/26/17	Frame(HH:MM:SS)	14:30:02

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	84	88	110
#2	89	95	104
#3	120	116	88
North End #4	83	210	90
#5	112	120	108
#6	190	225	124
Average Thickness	113	142	104

Additional Coating Thickness Inspection Data (A/R)

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/08/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	WAOI-4	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☒ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	3.66 (1'5"x2'7")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	N/A (pipe is suspended)

Comments/Issues/Discussion

WAOI-4 is in span W-35A

Minimum DFT thickness recorded was 84 mils, so no CP measurements were obtained.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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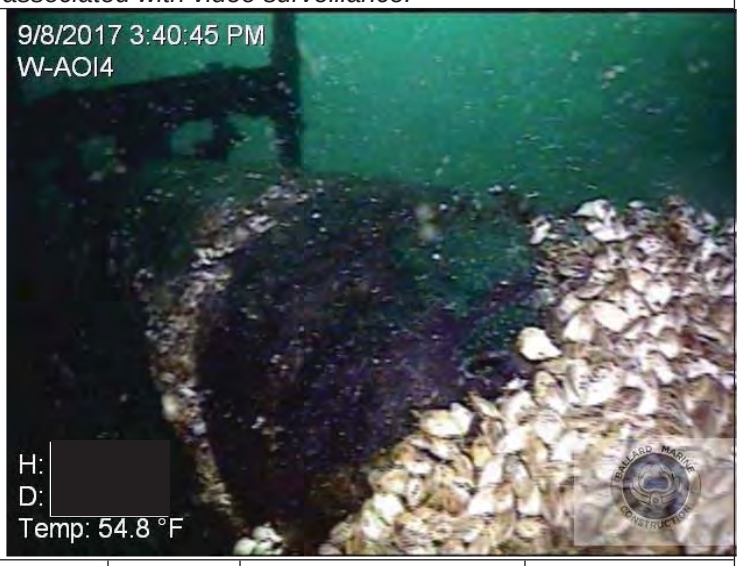
ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.



Date:	09/08/17	Frame(HH:MM:SS)	14:25:44	Date:	09/08/17	Frame(HH:MM:SS)	15:40:45

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	180	170	100
#2	180	100	110
#3	125	104	100
North End #4	160	180	84
#5	180	170	115
#6	115	115	125
Average Thickness	156	139	105

Additional Coating Thickness Inspection Data (A/R)

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ENBRIDGE

External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	08/21/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	WAOI-5	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☐ Disturbed Area ☒Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	2.72 (1.5'x1.11')
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	3-9 o'clock

Comments/Issues/Discussion

WAOI-5 is located between W-15 and W-16

Dislodged coating was collected from the East side of the pipe.

Minimum DFT thickness recorded was 72 mils, so no CP measurements were obtained.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	08/21/17	Frame(HH:MM:SS)	14:49:38	Date:	08/21/17	Frame(HH:MM:SS)	15:54:13

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
North End #1	205	215	72
#2	202	103	105
#3	115	140	75
South End #4	94	180	80
#5	105	175	115
#6	96	115	115
Average Thickness	136	155	94

Additional Coating Thickness Inspection Data (A/R)

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/06/17	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	WAOI-6	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☒ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	3.54 (1'3"x2'10")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	5-7 o'clock

Comments/Issues/Discussion

WAOI-6 is in span W-12

Outer wrap of coating appears to be lifting throughout this AOI.

Minimum DFT thickness recorded was 90 mils, so no CP measurements were obtained.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	09/09/17	Frame(HH:MM:SS)	15:53:02	Date:	09/06/17	Frame(HH:MM:SS)	16:39:10

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	105	94	115
#2	90	105	100
#3	125	100	110
North End #4	110	105	105
#5	120	100	110
#6	140	110	110
Average Thickness	115	102	108

Additional Coating Thickness Inspection Data (A/R)

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	08/29/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	WAOI-7	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☒ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	3.36 (1.10' X 1.10')
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	3-9 o clock

Comments/Issues/Discussion

WAOI-7 is between W-10 and W-11

Minimum DFT thickness recorded was 70 mils, so no CP measurements were obtained.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	08/29/17	Frame(HH:MM:SS)	17:00:56	Date:	08/29/17	Frame(HH:MM:SS)	18:01:45

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
South End #1	160	85	90
#2	160	120	115
#3	170	105	155
North End #4	84	84	70
#5	155	80	85
#6	160	160	90
Average Thickness	148	105	100

Additional Coating Thickness Inspection Data (A/R)

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	09/23/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	WAS-1	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

Holiday 1B	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.01 (2½" x ¾")
Holiday 4B	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.01 (3" x ½")
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
	☐ Disturbed Area ☐Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	N/A (pipe is suspended)

Comments/Issues/Discussion

WAS-1 within span of W-68A.

These 2 additional features in the general area of WAS-1 were originally covered with a white deposit. In preparation for recoating the original features, a decision was made to prepare these features for recoating at the same time; CP readings were not obtained.

Adjacent DFT documented are from original inspection of area #1 and #4 (1B and 4B were in close proximity to the original features 1 & 4). Deposits were removed with hydraulic wheel to expose substrate large enough for UT readings. As pipe metal was exposed using the hydraulic wheel (and because "other" is not an option on this template), these features have been classified as 'holidays'.

No external corrosion was detected by dive team.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)							
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:		Frame(HH:MM:SS)		Date:		Frame(HH:MM:SS)	

Coating Gauge Information			
Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data			
Thickness Measure (mil)	**Area of Interest**	**Undisturbed Area (< 2 in.)**	**Undisturbed Area (> 5 ft.)**
North End #1	80	105	105
#2	66	110	110
#3	110	105	95
South End #4	110	94	90
#5	105	95	85
#6	105	100	85
Average Thickness	96	102	95

Additional Coating Thickness Inspection Data (A/R)		
	Within AOI 5' from North	**Within AOI 10' from North**
North End	92	98
---	84	105
South End	80	110

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - 1B							
CP Reading #1 (mV)	N/R	CP Reading #2 (mV)	N/R	CP Reading #3 (mV)	N/R		
Temperature (°F)	42	DFT at Holiday (mil)	N/R	DFT Adjacent to Holiday (mil)	90, 93, 110		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	9/23/17	Frame(HH:MM:SS)	10:00:34	Date:		Frame(HH:MM:SS)	

Cathodic Protection and Coating Measurements (if Holiday is found) - 4B							
CP Reading #1 (mV)	N/R	CP Reading #2 (mV)	N/R	CP Reading #3 (mV)	N/R		
Temperature (°F)	42	DFT at Holiday (mil)	N/R	DFT Adjacent to Holiday (mil)	80, 80, 90		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							
Date:	9/23/17	Frame(HH:MM:SS)	09:56:43	Date:		Frame(HH:MM:SS)	

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External Pipeline Inspection Form for L5 Straits of Mackinac

General Information

Date:	08/25/2017	**Contractor:**	Ballard Marine Co
AFE / W.O.#:	20008990	**Company Rep / Inspector:**	[redacted]
Segment:	WAS-1	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

External Pipe Coating Inspection Results

General Area	☐ Disturbed Area ☒Dislodged Coating ☐Holiday	**Size of anomaly (ft^2):**	20.8 (13' x 1.6')
Holiday 1	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.06 (9" x 1")
Holiday 2	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.24 (1'2" x 2.5")
Holiday 3	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.07 (1'7" x ½")
Holiday 4	☐ Disturbed Area ☐Dislodged Coating ☒Holiday	**Size of anomaly (ft^2):**	0.01 (1'3" x 1/8")
Corrosion present:	☐YES ☒NO	**Biota present:**	☒YES ☐ NO
Dislodged coating observed on the lake floor: ☐YES ☒NO		**Lake floor location wrt pipe:**	N/A (pipe is suspended)

Comments/Issues/Discussion

WAS-1 within span of W-68A. Four (4) features with DFT measurements below the minimum resolvable thickness of gauge were found. The Polatrak CP gun was used to confirm the existence of bare metal at the following features:

Holiday 1 presented average CP reading of -1312mV CSE (holiday confirmed).
Holiday 2 presented average CP reading of -1312mV CSE (holiday confirmed).
Holiday 3 presented average CP reading of -1365mV CSE (holiday confirmed).
Holiday 4 presented average CP reading of -1408mV CSE (holiday confirmed).

No external corrosion was detected by dive team. A white deposit was found at the holiday area.

[redacted]	[redacted]
Contractor Signature	**Enbridge Representative/ Inspector Signature**

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Visual Inspection (General Coating Condition)

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	8/25/17	Frame(HH:MM:SS)	10:15:30	Date:	8/25/17	Frame(HH:MM:SS)	10:14:46

Coating Gauge Information

Manufacturer:	Elcometer Inspection Equip	**Product:**	211 Coating Thickness Gauge
Last Calibrated:	08/09/2017	**Next Calibration Due:**	08/09/2018
Gauge verified prior to use:	☒YES ☐ NO		

Coating Thickness Inspection Data

Thickness Measure (mil)	Area of Interest	Undisturbed Area (< 2 in.)	Undisturbed Area (> 5 ft.)
North End #1	80	105	105
#2	66	110	110
#3	110	105	95
South End #4	110	94	90
#5	105	95	85
#6	105	100	85
Average Thickness	96	102	95

Additional Coating Thickness Inspection Data (A/R)

	Within AOI 5' from North	Within AOI 10' from North
North End	92	98
---	84	105
South End	80	110

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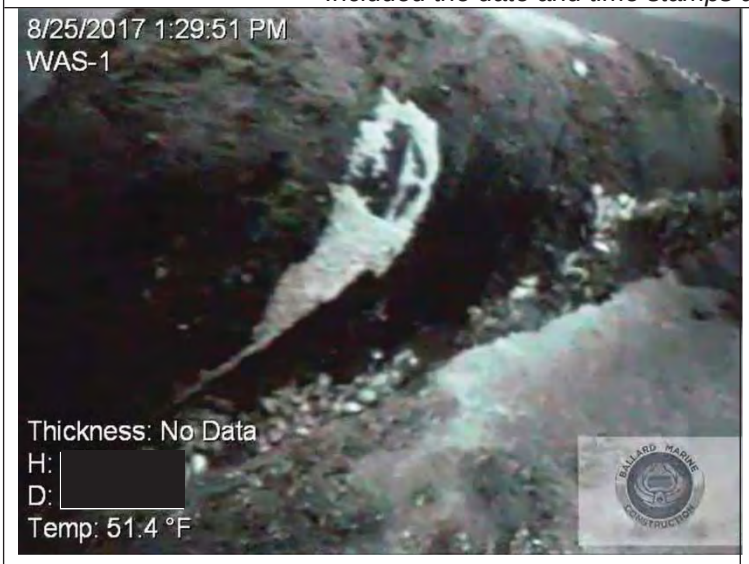
ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 1							
CP Reading #1 (mV)	-1300 -1362	CP Reading #2 (mV)	-1277 -1336	CP Reading #3 (mV)	-1277 -1322		
Temperature (°F)	43	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	90, 93, 110		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							

Date:	8/25/17	Frame(HH:MM:SS)	09:15:30	Date:	8/25/17	Frame(HH:MM:SS)	10:14:42

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 2							
CP Reading #1 (mV)	-1274 -1328	CP Reading #2 (mV)	-1283 -1237	CP Reading #3 (mV)	-1375 -1372		
Temperature (°F)	43	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	79, 94, 100		
For all sections of dislodged coating or holidays, provide pictures below. Included the date and time stamps associated with video surveillance.							



Date:	8/25/17	Frame(HH:MM:SS)	13:29:51	Date:	8/25/17	Frame(HH:MM:SS)	13:30:30

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ENBRIDGE	External Pipeline Inspection Form for L5 Straits of Mackinac

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 3						
CP Reading #1 (mV)	-1340 -1388	CP Reading #2 (mV)	-1342 -1389	CP Reading #3 (mV)	-1343 -1385	
Temperature (°F)	43	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	95, 83, 89	

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	8/25/17	Frame(HH:MM:SS)	09:14:35	Date:	8/25/17	Frame(HH:MM:SS)	10:15:41

Cathodic Protection and Coating Measurements (if Holiday is found) - Holiday 4						
CP Reading #1 (mV)	-1384 -1433	CP Reading #2 (mV)	-1390 -1430	CP Reading #1 (mV)	-1380 -1430	
Temperature (°F)	43	DFT at Holiday (mil)	≤ 25	DFT Adjacent to Holiday (mil)	80, 80, 90	

For all sections of dislodged coating or holidays, provide pictures below.
Included the date and time stamps associated with video surveillance.

Date:	8/25/17	Frame(HH:MM:SS)	09:14:19	Date:	8/25/17	Frame(HH:MM:SS)	09:14:26

Appendix E: Cathodic Protection Measurements

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Location	Feature	ON (-mV)	OFF (-mV)	Cell	Metal Contact?	CP Date	Comment
WAS-1	1	1300		Top	Yes	8/25/2017	Over/through deposit
WAS-1	1	1362		Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	1	1277	808	Top	Yes	8/25/2017	Over/through deposit
WAS-1	1	1336	870	Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	1	1277		Top	Yes	8/25/2017	Over/through deposit
WAS-1	1	1322		Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	2	1274		Top	Yes	8/25/2017	Over/through deposit
WAS-1	2	1328	848	Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	2	1283		Top	Yes	8/25/2017	Over/through deposit
WAS-1	2	1327	851	Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	2	1375	803	Top	Yes	8/25/2017	Over/through deposit
WAS-1	2	1372	851	Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	3	1340		Top	Yes	8/25/2017	Over/through deposit
WAS-1	3	1388		Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	3	1342		Top	Yes	8/25/2017	Over/through deposit
WAS-1	3	1389		Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	3	1343		Top	Yes	8/25/2017	Over/through deposit
WAS-1	3	1385		Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	4	1384		Top	Yes	8/25/2017	Over/through deposit
WAS-1	4	1433		Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	4	1390		Top	Yes	8/25/2017	Over/through deposit
WAS-1	4	1430		Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	4	1380		Top	Yes	8/25/2017	Over/through deposit
WAS-1	4	1430		Bottom	Yes	8/25/2017	Over/through deposit
WAS-1	2	471		Top	NO	9/22/2017	On deposit
WAS-1	2	509		Bottom	NO	9/22/2017	On deposit
WAS-1	2	460	199	Top	NO	9/22/2017	On deposit
WAS-1	2	451	211	Bottom	NO	9/22/2017	On deposit
WAS-1	2	1344	855	Top	Yes	9/22/2017	Scraped to metal
WAS-1	2	1370	848	Bottom	Yes	9/22/2017	Scraped to metal
WAS-1	2	1070	704	Top	Yes	9/22/2017	After wire brushing
WAS-1	2	1086	724	Bottom	Yes	9/22/2017	After wire brushing
WAS-1	4	334	223	Top	NO	9/22/2017	On deposit
WAS-1	4	360	250	Bottom	NO	9/22/2017	On deposit
WAS-1	4	1374	954	Top	Yes	9/22/2017	Scraped to metal
WAS-1	4	1402	860	Bottom	Yes	9/22/2017	Scraped to metal
WAS-1	4	1188	777	Top	Yes	9/22/2017	After wire brushing
WAS-1	4	1203	782	Bottom	Yes	9/22/2017	After wire brushing
WAS-1	3	269	172	Top	NO	9/22/2017	On deposit
WAS-1	3	295	197	Bottom	NO	9/22/2017	On deposit
WAS-1	3	1382	846	Top	Yes	9/22/2017	Scraped to metal
WAS-1	3	1411	826	Bottom	Yes	9/22/2017	Scraped to metal
WAS-1	3	1221	768	Top	Yes	9/22/2017	After wire brushing
WAS-1	3	1239	779	Bottom	Yes	9/22/2017	After wire brushing
EAS-1	1	1676		Top	Yes	8/15/2017	Over/through deposit
EAS-1	1	1683		Bottom	Yes	8/15/2017	Over/through deposit
EAS-1	1	1674		Top	Yes	8/15/2017	Over/through deposit

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Location	Feature	ON (-mV)	OFF (-mV)	Cell	Metal Contact?	CP Date	Comment
EAS-1	1	1681		Bottom	Yes	8/15/2017	Over/through deposit
EAS-1	1	1690		Top	Yes	8/15/2017	Over/through deposit
EAS-1	1	1674		Bottom	Yes	8/15/2017	Over/through deposit
EAS-1	1B	298		Top	NO	10/6/2017	Over/through deposit
EAS-1	1B	298		Bottom	NO	10/6/2017	Over/through deposit
EAS-1	1B	1616		Top	Yes	10/6/2017	After deposit removal
EAS-1	1B	1606		Bottom	Yes	10/6/2017	After deposit removal
EAS-1	1B	1394		Top	Yes	10/6/2017	After deposit removal
EAS-1	1B	1418		Bottom	Yes	10/6/2017	After deposit removal
EAS-1	1B	1390		Top	Yes	10/6/2017	After deposit removal
EAS-1	1B	1407		Bottom	Yes	10/6/2017	After deposit removal
EAS-1	1C	277		Top	NO	10/6/2017	Over/through deposit
EAS-1	1C	279		Bottom	NO	10/6/2017	Over/through deposit
EAS-1	1C	1569		Top	Yes	10/6/2017	After deposit removal
EAS-1	1C	1578		Bottom	Yes	10/6/2017	After deposit removal
EAS-1	*1C*		*956*	*Top*	*Yes*	*10/6/2017*	*OFF reading, or poor pipe contact.*
EAS-1	*1C*		*998*	*Bottom*	*Yes*	*10/6/2017*	*OFF reading, or poor pipe contact.*
EAS-1	*1C*		*945*	*Top*	*Yes*	*10/6/2017*	*OFF reading, or poor pipe contact.*
EAS-1	*1C*		*960*	*Bottom*	*Yes*	*10/6/2017*	*OFF reading, or poor pipe contact.*
EAS-1	1D	1582		Top	Yes	10/6/2017	Over/through deposit
EAS-1	1D	1602		Bottom	Yes	10/6/2017	Over/through deposit
EAS-1	1D		1133	Top	Yes	10/6/2017	After deposit removal
EAS-1	1D	1496		Bottom	Yes	10/6/2017	After deposit removal
EAS-1	1D	1437		Top	Yes	10/6/2017	After deposit removal
EAS-1	1D	1439		Bottom	Yes	10/6/2017	After deposit removal
EAS-1	1D	1435		Top	Yes	10/6/2017	After deposit removal (video)
EAS-1	1D		1127	Bottom	Yes	10/6/2017	After deposit removal (video)
EAS-1	1D	1471		Top	Yes	10/6/2017	After deposit removal
EAS-1	1D	1460		Bottom	Yes	10/6/2017	After deposit removal
EAS-1	1E	560		Top	NO	10/6/2017	Over/through deposit
EAS-1	1E	554		Bottom	NO	10/6/2017	Over/through deposit
EAS-1	1E	600		Top	NO	10/6/2017	After deposit removal
EAS-1	1E	591		Bottom	NO	10/6/2017	After deposit removal
EAS-1	1E	530		Top	NO	10/6/2017	After deposit removal
EAS-1	1E	501		Bottom	NO	10/6/2017	After deposit removal
EAS-1	1E	1406		Top	Yes	10/6/2017	After deposit removal
EAS-1	1E	1403		Bottom	Yes	10/6/2017	After deposit removal
EAS-1	1F	512		Top	NO	10/6/2017	Over/through deposit
EAS-1	1F	503		Bottom	NO	10/6/2017	Over/through deposit
EAS-1	1F	1669		Top	Yes	10/6/2017	After deposit removal
EAS-1	1F	1674		Bottom	Yes	10/6/2017	After deposit removal
EAS-1	1F	1478		Top	Yes	10/6/2017	
EAS-1	1F	1494		Bottom	Yes	10/6/2017	
EAS-1	1F	1478		Top	Yes	10/6/2017	
EAS-1	1F	1494		Bottom	Yes	10/6/2017	
EAS-2	1	261		Top	NO	8/24/2017	No CP readings (DFT>70)
EAS-2	1	291		Bottom	NO	8/24/2017	No CP readings (DFT>70)

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Location	Feature	ON (-mV)	OFF (-mV)	Cell	Metal Contact?	CP Date	Comment
EAS-3	1	852		Top	Yes	8/29/2017	ON reading from dive video
EAS-3	1	886		Bottom	Yes	8/29/2017	
EAS-3	1	804		Top	Yes	8/29/2017	
EAS-3	1	842		Bottom	Yes	8/29/2017	
EAS-3	1	834		Top	Yes	8/29/2017	
EAS-3	1	875		Bottom	Yes	8/29/2017	
EAS-3	1	799	620	Top	Yes	8/29/2017	ON/OFF readings from dive video
EAS-3	1	836	666	Bottom	Yes	8/29/2017	ON/OFF readings from dive video
EAS-4	1	955		Top	Yes	8/30/2017	
EAS-4	1	991		Bottom	Yes	8/30/2017	
EAS-4	1	938		Top	Yes	8/30/2017	
EAS-4	1	965		Bottom	Yes	8/30/2017	
EAS-4	1	951		Top	Yes	8/30/2017	
EAS-4	1	979		Bottom	Yes	8/30/2017	
EAS-4	2	981		Top	Yes	8/30/2017	
EAS-4	2	1012		Bottom	Yes	8/30/2017	
EAS-4	2	907	682	Top	Yes	8/30/2017	OFF reading from dive video
EAS-4	2	933	705	Bottom	Yes	8/30/2017	OFF reading from dive video
EAS-4	2	944	701	Top	Yes	8/30/2017	OFF reading from dive video
EAS-4	2	974	722	Bottom	Yes	8/30/2017	OFF reading from dive video
EAOI-1		234		Top	NO	9/8/2017	
EAOI-1		281		Bottom	NO	9/8/2017	
EAOI-1		440		Top	NO	9/8/2017	
EAOI-1		316		Bottom	NO	9/8/2017	
EAOI-1		320		Top	NO	9/8/2017	
EAOI-1		260		Bottom	NO	9/8/2017	
EAOI-5		391		Top	NO	9/6/2017	
EAOI-5		326		Bottom	NO	9/6/2017	
EAOI-7	1	1155	849	Top	Yes	10/13/2017	Under deposit
EAOI-7	1	1158	841	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1	1188	832	Top	Yes	10/13/2017	Under deposit
EAOI-7	1	1101	815	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1	1085	832	Top	Yes	10/13/2017	Under deposit
EAOI-7	1	1081	814	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1A	1235	894	Top	Yes	10/13/2017	Under deposit
EAOI-7	1A	1238	837	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1A	1223	893	Top	Yes	10/13/2017	Under deposit
EAOI-7	1A	1269	836	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1A	1206	886	Top	Yes	10/13/2017	Under deposit
EAOI-7	1A	1195	869	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1B	1185	879	Top	Yes	10/13/2017	Under deposit
EAOI-7	1B	1196	870	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1B	1281	918	Top	Yes	10/13/2017	Under deposit
EAOI-7	1B	1277	903	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1B	1278	932	Top	Yes	10/13/2017	Under deposit
EAOI-7	1B	1279	918	Bottom	Yes	10/13/2017	Under deposit

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Location	Feature	ON (-mV)	OFF (-mV)	Cell	Metal Contact?	CP Date	Comment
EAOI-7	1C	1511	1109	Top	Yes	10/12/2017	Under deposit
EAOI-7	1C	1528	1114	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1C	1485	1119	Top	Yes	10/12/2017	Under deposit
EAOI-7	1C	1511	1111	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1C	1505	1109	Top	Yes	10/12/2017	Under deposit
EAOI-7	1C	1515	1111	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1D	1359	1077	Top	Yes	10/12/2017	Under deposit
EAOI-7	1D	1370	1086	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1D	1355	1077	Top	Yes	10/12/2017	Under deposit
EAOI-7	1D	1367	1062	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1D	1365	1079	Top	Yes	10/12/2017	Under deposit
EAOI-7	1D	1373	1085	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1E	1174	908	Top	Yes	10/12/2017	Under deposit
EAOI-7	1E	1187	914	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1E	1205	914	Top	Yes	10/12/2017	Under deposit
EAOI-7	1E	1214	921	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1E	1186	921	Top	Yes	10/12/2017	Under deposit
EAOI-7	1E	1087	926	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1E	485	344	Top	NO	10/12/2017	Over deposit pH 11
EAOI-7	1E	484	347	Bottom	NO	10/12/2017	Over deposit pH 11
EAOI-7	1E	432	359	Top	NO	10/12/2017	Over deposit pH 11
EAOI-7	1E	437	364	Bottom	NO	10/12/2017	Over deposit pH 11
EAOI-7	1F	1568	1133	Top	Yes	10/12/2017	Under deposit
EAOI-7	1F	1570	1122	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1F	1561	1125	Top	Yes	10/12/2017	Under deposit
EAOI-7	1F	1570	1135	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1F	1552	1124	Top	Yes	10/12/2017	Under deposit
EAOI-7	1F	1558	1125	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1F	429	310	Top	NO	10/12/2017	Over deposit pH 12
EAOI-7	1F	437	314	Bottom	NO	10/12/2017	Over deposit pH 12
EAOI-7	1F	472	381	Top	NO	10/12/2017	Over deposit pH 12
EAOI-7	1F	478	384	Bottom	NO	10/12/2017	Over deposit pH 12
EAOI-7	1G	272	199	Top	NO	10/12/2017	Under deposit
EAOI-7	1G	254	211	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1G	227	187	Top	NO	10/12/2017	Under deposit
EAOI-7	1G	184	189	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1G	251	187	Top	NO	10/12/2017	Under deposit
EAOI-7	1G	248	185	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1H	1577	1091	Top	Yes	10/12/2017	Under deposit
EAOI-7	1H	1571	1079	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1H	1562	1071	Top	Yes	10/12/2017	Under deposit
EAOI-7	1H	1575	1074	Top	Yes	10/12/2017	Under deposit
EAOI-7	1H	1559	1053	Bottom	Yes	10/12/2017	Under deposit
EAOI-7	1I	1486	1044	Top	Yes	10/13/2017	Under deposit
EAOI-7	1I	1468	1032	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1I	1551	1063	Top	Yes	10/13/2017	Under deposit

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Location	Feature	ON (-mV)	OFF (-mV)	Cell	Metal Contact?	CP Date	Comment
EAOI-7	1I	1508	1055	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1I	1524	1070	Top	Yes	10/13/2017	Under deposit
EAOI-7	1I	1517	1054	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1J	270	237	Top	NO	10/12/2017	Under deposit
EAOI-7	1J	290	263	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1J	252	222	Top	NO	10/12/2017	Under deposit
EAOI-7	1J	273	241	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1J	401	299	Top	NO	10/12/2017	Under deposit
EAOI-7	1J	349	255	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1K	311	301	Top	NO	10/12/2017	Under deposit
EAOI-7	1K	282	230	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1K	276	238	Top	NO	10/12/2017	Under deposit
EAOI-7	1K	258	223	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1K	276	234	Top	NO	10/12/2017	Under deposit
EAOI-7	1K	261	217	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1L	278	239	Top	NO	10/12/2017	Under deposit
EAOI-7	1L	265	227	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1L	267	235	Top	NO	10/12/2017	Under deposit
EAOI-7	1L	252	220	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1L	280	239	Top	NO	10/12/2017	Under deposit
EAOI-7	1L	259	216	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1M	434	420	Top	NO	10/12/2017	Under deposit
EAOI-7	1M	429	384	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1M	407	408	Top	NO	10/12/2017	Under deposit
EAOI-7	1M	403	397	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1M	446	437	Top	NO	10/12/2017	Under deposit
EAOI-7	1M	416	395	Bottom	NO	10/12/2017	Under deposit
EAOI-7	1N	1436	1011	Top	Yes	10/13/2017	Under deposit
EAOI-7	1N	1430	999	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1N	1025	785	Top	NO	10/13/2017	Invalid due to companion (high contact resistance)
EAOI-7	1N	1043	744	Bottom	NO	10/13/2017	Invalid due to companion (high contact resistance)
EAOI-7	1N	1401	963	Top	Yes	10/13/2017	Under deposit
EAOI-7	1N	1406	967	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1O	1291	939	Top	Yes	10/13/2017	Under deposit
EAOI-7	1O	1302	989	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1O	1466	1052	Top	Yes	10/13/2017	Under deposit
EAOI-7	1O	1459	1036	Bottom	Yes	10/13/2017	Under deposit
EAOI-7	1O	1212	908	Top	Yes	10/13/2017	Under deposit
EAOI-7	1O	1218	895	Bottom	Yes	10/13/2017	Under deposit

Dive Inspection CP Measurements - Introduction:

Enbridge executed underwater CP measurements as per section 3.2.1 of the BIWP. These measurements were recorded using the Polatrak CP Gun, which is specifically designed for underwater work. This tool contains two independent precision voltmeters, two reference electrodes, and a sharp metal electrode that is used to make electrical contact with the pipe.

This was the first diver executed underwater CP survey in Enbridge history in the Straits. As a result, Enbridge made various procedural modifications aimed at improving the quality and value of the CP measurements as the BIWP progressed. Some of the challenges experienced and procedural modifications which resulted are discussed below:

- **Pipe Contact Resistance:** As a pipe-to-soil potential measurement requires good metallic contact with the pipe, any contact resistance between the Polatrak CP Gun's metal tip and the pipe will introduce reading error. Measurements conducted early in the study demonstrated instability which was attributed to high resistance contact between the CP gun and the pipe metal. In the interest of minimizing dive inspection related coating damage, Enbridge instructed divers to use 'firm pressure' when taking CP readings and to avoid using excessive pressure that could cause coating damage. As a consequence, the CP potentials became relevant as an indicator of possible existence of bare pipe metal. Enbridge instituted a criterion of -600mV (300mV more electronegative than open water readings) as a preliminary indicator of bare metal – this was used to confirm diver's visual observations of coating damage or possible metal exposure. This criterion was established in consideration of the guidance provided in the Polatrak CP Gun operating manual, the half-cell potential difference between Ag-AgCl and CSE reference cells, and dive logistics. It should be noted that the -600mV CSE criterion does not independently verify good electrical contact with the pipe metal if other CP readings taken from the same feature or at the same dive site are substantially more electronegative.
- **Loss of Reference Cell calibration:** The Polatrak CP Gun contains two copper/copper sulphate electrodes (CSE) that are used as a voltage reference for the pipe CP measurements. These electrodes are comprised of a copper wire within a plastic barrel containing saturated copper sulphate solution that is electrolytically coupled to the environment through a porous plug. The calibration of the electrodes was found to drift after successive dives, and this was attributed to cyclical ingress and egress of lake water through the porous plug during successive dives: a process exacerbated if the reference

cells contained air bubbles. In response, Enbridge instituted more frequent calibrations of the reference cells, and employed an electrolyte replenishment procedure intended to minimize air in the reference cell. Some of the pipe-to-soil potentials recorded in the first few days of the project were affected by calibration error.

- **Rectifier Interruption Status:** The interpretation of CP potential readings requires consideration of voltage effects other than those across the structure to electrolyte boundary; the most common method of removing extraneous CP reading error is to simultaneously interrupt all current sources that affect CP levels on the structure of interest. Potential measurements recorded under the influence of operating cathodic protection current sources are referred to as "ON" readings; potentials recorded with current sources briefly deactivated are commonly called "OFF" or "Polarized" potentials. The most recent (2017) CP study discussed previously identified several rectifiers (both Enbridge and foreign) with influence on the Straits dual pipelines. To the best of the ability of Enbridge field staff, these rectifiers were simultaneously interrupted; however, some foreign CP sources were not consistently interrupted due to equipment failures and coordination issues. Enbridge regional CP staff summarized the status of rectifier interruption during each day of survey, and these have been considered in evaluating the CP potential obtained.
- **Special Investigation:** In order to explore the transient processes (time dependent polarization of freshly exposed metal), Enbridge dive personnel obtained additional cathodic protection readings on select dives. Where logistics and time permitted, CP readings were taken on select features before and after the power wire wheel brush was used to clean the calcareous deposit from the pipe surface. The intent of this exercise was to investigate how significantly the CP potentials were affected by the calcareous deposit, and to demonstrate the level of protection that would be immediately available to freshly exposed pipe metal surface. It was observed that completely removing calcareous deposit (using a power wire brush) could dramatically decrease the level of cathodic protection measured.

Dive Inspection Summaries:

WAS-1:

44 cathodic protection potential measurements were recorded from this location over several dives conducted on 24/08/2017 and 22/09/2017. Calcareous deposits and residual coating

created high resistance between the pipe and the tip of the Polatrak CP Gun on 8 of these readings (which averaged -314 mV) and these have not been considered in this analysis.

The “ON” readings (potentials recorded with the CP systems operating) ranged from -1274 mV to -1433 mV CSE (average of -1358 mV), indicating substantial availability of cathodic protection current at this site. “OFF” readings (potentials obtained with most current sources briefly deactivated) indicated a range of -803 mV to -954 mV, with an average of -852 mV CSE. One foreign CP system was not interrupted at the time these readings were taken; and this fact is estimated to produce an electropositive shift in the “OFF” readings of 33 mV at this location[1]. The error corrected “OFF” readings (after considering the voltage gradient produced by the foreign influence) are estimated at -836 mV (minimum) with an average of -885 mV, indicating marginal to complete levels of cathodic protection. The CP data summary table in the report body reflects these error corrected data.

Additional CP measurements were obtained immediately after a hydraulic power wire brush was used to remove calcareous deposit and residual coating material (the cup-disk brush wheel used at this site exposed large areas of bare metal). The readings obtained before the wire brushing reflect residual chemical polarization from alkaline species contained by, or trapped within, any remaining calcareous deposit; the readings after wire brushing represent the ‘worst case’ condition of a newly developed coating holiday (with freshly exposed bare metal). Average “ON” and “OFF” readings taken after the wire brushing were -1167 mV and -755 mV CSE, respectively. These data clearly demonstrate that the removal of the calcareous deposit decreased the effective level of CP by nearly 100mV at this location.

As all of the recorded pipe potentials involved as least some disruption of the calcareous deposits to make electrical contact between the CP gun and the pipe wall, it is believed that all CP data recorded during the 2017 BIWP dive inspections contains some electropositive error (the CP readings may indicate lower levels of cathodic protection than would have existed before the deposits were disrupted). In order to collect accurate CP measurements that represent the actual level of cathodic protection being received by the dual pipelines under normal operating conditions, it is recommended to leave these deposits intact for the duration of the survey.

[1] The adjustments made to “OFF” potential readings recorded during the BIWP are based upon rectifier influence testing performed by Lake Superior Consulting, and uses the methodology developed to compensate for transient interference of CIS data. Ref: “Practical Telluric Compensation for Pipeline Close Interval Survey”, Paper #00741, Corrosion 2000 Symposia, NACE International, Houston TX (2000).

Alternatively, any CP survey performed after deposit removal should be delayed until the subsequent recoating program has been completed.

EAS-1:

48 cathodic protection potential measurements were recorded from this location over several dives conducted on 15/08/2017 and 10/06/2017. Calcareous deposits and residual coating created high resistance between the pipe and the tip of the Polatrak CP Gun on 12 of these readings (which averaged -458 mV) and these have not been considered in this analysis.

The “ON” readings observed ranged from -1390 mV to -1690 mV CSE (average of -1535 mV), indicating substantial availability of cathodic protection current at the site. “OFF” readings ranged from -945 mV to -1133 mV, with an average of -1019 mV CSE. These readings indicate complete cathodic protection in accordance with industry best practice and applicable regulations.

EAS-2:

2 cathodic protection potential measurements were recorded from this location during dives on 08/24/2017. Calcareous deposits and residual coating created high resistance between the pipe and the tip of the Polatrak CP Gun on all 2 of these readings (which averaged -276 mV). No valid “ON” or “OFF” CP readings could be obtained at this location.

EAS-3:

The coating damage at this site was created by a communication cable rub that occurred on August 26, 2017 during execution of the BIWP. This exposed metal consists of one feature with an area of 0.93 ft^2.

8 cathodic protection potential measurements were recorded from this location during dives conducted on 8/29/2017.

The “ON” readings observed ranged from -799 mV to -886 mV CSE (average of -841 mV), indicating lower availability of cathodic protection current at this site compared to other dive sites. “OFF” readings obtained from dive video analysis ranged from -620 mV to -666 mV, with an average of -643 mV CSE. One foreign CP system was not interrupted at the time these readings were taken; and this fact is estimated to produce an electropositive shift in the “OFF” readings of 163 mV at this location. The error corrected “OFF” readings (after considering the voltage gradient produced by the foreign influence) are estimated at -783 mV (minimum) with an average

of -806 mV, indicating marginal levels of cathodic protection. The CP data summary table in the report body reflects these error corrected data.

While there are numerous possible sources of error in the collection of 'ON' and 'OFF' CP readings by divers (discussed previously), the marginal levels of CP observed at this site are believed to be a consequence of the relatively large size of the bare metal area in conjunction with the very short time between metal exposure and the CP survey. This short timeframe (~3 days) was inadequate for calcareous deposit to form (none was observed) and appears to be inadequate for cathodic polarization to achieve a steady state. Based on observations from other dive sites, it is expected that a calcareous coating would eventually grow to cover this feature, resulting in increased chemical polarization and complete cathodic protection.

EAS-4:

The coating damage at this site was created by a communication cable rub that occurred on August 26, 2017 during execution of the BIWP. This exposed area consists of one feature with an area of 1.64 ft^2

12 cathodic protection potential measurements were recorded from this location during dives conducted on 8/30/2017.

The "ON" readings observed ranged from -907 mV to -1012 mV CSE (average of -961 mV), indicating moderate availability of cathodic protection current at the site. "OFF" readings obtained from dive video analysis ranged from -682 mV to -772 mV, with an average of -703 mV CSE. One foreign CP system was not interrupted at the time these readings were taken; and this fact is estimated to produce an electropositive shift in the "OFF" readings of 162 mV at this location. The error corrected "OFF" readings (after considering the voltage gradient produced by the foreign influence) are estimated at -844 mV (minimum) with an average of -865 mV, indicating marginal to complete levels of cathodic protection. The CP data summary table in the report body reflects these error corrected data.

While there are numerous possible sources of error in the collection of 'ON' and 'OFF' CP readings by divers (discussed previously), the marginal levels of CP observed at this site are believed to be a consequence of the relatively large size of the bare metal area in conjunction with the very short time between metal exposure and the CP survey. This short timeframe (~4 days) was inadequate for calcareous deposit to form (none was observed) and appears to be inadequate for cathodic polarization to achieve a steady state. It is noted that the cathodic

protection levels recorded at EAS-4 were measurably improved as compared to the smaller area of exposed metal at EAS-3. This may be attributable to the additional day of cathodic protection that EAS-4 received. Based on observations from other dive sites, it is expected that a calcareous coating would eventually grow to cover this feature, resulting in a higher level of chemical polarization and complete cathodic protection.

EAOI-1:

6 cathodic protection potential measurements were recorded from this location during dives conducted on 9/8/2017. Calcareous deposits and residual coating created high resistance between the pipe and the tip of the Polatrak CP Gun on all 6 of these readings (which averaged -309mV). No valid “ON” or “OFF” readings could be obtained from this location.

EAOI-5:

2 cathodic protection potential measurements were recorded from this location over one dive conducted on 9/06/2017. Calcareous deposits and residual coating created high resistance between the pipe and the tip of the Polatrak CP Gun on all 2 of these readings (which averaged -359mV). No valid “ON” or “OFF” readings could be obtained from this location.

EAOI-7:

103 cathodic protection potential measurements were recorded from this location over several dives conducted on 10/12/2017 and 10/13/2017. Calcareous deposits and residual coating created high resistance between the pipe and the tip of the Polatrak CP Gun on 40 of these readings (which averaged -338 mV) and these have not been considered in this analysis.

The “ON” readings observed ranged from -1081 mV to -1577 mV CSE (average of -1362 mV), indicating substantial availability of cathodic protection current at the site. “OFF” readings ranged from -814 mV to -1135 mV, with an average of -992 mV CSE. The ATC rectifier was not interrupted at the time these readings were taken; and this fact is estimated to produce an electropositive shift in the “OFF” readings of 89 mV at this location. The error corrected “OFF” readings (after considering the voltage gradient produced by the ATC rectifier) are estimated at -903 mV (minimum) with an average of -1081 mV, indicating complete cathodic protection in accordance with industry best practice and all applicable regulations. The CP data summary table in the report body reflects these error corrected data.

Discussion:

Cathodic protection potentials recorded during the BIWP dive inspections generally exhibited substantial availability of cathodic protection current – as indicated by current applied 'ON' CP readings. The average of all 'ON' readings was -1328 mV CSE, which is approximately 700mV more electronegative than the expected native potential of steel in freshwater. Moderate to high levels of cathodic polarization were also observed in the majority of data – as indicated by the current interrupted 'OFF' CP readings. The average of all 'OFF' readings was -940 mV CSE, which exceeds the requirements of industry best practice[i] and applicable regulations[ii].

It is noted that many of the CP readings obtained during the BIWP CP survey were affected by measurement errors associated with equipment (rectifier interruption issues, CP gun calibration), procedures (long 'OFF' cycle depolarization, manual meter reading, and disruption of calcareous deposits), and problems associated with contact resistance.

While some sites demonstrated marginal levels of cathodic polarization, the absence of any detectable external corrosion metal loss demonstrates that the cathodic protection being received by the dual pipelines has been successful at preventing external corrosion over the long history of the pipelines operation.

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[i] NACE SP0169-13, "Control of External Corrosion on Underground or Submerged Metallic Piping Systems", NACE International, Houston TX, (2013).

[ii] Title 49, CFR 195, "Transportation of Hazardous Liquids by Pipeline", Office of the Federal Register, Washington DC (2017).

Appendix F: Line 5 Biota Investigation Report (GEI)

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Line 5 Biota Investigation Report

Straits of Mackinac, Michigan

Submitted to:

Enbridge Energy, Limited Partnership

Submitted by:

GEI Consultants of Michigan, P.C.
1775 Barlow Street
Traverse City, MI 49686

March 28, 2018

Project No. 1411170/1800503

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Acronym/Definition List

°C	temperature in degrees Celsius
µS/cm	microsiemens/centimeter
% sat	Percent saturation; Unit of measure for dissolved oxygen (DO)
AGN	Acetogens; acetogenic strains of bacteria
APB	Acid-producing bacteria
AOI	Area of Interest
APS	Sulfate-producing strain of bacteria
AS	Additional Sites
ATS	Ann Arbor Technical Services
BMC	Ballard Marine Construction
Biomass	Mass (weight) of mussels, macrophytes, macroinvertebrates, periphyton, and algae
BioSan, Inc.	BioSan
cells/mL	cells of bacteria/milliliter
CENSUS or Census	a nucleic acid based approach to quantify host specific genetic markers to identify sources of fecal contamination, inclusive of specific strains of bacteria
CoC	Chain-of-custody
CP	Cathodic Protection
DL	Detection limit
DNA	Deoxyribonucleic Acid
DO	Dissolved oxygen
Durocher Marine	Durocher Marine
Enbridge	Enbridge Energy, Limited Partnership
FNU	Formazin Nephelometric Unit; Unit of turbidity that uses an infrared light source to measure the scattered light at 90 degrees from the incident light
ft	feet
GEI	GEI Consultants of Michigan, P.C.
g	Grams
ID	Sample identification
ITP	Independent Third Party
J-flagged	A data qualifier (aka “flag”) indicating an estimated value that is greater than zero but lower than the calibration curve or range.
Line 5	The pipeline owned by Enbridge Energy, Limited Partnership that runs under the Straits of Mackinac, MI
MDNR	Michigan Department of Natural Resources
MOI	Material of Interest
mg/L	milligrams/liter
mV	Millivolts
n	Number
ND	Non-detect
N.T.S.	Not to scale
ORP	Oxidation-reduction Potential
PVC	Polyvinyl chloride

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qPCR	Quantitative Polymerase Chain Reaction
RL	Reporting limit
ROV	Remote operated vehicle
QA/QC	Quality Assurance/Quality Control
SOP	Standard Operating Procedures
SRB	Sulfate-reducing bacteria
USEPA	United States Environmental Protection Agency
BIWP	*Enbridge Line 5, Straits of Mackinac, MI - Biota Investigation BIWP.* Submitted to USEPA on May 18, 2107; approved by the USEPA on June 13, 2017
WPS	WPS USA

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Executive Summary

Enbridge Energy, Limited Partnership, was required by federal consent decree to conduct a Biota Investigation to characterize biological organisms (Biota) found on the surface of their Line 5 pipelines, which cross Lake Michigan at the Straits of Mackinac, MI. The overall objective of the Biota Investigation was to assess the extent to which Biota impacts the integrity of the dual Line 5 pipelines. The Biota Investigation was executed in August and September 2017, with additional efforts taking place in December 2017. USEPA-appointed Independent Third Party personnel were present for the duration of the August and September field portion of the Biota Investigation.

Over one hundred-fifty (150) Biota samples were collected during the Biota Investigation and were used for Biota characterization or analysis of acid-producing bacteria (APB) and sulfate-reducing bacteria (SRB). Water and sediment samples were also collected and analyzed for APBs and SRBs.

Quagga mussels (*Dreissena bugensis*) were observed on both Line 5 pipelines, on all positions of the pipelines (top, bottom, and sides), and in all water depths from which Biota was sampled. Quagga mussels were unevenly distributed across the pipelines, wherein mussels would appear very dense in a given area, then sparse just a few feet away. Mussel density and the weight of mussels and other Biota on the pipelines was varied. Adult zebra mussels *(Dreissena polymorpha*) were not observed in any of the Biota samples.

Findings do not suggest that the integrity of the pipelines coating or the underlying metal is being adversely impacted by the accumulation of mussels and other Biota on the pipelines. The coating of the pipeline appeared to be intact at all of the sixteen (16) randomly-selected Biota sampling sites. Examination of the byssal threads of the mussels via electron microscopy indicated that byssal threads are not penetrating the pipelines coating. Mussels and other Biota were not observed damaging or removing the coating of the pipe.

Mussels and other larger Biota (e.g., macroinvertebrates) were not preferentially accumulating or colonizing at Holidays, Areas of Interest, or Additional Sites. For reasons that are not known, mussels and other larger Biota were much less abundant at most of those sites when compared to adjacent areas and Biota sites. Hence, based on the present data, mussels and larger Biota are likely not impacting the pipelines coating or underlying metal at Holidays because they are generally absent from those locations.

Mussels were the predominant Biota type (in abundance and biomass) observed on the pipelines. Other Biota such as periphyton, and macroinvertebrates were present, but to a lesser degree. The observations and data obtained during the Biota Investigation do not suggest the lesser-abundant Biota were impacting the integrity of the pipelines coating or

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underlying metal. Visual examination of the byssal threads of the mussels via electron microscopy indicate that byssal threads are not penetrating the coating around the pipe but merely 'splaying' out and adhering to the surface of the coating.

APBs and SRBs were analyzed in Biota, water, and sediment samples with qualitative (APB) and semi-quantitative (SRB) field test kits and via Deoxyribonucleic Acid (DNA) analysis techniques. Inconsistencies in APB field test kit quality assurance/quality control samples suggests that APB field test kit data should be utilized with caution and that the results of the APB and SRB DNA analysis should be utilized instead of field test kit bacteria data.

Results of APB/SRB field test kits and Census qPCR DNA analysis support that APBs and SRBs are present to varying degrees in Biota collected from the pipeline surface, in water from Lake Michigan, and in sediment collected near the pipelines. However, no visible corrosion or metal loss was observed at the sites sampled, even when Biota density was high.

Census qPCR APB and SRB DNA analysis results demonstrate that there are detectable concentrations of APBs and SRBs in Biota obtained from the pipeline surface. APBs were infrequently detected above the laboratory reporting limit in Biota samples but when detected, ranged from approximately $1.0 \times 10^5 – 2.0 \times 10^5$ cells/gram. SRB concentrations were consistent across both pipelines, and generally ranged from $1.0 \times 10^5 – 1.0 \times 10^7$ cells/gram. APBs and SRBs were detected above the laboratory reporting limit in all (n=6) of the water samples analyzed but concentrations were low, ranging from 0.6 – 74 APB cells/mL, and 26 – 113 SRB cells/mL. In sediment, APBs were detected above the laboratory reporting limit in 25% (1/4) of the samples collected, whereas SRBs were observed above the laboratory reporting limit in 100% (4/4) of the samples. Two of the sediment SRB concentrations exceeded 1.0×10^8 SRB cells/gram, a value greater than 98% (69/70) of the SRB concentrations in Biota samples.

APB and SRB genera observed in water and sediment samples were the same genera observed in Biota samples. This strong overlap in DNA genera observed in the 2017 Biota Investigation samples suggests that Biota are likely not creating a unique microbiological environment, with respect to genera of APBs and SRBs analyzed by Microbial Insights, at the pipeline surface.

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1.0 Introduction & Objectives

Enbridge Energy, Limited Partnership (Enbridge) was required by federal consent decree (Case 1:16-cv-00914, ECF No. 3 filed 07/20/16) to conduct a Biota Investigation to assess whether any of the Biota found on the pipeline impacts the integrity of the dual twenty (20) inch Line 5 pipelines in the Straits of Mackinac (Straits). Enbridge submitted to the United States Environmental Protection Agency (USEPA) a plan for the Biota Investigation, titled "Biota Investigation Work Plan" (BIWP) Revision 2 on May 18, 2017 (Enbridge 2017a, 2017b).

The objective of the Biota Investigation was to generate information that could be utilized to inform the assessments presented below. This report details the methods and results of Biota sampling efforts conducted in the Straits and is consistent with the reporting requirements outlined in Section 6.0 of the approved BIWP. The federal consent decree outlined three requirements ("assessments") that the Biota Investigation should inform. The assessments were as follows:

- Assessment: *".....assess whether the accumulation of mussels and other Biota have impacted the integrity of the pipelines' coating or the underlying metal, including areas where there are openings or "holidays" in the pipeline coating."*
- Assessment: *".....evaluate whether the mussels and other Biota are creating a corrosive environment by, among other things, fostering the growth of anaerobic sulfate-reducing bacteria ("SRB") that may cause metal loss."*
- Assessment: *".....evaluate whether mussels and other Biota are introducing features that may threaten the integrity of either of the Dual Pipelines due to the weight of such biomass or the pressure caused by current or ice movement around such biomass in areas where the pipelines are suspended above the floor of the Straits."*

GEI Consultants of Michigan, P.C. (GEI) was tasked with supporting Enbridge with Biota sampling and analysis efforts outlined in the BIWP. GEI was involved with all aspects of the BIWP except efforts related to coating thickness, cathodic protection, coating integrity testing, and engineering stress analysis. Enbridge was assisted in the development of the BIWP by several firms. Brief descriptions of each firm's contribution, roles and responsibilities are provided below:

- Enbridge:
    - Ballard Marine Construction (BMC) – Dive manager, collection of Biota samples by diver(s), support staff;
    - Durocher Marine (Durocher) – Tow barge operation and crane operation;

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  - WSP – BIWP development and implementation, logistics;
  - GEI – Biologists supporting the Biota Investigation efforts.
- USEPA:
  - Independent Third Party (ITP) representatives appointed by USEPA were on-board the work barge and involved with oversight of all Biota sampling activities that took place in August and September 2017.

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2.0 Methods

The methodologies employed during the Biota Investigation were consistent with protocol outlined in the BIWP. Any modifications or refinements to the protocol due to the results of test dives and/or conditions encountered during the investigation were detailed in BIWP Addendums, which are referred to throughout this report, and summarized in Section 2.2.3.

2.1 Literature Searches and Reviews

Literature searches and reviews were conducted during the development of the BIWP. The searches included, but were not limited to, limnological data for the Straits, physical and chemical features of aquatic Biota previously observed on the pipelines, field data collection methodologies, cathodic protection, as well as for acid-producing bacteria (APB) and sulfate-reducing bacteria (SRB).

2.2 Biota Study Zones and Sampling Locations

2.2.1 Qualitative Assessment of Underwater Video

Extensive video footage taken during previous remote operated vehicle (ROV) surveys of the dual pipelines was reviewed to qualitatively assess the Biota on the pipelines. This information was valuable towards characterizing general types of Biota present on the pipelines and water depth ranges that were ultimately implemented in the current Biota study (GEI 2014, 2016).

2.2.2 Biota Study Zones

Biota study Zones were consistent with those proposed in the BIWP and were determined based upon a number of factors including a qualitative review of underwater video footage of the dual pipelines from 2014 and 2016. A total of four limnologic Zones (A, B, C, and D) were designated on the east and west pipelines. Figure 1 displays a cross section of the Zones and their water depth ranges and a description of each Zone is provided below:

- Zone A – 50- to 100-foot water depth; periphyton most abundant; mussels present.
    - This depth range is found on the north and south ends of the Dual Pipelines. Hence, there is a Zone A “north” and a Zone A “south”.
- Zone B – 100- to 150-foot water depth; periphyton moderate, mussels moderate.
    - This depth range is found on the north and south ends of the Dual Pipelines. Hence, there is a Zone B “north” and a Zone B “south”.
- Zone C – 150- to 200-foot water depth; periphyton sparse, mussels abundant.

  - This depth range is found on the north and south ends of the Dual Pipelines. Hence, there is a Zone C "north" and a Zone C "south".

- Zone D – Over 200-foot water depth; mussels abundant.
  - This depth range represents the deepest water depth for the Dual Pipelines. Thus, there is only one Zone D. However, for data summaries and analysis, Zone D samples were spatially identified as being from the northern or southern end of the Zone.

As shown in Figure 1, each pipeline passes through water depths associated with Zones A, B, and C before reaching the deepest waters of Zone D, and passing through Zones C, B, and A again before reaching the other side of the Straits.

2.2.3 Biota Sampling Locations

Biota sampling took place at all locations outlined in the BIWP. There were multiple categories of sites at which Biota sampling occurred, all of which are summarized below.

2.2.3.1 Biota Sites

A total of sixteen (16) Biota sampling locations were designated; eight (8) on each pipeline. These locations are referred to as "Biota sites" throughout the rest of this report. Biota sites were located such that four (4) sampling locations would be within each limnologic Zone (Figure 1, Table 1).

2.2.3.2 Area of Interest and Additional Sites

Consistent with the BIWP, Biota was also evaluated at eighteen (18) Areas of Interest and three (3) Additional Sites (Figure 1, Table 1). These twenty-one (21) sites were identified during previous video surveys and were selected based on their appearance, distribution through the four limnologic Zones, and proximity to other target sampling locations. As stated in the BIWP, visual criteria used to select these sites include: (1) the normal (local) Biota is unexpectedly absent (and the disruption is not consistent with Biota removal caused by past maintenance and monitoring activities), or (2) there is evidence of possible coating damage.

2.3 Pre-Sampling Activities

2.3.1 Biota Sampling Checklist Development

Biota sampling checklists (Appendix A) based on BIWP objectives were developed for use during Biota sampling. The checklists included step-by-step actions for each type of sampling site. The use of these checklists ensured that information related to Biota sampling was consistent across sites and that all tasks were completed.

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2.3.2 Pre-Job Meetings, Field Testing

On August 8th, 2017, a meeting was called by Enbridge to discuss aspects of upcoming efforts on the Straits, including the Biota Investigation. This meeting was attended by Enbridge, BMC, Durocher, and GEI. Health and safety, major project objectives, timelines, etc. were discussed at this meeting. On August 11th, 2017, a follow-up meeting was held with personnel from Enbridge, BMC, Durocher, and GEI who would be directly involved with the implementation of the BIWP. This meeting was held on and near the work barge (at the Durocher facility in Cheboygan, MI) that would serve as the primary work platform for Biota sampling, and a short land-based walk through of tasks required in the BIWP was conducted. Discussions related to sampling specifics, including the final preparation of sampling containers, were also held at this time. The aforementioned checklists were reviewed, and where necessary, were modified based on feedback from the BMC Project Manager and professional divers who would be collecting the Biota samples.

Field testing (aka "practice dive") of sample collection and handling techniques was conducted on the Straits on the morning of August 14th, 2017. During this effort, a single dive was made on the east pipeline, in Zone A (south), to a depth of approximately 72 feet. The practice dive was meant to simulate a dive at an Area of Interest and as such, a total of four Biota samples were collected. These samples were not retained as the practice dive was not at a Biota sampling location.

2.3.3 Amendments to Protocol

On a couple of occasions, it was determined that protocol outlined in the BIWP needed to be modified based on factors such as diver logistics and/or safety. These modifications were detailed in BIWP Addendums ("Addendum A" and "Addendum B") that were sent to USEPA for approval and are attached in Appendix B. Addendum A, approved by USEPA via emails on August 11, 15-16, and 21, 2017, contained procedural and logistical updates, some of which involved Biota sampling and Biota sample handling. Addendum B primarily focused on proposed water and sediment sampling that was subsequently conducted in December 2017. Addendum B also stated that Biota, sediment, and water samples would be analyzed for bacteria Deoxyribonucleic Acid (DNA) via polymerase chain reaction (qPCR). Addendum B was not approved, nor denied, by USEPA. However, the results of the DNA analysis provide critical quantitative data relative to bacteria concentrations in Biota, sediment, and water samples and because of this, the DNA analysis and results were integrated into the current report.

2.4 Pre-Dive Communication and "Dive Plan"

Open and consistent communication with all parties was required throughout the Biota Investigation. A communication framework was developed during the practice dive and initial Biota sampling dives. The framework consisted of the following general steps, each of which was taken before and during Biota sampling dives:

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- Assemble representatives from Enbridge, Enbridge contractors, and the ITP inside the "dive shack", which was a conex box (i.e., a large, steel-reinforced box often used as a shipping container – Photograph 3) outfitted with multiple computer screens and televisions that were used to view video footage during dives. This group of individuals was kept as consistent as possible throughout the course of operations;
- Discuss and confirm the target sample location with BMC Project Manager;
- Navigate ROV (made by VideoRay, LLC) to the sampling site and evaluate the site via real-time video feed from the ROV to the work barge. Additional details related to the evaluation of the pipelines with the ROV is provided in Section 2.5.1;
- Complete applicable portions of the Biota sampling checklists, which are described in more detail below;
- Based on the results of the ROV evaluation, reach consensus among all parties with regards to the number of Biota samples targeted for collection and the specific locations on the pipelines (i.e., top, bottom, east, west) from which the Biota samples would be collected, hereafter referred to as the Dive Plan.

After completion of the steps above, the diver assigned to collect Biota samples at the target site would enter the dive shack and the BMC Project Manager would communicate the Dive Plan to the diver. The ROV was again navigated around the sampling site so the diver could view the site and the exact locations where each Biota sample was to be collected.

2.5 Underwater Biota Surveys, Measurements, and Sampling

Biota sampling methods were consistent at all sampling sites and commenced after the Dive Plan was developed and the diver had reached the pipeline. A synopsis of methods for the Biota surveys, measurements, and sampling is summarized below.

2.5.1 Visual Surveys

The ROV was utilized at each Biota sampling location and was critical to the Biota sampling efforts as it allowed for a qualitative, visual evaluation of the target sampling area(s) prior to any divers entering the water. The ROV completed multiple passes around the target sample site, with attempts being made to inspect all accessible areas of the pipeline (e.g., top, sides, and bottom). GPS on-board the barge ensured that the correct location of the pipeline was being assessed, while a camera on the ROV provided live (color) video feed to personnel on the barge deck and on multiple television and computer monitors in the dive shack. The ROV video footage enabled biologists to complete sections of the Biota sampling checklist such as qualitatively assessing the density of mussels at and around the sample site and the assessment of the general types (e.g., mussels, periphyton, vegetation, etc.) and layers of Biota at each site. Photography of the targeted sample site and surrounding areas were taken by the ROV operator (BMC) during visual surveys. Video taken by the ROV camera and the

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camera on the diver was viewed throughout each dive in which Biota samples were targeted for collection.

2.5.2 Pipeline Circumference (Biota Thickness)

As per the BIWP, pipeline circumference measures were taken in a manner consistent with the BIWP to generate data relative to the thickness of Biota attached to the pipelines. Circumference measurements were taken at seven (7) of the sixteen (16) biota sites but could not be taken at the other nine (9) sites because the bottom of the pipeline was partially buried was not safely accessible (i.e., a diver could not safely wrap the tape measure around the entire pipeline). Pipeline circumference was measured with a flexible tape measure, with care taken to ensure that the tape measure was securely wrapped around the pipeline but not so securely that it slipped into the crevices between mussels, which would underestimate Biota thickness. Once the first measurement was taken, the diver gently, but comprehensively, removed all attached material from the pipeline and measured the circumference again, yielding two circumference measures; one measure with Biota, one measure without Biota. Circumference measures were then repeated at two more locations, each approximately three feet up-current of the last measurement. A total of six (6) measurements (3 with Biota, 3 without Biota) were taken at each site where circumference measures were possible. Data from these circumference measurements was used to calculate the thickness of Biota around the pipeline at these sites. Circumference measurement locations were easily observed by personnel on the barge via the ROV and diver video footage (Photographs 11-12, Appendix C).

2.5.3 Biota Sampling

Biota sampling took place at all locations outlined in the BIWP, including the sixteen (16) designated Biota sites (8 on each pipeline) and the Area of Interest and Additional Sites shown on Figure 1 and discussed in more detail in Section 2.2.3. Sampling occurred at randomly-selected areas at each of the sixteen (16) Biota sites; Biota sampling sites were not selected based on mussel density. The same type of Biota sampling equipment was utilized at all sites (Figure 2). Sampling devices were cleaned before each use (Section 2.8.1). Sampling methodology is further summarized below.

2.5.3.1 Biota Sites

Biota sampling at the sixteen (16) Biota sites was conducted according to guidance outlined in the BIWP and in Addendums A and B (Section 2.3.3; Appendix B). A set of two samples was taken from each of the pipeline positions (top, bottom, east, west) that were safely accessible for a total of up to eight (8) samples per Biota site (Figure 3). Spacing of the paired set of samples was as close to one another as possible. Samples were not collected from the bottom of the pipeline if it was not safely accessible or if the bottom was in contact with the lake bed.

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2.5.3.2 Biota sampling at Areas of Interest and Additional Sites

At these sites, a set of two Biota samples was taken from the Area of Interest or Additional Site and another set of two samples was taken from an undisturbed area adjacent to the Area of Interest (Figure 4). Samples collected from the undisturbed area adjacent to the Area of Interest or Additional Site are referred to as "adjacent samples" throughout the remainder of this report. To the extent possible, the undisturbed area selected for the adjacent samples was at the same general position on the pipeline as the Area of Interest or Additional Site samples. Areas of Interest and Additional Sites were defined, and described in more detail, in Section 2.2.3.2.

Seven (7) of the eighteen (18) Areas of Interest also coincided with a Biota site (Figure 1). At these seven (7) sites, paired sampling at the Area of Interest was conducted first, before the pipeline was cleaned for inspection, followed by the Biota sampling (6-8 samples around the pipeline) at a randomly-selected location near (10 – 30 feet) the Area of Interest (Addendum A).

As required by Addendum A, if no Holiday was found at a given Area of Interest or Additional Site, the Biota samples collected at that location were euthanized and disposed of in accordance with the Michigan Department of Natural Resources (MDNR) scientific collector's permit issued to GEI. Therefore, these Biota samples were not evaluated for Biota or bacteria. However, it is important to note that this Addendum clause did not apply to the seven (7) Areas of Interest or Additional Sites mentioned in the previous paragraph. At those seven (7) locations, Biota samples were kept and evaluated, regardless of whether or not a Holiday was found.

The BIWP included major objectives to be executed at each sampling location. A more detailed, summary of specific tasks carried out at each sampling location is as follows:

- Tug boat and barge arrive and anchor at the target site and the ROV is deployed;
- Initial ROV inspection begins once ROV arrives at pipeline;
- A random number is used to determine the target sampling site at the sixteen (16) Biota sites (Addendum A); Area of Interest and Additional Sites have pre-determined sampling locations;
- Dive bell (Photographs 13-14, Appendix C) is lowered to vicinity of pipeline;
- The dive plan is established and discussed with the diver (Section 2.4);
- Diver enters water and descends to the pipeline;
- Diver retrieves pre-cleaned sampling containers (Figure 2) from a steel tool crib lowered to lake bed before diver entered water;

- Diver proceeds to target Biota sampling site and confirms the exact sampling location (i.e., top of the pipeline, side of the pipeline, on an Area of Interest, etc.) via pointing to the pipeline and through radio communications with personnel in the dive shack;
- Diver holds up first sampling container (all of which were uniquely numbered) so that the container number is clearly visible to personnel viewing the video feed (Photograph 17, Appendix C);
- Diver collects a Biota sample by 1) removing the aluminum plate covering the opening of the sampling device (Photograph 22, Appendix C), 2) firmly pushing the opening of the sampling device onto the pipeline, and 3) gently sliding the aluminum plate back into place, thereby detaching Biota from the side of the pipeline and trapping the Biota in the sampling container;
- Diver points to the exact location from which the sample was collected and the ROV and diver camera records video footage of the sampling site;
- Diver repeats the Biota sampling process above until all targeted Biota samples (6-8 at Biota sites, 4 at Area of Interest or Additional Sites) have been collected (Figures 3 & 4);
- Sample containers are returned to the steel tool crib and the tool crib is raised through the water column and back onto the deck of the barge.

Steps taken following the arrival of the Biota samples on the deck of the barge are summarized in Sections 2.6 and 2.7.

2.5.3.3 Opportunistic Sampling

As required by the BIWP, material encountered along the lake floor or in the vicinity of Biota sampling locations was opportunistically sampled by divers. In these instances, the diver would place the material in a plastic bag, or put it into the steel tool crib. Details related to the disposition of the material (i.e., where it was found, was it attached to anything, etc.) were discussed with the diver during collection of the opportunistic samples.

Opportunistic samples that contained mussels were processed in accordance with the MDNR scientific collector's permit and then sent to GEI's ecological lab for evaluation. One of these samples was subsequently transferred to Ann Arbor Technical Services (ATS) lab for analysis.

2.5.4 Water Chemistry Evaluation

Water chemistry parameters were measured towards the end of the August/September Biota sampling effort and during the December water and sediment sampling effort (Figure 5, Table 2). Measurements were taken using a YSI® EX02 multi-parameter sonde. Parameters measured included depth (feet), temperature (°C), specific conductance (µS/cm), pH,

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oxidation-reduction potential (ORP, mV), turbidity (FNU), dissolved oxygen (DO, mg/L), and DO percent saturation. Currents in the Straits precluded lowering the sonde over the edge of the barge. Thus, the sonde was attached to the steel tool crib that served as the container for the Biota sampling containers (Photograph 24, Appendix C). The tool crib was lowered into the water, at which point the sonde would activate and begin capturing water chemistry measurements on its way down to the bottom. Measurements continued while the tool crib was on the bottom and during its return to the surface. The frequency at which measurements were taken varied from 10 – 60 seconds. The tool crib was typically placed less than 10 m from the pipeline.

2.5.5 December 2017 Water and Sediment Sampling

The rationale and methodology for December 2017 water and sediment collection was documented in BIWP Addendum B (Appendix B). The collection of lake water and bottom sediment was done to generate background levels of bacteria in the water column and sediment to provide additional context to the data generated from the Biota samples. Water and bottom sediments were collected in conjunction with on-going barge operations. Thus, the locations sampled were predicated by the barge work locations and were limited to collection at two sites, both on the east pipeline (Figure 5, Table 3). Representative photographs taken during the water and sediment sampling effort can be found in Appendix C.

Water samples were collected at near surface (~ two feet of depth), approximate mid-depth, and near the bottom for a total of three (3) water samples per location. Bottom water samples were collected using a decontaminated Niskin sampler that was attached to the dive bell. All other water samples were collected using a decontaminated Van Dorn sampler that was attached to the dive bell (for mid-depth samples) or deployed over the side of the barge (for surface water samples). For the bottom water samples, the diver triggered the sampling device while on the lake bottom. For the mid-depth water samples, the diver triggered the Van Dorn sampler while being transported back to the surface. Water samples were then transferred to a laboratory-supplied bottle for subsequent handling and shipment.

Sediment samples were collected using decontaminated sampling polyvinyl chloride (PVC) devices (Figure 2) that were used during Biota sample collection. The PVC pipe (4” inside diameter) was used to “scoop” sediment into the container to a depth of approximately two inches. At this point, the aluminum lid was slid back over the PVC pipe opening and the sampling container was placed into a mesh dive bag attached to the dive bell. Two sediment samples (i.e., replicate samples) were collected within six inches of each other at each site. Each sediment sample was homogenized inside the sampling container using a decontaminated stainless-steel spatula prior to being transferred to pre-cleaned, laboratory-supplied glass jars.

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2.6 Sample Handling and Shipment

Prior to handling the samples, the steel tool crib which contained the samples was brought onto the deck of the barge (Photograph 24, Appendix C). Each pair of samples was then randomly-assigned to one of two groups, with one group of samples designated for APB/SRB field kit testing and DNA analysis (Microbial Insights, Knoxville, TN), and the other group designated for Biota evaluation at the GEI ecological lab in Denver, CO. The same sample used for APB/SRB field kit testing was later analyzed through DNA testing as described in Work Scope Addendum B. The random assignment of samples was conducted in the presence of ITP personnel. As an example, if the first sample container removed from the tool crib was identified as coming from the top of the pipeline, then the other sample from the top of the pipeline would be removed from the tool crib and those sample would be randomly-assigned (coin-flip) to each of the groups. Addendums A and B provide additional detail specific to the DNA analysis. Sections 2.6.1 – 2.6.4 describe handling and shipment methods for each group of samples collected during the Biota Investigation.

2.6.1 APB/SRB Field Test Kit and DNA Analysis Samples

Samples designated for APB/SRB field kit testing were handled in accordance with instructions provided by the manufacturer (BioSan, Inc., Appendix D) and are summarized below (Photographs 28-35, Appendix C):

- The contents of a sampling container were poured onto a piece of flexible 580 micron mesh screen, which was laid on top of a sieve with a mesh size of 254 microns. Material remaining inside the container was washed out of the container using a spray bottle containing lake surface water. The majority of the water inside the sample container passed through the mesh screen, with the Biota remaining on the mesh;
- An APB and SRB field test kit was then initiated following instructions provided by BioSan. A swab provided with each test kit was pressed ("dabbed") into multiple areas of the Biota sample for a period of 8-10 seconds total for each swab. All types of material (mussels, periphyton, vegetation, sand/detritus, etc.) were contacted by the swab;
- Each swab was then immersed in its associated test tube and the test tube was labeled with a sample identification (ID) code and the date and time in which the sample was collected;
- APB and SRB test tubes were then placed into a BioSan SaniCheck 120v incubator set at 30°C;
- Test tubes were then monitored per BioSan instructions for up to five days or until a color change was observed in the test tube (Appendix D), whichever came first;

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- Periphyton and all non-mussel Biota that was presumed to be attached to the pipeline was picked from the sample using pre-cleaned stainless-steel instruments (spatulas and tweezers);
- The periphyton sample was then placed into a plastic bag (Ziploc®) that was labeled with information such as the date and time of collection, and the sample ID;
- The sample bag was then sealed and placed inside another plastic bag, which was also sealed;
- Periphyton samples were then placed into a cooler filled with ice for transport back to a secure facility;
- Quagga mussels (*Dreissena bugensis)* removed from samples destined for APB/SRB testing and DNA analysis were euthanized and preserved by immersion in ethanol and subsequently disposed of as required by the MDNR scientific collector permit issued to GEI.

2.6.2 Biota Evaluation Samples

Samples designated for Biota characterization (i.e., Biota classification, measurements, etc.) were handled according to steps summarized below (Photographs 37-39, Appendix C):

- The contents of a sampling container were poured onto a piece of flexible 580 micron mesh screen, which was laid on top of a sieve with a mesh size of 254 microns. Material remaining inside the container was washed out of the container using a spray bottle containing lake surface water. The majority of the water inside the sample container passed through the mesh screen, with the Biota remaining on the mesh;
- The corners of the mesh bag were then folded inward and the contents of the mesh bag were securely wrapped up before being hung to drip-dry (dewater) for approximately five (5) minutes;
- The mesh bag was then placed into a plastic bag (Ziploc®) that was labeled with information such as the date and time of collection, and the sample ID;
- Biota samples were then placed into a cooler filled with ice for transport back to a secure facility.

2.6.3 Water and Sediment Samples

Water and sediment samples collected in December 2017 were handled on the barge in the following manner (Photographs 25-27, Appendix C):

- Water: APB and SRB field test kits were initiated for water samples following BioSan instructions. The test kits were started while the water was still in the

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collection vessel (Niskin or VanDorn sampler). After APB and SRB field test kits were started, the water was transferred to a pre-cleaned, lab-supplied water bottle.

- Sediment: water inside the sampling container was first poured out, taking care to minimize sediment loss during dewatering. Collected sediment was then homogenized inside the sampling container using pre-cleaned stainless-steel spatulas and transferred to pre-cleaned, laboratory-supplied glass jars. Once inside the glass jars, APB and SRB field test kits were initiated following BioSan instructions.
- Water and sediment samples were then labeled with information such as the date and time of collection, and the sample ID and placed into a cooler filled with ice for transport back to a secure facility.

2.6.4 Opportunistic Samples

Opportunistically-collected samples were visually inspected by Enbridge, BMC, ITP, and GEI personnel. Following this, photographs of the samples were taken and information related to the appearance of the samples was recorded. Samples were then placed into a plastic bag (Ziploc®) that was labeled with information such as the date and time of collection, and the sample ID. Bagged samples were then placed into a cooler filled with ice for transport back to a secure facility. All opportunistically-collected samples were transferred to the GEI ecological lab for storage.

2.6.5 Handling and Processing at Secure Facility

Additional sample handling and processing (Photograph 40, Appendix C) of Biota samples destined for characterization by the ecological lab occurred at a secure field-based facility. At the secure facility, the mass (weight) of each Biota sample was measured with a calibrated balance (Ohaus® Scout SPX621). After this, a measured volume of reagent grade ethanol (VWR, Inc.) was poured into the plastic bag containing the Biota samples to euthanize the mussels per MDNR permit. Periphyton, water, and sediment samples destined for extraction and Census qPCR analysis by Microbial Insights required no additional processing (i.e., ethanol was not added as mussels had been removed from those samples). Chain-of-custody (CoC) paperwork for all sample types (Biota, water, sediment, etc.) were then completed (Photograph 41, Appendix C).

Samples were then transferred to a refrigerator for temporary (typically less than 24 hours) holding while awaiting shipment. Upon making shipment arrangements, samples and CoC documents were placed into a cooler, which was secured using packing tape and custody-sealed such that the custody seal would need to be broken in order to access the contents of the cooler (Photograph 42, Appendix C). Samples were then transported to FedEx or UPS for overnight shipment to Microbial Insights (Knoxville, TN) for DNA extraction and analysis, or to the GEI ecological lab in Denver, CO. Ice was not required for samples sent to the GEI ecological lab as those samples were preserved with ethanol to euthanize quagga mussels as required by the MDNR permit. Bagged ice was included in coolers containing samples

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shipped to Microbial Insights. Most samples were shipped within 24 hours of collection, with exceptions being samples that were collected on a Friday or Saturday, which could not be shipped until the following Monday. In those cases, samples were kept refrigerated until shipment.

2.7 Sample Processing and Evaluation

2.7.1 APB/SRB Field Test Kits

As described above, APB/SRB field test kits were initiated and maintained according to BioSan instructions (Appendix D). Once a test was initiated, the test tube was placed in the incubator set to 30°C as recommended by BioSan. All test tubes were checked on a daily basis for color change that would be indicative of the presence of APBs or SRBs. The magnitude of the color change and the speed at which the color change took place were compared to evaluation charts provided by BioSan to make a qualitative determination of the presence of APBs and SRBs. For both test types, the test is discontinued after five (5) days if no color change is observed in that time frame. More detail on APB/SRB field test kit use and the evaluation charts are provided in Appendix D. Color change (if any) and time associated with the observed color change was recorded daily on an APB/SRB track log. Photographs were taken of all test tubes in which a color change was noted (Photographs 43-44, Appendix C). For reference purposes, a new, unopened test tube was placed next to the test tube in which color change had been observed to allow for better interpretation of the magnitude of the color change. On a few occasions, photographs of test tubes were sent via email to BioSan for confirmation of the color change documented by GEI. In all cases, BioSan agreed with the interpretation made by GEI.

2.7.2 Biota Counts, Densities, and Weights

At the ecological lab, Biota samples were evaluated and separated into general categories: mussels, benthic macroinvertebrates, macrophytes and periphyton. Qualitative wet weights of the entire sample mass and its components along with quantitative dry weights of whole mussels, mussel shell fragments, benthic macroinvertebrate, and periphyton components were obtained (macrophytes were not observed). Following the separation of the Biota components, each sample contained inorganic material (e.g. sediment/sand/grit) and some samples contained “material of interest” (MOI), the latter of which was material not able to be positively identified during barge operations. Therefore, two additional categories (inorganic material and MOI) were created to account for these remaining dry weight components. All mussels were identified and enumerated. All mussels were measured for length, width, and height of the base and sorted by size class. Benthic macroinvertebrate, periphyton and planktonic algae/zooplankton were identified to the lowest practical level. The microscopic planktonic algae/zooplankton required an additional level of taxonomic evaluation and as such, eight (8) samples from both the east and west pipelines (n=16 samples total) were sent to PhycoTech, St. Joseph, MI, to identify and determine

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presence/absence of planktonic algae/zooplankton. A complete description of Biota sample evaluation is detailed in GEI Standard Operating Procedures (SOP) documents (Appendix E) and raw data (e.g., mussel measurements, algae classification, etc.) from the Biota characterization is provided in Appendix F.

MDNR required euthanization of mussels via ethanol to minimize the potential risks related to the shipping an invasive species. The addition of ethanol to the Biota samples is a variable that could influence the wet weights of Biota samples recorded at the laboratory. To control for this, the dry weight of all Biota samples and sample strata was also generated (as described in the previous paragraph) and dry weights are most commonly referenced in the remainder of this document.

2.7.3 DNA Extraction and Analysis

Samples sent to Microbial Insights were designated for extraction upon receipt, preserving the opportunity to perform DNA analysis indefinitely. Extraction and analysis methodology is outlined in Appendix G, which was provided to GEI in a redacted and locked form to protect proprietary information. Parts of the methodology were redacted by Microbial Insights to protect business confidential details. Census qPCR (quantitative polymerase chain reaction) DNA analysis was carried out on all samples extracted. This type of analysis enables enumeration of specific organisms or genes encoding specific biological functions. The targets selected for evaluation were APBs and SRBs. Reported APB results are a sum of five different assays, while reported SRB results are a sum of seven different assays. The genera targeted by each of the assays are listed below.

Acid Producing Bacteria

AGN-1: *Moorella*

AGN-2: *Sporomusa*

AGN-3: *Treponema*

AGN-7: *Acetobacterium*

AGN-8: *Eubacterium*

Sulfate Reducing Bacteria

APS-1: *Desulfobacula, Desulfosarcina, Desulfobulbus, Desulfobacterium, Desulfatibacillum, Desulfofustis, Desulfocapsa, Desulfopila, Desulfobacter, Desulforhopalus, Desulfofaba, Desulfococcus, Desulfotignum, Desulfonema, Desulfocella, Desulfospira, Desulfobotulus*

APS-2: *Desulfovibrio, Desulfomicrobium, Desulfonatronum, Desulfocaldus, Desulfonatronovibrio, Desulfohalobium (Desulfovibrionales)*

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APS-3: *Desulfotomaculum, Desulfacinum, Desulfobacterium, Deulforudis, Desulforhabdus, Syntrophobacter (Syntrophobacterales, Firmicutes)*

APS-4: *Thermodesulfobacterium, Thermodesulfatator*

APS-5: *Thermodesulfovibrio*

APS-6: *Thermodesulfobium*

APS-7: *Desulfobacterium corrodens*

2.8 Quality Assurance/Quality Control (QA/QC) Actions

A Quality Assurance/Quality Control Project Plan (commonly referred to as a "QAPP") was not a requirement of the Consent Decree, nor was it recommended by reviewers of the BIWP. Nevertheless, QA/QC measures and protocol were implemented and followed throughout the Biota Investigation to ensure sufficient and complete documentation and the integrity of Biota samples and subsequent data generated from their analysis. Many of the QA/QC measures implemented in the Biota Investigation were consistent with quality assurance procedures recommended by USEPA (USEPA 2002a, 2002b, 2002c). QA/QC measures are summarized below:

2.8.1 Documentation and General QA/QC

The development and use of detailed checklists (Appendix A) for each type of Biota sampling location (Area of interest, Additional Site, Biota site) was a primary means of ensuring consistent documentation throughout the effort. Field notes including field illustrations (when relevant) were captured in field data sheets (Appendix H). Daily field activity logs (Appendix I) were created to summarize all sampling activity and communication related to Biota sampling. Time and date-stamped photos were taken throughout the effort (Appendix C). GEI utilized a total of three staff members for the Biota sampling effort, with two of the staff members present nearly every day of the effort. Strict CoC protocol was also adhered to for all samples collected throughout the effort (Appendix J).

Sample IDs were structured in an attempt to provide a unique ID that would communicate the pipeline sampled, Zone, and pipeline position from which a biota sample came from. There were instances where a sample ID was assigned to more than one sample due to the random selection of numbered sampling containers by the diver. In all cases, additional information such as the date and time of collection, site ID and depth of sample collection enable differentiation of those samples. Appendix F includes a table reporting sample IDs that were used more than once during the Biota Investigation.

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2.8.2 Equipment Decontamination

Equipment such as the Biota sample containers, spatulas used for sorting samples, and surfaces that could come into contact with Biota samples was regularly washed with non-phosphate detergent (Liquinox®). Care was taken to ensure that all sample material, sediment, and mussels were washed from the Biota sampling containers between each sampling site. Lake water was used as a final equipment rinse during the August/September Biota sampling effort. APBs were observed in several of the August/September QA/QC samples that were rinsed with lake water (Section 3.7). Because of this, distilled water was used to rinse equipment during the December water and sediment effort. Equipment was also rinsed with ethanol as an additional decontamination step in the December water and sediment effort.

2.8.3 Verification of APB/SRB Field Test kits

As discussed in Section 2.7.1, the presence (or lack thereof) of APB/SRBs in field test kits is predicated by color change (if any), and the speed at which the color change was observed. For all tests, both factors were compared to evaluation charts provided by BioSan to determine the presence of APBs and SRBs. The magnitude of color change can be a subjective measure and in a few instances, it was not clear which narrative category (i.e., "Heavy", "Moderate") APB/SRB category should be assigned. In those cases, photographs of test tubes were sent via email to BioSan for confirmation of the color change documented by GEI. In all cases, BioSan agreed with the interpretation made by GEI.

Multiple types of QA/QC samples were also generated in association with APB/SRB field test kits. These samples were first initiated approximately one week into the Biota sampling program after multiple discussions related to the observation that all APB/SRB field test kits utilized thus far on Biota samples had resulted in "Strong" APB and "Heavy" SRB results based on evaluation charts provided by BioSan (Appendix D). The QA/QC samples included, but were not limited to:

- Equipment blanks – this was water (of various types) poured over equipment used during Biota sampling and handling then the equipment was swabbed with the APB/SRB field test kit swabs. Examples would be water poured over nitrile gloves, water poured over decontaminated sample container, etc.
- Water blanks – APB/SRB field test kit swabs were directly immersed in lake water (surface, at depth), distilled water, bottled water, and tap water. Sterile water purchased from BioSan was also evaluated during the December 2017 water and sediment effort.
- Atmospheric blanks – APB/SRB field test kit swabs waved through the air inside the portable shelter that Biota samples were handled in.

In most cases, QA/QC samples were generated in duplicate to evaluate the consistency of APB/SRB field test kit results. Duplicate field test kits are those which were taken concurrently from the same sample and medium as the initial (aka "parent") sample.

2.8.4 QA/QC of Biota Samples Sent to Ecological Lab

A summary of QA/QC measures for Biota samples evaluated by the GEI ecological lab can be found in GEI SOP documents (Appendix E). QA/QC measures generally involved verification of metrics for approximately 10% of samples collected. This verification included, but was not necessarily limited to:

- Verification of dry weights through replication of massing procedures;
- Verification of taxonomic classification of benthic macroinvertebrates (including Dreissenid mussels) by a certified taxonomist;
- Evaluation of CoC files, GEI laboratory sample receipt sheets, and electronic bench sheets for discrepancies in sample IDs, data entry/transcription errors, and any formulas used in required calculations.

2.8.5 QA/QC of Census qPCR DNA Analytical Results

Census qPCR DNA analytical results received by Microbial Insights were evaluated for completeness (i.e., verification that results were received for all samples). Sample IDs were verified for all results and any discrepancies or clarification questions needed were resolved via email communication with Microbial Insights.

2.9 Data Analysis

Consistent with the BIWP, the weights of mussels and other Biota were summarized and evaluated statistically to determine if there were differences in the biomass with respect to the pipeline (east or west), study Zone (A-D), position on the pipeline, or whether there was an interaction between pipeline and position which may affect biomass accumulation. A summary of statistical methodology for Biota Sites, Areas of Interest, and Additional Sites is provided below.

2.9.1 Biota Sites

Using data from the sixteen (16) Biota sampling sites, sum and mean dry weight for periphyton, macroinvertebrate, mussel, and total biomass components for top, bottom, east, and west position Biota samples were summarized by pipeline (east and west pipelines), pipe end (north and south halves of the pipeline), and individual study Zones (A-D). Periphyton, macroinvertebrate, and mussel total wet and dry weights were graphed by pipeline position (top, bottom, east, and west), pipeline, pipe end, and study Zone.

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Mean number of mussels per square foot and their dry weight per square foot collected at top, bottom, east, and west pipeline positions were summarized by the east and west pipeline, and the north/south Zones. Mean number of mussels and dry weight per square foot were also graphed by pipeline position, pipeline, and north/south Zones.

Pipeline and position data were compared for biomass and total dry weight Biota. Box plots of biomass and total dry weight by pipeline position and pipeline were made. Bottom position data was sparse or nonexistent and were excluded so comparisons of position would have similar N-values. Dry weight data did not meet the assumption of normality and was transformed by taking the square root of the values which improved normality. Between-subjects effects of pipeline and pipeline position for Biota and dry weight were evaluated using a General Linear Model Two-Way Analysis of Variance. Descriptive statistics were generated.

Pipeline and pipe end (north/south) data were also compared for biomass and total dry weight Biota. Between-subjects effects of pipeline, pipe end, and their combined effect for Biota and dry weight were calculated using a General Linear Model Two-Way Analysis of Variance. Descriptive statistics were generated. Significance was determined at the alpha 0.05 level.

2.9.2 Areas of Interest and Additional Sites

The dry weight data for periphyton, macroinvertebrate, mussel, and total biomass collected for the different site types (Areas of Interest, Additional Sites, and samples from undisturbed areas adjacent to those sites) were also summarized by east/west pipeline, and north/south Zones.

Area of Interest, Additional Site, and adjacent samples were evaluated for biomass and total dry weight Biota. Box plots of biomass and total dry weight by site type were made. The Mann Whitney U test was used to compare the biomass collected from Area of Interest and Additional Sites to adjacent samples. A ranks test of site type for Biota and dry weight and descriptive statistics were generated.

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3.0 Results

The 2017 Biota Investigation effort generated one hundred fifty-eight (158) samples, including Biota and opportunistic samples, that were sent to labs for Biota characterization, DNA analysis, and/or APB/SRB field testing. Eighty-four (84) of the samples were shipped to the GEI ecological lab for Biota evaluation. Seventy-four (74) Biota samples were sent to Microbial Insights for DNA analysis. An additional four (4) sediment and six (6) water samples were collected during follow-up efforts in December 2017. APB/SRB field test kits were utilized on ninety-six (96) Biota samples, which included all samples that were submitted to Microbial Insights, QA/QC samples, and opportunistic samples. A descriptive summary of samples collected can be found in Tables 4 & 5.

3.1 Visual Surveys

A visual record of each Biota sampling site was created through video-photography produced by the ROV camera and a camera mounted on the helmet worn by each diver. Biologists were present during all Biota sampling efforts and viewed all video footage produced during Biota sampling dives in real-time (i.e., during the actual dives). This enabled biologists to observe and qualitatively characterize factors such as the relative level of mussel colonization (e.g., sparse, moderate, heavy) on the pipelines and the number of Biota layers (one or multiple) present on the pipelines, which is reported in Table 4. Round gobies (*Neogobius melanostomus*) were observed and recorded by video-photography at many sampling sites, particularly in Zones A and B, and were often seen consuming mussels in an around the pipeline, which is consistent with French and Jude (2001). Other fish species were observed but could not be positively identified as they typically vacated the area when the ROV drew near.

3.2 Biota Samples

Eighty-four (84) samples were shipped to the GEI ecological lab and Biota was characterized in seventy-five (75) of those samples. The other nine (9) samples were collected opportunistically by divers as required in the BIWP and are discussed in Section 3.5. Fifty-six (56) of the eight-four (84) samples were collected at Biota sampling sites, twenty-one (21) from Area of Interest sites, and seven (7) from Additional Sites (Figures 6 and 7, Table 4).

Samples were received by the analytical labs in good condition (i.e., mussels could be counted, measured, weighed, and DNA could be extracted). A couple of sets of samples had to be refrigerated more than twenty-four (24) hours before shipment due to weekend shipping logistics (i.e., no Sunday shipments). However, no impact to Biota measurements nor to Census qPCR concentrations occurred (personal communication – GEI and Microbial Insights).

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Biota samples examined showed the presence of one species of dreissenid mussel, the quagga mussel *(Dreissena bugensis)*. No adult zebra mussels *(Dreissena polymorpha)* were identified in any of the samples containing Biota. In some cases, juvenile dreissenid mussels could not be positively identified to species and were determined to be quagga mussels given the lack of adult zebra mussels found in Biota samples. Literature supports the prevalence of quagga mussels over that of zebra mussels in these deeper, colder environments of the Great Lakes (Mills et al. 1996; Wilson et al., 2006; Peyer et. al., 2009).

3.2.1 East Pipeline Biota Results

Eight (8) Biota sites, eleven (11) Area of Interest sites, and two (2) Additional Sites were sampled on the east pipeline (Figure 6, Table 1). As per the BIWP, if it was determined that no Holidays were present at an Area of Interest or Additional Site, the Biota samples collected at that location were not evaluated and were disposed of in accordance with the MDNR scientific collector permit issued to GEI. Sampling efforts occurred in all Zones of the east pipeline, at depths ranging from 71 to 216 feet.

3.2.1.1 East Pipeline Circumference Measurements (Biota Thickness)

Pipeline circumference measurements were taken at three (3) locations on the east pipeline; once each in south Zones A, B, and C. The depth at which the circumference was measured ranged from 81 feet (Zone A) to 175 feet (Zone C). Mussel colonization was “Heavy” at all locations where circumference was measured. The average (mean) thickness of Biota was calculated at these sites using the circumference measurements and ranged from 1.21 – 2.63 cm thick. A summary of Biota thickness results is presented in Table 6. Pipeline circumference measures were not possible at the other five (5) east pipeline Biota sampling locations as the bottom of the pipeline was partially embedded in the lake bed or not safely and fully accessible to divers at those locations.

3.2.1.2 East Pipeline Mussels

Quagga mussels were found in all Zones and on all pipeline positions sampled on the east pipeline. No adult zebra mussels were identified in any of the samples. Mussels were the dominant type of Biota and contributed the greatest amount to the total biomass in all samples collected (Table 7). The total weight of mussels, including mussel fragments, in east pipeline samples varied, ranging from less than one gram to approximately 47 grams (dry weight; Figure 8), with an average of approximately 16 grams of mussels (dry weight) per sample (Table 8). Mussel dry weight per square foot, including and excluding mussel fragments, is provided in Table 9. Mussel density varied with an average density by Zone ranging from approximately 11 to 593 mussels per square foot (Table 9). Sample-specific results for mussel density and dry weight per square foot is provided in Appendix F.

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3.2.1.2.1 East Pipeline Mussels by Zone

The weight of mussels in east pipeline Biota samples varied according to Zones (Figure 8; Table 10). Average dry weight due to mussels was least in north Zones A and B and greatest in south Zones A and B (Table 10). When considering the weight of mussels by Zone it should be noted that sample sizes sometimes differed across Zones due to the accessibility (or lack thereof) of the bottom of the pipeline at a given sampling site.

3.2.1.2.2 East Pipeline Mussels by Position on Pipeline

The weight of mussels in the east pipeline Biota samples also varied according to the pipeline position (i.e., top, bottom, east side, west side) from which they were sampled (Figure 8; Table 11). In general, the greatest mussel weights were observed in samples from the sides (east and west) of the pipeline, as opposed to the top and the bottom, but the bottom of the pipeline was not accessible for sampling at all west pipeline locations.

3.2.1.3 East Pipeline Macrophytes, Periphyton, Algae, and Benthic Macroinvertebrates

Macrophytes were not observed in any of the Biota samples from the east pipeline. Video footage viewed during initial dives suggested that macrophytes were present, particularly in shallower Zone A. However, the suspected macrophytes were subsequently confirmed to be *Cladophora* sp., a filamentous green algae. Other types of Biota were observed to varying degrees in east pipeline Biota samples. These included, but were not limited to various types of free and attached algae, as well as copepods (zooplankton), and benthic macroinvertebrates such as amphipods and isopods. Appendices F and K provide a comprehensive listing of the types of periphyton and algae, and benthic macroinvertebrates found in samples from the east pipeline.

The total biomass of non-mussel strata such as algae and benthic macroinvertebrates was negligible in comparison to the biomass of mussels (Figures 9 and 10; Table 7), and was less than one gram (dry weight) in all but two sites, both of which were in Zone A south. However, it should be noted that the diversity and abundance of these types of Biota may have been underestimated due to design characteristics of the Biota sampling device, which exposed sample contents to the water column for a brief amount of time while the device was being closed following sample collection. Since these smaller Biota would represent an insignificant amount of weight (less than one gram, dry weight) on the pipeline, there is no impact on the validity of the assessment.

3.2.1.4 East Pipeline Opportunistic Samples

Five (5) samples were opportunistically collected by divers during east pipeline Biota sampling efforts (Table 4). The origin or makeup of these samples could not be verified during barge operations so these samples were identified as “Material of interest” (MOI), “presumed detached coating”, etc. (Photographs 45-51).

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3.2.2 West Pipeline Biota Results

Eight (8) Biota sites, seven (7) Area of Interest sites, and one (1) Additional site were sampled on the west pipeline (Figure 7; Table 1). As per the BIWP, if it was determined that no Holidays were present at an Area of Interest or Additional Site, the Biota samples collected at that location were not evaluated and were disposed of in accordance with the MDNR scientific collector permit issued to GEI. Sampling efforts occurred in all Zones of the west pipeline, at depths ranging from 77 to 245 feet.

3.2.2.1 West Pipeline Circumference Measurements (Biota Thickness)

Pipeline circumference measurements were taken at four (4) locations on the west pipeline; once in north Zones A and C, once in south Zone B, and once in Zone D. The depth at which the circumference was measured ranged from 77 feet (Zone A) to 234 feet (Zone D). Mussel colonization was “Heavy” at all locations where circumference was measured, except for the north Zone A location, where colonization was “Moderate”. The average thickness of Biota was calculated at these sites using the circumference measurements and ranged from 0.81 – 2.02 cm thick. A summary of Biota thickness results is presented in Table 12. Pipeline circumference measures were not possible at the other four (4) west pipeline Biota sampling locations as the bottom of the pipeline was partially embedded in the lake bed or not fully accessible to divers at those locations.

3.2.2.2 West Pipeline Mussels

Quagga mussels were found in all Zones and on all pipeline positions sampled on the west pipeline, except for three samples which did not contain any mussels. No adult zebra mussels were identified in any of the samples. Mussels were the dominant type of Biota and contributed the greatest amount to the total biomass in nearly every Biota sample collected from the west pipeline (Table 13). The weight of mussels, including mussel fragments, in west pipeline samples varied, ranging from zero grams to approximately 29 grams (dry weight), with an average of approximately 10 grams of mussels (dry weight) per sample (Table 14). Mussel dry weight per square foot, including and excluding mussel fragments, is provided in Table 15. Mussel density also varied, with an average density by Zone ranging from approximately 8 to 527 mussels per square foot (Table 15). Sample-specific results for mussel density and dry weight per square foot is provided in Appendix F.

3.2.2.2.1 *West Pipeline Mussels by Zone*

The weight of mussels in east pipeline Biota samples varied according to Zones (Figure 11; Table 16). Average dry weight due to mussels was least in north Zone A and greatest in south Zones A (Table 16). When considering the weight of mussels by Zone it should be noted that sample sizes sometimes differed across Zones due to the accessibility (or lack thereof) of the bottom of the pipeline at a given sampling site.

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3.2.2.2.2 West Pipeline Mussels by Position on Pipeline

The weight of mussels in the west pipeline Biota samples also varied according to the pipeline position (i.e., top, bottom, east side, west side) from which they were sampled (Figure 11; Table 17). In general, the greatest mussel weights were observed in samples from the sides (east and west) of the pipeline, as opposed to the top and the bottom, but the bottom of the pipeline was not able to be safely sampled at all west pipeline locations.

3.2.2.3 West Pipeline Macrophytes, Periphyton, Algae, and Benthic Macroinvertebrates

Non-mussel Biota on the west pipeline was generally similar to the east pipeline. Macrophytes were not observed in any of the Biota samples from the west pipeline. *Cladophora* sp., a filamentous green algae, was present on the west pipeline. Other types of Biota including, but not limited to free and attached algae, copepods (zooplankton), amphipods, chironomids, and isopods were also documented. Appendices F and K provide a comprehensive listing of the types of periphyton and algae, and benthic macroinvertebrates found in samples from the west pipeline.

The total biomass of non-mussel strata such as algae and benthic macroinvertebrates was negligible in comparison to the biomass of mussels (Figures 12 and 13; Table 13), and was less than one gram (dry weight) at the few sites where these strata were found. However, as stated in the east pipeline results, the diversity and abundance of these types of Biota may have been underestimated due to design characteristics of the Biota sampling device. Since these smaller Biota would represent an insignificant amount of weight (less than one gram, dry weight) on the pipeline, there is no impact on the validity of the assessment.

3.2.2.4 West Pipeline Opportunistic Samples

Three (3) samples were opportunistically collected by divers during west pipeline Biota sampling efforts (Table 4). The origin or makeup of these samples could not be verified during barge operations so these samples were identified as “Material of interest”, “presumed detached coating”, etc. (Photographs 52-55).

3.2.3 Statistical Test to Evaluate Mussel Biomass on Pipelines

As discussed above, the mussel biomass varied between the pipelines and the position on the pipeline where the samples were collected. To evaluate whether the location of each pipeline (east or west) or the sampling position on the pipeline (top, east side, west side) influenced the total mussel biomass (dry weight) a Two-Way Analysis of Variance test was performed. Because the bottom position data was sparse or nonexistent these data were excluded so comparisons of position would have the same sample size. The dry weight data was transformed (square root) to improve normality. Between-subject effects of pipeline and position were calculated using the General Linear Model routine in SPSS (ver. 19) and setup as a Two-Way ANOVA to evaluate the hypothesis that mussel biomass is the same on each pipeline and that the sampling position did not influence the biomass. The test confirmed that

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each pipeline is statistically indistinguishable with respect mussel biomass (p = 0.400) and that the sampling positions are also statistically indistinguishable from each other (p = 0.317). There was also no effect due to the interaction of the pipeline and sampling position (p = 0.939) on mussel biomass. Statistical analyses tables are provided in Appendix L.

3.2.4 Biota Samples from Areas of Interest and Additional Sites

Biota samples were collected from a total of five (5) Area of Interest and Additional Sites on the east and west pipelines, respectively (Table 18 and 19). As described in Section 2.2.3, "paired" Biota samples were taken at these sites, with one pair being taken directly at the Area of Interest or Additional Site, and the other pair collected from an undisturbed area adjacent to the first pair of samples (Figure 4). Biota samples were not evaluated (i.e., were disposed of per MDNR permit requirements) at Area of Interest and Additional Sites at which a holiday was not confirmed (Appendix B).

At a couple of locations (Site IDs E-AS1 and E-AS2; Figure 6), paired samples were proactively collected (as described in BIWP Addendum A) from the area where a Holiday was suspected to be. Consistent with the protocol, the general area was cleaned off (i.e., Biota was wiped away by hand by divers) following sample collection to facilitate more detailed inspection of the site. Inspection revealed no holiday where the paired samples were collected. However, a holiday was found within three (3) feet of the sample collection site. Field notes from these sites indicate that the appearance of the pipeline and Biota was generally consistent where the Biota samples were collected and where the Holiday was subsequently found.

3.2.4.1 Area of Interest and Additional Site Pipeline Circumference Measurements (Biota Thickness)

Per the BIWP, pipeline circumference was not measured at any of the Area of Interest or Additional Site locations. Biota, including mussels, were less abundant at Areas of Interest and Additional Sites (as outlined in more detail in the next section). Thus, it is likely that average Biota thickness would have been lesser at Areas of Interest and Additional Sites.

3.2.4.2 Area of Interest and Additional Site Mussels

Quagga mussels were generally absent, or observed in very low numbers in the majority (7/10) of Biota samples from Areas of Interest or Additional Sites. In contrast, mussels were present in nine (9) of ten (10) samples collected from an undisturbed area adjacent to the Area of Interest or Additional Site (Tables 18 and 19). The average mass of mussels, including mussel fragments, in Biota samples from adjacent sites was often more than an order of magnitude greater than the average mass of mussels in Biota samples collected at Area of Interest or Additional sites. In the adjacent samples, Biota sample weight due to mussels ranged from 4.42 to 25.29 grams (dry weight) for the east pipeline, and zero (0) to 27.01 grams (dry weight) for the west pipeline (Table 18).

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3.2.4.3 Area of Interest and Additional Site Macrophytes, Periphyton, Algae, and Benthic Macroinvertebrates

Non-mussel Biota was generally absent in Biota samples from Areas of Interest, Additional Sites, and adjacent areas (Table 20). Macrophytes were not observed in samples from Areas of Interest, Additional Sites, nor adjacent areas. *Cladophora* sp. and isopods (benthic macroinvertebrates) were documented in two (2) samples collected from an Area of Interest or Additional Site. Planktonic algae/zooplankton was evaluated in one Area of Interest sample and found to be similar to the organisms documented in samples collected from Biota sites (Appendices F and K).

3.2.4.4 Statistical Test to Evaluate Mussel Biomass at Areas of Interest or Additional Sites

To determine whether the noted differences in mussel biomass (dry weight) at the Areas of Interest or Additional sites relative to the adjacent areas were statistically significant, a non-parametric Mann Whitney U test was performed. The square root transformation did not improve the normality of these data; therefore, the non-parametric test was used. Test showed there was a statistically significant difference in mussel biomass ($p = 0.007$) with the adjacent sites containing more mussel biomass than the corresponding Area of Interest or Additional Site. Statistical analyses tables are provided in Appendix L.

3.3 Water Chemistry

Water chemistry parameters were measured at a total of five (5) sites on the east pipeline and at two (2) sites on the west pipeline (Figure 5; Table 2). Most of the measurements occurred in early September 2017, with follow-up efforts taking place in mid-December 2017 (Table 2). Results were consistent across the east and west pipelines, with depth at which the measurements were taken being the factor driving any variability observed. During the September efforts, DO was in the 9-11 mg/L range at all locations and depths, temperature ranged from approximately 18 (°C) at the surface to 8 (°C) at 234 feet of depth, and stratification was observed at the deeper (≥ 80 feet in depth) sites. Measurements taken at the bottom, nearest the pipeline, varied 20% or less across all sites, with the exception being ORP, which was consistent at all sites except E-S8 in Zone A (Appendix M). As expected, conditions had changed by mid-December. Dissolved oxygen was robust, ranging from 12-14 mg/L at both sites. Mixing of the water column resulted in temperature profiles ranging less than 4 (°C) from top to bottom (minimum 1 °C, maximum 4 °C). Measurements taken at the lake bed, closest to the pipeline, were again consistent across sites with the only exception being ORP, which for reasons unknown, varied 2-3-fold across sites. Water chemistry measurements were taken at two sites, both on the east pipeline. A summary of water chemistry results from the bottom, nearest the pipeline, can be found in Table 21 and Appendix M provides water chemistry measures for all depths.

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3.4 Water and Sediment Samples

Water and sediment samples were collected from two sites in December 2017, both on the east pipeline (Table 5). Single water samples were collected from near the surface, the approximate middle of the water column, and near the bottom. One sediment sampling site was in south Zone A (~87 feet) and the other in south Zone B (~137 feet). Quagga mussels (live and dead) were present in the sediment samples to varying degrees and to the extent possible, were excluded from the sediment samples. A duplicate sediment sample was generated at site E-10. Water and sediment samples were evaluated using APB/SRB field test kits and analyzed by Microbial Insights for APB/SRB DNA via Census qPCR. Those results are reported below in Sections 3.5.1.2 and 3.7.

3.5 Opportunistic Samples

The nine (9) opportunistically-collected samples were collected from the lake bed or off the pipeline. Seven (7) of the samples had no attached Biota on them. Biota was found on the other two samples, which were collected at sites E-AOI11 and W-AOI1, respectively. On the sample from E-AOI11, 0.441 grams (dry weight) of quagga mussels (no mussel fragments were in the sample) were found, while 130.4 grams (dry weight) of quagga mussels, including mussel fragments, and 0.009 grams (dry weight) of macroinvertebrates were documented from the W-AOI1 sample. No other type of Biota was found in measurable amounts on those samples. Appendix F contains a table summarizing the opportunistic sample collection locations.

3.6 APB/SRB Field Test Kits

3.6.1 APB/SRB Field Test Kit QA/QC Samples

A total of forty-six (46) APB/SRB field test kits were utilized for QA/QC purposes during the Biota, water, and sediment sampling efforts. Of these, twenty-two (22) were generated during the August/September Biota effort and the other twenty-four (24) were generated during the December water and sediment effort. Forty-six percent (46%) of the APB field test kit QA/QC samples registered some level of acid production, while SRBs were observed in only four percent (4%) of the SRB field test kit QA/QC samples (Table 22). An ethanol rinse step, and the use of distilled water as rinse water instead of lake water, were added into equipment decontamination procedures during the December water and sediment sampling effort. As such, APB/SRB field test kit QA/QC sample results are presented in Sections 3.5.1.1 and 3.5.1.2 for each sampling effort.

For reference, BioSan APB and SRB field test kit interpretative tables and narrative categories for APB and SRB are shown below and in Appendix D. A quantitative interpretation of narrative categories of APB concentrations, similar to the scale used for SRB interpretation, is not available (this was also confirmed via email with BioSan) and therefore is not provided with BioSan APB field test kits.

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Evaluation Chart for Acid Production
due to the Growth of Acid Producing Bacteria

Appearance of Yellow	Acid Production
Day 1 – Day 2	Strong
Day 3 – Day 4	Medium
Day 5	Weak

	Sulfate Reducers/ml*				
Days of Incubation:	1	2	3	4	5
TUBE APPEARANCE					
completely black	$\geq 10^6$	$10^5 - 10^5$	$10^5 - 10^4$	$10^4 - 10^3$	$10^3 - 10^2$
narrow zone of black around applicator center	$10^6 - 10^5$	$10^5 - 10^4$	$10^4 - 10^3$	$10^3 - 10^2$	$10^2 - 10^1$
no reaction	$<10^5$	$<10^4$	$<10^3$	$<10^2$	$<10^1$

*Figures shown have been calculated by Biosan Laboratories using anaerobic plate counts and a pure culture of *Desulfovibrio desulfuricans* [ATCC #7757]

≥ greater than or equal to
< less than

Interpretation of Quantitative Results

Sulfate Reducers/ml	Interpretation
10^6 (100,000) or more/ml	Heavy
10^4-10^5 (1,000-10,000)/ml	Moderate
10^2-10^3 (100-1,000)/ml	Low
10^1-10^2 (10-100)/ml	Very Low
10^1 (10) or less/ml	Generally Insignificant

3.6.1.1 APB/SRB Field Test Kit QA/QC Samples: August/September 2017 Biota Sampling Effort

In the August/September effort, "Strong" acid production was observed in ten (10) QA/QC samples, while "Medium" acid production was observed in two (2) QA/QC samples. Equipment blanks and lake water samples were the QA/QC sample types where acid production was most frequently observed. Acid production was not observed (i.e., no yellow color change in agar tubes after five days of incubation) in the other ten (10) QA/QC samples. Inconsistent APB field test kit results for QA/QC samples were also observed during the August/September effort. This was most apparent when blanks were generated in duplicate (i.e., two blanks generated from the exact same sample). For example, "Strong" acid production was observed in the sample SSLAKEH20B4, which was lake water collected from the bottom via a Niskin sampler. The duplicate of that sample was SSLAKEH20B4DUP, which registered "No production". Conflicting results between a lake water sample and its duplicate were also observed in samples LAKEH20B4 (lake surface water sample), in which acid production was not observed ("No production"), and in its duplicate sample LAKEH20B4DUP, in which "Strong" acid production was observed (Table 22).

QA/QC sample results for SRBs were more consistent than those for APBs, with 91% (20/22) of the samples resulting in "Generally insignificant" concentrations of SRBs (Table 22).

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3.6.1.2 APB/SRB Field Test Kit QA/QC Samples: December 2017 Water and Sediment Sampling Effort

Acid production was observed in nine (9) of twenty-four (24) QA/QC samples evaluated in the December water and sediment sampling effort. Of those nine samples, acid production was categorized as "Medium" in four (4) of them, and "Weak" in the other five. In all cases where acid production was observed, the sample media was distilled water that was poured into a decontaminated water or sediment sampling device. Acid production was not observed in multiple samples of sterile water (purchased from BioSan) that was poured into decontaminated water or sediment sampling equipment (Table 22).

SRBs were not observed in any of the twenty-four (24) QA/QC samples evaluated during the December 2017 effort (Table 22).

3.6.2 APB/SRB Field Test Kits: Biota Samples

"Strong" acid production was observed in 100% of the APB field test kits utilized on Biota samples (Tables 23 and 24). "Heavy" or "Moderate" to "Heavy" concentrations of SRBs were observed in 100% of the SRB field test kits utilized on Biota samples (Tables 23 and 24). As such, there was no variation in APB/SRB field test kit response based on type of site (Biota site, Area of Interest, and Additional Sites), pipeline (east versus west), Zone, and/or pipeline position from which the samples were collected. Representative photographs of APB/SRB field test kits can be found in the Photolog (Appendix C).

Samples opportunistically collected (i.e., material of interest samples) by divers during Biota sampling efforts were also evaluated using APB/SRB field test kits. "Strong" acid production and "Heavy" SRB results were observed for all of these samples as well, regardless of pipeline, Zone, or pipeline position from which the samples were collected (Tables 23 and 24).

3.6.3 APB/SRB Field Test Kits: Water and Sediment Samples

APB/SRB field test kits were utilized on all water and sediment samples collected in December 2017. In general, the field test kits indicated the presence of lesser APB/SRBs in water than in sediment, but some variability was apparent (Figure 5, Table 25). In water, "Weak" and "Medium" acid production was observed in 66% (2/3) of samples from Zone A, whereas "No production" was observed in 100% (3/3) of the samples from Zone B. Generally insignificant" levels of SRBs were observed in 100% (6/6) of the water samples. In contrast, "Strong" acid production and "Heavy" SRB results were observed in all of the sediment samples collected, regardless of Zones.

3.7 Census qPCR DNA Analysis: Biota Samples

APBs were detected above the laboratory reporting limit in 4% (3/70) of the Biota samples while SRBs were detected above the reporting limit in 94% (66/70) of Biota samples

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(Figures 14 and 15). Four of the seven SRB DNA assays evaluated for were not present in any of the Biota samples. The other three assays (APS-1, APS-2, and APS-3) were detected in 89% or more of the Biota samples evaluated (Table 26). APBs were detected with lesser frequency in Biota samples, with assay AGN-2 being detected in 30% of the Biota samples and the other four assays detected in less than 9% of the Biota samples (Table 26). The laboratory report provided by Microbial Insights for Census qPCR results in Biota samples is presented as Appendix N.

3.7.1 Census qPCR DNA Analysis QA/QC

Many of the Census qPCR DNA results for Biota samples were "J-qualified" (aka J-flagged) by the lab, meaning that APBs were detected (concentrations greater than zero), but concentrations were below the sample-specific reporting limit set by the lab. As such, J-qualified results are considered estimated concentrations by the laboratory. Over 37% (26/70) of the APB results were J-qualified. SRB results were J-qualified to a far less degree. In addition, Microbial Insights reported that the small weight of the Biota samples (most were 3 grams or less, wet weight) resulted in elevated reporting limits for APBs. Four (4) Biota samples sent to Microbial Insights lacked sufficient mass and could not be extracted for Census qPCR analysis.

3.7.2 Census qPCR DNA Analysis by Zone

Concentrations of APBs in Biota samples ranged from approximately $1.0 \times 10^5 – 2.0 \times 10^5$ cells/gram on the east pipeline, but only three samples had APB concentrations above the reporting limit. APBs were not detected above the reporting limit in any samples from the west pipeline, precluding spatial comparisons to the east pipeline. SRB concentrations were generally consistent across both pipelines, with the vast majority of concentrations in the range of $1.0 \times 10^5 – 1.0 \times 10^7$ cells/gram, regardless of pipeline and Zone from which a Biota sample was taken (Figure 14).

3.7.3 Census qPCR Analysis by Position on Pipeline

There was no discernable pattern in APB concentrations in Biota samples based on pipeline position as most samples were J-qualified or not detected over the laboratory reporting limit. SRBs were detected above the laboratory reporting limit in samples from all pipeline positions and concentrations were relatively consistent (Figure 15).

3.7.4 Census qPCR Analysis at Areas of Interest and Additional Sites

There was no discernable pattern in APB concentrations in Biota samples between Area of Interest and Additional Sites and their respective adjacent samples as most samples were J-qualified or not detected over the laboratory reporting limit. SRBs were detected above the laboratory reporting limit in samples from all Areas of Interest, Additional Sites, and adjacent samples. East pipeline concentrations exhibited no apparent patterns between

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sample pairs. On the west pipeline, SRB concentrations within adjacent samples were higher in all cases where paired samples were collected (Figure 16).

3.8 Census qPCR DNA Analysis: Water and Sediment Samples

APBs and SRBs were detected above the laboratory reporting limit in 100% (6/6) of the water samples collected during the December 2017 sampling effort (Figure 17; Table 26). However, concentrations were very low, ranging from 0.6 – 74 APB cells/mL and 26 – 113 SRB cells/mL (Appendix N). APB/SRB detection and reporting limits for water samples were considerably lower than limits for Biota and sediment samples because the water samples are filtered and DNA is concentrated in the filtrate.

APBs were detected above the reporting limit in 25% (1/4) of the sediment samples collected in December 2017, whereas SRBs were observed above the reporting limit in 100% (4/4) of the sediment samples (Figure 18, Table 26). Two of the sediment SRB concentrations exceeded 1.0×10^8 SRB cells/gram, a value greater than 98% (69/70) of the SRB concentrations found in Biota samples collected during the August/September Biota sampling effort (Figure 14).

In general, the APB/SRB DNA genera documented in water and sediment samples were the same genera observed in Biota samples (Table 26). Water and sediment samples were collected only from the east pipeline, precluding comparisons to the west pipeline. The complete laboratory report provided by Microbial Insights for Census qPCR DNA analysis in water and sediment samples is presented as Appendix N.

3.8.1 Census qPCR DNA Analysis in Water and Sediment Samples by Zone

Water and sediment were collected from the east pipeline, south Zones A and B. No obvious spatial pattern was observed when comparing across Zones A and B where the samples were collected (Figures 17 and 18).

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4.0 Results Summary

A significant amount of data was obtained and generated from the visual observations, Biota measurements, and the assessments and analyses conducted on Biota, water, and sediment samples collected during the Biota Investigation. This section was developed to provide a concise summary of key observations and findings presented above in Section 3.0. Further discussion of the results most pertinent to the goals and objectives of the Biota Investigation is provided in Section 5.0 (Discussion).

4.1 Visual Observations

Use of underwater video-photography enabled qualitative assessment of the surface of the Line 5 pipelines, including observation of the Biota community on the pipelines. Key visual observations are bulleted below:

- Water clarity and the use of underwater lights on the ROV and diver enabled visual observations to be made of the pipeline and the surrounding environment.
- The east and west pipelines had similar types of Biota attaching to them.
- Inorganic matter (sediment/sand) was observed on the pipelines at nearly every location and was present to varying degree in most, if not all, Biota samples collected.
- Quagga mussels were observed on both pipelines, on all positions of the pipeline (top, bottom, and sides), and in all study Zones (A-D).
- Quagga mussels were unevenly distributed across the pipelines, wherein mussels would appear very dense in a given area, then sparse just a few feet away.
- Mussel density and weight was variable across pipelines, Zones, and pipeline positions (top, bottom, east, west).
- Mussels and other Biota were not observed damaging or removing the coating of the pipe.
- Dead quagga mussels were regularly observed in Biota samples and often appeared to remain attached to the pipelines.
- *Cladophora* (a filamentous green algae), was commonly observed in the shallow water areas of Zones A and B.
- Round gobies were regularly observed around and on the pipelines, frequently preying upon mussels.
- Suspected Holidays appeared to be covered with a whitish colored precipitated material later identified by lab analyses to be forms of calcium and magnesium carbonates (ATS 2018).

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- Visual examination of the byssal threads of the mussels via electron microscopy (Appendix O) indicate that byssal threads are not penetrating the coating around the pipe but are merely "splaying" out and adhering to the surface of the coating (Rees 2016).

4.2 Biota Measurements

Data obtained from Biota measurements supports the following:

- Quagga mussels comprised the vast majority of biomass in Biota samples collected from both pipelines in 2017.
- Mussels and mussel fragments comprised over 99% of the total biomass in the majority of the Biota samples from the sixteen (16) Biota sites.
- The weight of mussels accumulating on the east versus west pipelines varied but was not statistically different.
- The dry weight of mussels in samples from the sides (east and west) of the pipelines was generally greater than from the top or bottom locations but the difference was not statistically different.
- The distribution of mussel weights across the pipelines by Zone was highly variable.
- The greatest mussel weights were reported on south Zones A and B on the east pipeline and north and south Zone B on the west pipeline.
- The greatest mussel weights were reported for the sides (east and west) of the pipelines, as opposed to the top and the bottom.
- Macroinvertebrates were not abundant in samples, with the majority of them being found in the shallower Zones.
- Macroinvertebrates identified in the few Biota samples are detrivores and feed on the pseudo-feces and feces of mussels (Vanderploeg et al., 2002; Wilson et al., 2006).
- Biomass of benthic macroinvertebrates, phytoplankton, and algae was substantially less than the biomass of mussels.
- The thickness, density, and weight of mussels and other Biota was variable across Zones.
- The presence of Biota increased the overall circumference of the pipelines an average of 1.41-2.53 cm on the east pipeline and 1.15-1.92 cm on the west pipeline at the seven (7) locations where pipeline circumference (Biota thickness) could be measured.
- There was no statistical difference in the density of mussels with respect to their position on the pipeline (i.e. top, west, or east side of the pipe).

- Biota from the bottom of the pipe could not be statistically compared with a high level of confidence to the other pipe locations due to small sample size.
- Inorganic material (sediment/sand) was present in all of the Biota samples.
- The Areas of Interest and Additional Sites contained significantly less mussel biomass than the undisturbed areas directly adjacent to those sites. The difference was statistically significant.

4.3 APB and SRB Field Test Kit Results

- Acid production from was unexpectedly observed in QA/QC samples such as distilled water, and tap water.
- APB field test kit results were inconsistent in several duplicate sample pairs.
- The validity of APB field test kit results, particularly those from the August/September sampling effort, is uncertain.
- APB field test kit results were more consistent after adding an ethanol rinse to equipment decontamination procedures. Discrepancies between duplicate samples were still observed, but to a lesser degree.
- Acid production and SRBs were observed in all of the field test kits used on Biota and sediment samples, regardless of pipeline, Zone, and pipeline position sampled.
- Acid production and SRBs were observed on samples opportunistically collected by divers.
- Acid production and SRBs were observed in some of the water samples from Lake Michigan and all bottom sediment samples collected.
- APB field test kit data did not correlate well with Census qPCR DNA APB data.
- SRB field test kit data correlated reasonably well with Census qPCR DNA SRB data.

4.4 Biota Census qPCR DNA Results

- Some genera of APBs and SRBs analyzed for by Census qPCR were not detected in any of the Biota samples.
- The present data suggest that SRBs are ubiquitous in the Straits, with strong overlap in the DNA genera observed in sediment, water, and Biota samples.
- Strong overlap in DNA genera observed in sediment, water, and Biota suggests that Biota are not creating a unique microbiological environment, with respect to genera of APBs and SRBs analyzed by Microbial Insights, at the pipeline surface.
- Census qPCR DNA results demonstrate that there are detectable concentrations of APBs and SRBs in Biota obtained from the pipeline surface.

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- Greater SRB concentrations in the Biota samples in comparison to lake water samples could be attributed to the presence of sediment/sand and other inorganic material in those samples.
- APBs were infrequently detected above the Census qPCR reporting limit in Biota samples, but the reporting limit was elevated in many samples due to the small size (mass) of many of the Biota samples.
- APBs may have been present in Biota samples at levels below the Census qPCR DNA reporting limit.
- There is no discernable spatial pattern in APB concentrations in Biota samples, including at Areas of Interest, Additional Sites, and adjacent samples.
- SRBs were detected above the Census qPCR reporting limit in nearly all of the Biota samples tested, regardless of pipeline, Zone, or pipeline position sampled.
- Assuming that cells/gram approximates cells/mL (as recommended by BioSan), concentrations of SRBs reported by Census qPCR analysis are similar to those indicated by SRB field test kits.
- SRB concentrations vary across both pipelines and by Zones, spanning as much as several orders of magnitude, and showing no obvious spatial pattern.
- SRBs were present in Biota samples at all Areas of Interest, Additional Sites, and adjacent samples.
- East pipeline APB and SRB concentrations exhibited no apparent patterns when comparing Areas of Interest, Additional Sites, and their adjacent sample pairs.
- West pipeline APB concentrations exhibited no apparent patterns between Areas of Interest, Additional Sites, and adjacent sample pairs.
- West pipeline SRB concentrations in Areas of Interest and Additional Sites were greater than concentrations in adjacent samples.

4.5 Water Census qPCR DNA Results

- Census qPCR DNA results demonstrate that there are detectable concentrations of APBs and SRBs in water obtained from multiple depths in the water column proximal to the pipelines.
- APBs and SRBs were detected in all water samples collected, regardless of depth, but the concentrations were low very low (maximum of 74 APB cells/mL and 113 SRB cells/mL).
- The present data suggest that SRBs are ubiquitous in the Straits, with strong overlap in the DNA strains observed in sediment, water, and Biota.

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- Bacteria in the water column were two to four orders of magnitude less than bacteria detected in Biota and in the lake bed sediments.

4.6 Sediment Census qPCR DNA Results

- Census qPCR DNA results demonstrate that there are detectable concentrations of APBs and SRBs in sediment obtained from the lakebed near the pipelines, but sample size was small (n=4).
- SRBs were detected above the Census qPCR reporting limit in all of the sediment samples collected but sample size was small (n=4).
- APBs were detected above the Census qPCR reporting limit in one of four (25%) sediment samples collected but sample size was small (n=4).
- The greatest SRB concentrations observed in the study, all sample types included, was in bottom sediments but sediment sample size was small (n=4).
- The present data suggest that SRBs are ubiquitous in the Straits, with strong overlap in the DNA strains observed in sediment, water, and Biota.

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5.0 Discussion

5.1 Sample collection

As outlined in Section 2.4, there was mutual consensus among all parties (e.g., Enbridge, BMC, and GEI) that the sampling approach and procedures at each location were consistent with the BIWP and Addendums A and B. Biota samples returned to the surface for evaluation were representative of what was observed being collected by divers. Water clarity, the use of underwater lights on the ROV and diver, and constant radio contact with the divers enabled observations to be made of the pipeline and the surrounding environment. When necessary, the diver was instructed (by the dive master at the request of GEI, ITP, or BMC) to shift their position to provide better lighting and viewing of the underwater activities or pipeline. For safety reasons, only one diver could perform work on the lake bed at a time. Currents on the bottom and bottom time (the amount of time a diver could spend working at the pipeline) limitations were challenges regularly encountered during sample collection dives. Bottom time was particularly limited (30-40 minutes) at deeper (180'+) depths, and in some cases, sample collection activities required multiple dives.

Obtaining Biota samples from the surface of a pipeline also presented unique challenges. Bottom time limitations and current on the bottom, coupled with cold water temperatures, and thick gloves worn by the divers required Biota sample collection equipment and techniques to be easily handled and time efficient. The device used to collect Biota samples was very effective at collecting mussels and larger Biota as evident by minimal to no Biota remaining on the pipeline at sampling sites following Biota sample collection. The aluminum cover of the sampling container formed a relatively tight barrier over the PVC pipe, but it was not airtight (Photograph 18). Thus, it is possible that some small Biota such as benthic invertebrates, phytoplankton, and algae may have "leaked" out of the sampling device in the fraction of time the device was being closed following sample collection. These smaller Biota would represent an insignificant amount of weight (less than 1 gram, dry weight) on the pipeline. There was consensus by all parties on the barge that the Biota collected inside the sampling containers was representative of Biota observed on the surface of the pipelines.

Because the aluminum cover of the sampling container was not airtight, lake water inside the Biota sample containers may have mixed with lake water inside the steel tool crib while the samples were raised to the lake surface (Photograph 18). The degree to which the water may have mixed is unknown but would not be expected to impact Biota APB and SRB concentrations based on relatively consistent (and low) APB and SRB concentrations in lake water samples from December (Figure 17).

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5.2 Biota observations

The sampling scheme at the sixteen (16) Biota sites was developed to generate consistent data across both pipelines and across Zones within each pipeline (i.e., a Biota sampling site was located in every Zone of both pipelines). The data indicate that total biomass of Biota varies by pipeline, Zone, and pipeline position, likely due to the uneven distribution of mussels, the random selection of sampling sites (i.e., sites were not selected based on mussel density), and the number of sampling sites in relation to the length of the pipelines. In some cases, patterns were observed in the data. For example, the central tendency (mean) of total biomass is generally consistent across both pipelines (Figure 19). The central tendency (mean) of total biomass is also generally consistent across both pipelines when pipeline position is accounted for. Biomass from Biota collected from the top of the east pipeline is not statistically different than that of Biota from the top of the west pipeline (Appendix L). No apparent patterns were observed in biomass results across Zones of both pipelines.

Mussels and mussel fragments comprised the majority of the total biomass in Biota samples collected from the sixteen (16) Biota sampling sites. In these samples, mussels and mussel fragments were on average, 85% of the total biomass, with the median value being 99.3%. More than 50% of the Biota samples from the sixteen (16) Biota sites were comprised of more than 99.3% mussels and mussel fragments.

Mussel density and weight was variable across pipelines, Zones, and pipeline positions (top, bottom, east, west), with density spanning multiple orders of magnitude, from 0 to over 1,000 mussels per square foot (Figure 21 and Appendix F). Again, this variability is likely driven by the uneven distribution of mussels and the random selection of sampling sites. The uneven distribution can be observed in photographs from previous surveys of the pipelines (Figure 5 – location E-40, Enbridge 2017b). For reasons unknown, fewer mussels were present on the top of the pipeline as opposed to the sides. Mussel recruitment was evident based on the appearance of multiple age classes of mussels in Biota samples (Photograph 36) from nearly all Zones of both pipelines (Mills et al. 1996; Wilson et al., 2006). Dead quagga mussels were regularly observed in Biota samples and often appeared to still be attached to the pipelines.

The biomass of Biota was generally far less at Areas of Interest and Additional Sites than at samples collected from an undisturbed area directly adjacent to those sites (Figure 20; Tables 18 and 19). This difference is statistically significant ($p < 0.05$). These data directly support video footage observed during the Biota sampling dives, which clearly showed far less Biota at Areas of Interest and Additional Sites when compared to immediately adjacent undisturbed areas. This also directly correlates to the visual criteria outlined in Section 3.2 of the BIWP that was used to select the Areas of Interest and Additional Sites. It is unclear why fewer mussels and other Biota were observed at those areas during the BIWP work reported herein.

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Visual examination of the byssal threads of the mussels via electron microscopy (Appendix O) indicated that byssal threads are not penetrating the coating around the pipe but are merely "splaying" out and adhering to the surface of the pipelines. This is supported by observations made during field operations wherein biologists separating mussels from periphyton compared the process to that of pulling velcro apart. Rees et al. (2016) explain how quagga mussels stick to underwater surfaces through the use of proteinaceous "anchors" (byssus), consisting of a series of threads linked to adhesive plaques.

Inorganic material (sediment/sand) was present in all of the Biota samples. This material is transported in the water column and presumably deposited on the pipeline. Inorganic material was present in Biota samples taken from all positions on the pipe. Given the results of the census qPCR APB/SRB DNA analysis of sediment samples, it is reasonable to assert that APBs and/or SRBs in sediment may be contributing to concentrations of APBs/SRBs observed in Biota samples.

Suspected holidays appeared to be covered with a whitish colored precipitated material that was later identified by lab analyses to be forms of calcium and magnesium carbonates (ATS 2018). The calcium and magnesium carbonates appear to have precipitated out and adhered to the pipelines in those areas, presumably forming a protective coating at that location. Jack (2002) state that the precipitation of these calcium and magnesium can create a protective coating and may limit corrosive processes. Jack (2002) further states that "the presence of a hard, white, calcium carbonate scale is good evidence that effective CP [cathodic protection] potentials were achieved on metal surfaces where it is found."

5.3 APB/SRB presence based on field test kits

APB field test kit results were variable and in some cases inconsistent. For example, APBs were observed in some unexpected QA/QC samples such as distilled water and tap water (Table 22). Many of those samples had come into contact with equipment that had been in contact with lake water, so it is unclear if the test kits were registering "false positives" or perhaps reacting to APBs in residual lake water on the sampling equipment. More problematic though were the inconsistencies observed in APB field test kits that were used on duplicate samples. In duplicate samples, one would expect to see the exact same results from field test kits since duplicate samples are created from the same parent sample. However, in some cases, the APB results differed, sometimes considerably, between the duplicate samples. The reason for this is unclear. Variable APB field test kit results were also observed in several lake water samples collected in September 2017 as part of the Biota sampling program (Table 22). The variability observed in those samples was outlined in greater detail in Section 3.6.1.1.

APB field test kit results did not correlate with Census qPCR APB DNA results. APBs were detected above the Census qPCR laboratory reporting limit in only 4% (3/70) of the biota samples analyzed. Conversely, "Strong" acid production was documented in all (70/70) of

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the APB field test kits utilized on those same samples. The cause of this discrepancy is not known. However, email communication with BioSan on September 13th, 2017, noted that *"…positive APB results can be observed in water that may contain microorganisms and that common environmental organisms such as Bacillus can produce a large amount of acid. One of these organisms in 100 ml has the potential to produce a color change in our Sani-Check APB Test Kit in 1-2 days. This is why the interpretation chart is based on the amount of acid production and not the amount of APB. Not all APB produce the same amount of acid."* Thus, it is possible that APB field test kit results may have been influenced by other types of acid-producing organisms. Given these factors, the weight of evidence suggests that APB field test kit results generated during the Biota Investigation may not be a reliable indicator of actual APB presence or APB concentration and should be used with caution. Census qPCR DNA analysis was initiated to directly measure APB and SRB concentrations.

SRB field test kit results were consistent with Census qPCR SRB DNA results. SRBs were detected above the Census qPCR laboratory reporting limit in 94% (66/70) of the biota samples analyzed and were observed in all (70/70) SRB field test kits utilized on those same samples. SRB field test kit results were "Heavy" (i.e., $\geq 1.0 \times 10^5$ SRB cells/mL according to BioSan instructions) in 99% (69/70) of the biota samples, which correlates well with Census qPCR DNA SRB concentrations.

Notwithstanding the issues above, APB and SRB field test kit results showed the presence of APBs and SRBs in all Biota and sediment samples (Tables 23-25). APBs and SRBs were observed in some, but not all, lake water samples. The majority of the water column APB/SRB field test kit data was from the December sampling effort and it is unclear if those results are representative of APB and SRB concentrations in the water column at other times of the year.

It is possible that APBs and SRBs in the water column may have been contributing to the presence of APBs and SRBs in the field test kits used for Biota (and sediment) samples. The Biota samples were dewatered on mesh (Photograph 28, Appendix C) prior to using APB and SRB field test kits. Samples would still have contained a residual amount of lake water during initiation of APB and SRB field test samples. The possibility that residual lake water in Biota and sediment samples is contributing to APBs and SRBs in the field test kits is supported by the Census qPCR APB/SRB DNA data that indicate the presence of low levels of APBs and SRBs in all lake water samples analyzed (Section 4.5).

5.4 APB/SRB presence based on Census qPCR DNA Analysis

To the authors knowledge, the current study is the first study to report concentrations and composition (i.e., genera) of bacteria in Biota collected from pipelines at varying depth levels in the Great Lakes. As such, "background" (i.e., reference condition) levels of APBs and SRBs, nor methods to assess bacteria collected from pipelines in the Great Lakes presumably do not exist, or were not located during literature searches. The Census qPCR DNA results

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should be considered the primary set of bacteria data to utilize, superseding the field test kit data, given the inconsistency of the latter (particularly the APB field test kits) and the quantitative nature of the Census qPCR techniques.

Census qPCR DNA results demonstrate that there are detectable concentrations of APBs and SRBs in water obtained from multiple depths in the water column proximal to the pipelines. Concentrations of APBs and SRBs in water were very low (2-4x lower) when compared to concentrations in Biota and sediments (Figures 14-18). Census qPCR DNA results also demonstrate that there are detectable concentrations of APBs and SRBs in sediment obtained from the lakebed near the pipelines (Figure 18) but sediment sample size was small (n=4). The greatest SRB concentrations observed in the study were in bottom sediments but sediment sample size was small (n=4).

Census qPCR DNA results demonstrate that there are detectable concentrations of APBs and SRBs in Biota obtained from the pipeline surface (Figures 14-16; Table 26; Appendix N). APBs were infrequently detected above the Census qPCR reporting limit in Biota samples, but the reporting limit was typically elevated due to the small size of many of the Biota samples. Thus, APBs in Biota samples may have been present in concentrations at, or below, the Census qPCR reporting limit (Figures 14 and 15). The present data suggest that SRBs are ubiquitous in the Straits, with strong overlap in the DNA genera (Table 26) observed in sediment, water, and Biota. Concentrations of SRB in the Biota samples may be attributable to some degree to the contribution of SRBs from sediment/sand in those samples (Figures 14 and 15).

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6.0 Consent Decree Assessments

The 2017 Biota Investigation study generated information that is directly applicable to the USEPA consent decree requirements, specifically to whether mussels and other Biota have impacted, are creating, or introducing features that could impact the integrity of the dual pipelines. Observations related to each of the consent decrees assessments are summarized below:

Assessment #1: *"…..assess whether the accumulation of mussels and other Biota have impacted the integrity of the pipelines' coating or the underlying metal, including areas where there are openings or "holidays" in the pipeline coating."*

Findings presented in the previous section of this report (Section 5.0 Summary of Findings) do not suggest that the integrity of the pipelines coating or the underlying metal is being adversely impacted by the accumulation of mussels and other Biota on the pipelines. The coating of the pipeline appeared to be intact at all of the sixteen (16) randomly-selected Biota sampling sites. Small flakes (typically less than five [5] millimeters in length/width) of apparent outer coating were observed attached to mussel byssal threads in Biota samples. However, this was likely due to the method of sample collection, which involved scraping a thin aluminum plate across the pipeline to dislodge Biota.

Examination of the byssal threads of the mussels, by Enbridge (2016) and by ATS (Appendix O) indicate that these threads do not appear to be penetrating the coating around the pipeline. The imagery suggests the threads are "splaying" out and adhering to the surface of the coating. Underwater video-photography also showed mussels, live and dead, being easily removed from the pipelines by the divers gloved hand during pipeline inspections.

Mussels and other larger Biota (e.g., macroinvertebrates) were not preferentially accumulating or colonizing at Holidays, Areas of Interest, or Additional Sites. For reasons that are not known, mussels and other larger Biota were much less abundant at most of those sites when compared to adjacent areas and Biota sites. Hence, based on the present data, mussels and larger Biota are likely not impacting the pipelines coating or underlying metal at Holidays because they are generally absent from those locations.

Mussels were the predominant Biota type (in abundance and biomass) observed on the pipelines. Other Biota such as periphyton, and macroinvertebrates were also present. The observations and data made during the Biota Investigation do not suggest the lesser-abundant Biota were impacting the integrity of the pipelines coating or underlying metal.

Assessment #2: *"…..evaluate whether the mussels and other Biota are creating a corrosive environment by, among other things, fostering the growth of anaerobic sulfate-reducing bacteria ("SRB") that may cause metal loss."*

Results of APB/SRB field test kits and Census qPCR DNA analysis support that APB and SRB is present to varying degrees in Biota collected from the pipeline surface, in water from Lake Michigan, and in sediment collected near the pipelines. However, no visible corrosion or metal loss was observed, even in locations where Biota density was high.

The limited number (n=4) of Census qPCR results for sediment indicate that concentrations of SRBs in sediment are greater than SRB concentrations in Biota and substantially greater than concentrations in lake water taken at multiple depths. Therefore, it can be presumed that, when compared to sediment, Biota on the pipelines are not creating an environment more conducive to the growth of bacteria.

Biota from the pipelines contains both sediment/sand and water components. In addition, Census qPCR DNA analysis indicates that there is strong overlap in the strains of APB and SRB bacteria that were found in sediment, Biota, and to a lesser extent, water samples. The strong overlap in DNA genera observed in the 2017 Biota Investigation samples suggests that Biota are likely not creating a unique microbiological environment, with respect to genera of APBs and SRBs analyzed by Microbial Insights, at the pipeline surface. Given the present data, it cannot be determined whether bacteria in Biota samples is attributable to the sediment/sand or from lake water, that are both components of the Biota sampled from the pipelines.

Assessment #3: *"…..evaluate whether mussels and other Biota are introducing features that may threaten the integrity of either of the Dual Pipelines due to the weight of such biomass or the pressure caused by current or ice movement around such biomass in areas where the pipelines are suspended above the floor of the Straits."*

Mussels and other Biota add biomass to the pipeline. However, the weight (biomass) of mussels and other Biota on the dual pipelines appears to be relatively insignificant when compared to the weight of the pipelines and supporting infrastructure. Engineering analysis by others will investigate the impact of biomass on the integrity of the Dual Pipelines.

The growth of mussels and other Biota increases the overall thickness (circumference) of the pipelines. However, Biota thickness was in the 1.4 – 2.5 cm range, resulting in an average increase in pipeline circumference of approximately 6-7% at locations where pipeline circumference could safely be measured. Engineering analysis by others will investigate the impact of increased circumference and surface roughness on the integrity of the Dual Pipelines.

Visual observations of the pipeline using video-photography from 2016 and the underwater cameras and ROV during the 2017 study suggest that the general appearance of the pipeline was consistent across all Zones regardless of the abundance and biomass of mussels and other Biota on the pipelines. This includes areas where the pipeline was suspended (i.e., in span) and supported by anchors.

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The Biota Investigation was conducted during timeframes when ice was not observed at any Biota sampling locations, including on/near the lake bed where the pipeline is located.

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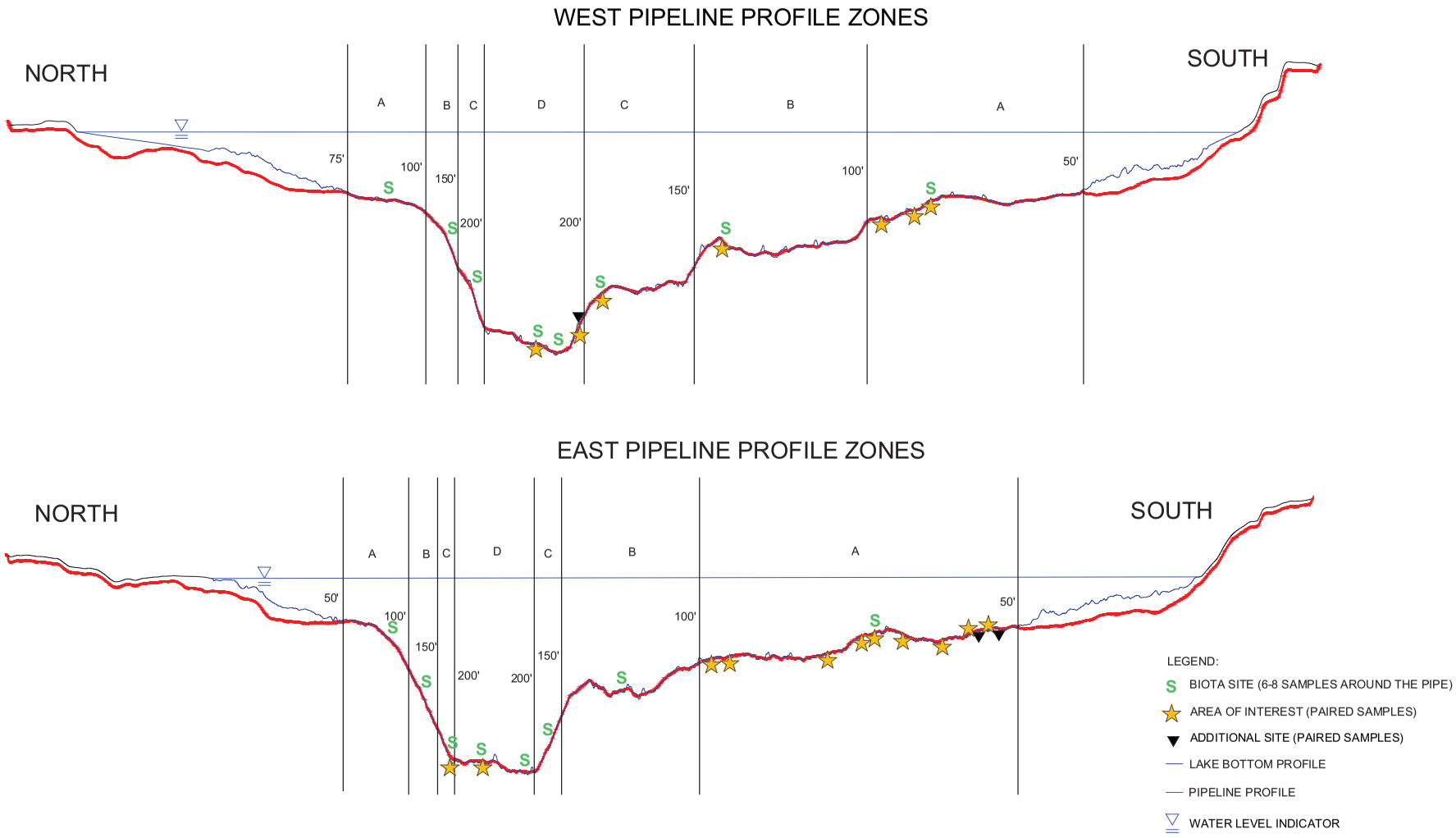

DATE: 2/20/18	Figure 1: 2017 Biota Sampling Sites	ENBRIDGE

Sources: Topographic imagery from ArcGIS Online. Topographic Data from Ballard Marine Construction

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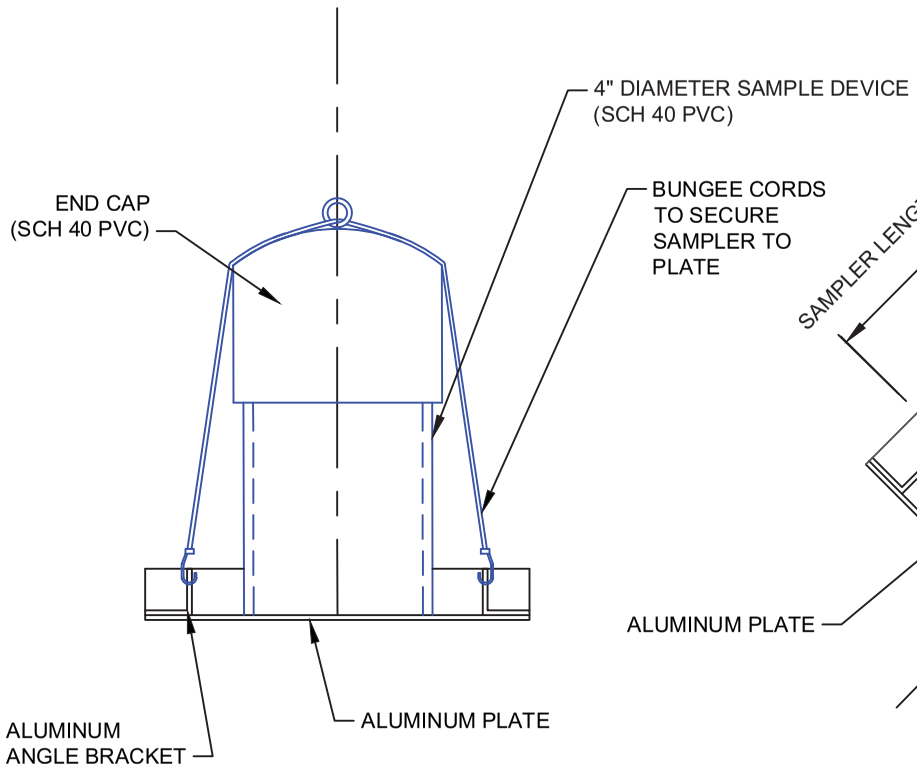
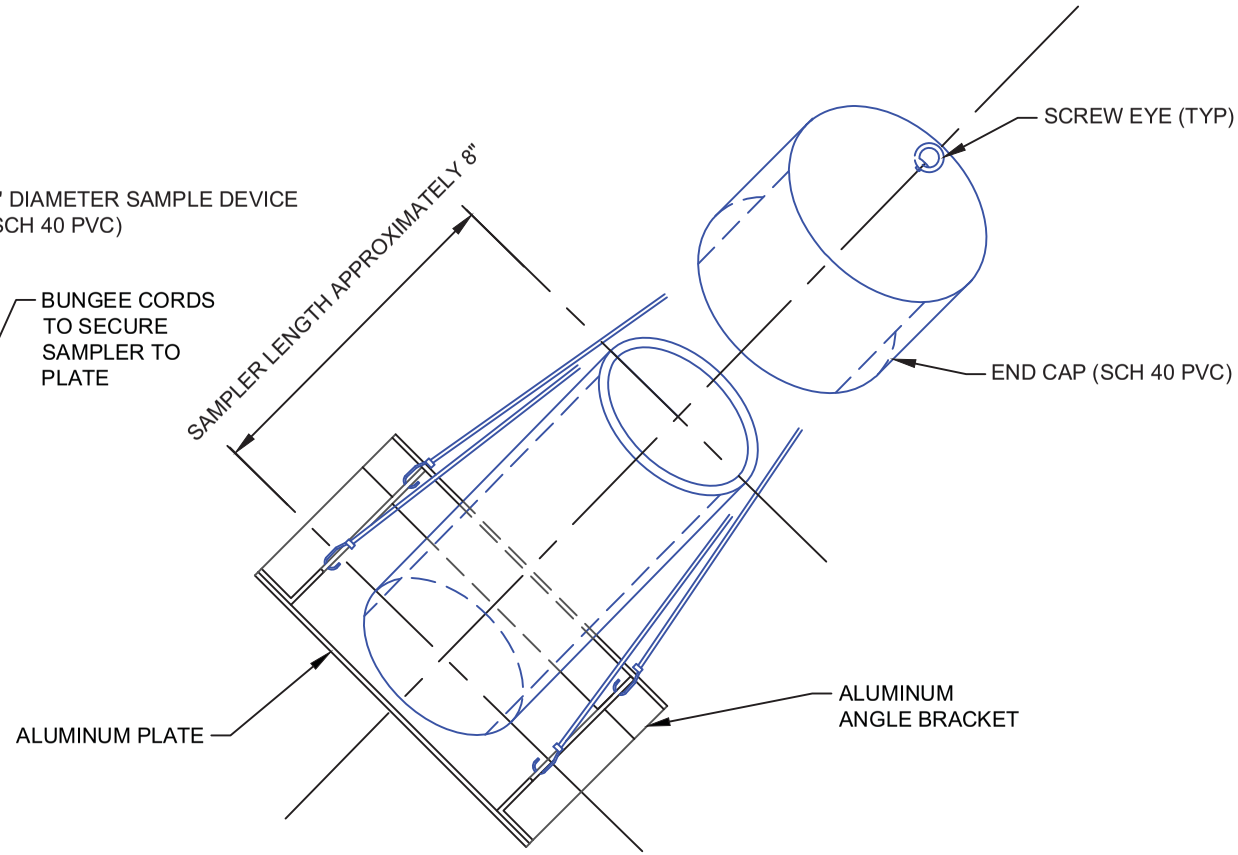
BIOTA SAMPLER SIDE VIEW

SCALE: N.T.S.





BIOTA SAMPLER ISOMETRIC VIEW

SCALE: N.T.S.

DATE: 11/14/2017	Figure 2: Biota Sampling Device	ENBRIDGE

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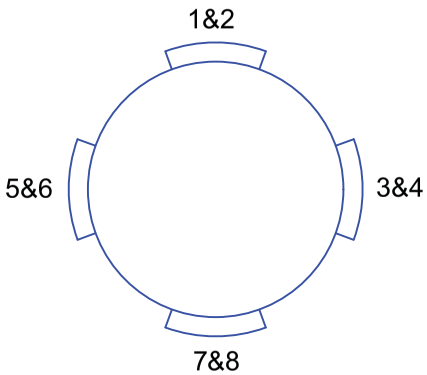

BIOTA SAMPLING SECTION LAYOUT

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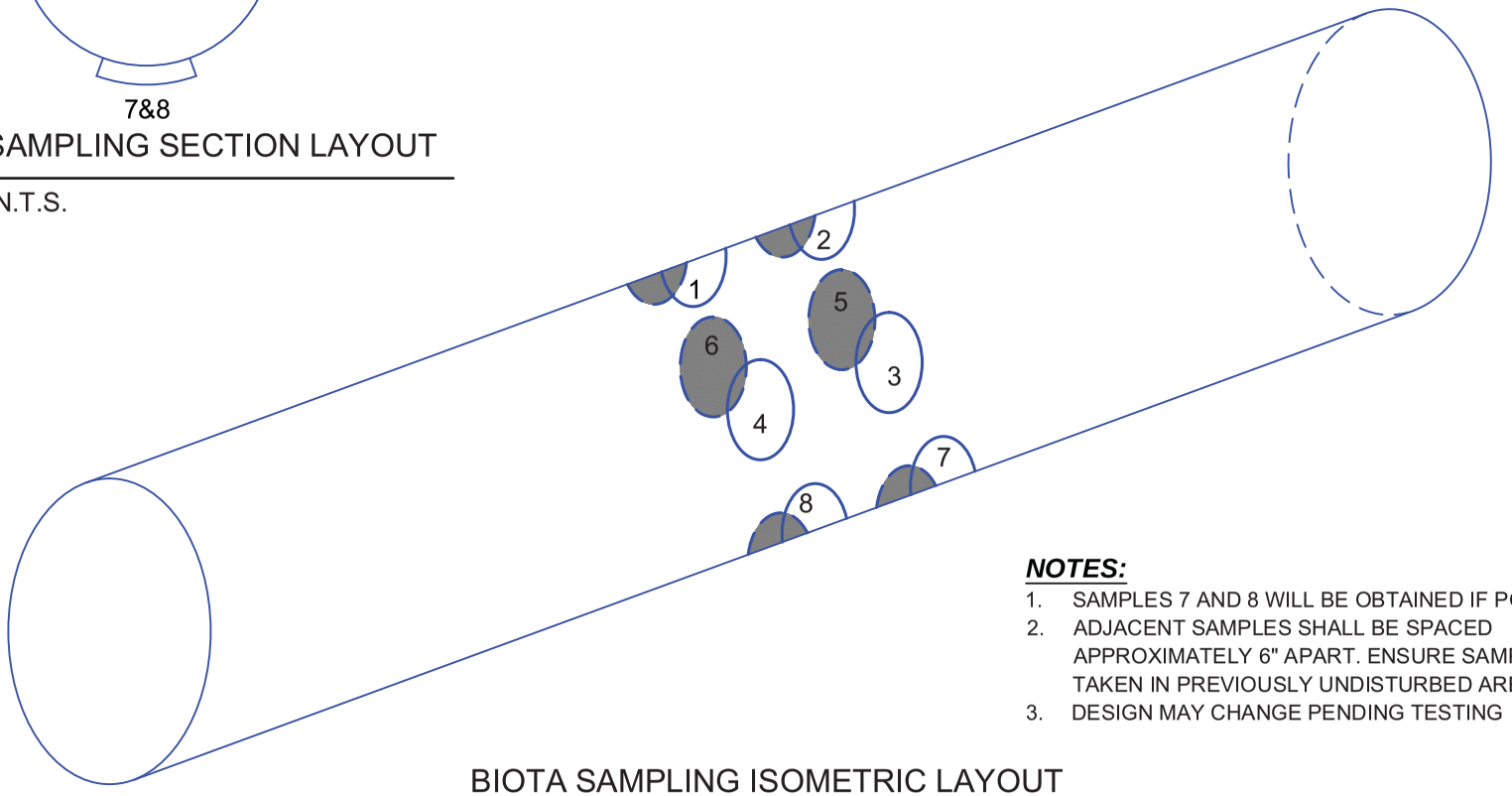

NOTES:

1. SAMPLES 7 AND 8 WILL BE OBTAINED IF POSSIBLE.
2. ADJACENT SAMPLES SHALL BE SPACED APPROXIMATELY 6" APART. ENSURE SAMPLES ARE TAKEN IN PREVIOUSLY UNDISTURBED AREAS.
3. DESIGN MAY CHANGE PENDING TESTING

BIOTA SAMPLING ISOMETRIC LAYOUT

SCALE: N.T.S.

DATE: 2/9/2018	Figure 3: 2017 Biota Sampling Positions at Biota Sites	ENBRIDGE

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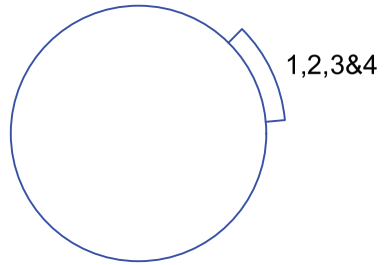

BIOTA SAMPLING SECTION LAYOUT

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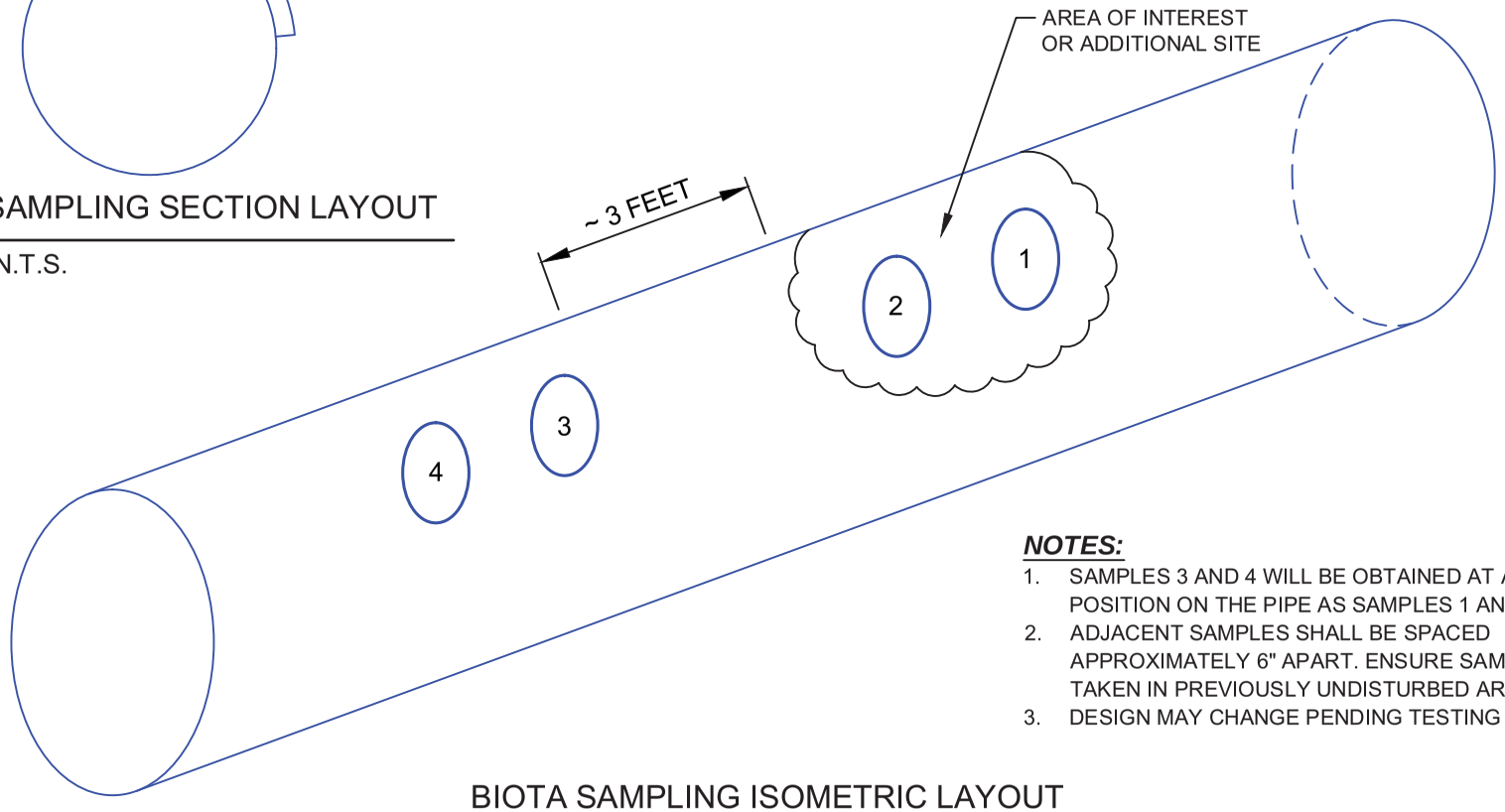

NOTES:

1. SAMPLES 3 AND 4 WILL BE OBTAINED AT A SIMILAR POSITION ON THE PIPE AS SAMPLES 1 AND 2.
2. ADJACENT SAMPLES SHALL BE SPACED APPROXIMATELY 6" APART. ENSURE SAMPLES ARE TAKEN IN PREVIOUSLY UNDISTURBED AREAS.
3. DESIGN MAY CHANGE PENDING TESTING

BIOTA SAMPLING ISOMETRIC LAYOUT

SCALE: N.T.S.

DATE: 2/9/2018	Figure 4: 2017 Biota Sampling Positions at Areas of Interest and Additional Sites	ENBRIDGE

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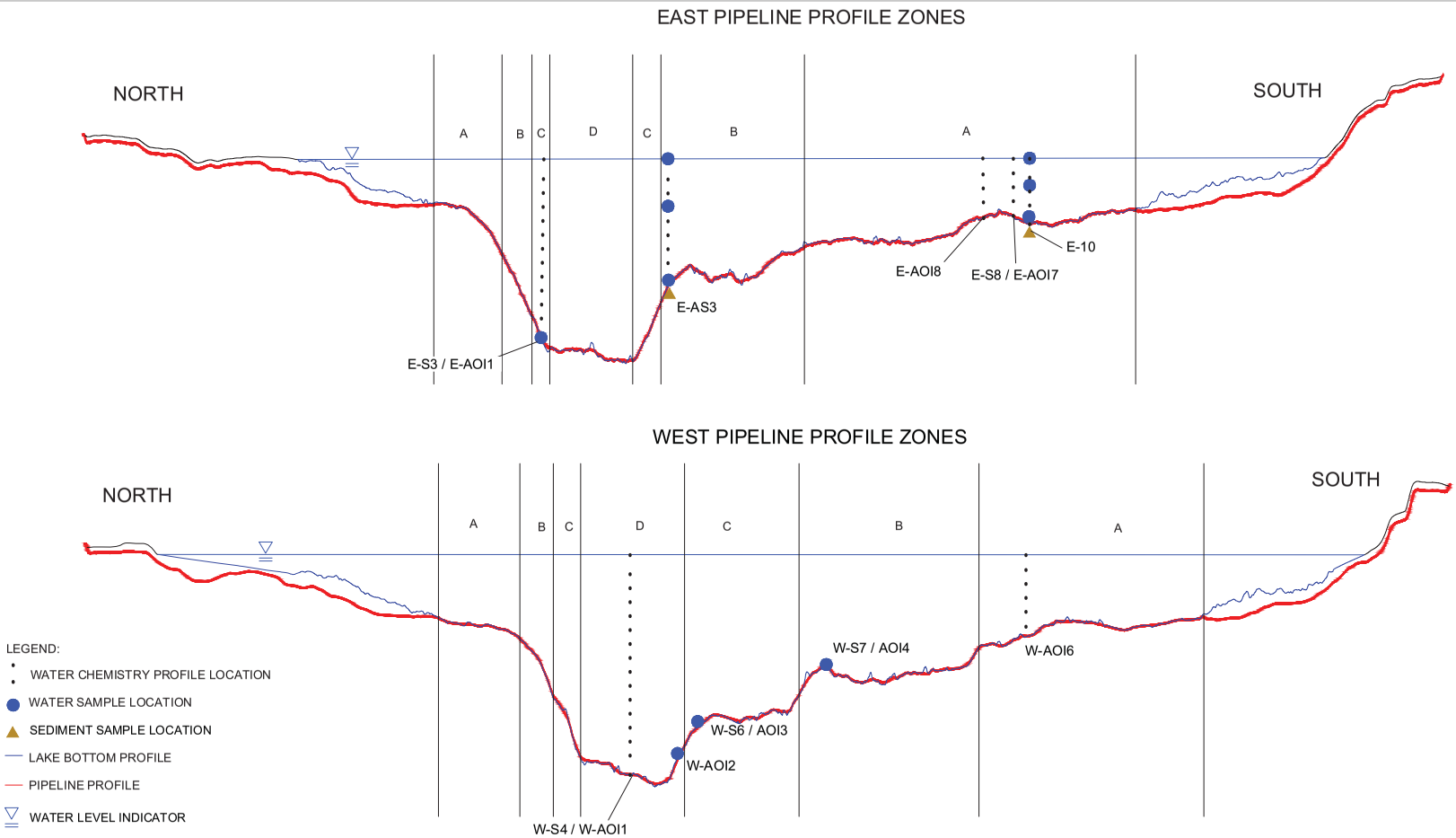

2017 East Pipeline Water and Sediment Collection Summary

Site ID	Date	Bottom Depth (ft)	Notes
E-S3/E-AOI1	9/8/2017	193	Water chemistry
E-AS3	12/15/2017	137	Water chemistry; Water column samples[1] (1ft, 70ft, 137ft); Bottom sediment samples (2 Replicates)
E-S8/E-AOI7	9/5/2017	76	Bottom water sample
E-AOI8	9/6/2017	78	Bottom water sample
E-10	12/13/2017	87	Water chemistry; Water column samples[1] (1ft, 42ft, 87ft); Bottom sediment samples (2 Replicates, 1 Duplicate)

[1] Water samples evaluated via Cocus qPCR

All water and sediment samples were evaluated with APB/SBB field test kits

2017 West Pipeline Water Collection Summary

Site ID	Date	Bottom Depth (ft)	Notes
W-S4/W-AOI1	9/7/2017	234	Water chemistry
W-AOI2	9/7/2017	201	Bottom water sample
W-S6/W-AOI3	8/26/2017	178	Bottom water sample
W-S7/W-AOI4	9/8/2017	129	Bottom water sample
W-AOI6	9/6/2017	88	Water chemistry

DATE: 2/26/2018

Figure 5: 2017 Water and Sediment Sampling Sites

Sources: Topographic imagery from ArcGIS Online. Topographic Data from Ballard Marine Construction

ENBRIDGE

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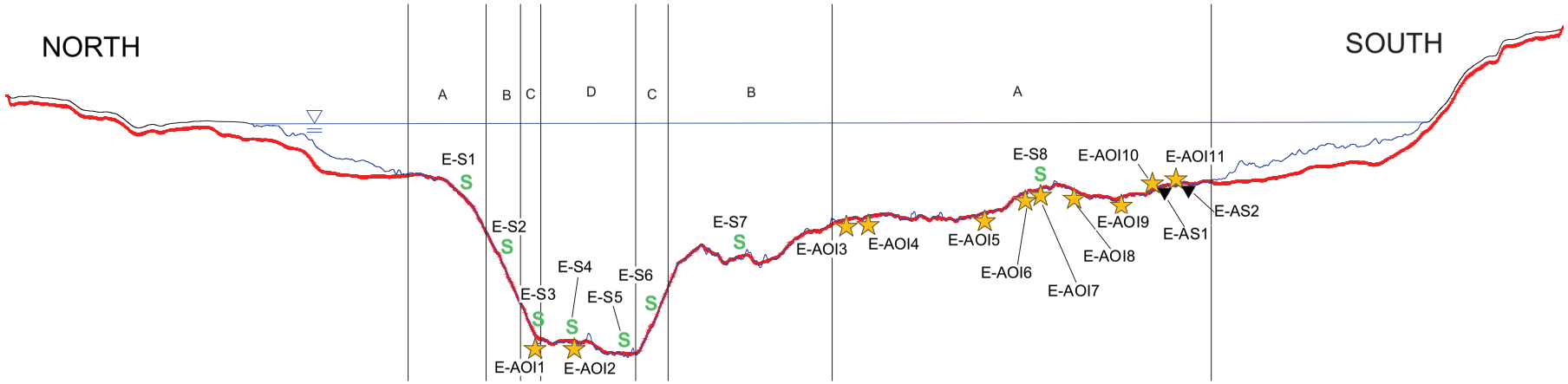

Site ID	Bottom Depth (ft)	Biota Samples	Notes
E-S1	71	6	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
E-S2	144	6	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
E-S3	194	6	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
E-AOI1	194	4	No holiday observed; Samples retained per Work Plan
E-S4	216	6	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
E-AOI2	216	4	No holiday observed; Samples retained per Work Plan
E-S5	229	6	Bottom of pipe not accessible - could not be sampled
E-S6	175	8	-
E-S7	149	8	-
E-AOI3	107	0	No holiday observed; Samples not evaluated per Work Plan
E-AOI4	102	0	No holiday observed; Samples not evaluated per Work Plan
E-AOI5	103	0	No holiday observed; Samples not evaluated per Work Plan
E-AOI6	82	0	No holiday observed; Samples not evaluated per Work Plan
E-S8	81	8	-
E-AOI7	81	4	Holiday identified
E-AOI8	81	0	No holiday observed; Samples not evaluated per Work Plan
E-AOI9	82	0	No holiday observed; Samples not evaluated per Work Plan
E-AOI10	77	0	No holiday observed; Samples not evaluated per Work Plan
E-AS1	74	4	Holiday identified; Samples collected prior to identification - sample location within 3 ft of Holiday
E-AOI11	72	0	No holiday observed; Samples not evaluated per Work Plan
E-AS2	75	4	Holiday identified; Samples collected prior to identification - sample location within 3 ft of Holiday

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details): E-S3 and E- AOI1; E-S4 and E-AOI2; E-S8 and E-AOI7

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

LEGEND:

- S BIOTA SITE (6-8 SAMPLES AROUND THE PIPE)
- AREA OF INTEREST (PAIRED SAMPLES)
- ADDITIONAL SITE (PAIRED SAMPLES)
- LAKE BOTTOM PROFILE
- PIPELINE PROFILE
- WATER LEVEL INDICATOR

DATE: 2/26/2018

Figure 6: East Pipeline Biota Sampling Sites with Sample Summary

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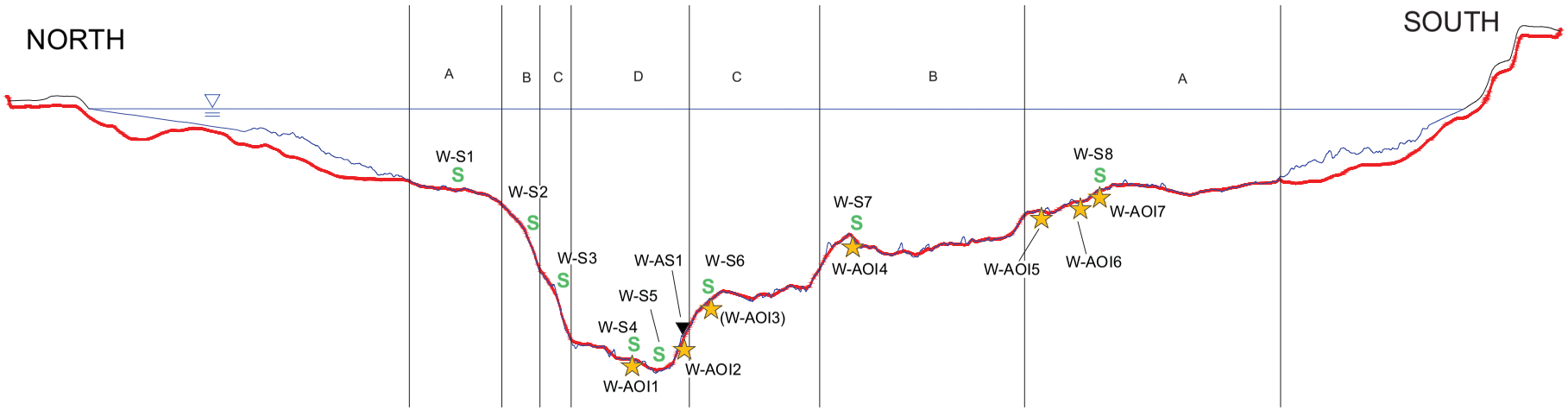

Site ID	Bottom Depth (ft)	Biota Samples	Notes
W-S1	77	8	-
W-S2	128	6	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
W-S3	188	8	-
W-S4	234	8	-
W-AOI1	234	4	No holiday observed; Samples retained per Work Plan
W-S5	245	6	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
W-AOI2	201	0	No holiday observed; Samples not evaluated per Work Plan
W-AS1	196	4	Holiday identified
W-S6	178	6	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
W-AOI3	178	4	No holiday observed; Samples retained per Work Plan
W-S7	129	8	-
W-AOI4	129	4	No holiday observed; Samples retained per Work Plan
W-AOI5	100	0	No holiday observed; Samples not evaluated per Work Plan
W-AOI6	90	0	No holiday observed; Samples not evaluated per Work Plan
W-S8	80	6	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
W-AOI7	80	4	No holiday observed; Samples retained per Work Plan

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details): E-S3 and E- AOI1; E-S4 and E-AOI2; E-S8 and E-AOI7

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

LEGEND:

- S BIOTA SITE (6-8 SAMPLES AROUND THE PIPE)
- AREA OF INTEREST (PAIRED SAMPLES)
- ADDITIONAL SITE (PAIRED SAMPLES)
- LAKE BOTTOM PROFILE
- PIPELINE PROFILE
- WATER LEVEL INDICATOR

DATE: 2/26/2018

Figure 7: West Pipeline Biota Sampling Sites with Sample Summary

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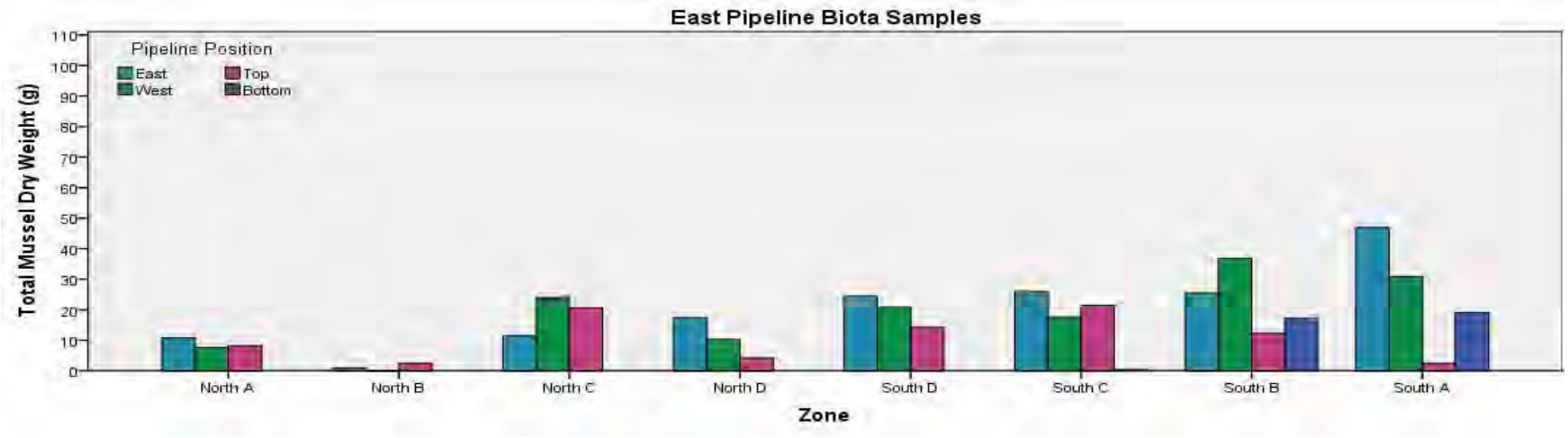

Figure 8: 2017 East Pipeline Mussel Biomass (dry weight)

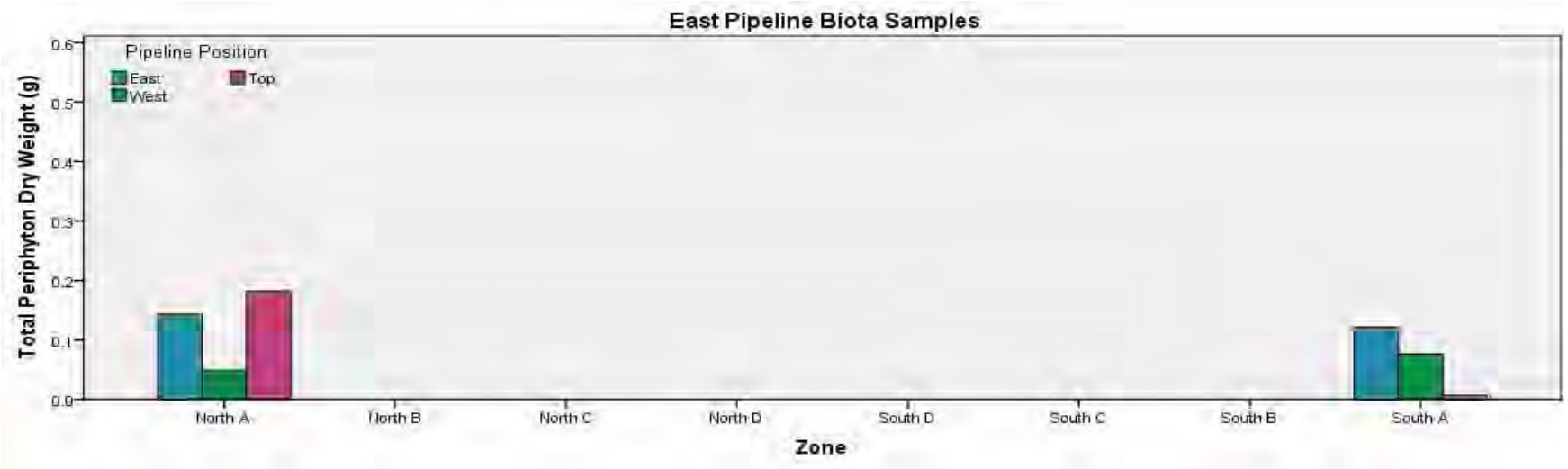

Figure 9: 2017 East Pipeline Total Periphyton Biomass (dry weight)

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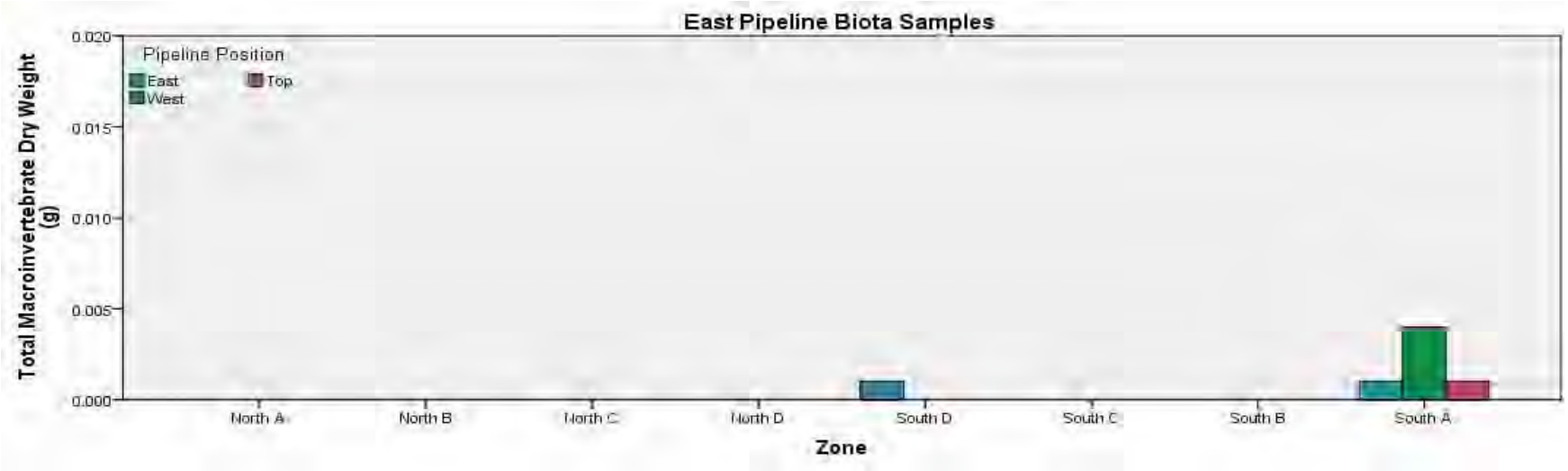

Figure 10: 2017 East Pipeline Total Macroinvertebrates Biomass (dry weight)

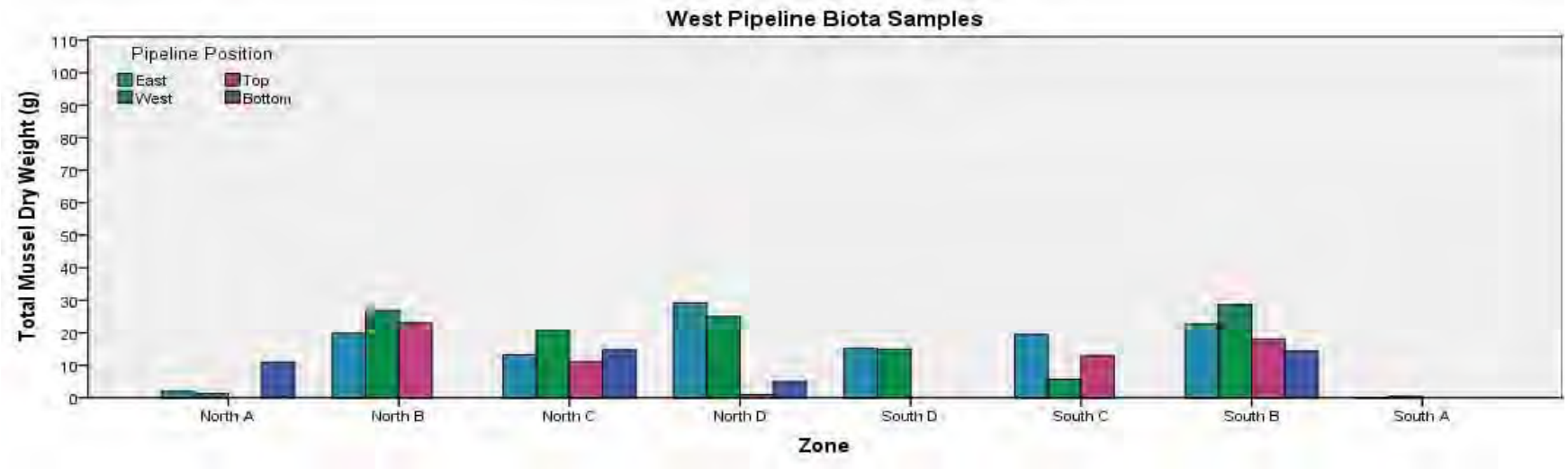

Figure 11: 2017 West Pipeline Total Mussel Biomass (dry weight)

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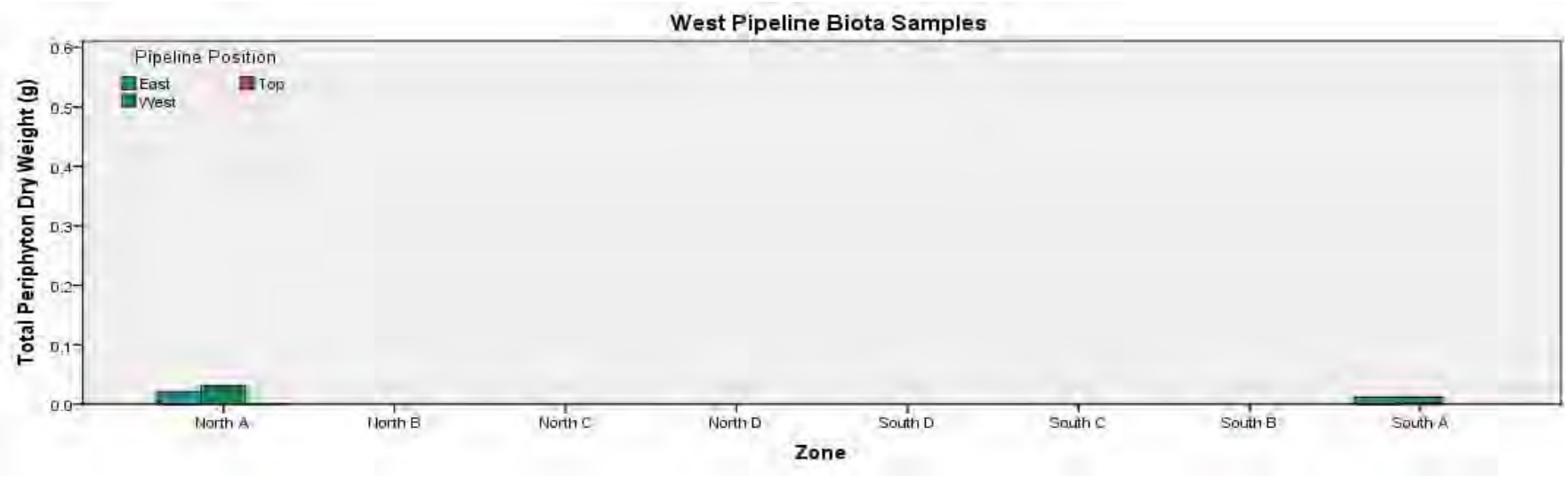

Figure 12: 2017 West Pipeline Total Periphyton Biomass (dry weight)

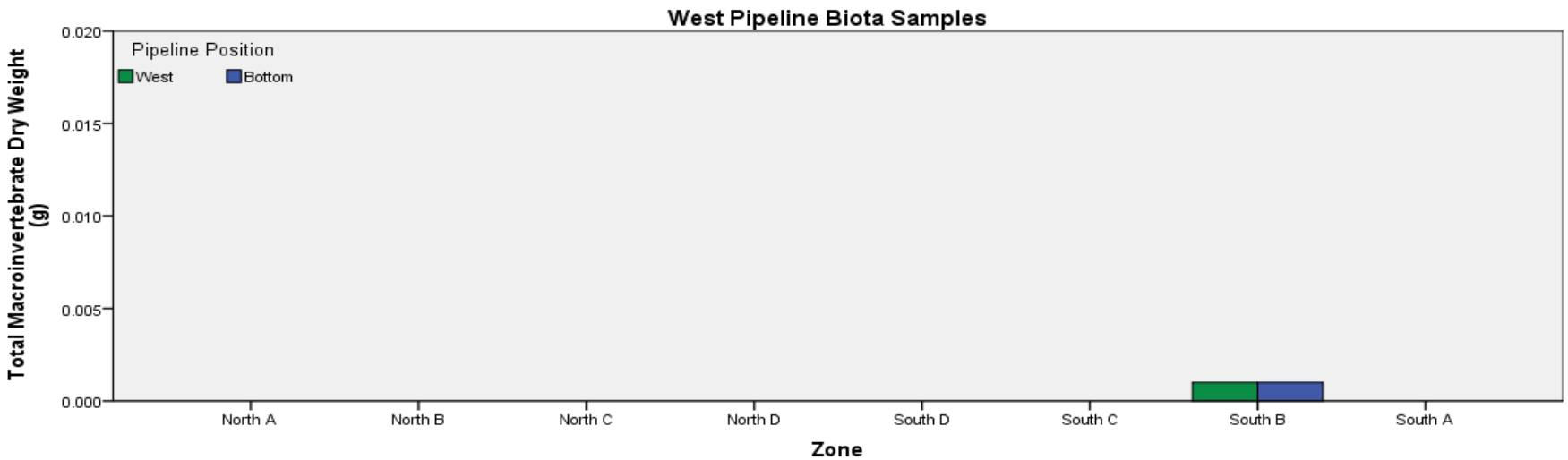

Figure 13: 2017 West Pipeline Total Macroinvertebrates Biomass (dry weight)

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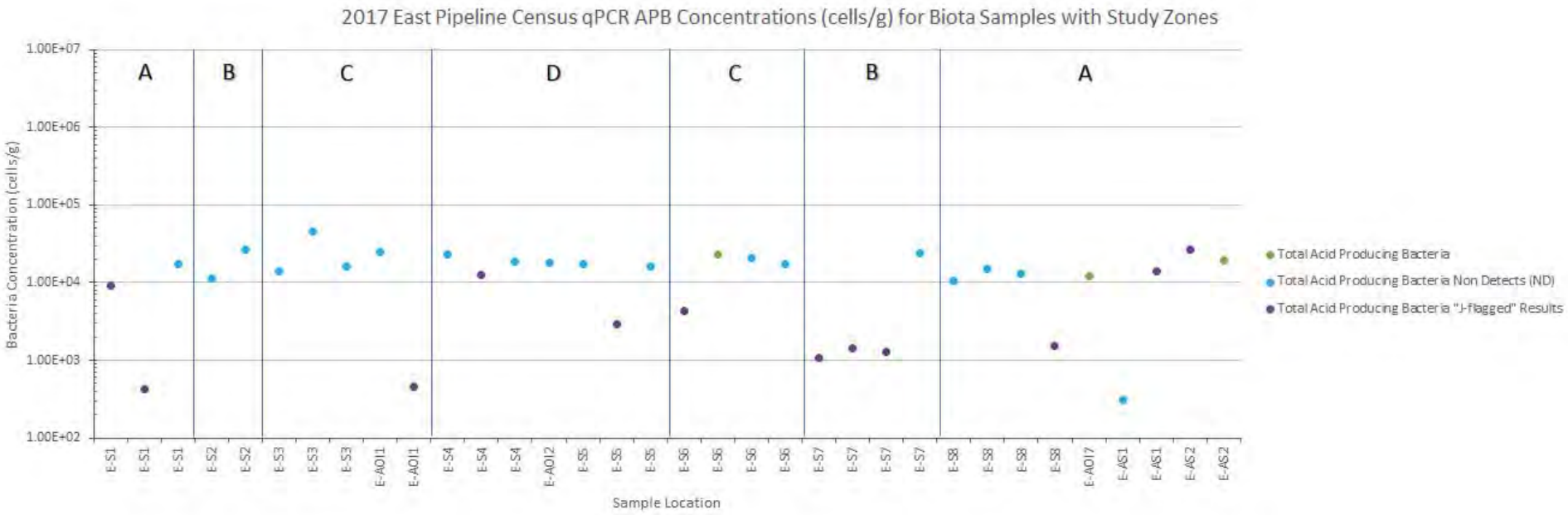

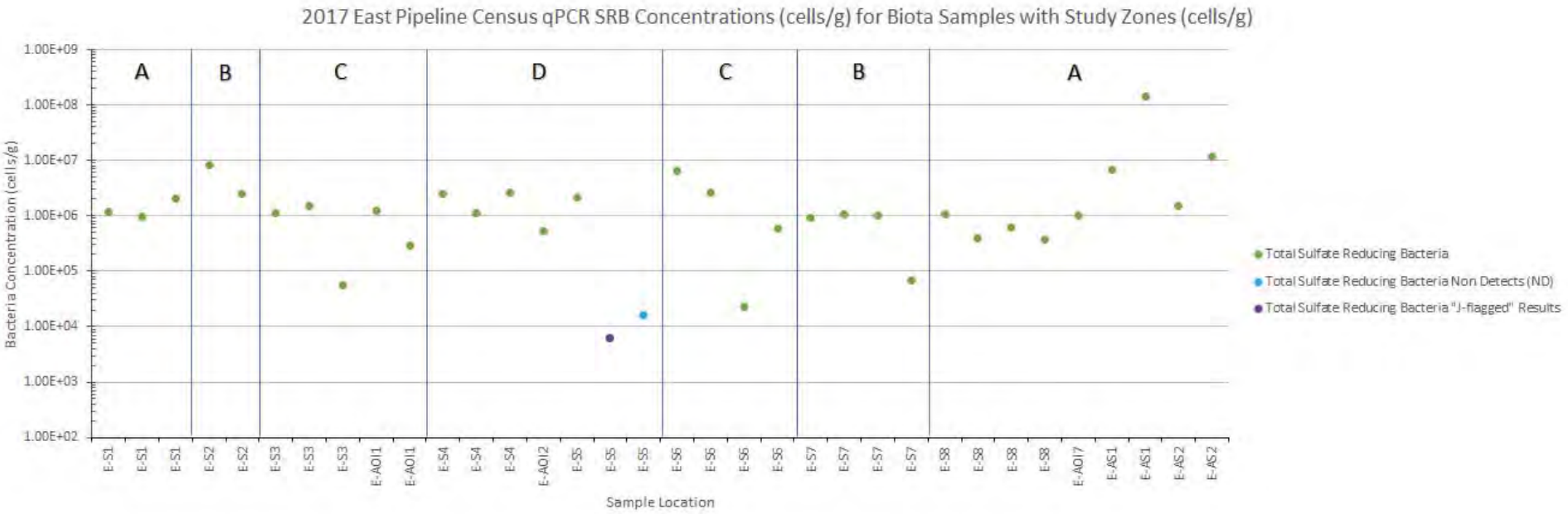

Figure 14: 2017 East Pipeline Census qPCR APB/SRB Concentrations for Biota Samples

"J-Flagged" indicates results less than the Reporting Limit (RL), and greater than the Dectection Limit (DL)

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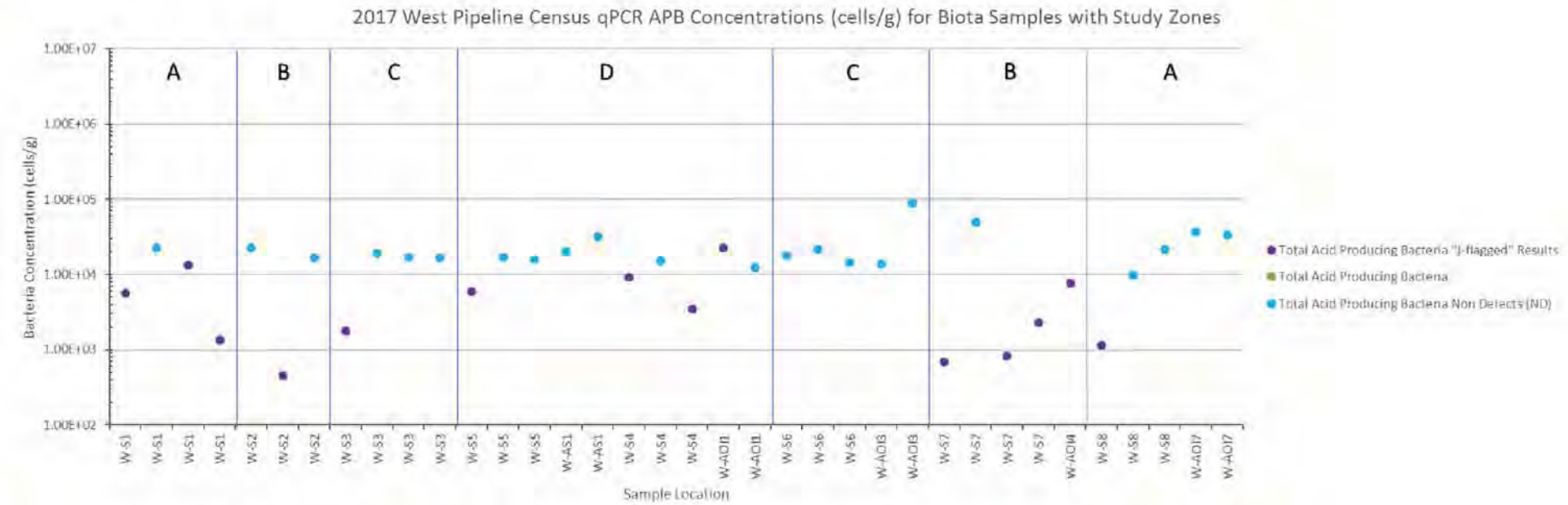

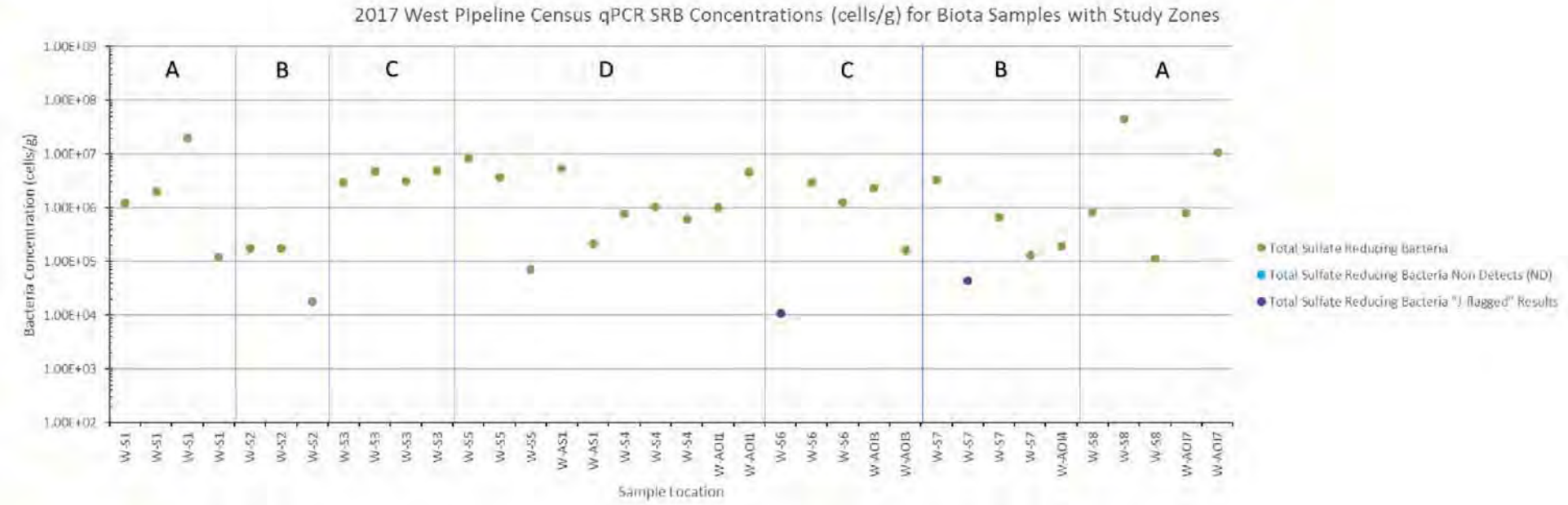

Figure 14: 2017 West Pipeline Census qPCR APB/SRB Concentrations for Biota Samples

"J-Flagged" indicates results less than the Reporting Limit (RL), and greater than the Dectection Limit (DL)

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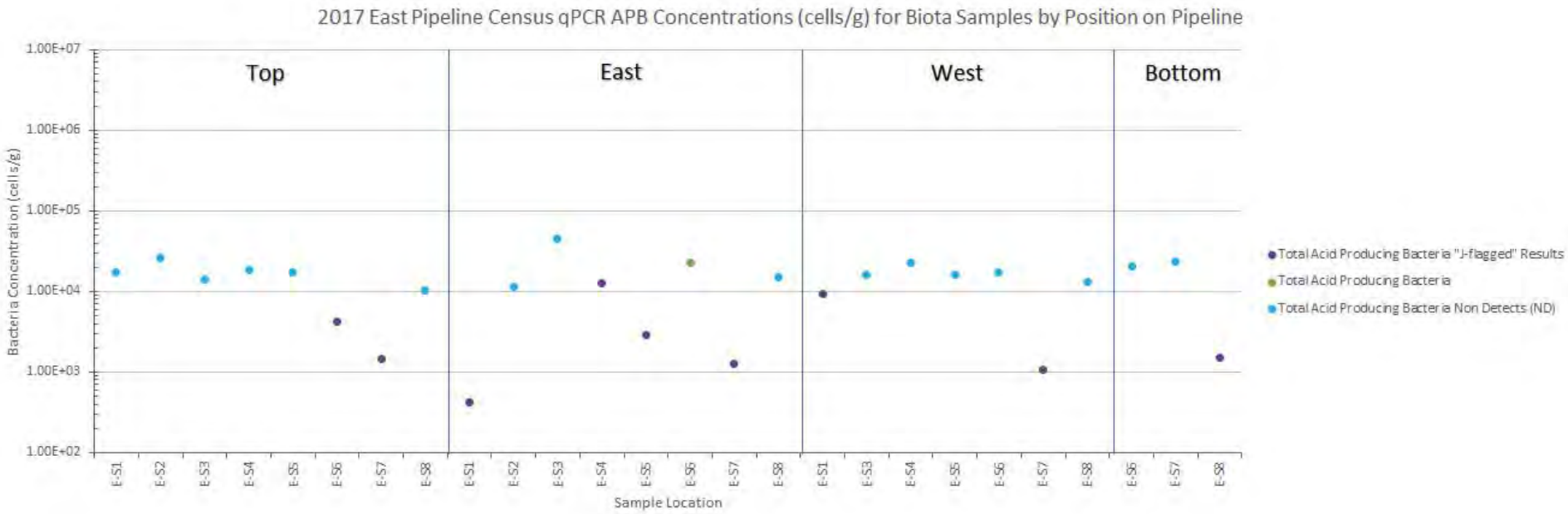

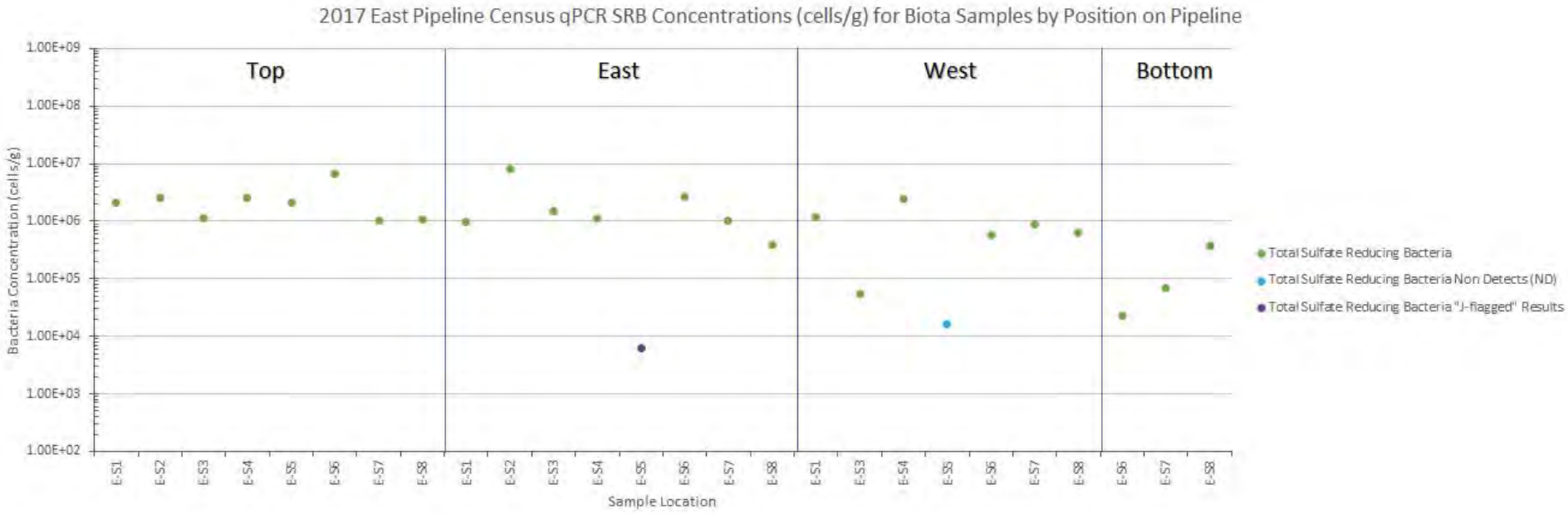

Figure 15: 2017 East Pipeline Census qPCR APB/SRB Concentrations for Biota Samples by Position on Pipeline

"J-Flagged" indicates results less than the Reporting Limit (RL), and greater than the Dectection Limit (DL)

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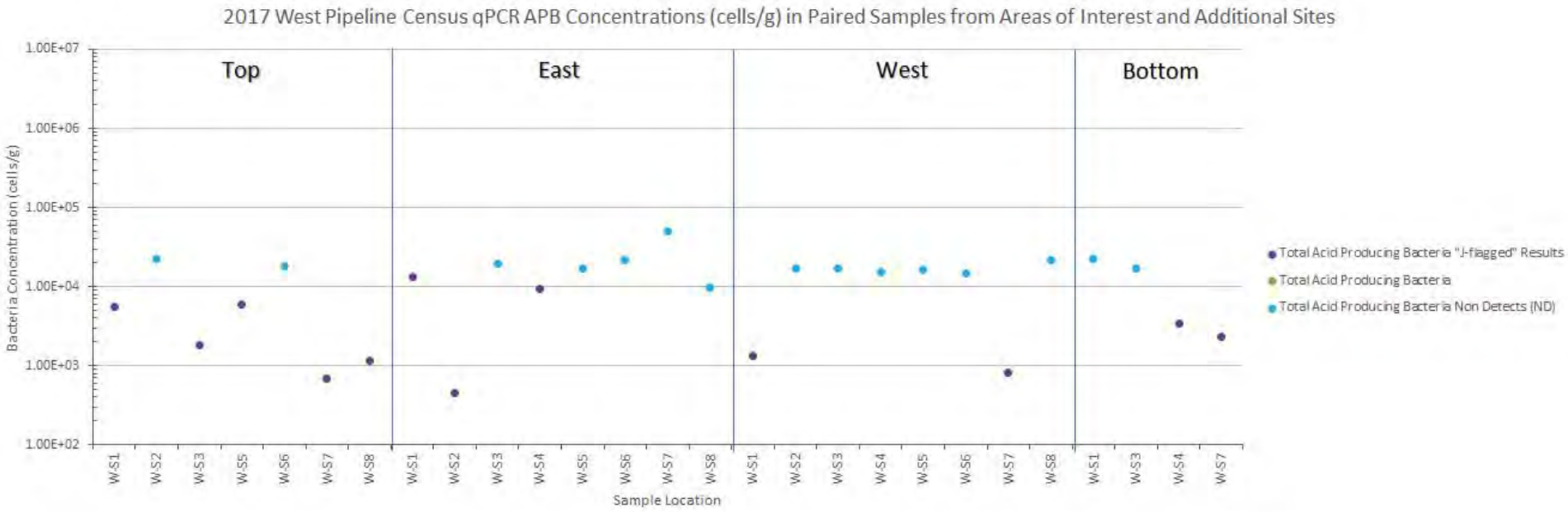

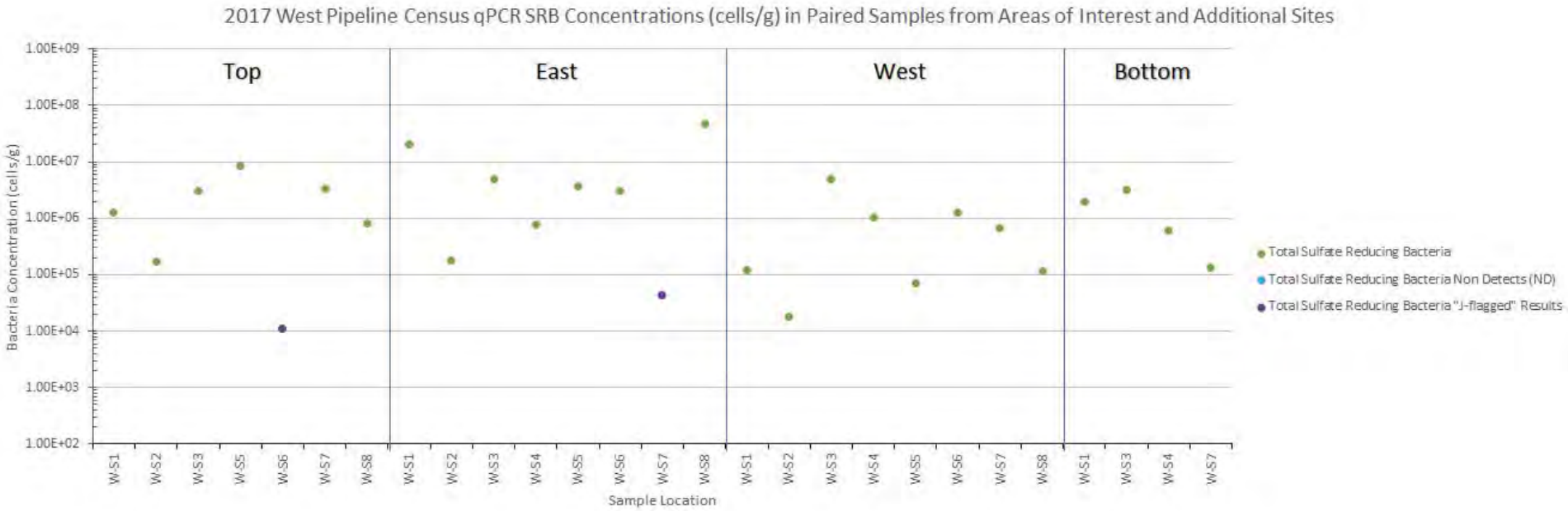

Figure 15: 2017 West Pipeline Census qPCR APB/SRB Concentrations for Biota Samples by Position on Pipeline

"J-Flagged" indicates results less than the Reporting Limit (RL), and greater than the Dectection Limit (DL)

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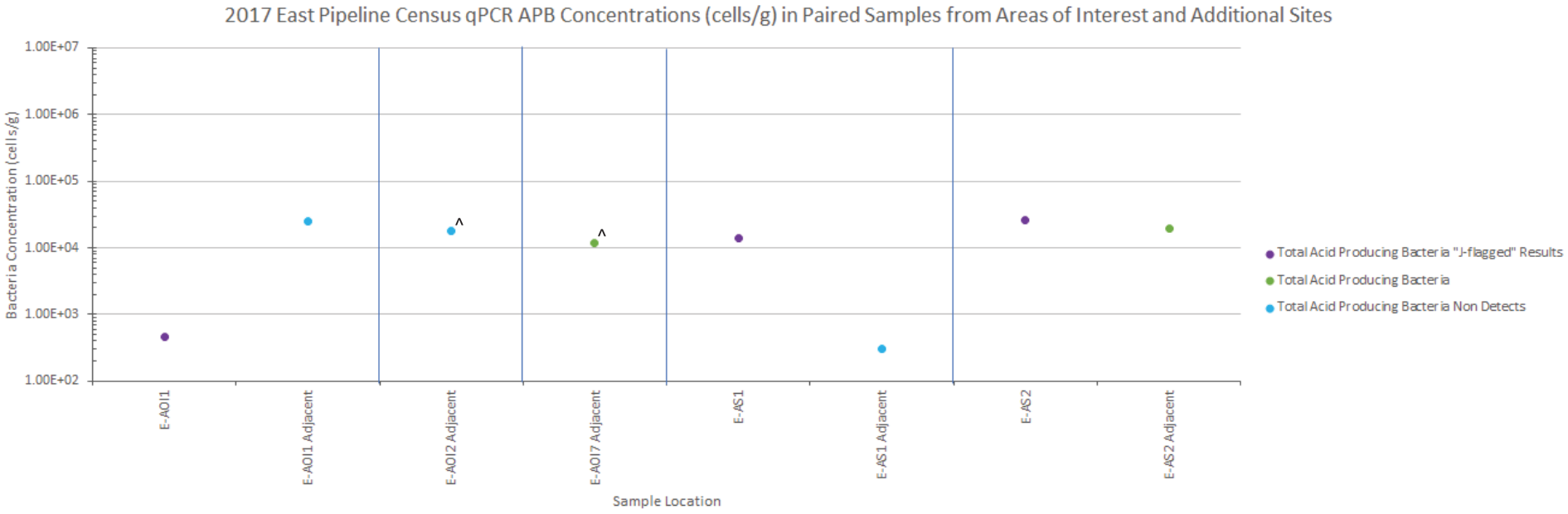

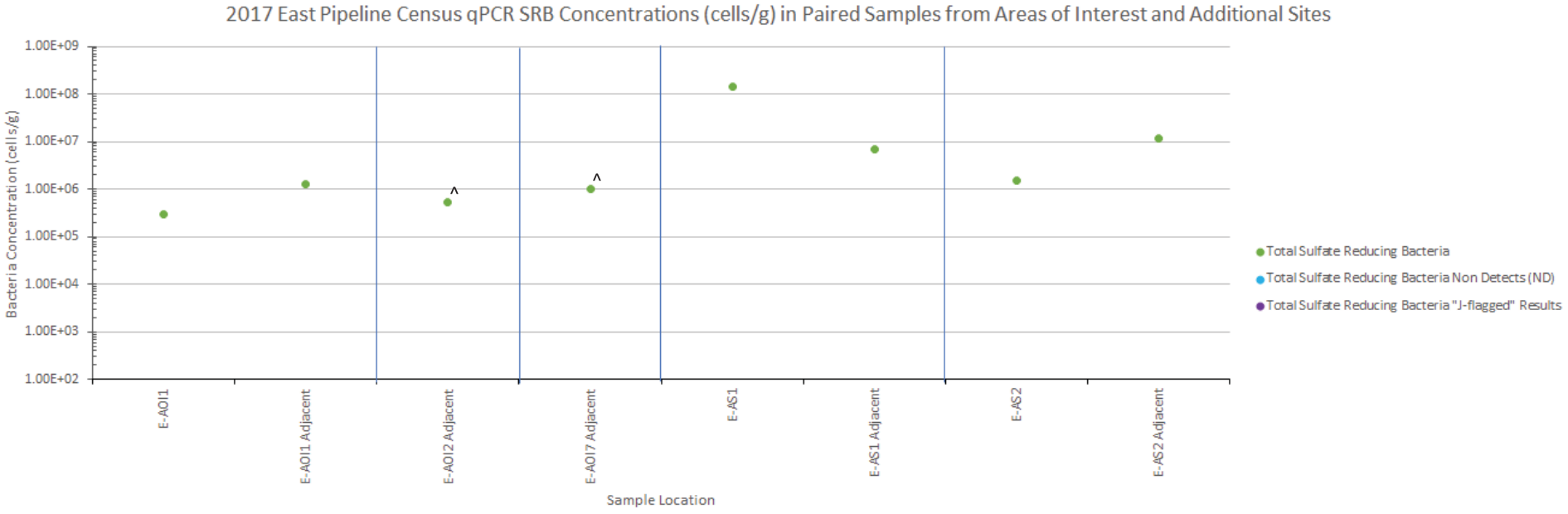

Figure 16: 2017 East Pipeline Census qPCR APB/SRB Concentrations in Paired Samples from Areas of Interest and Additional Sites

^Paired sample from AOI/Additional Site not analyzed due to insufficient mass or sample loss

"J-Flagged" indicates results less than the Reporting Limit (RL), and greater than the Detection Limit (DL)

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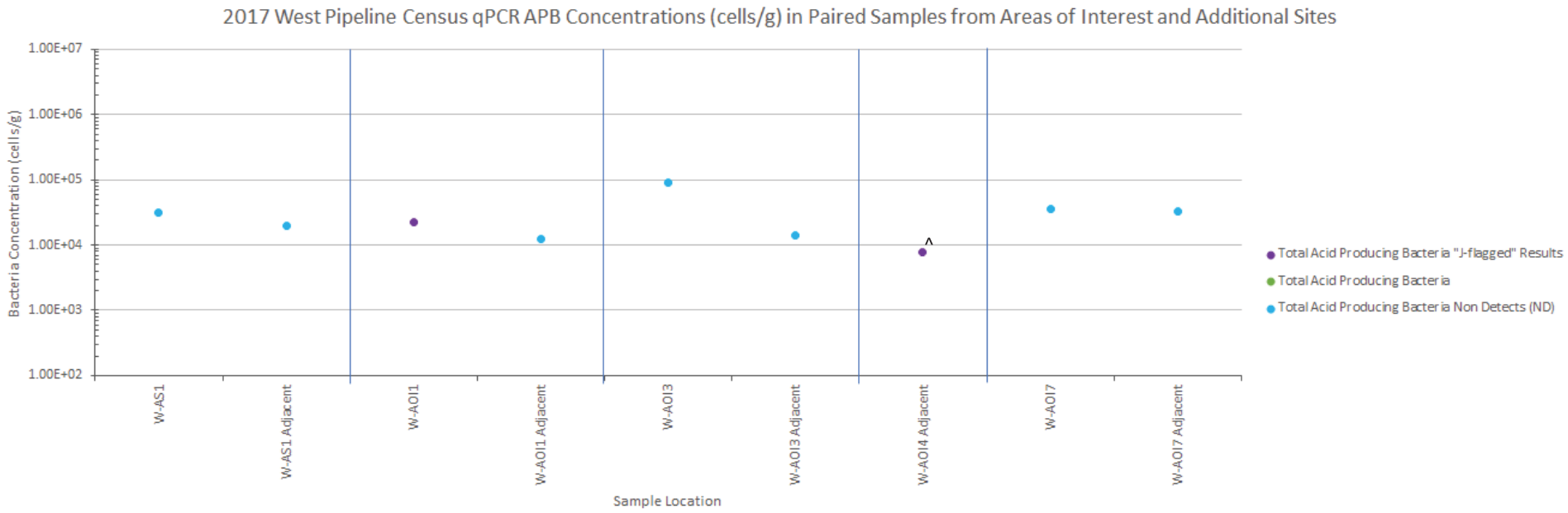

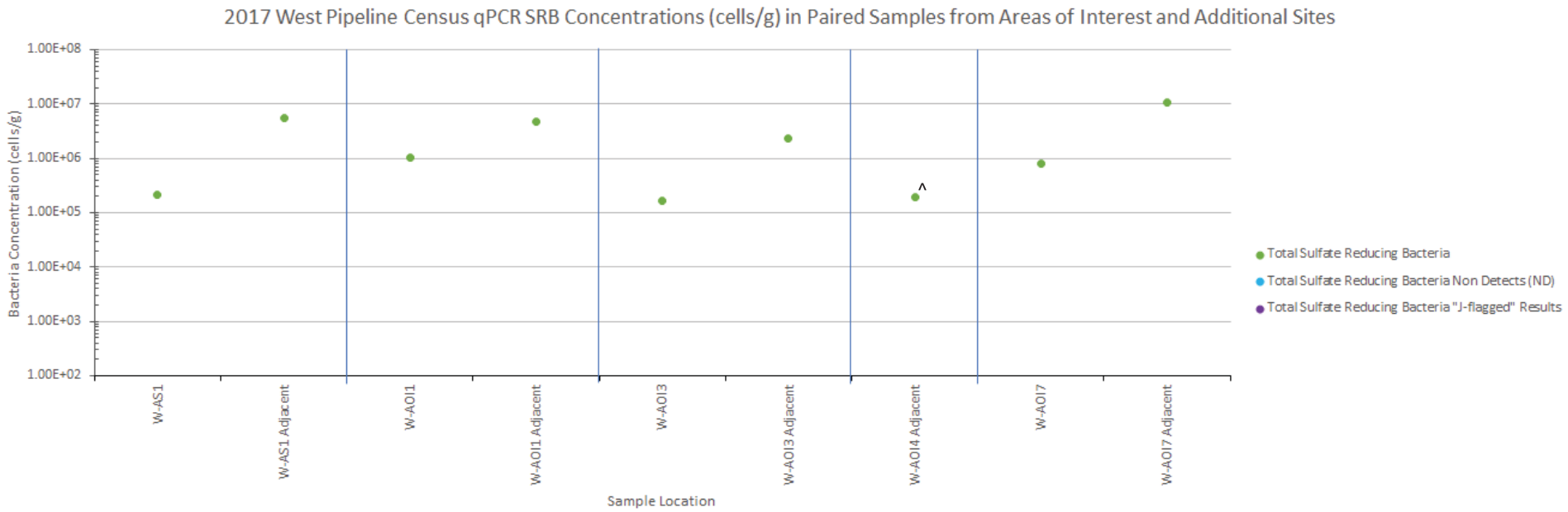

Figure 16: 2017 West Pipeline Census qPCR APB/SRB Concentrations in Paired Samples from Areas of Interest and Additional Sites

^Paired sample from AOI/Additional Site not analyzed due to insufficient mass or sample loss

"J-Flagged" indicates results less than the Reporting Limit (RL), and greater than the Detection Limit (DL)

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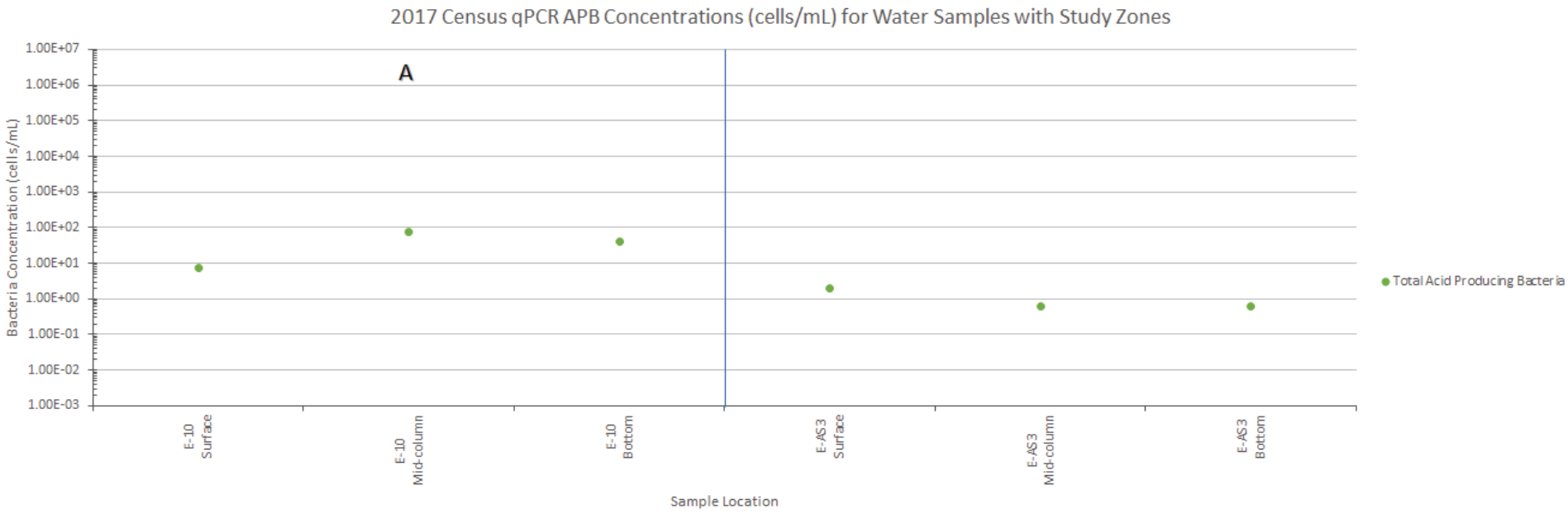

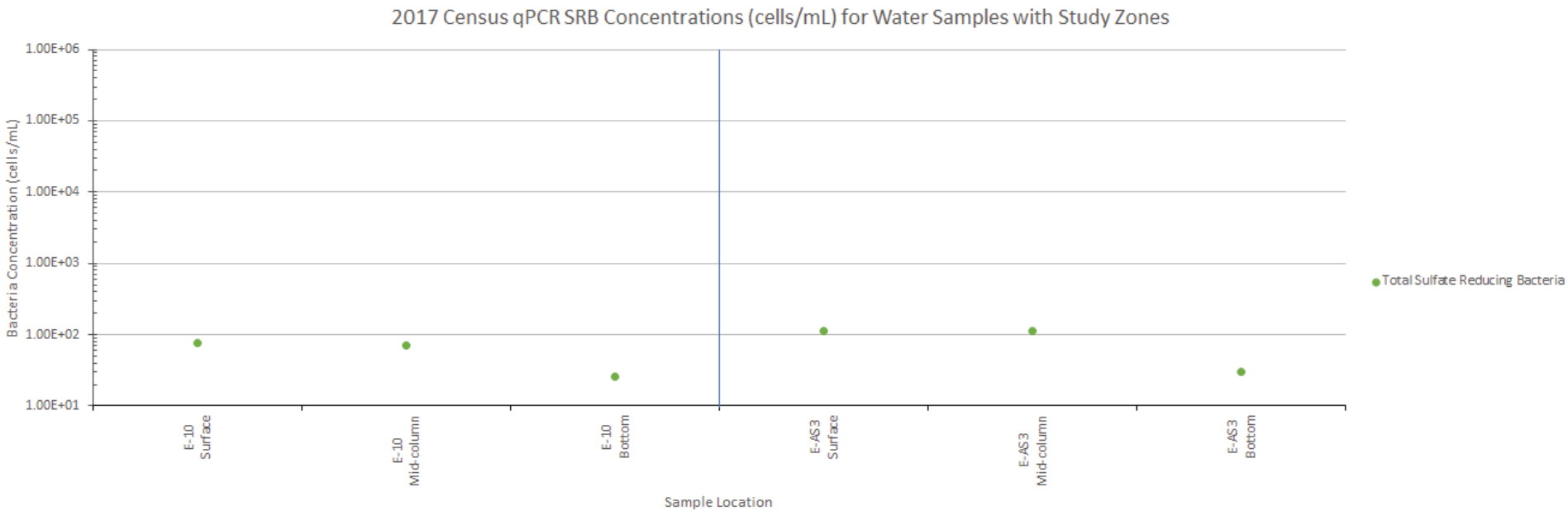

Figure 17: 2017 Census qPCR APB/SRB Concentrations for Water Samples

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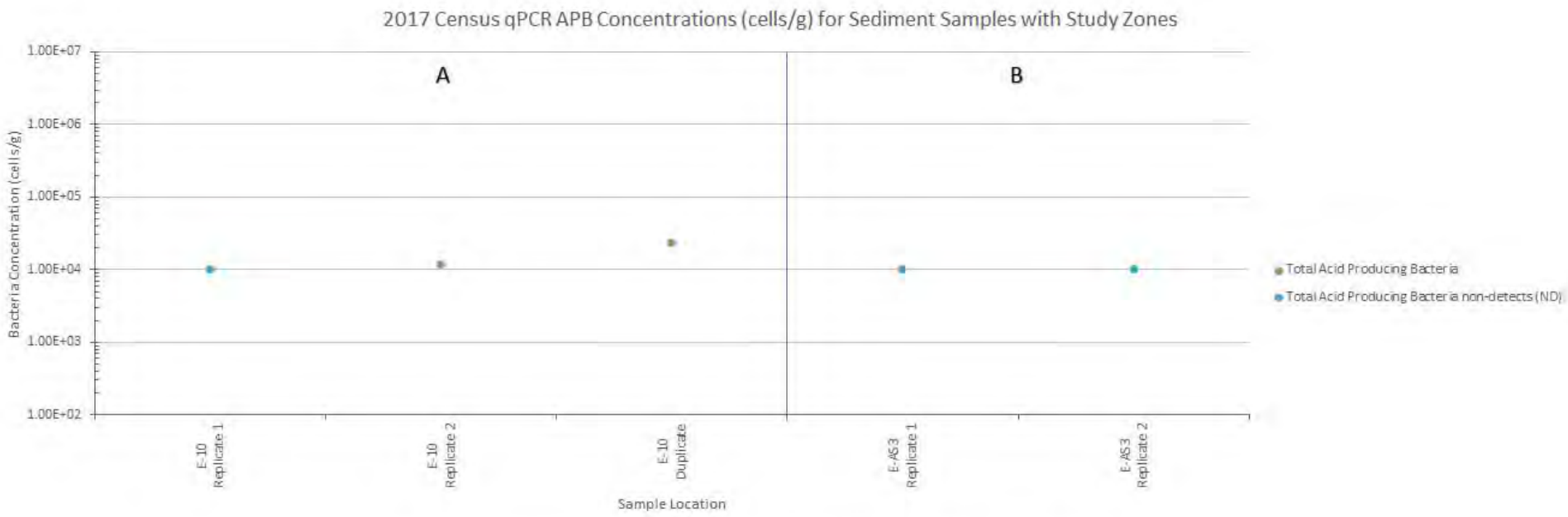

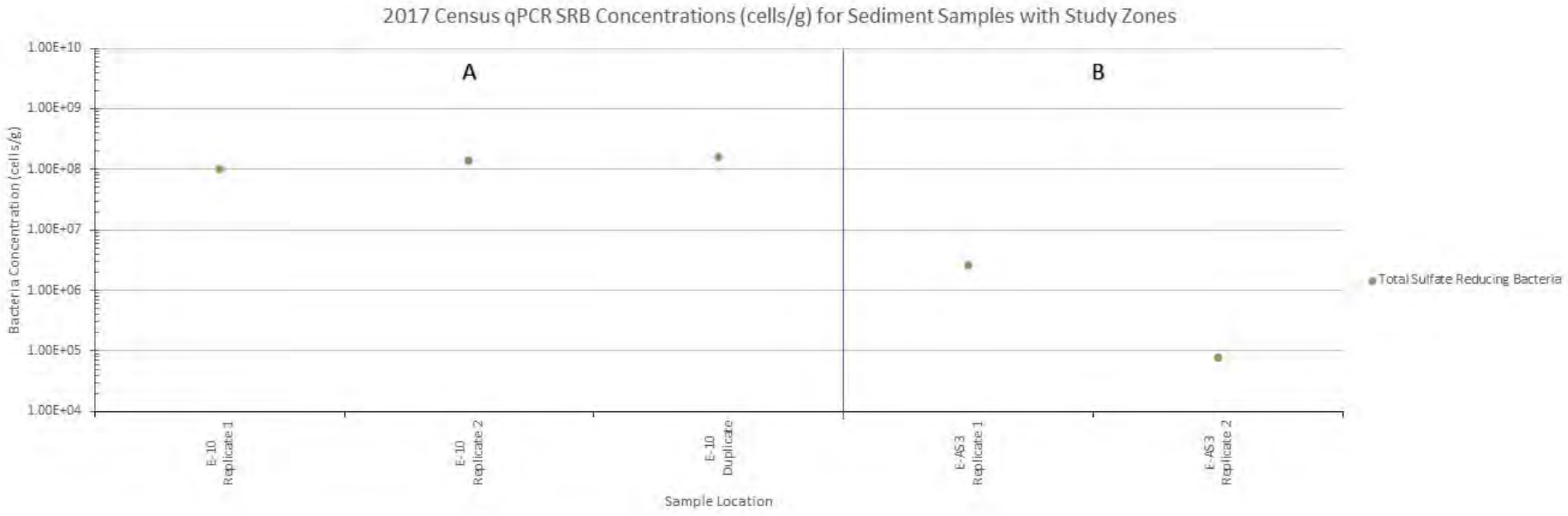

Figure 18: 2017 Census qPCR APB/SRB Concentrations for Sediment Samples

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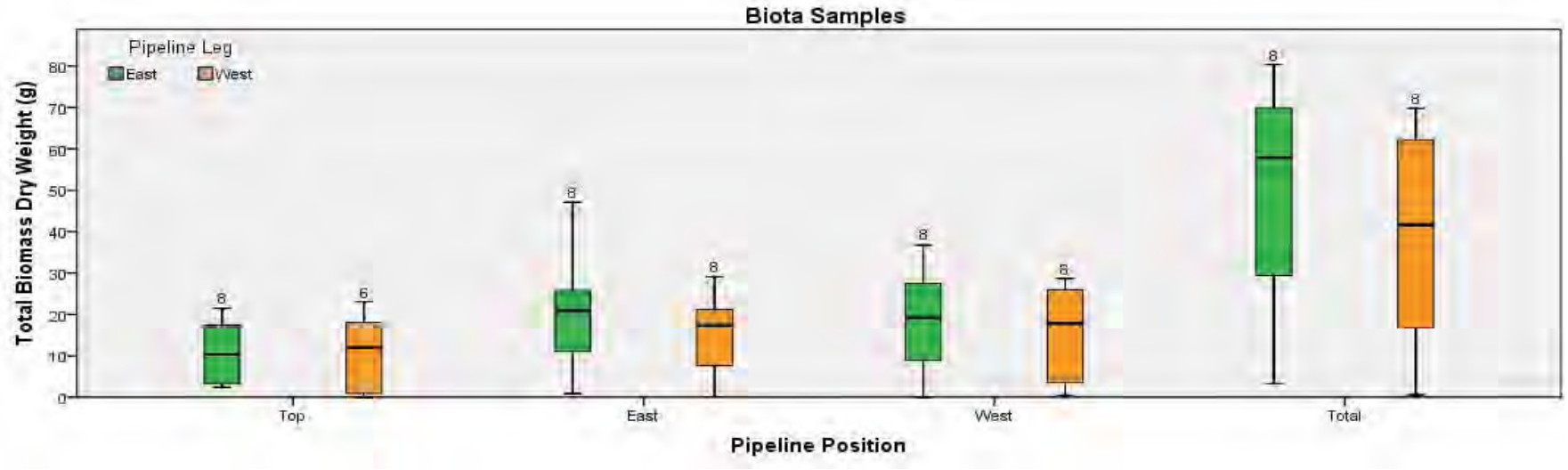

Figure 19: 2017 Comparison of Total Biota Biomass (dry weight) for East and West Pipeline by Position on Pipeline

Box plots identify median (center bar) and data distribution (25th & 75th percentiles [box], 10th & 90th percentiles [whiskers]) Number above whisker indicates *n*-value (sample quantity) - bottom pipe position data excluded

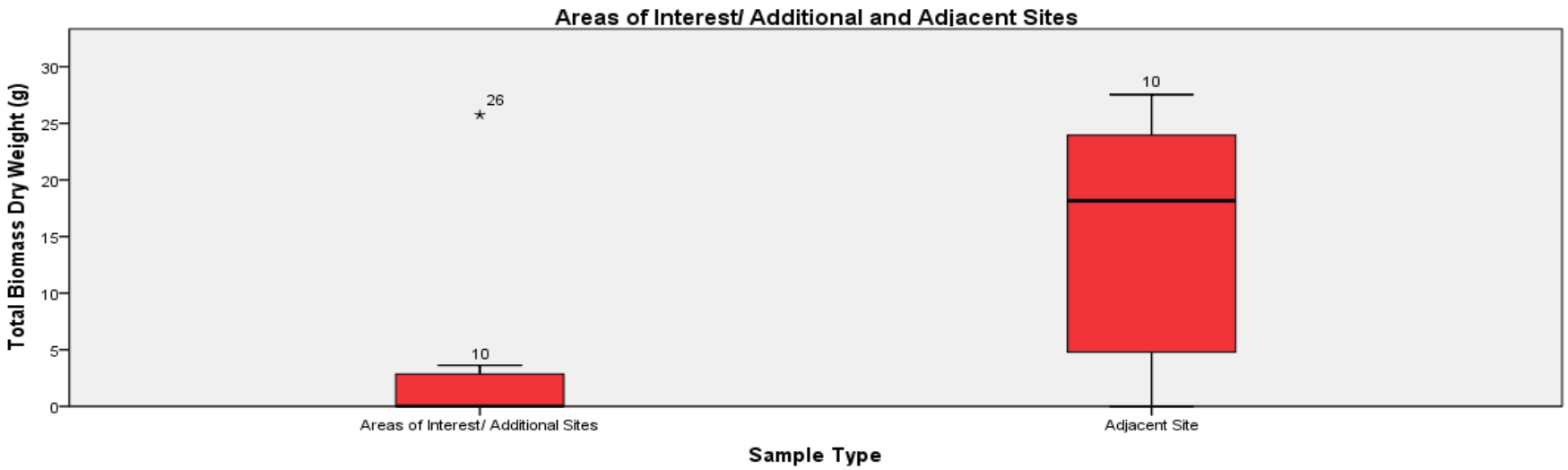

Figure 20: 2017 Comparison of Total Biota Biomass (dry weight) for Paired Samples form Areas of Interest and Additional Sites

*Indicates maximum value

Box plots identify median (center bar) and data distribution (25th & 75th percentiles [box], 10th & 90th percentiles [whiskers]) Number above whisker indicates n-value (sample quantity)

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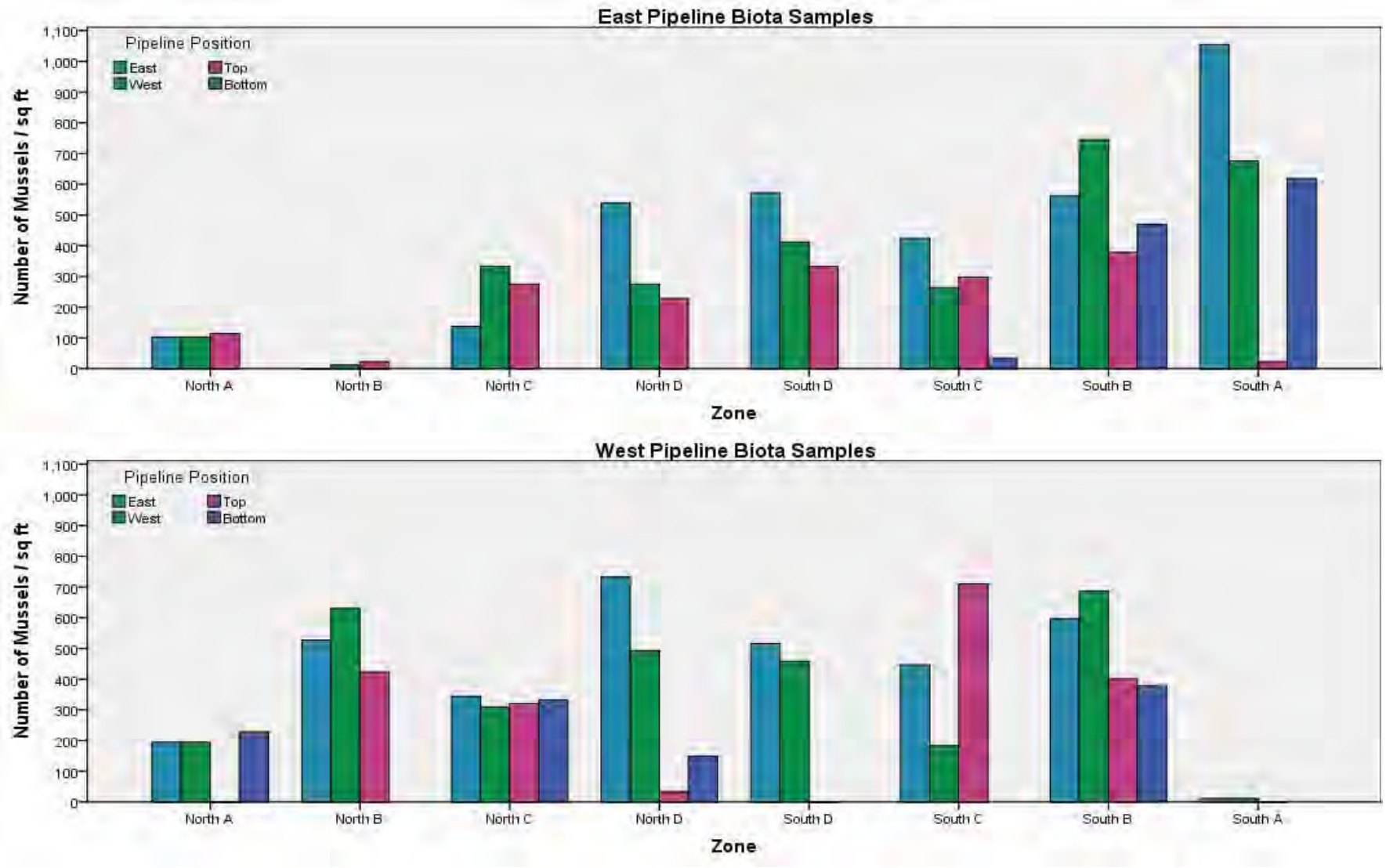

Figure 21: 2017 Biota Sample Mussel Density by Study Zone and Pipeline Positionsion

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Table 20: 2017 Areas of Interest, Additional Sites and Paired Adjacent Sample Dry Weights (g)

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Table 22: 2017 APB and SRB Field Test Kit QA/QC Results

Table 23: 2017 East Pipeline APB and SRB Field Test Kit Results

Table 24: 2017 West Pipeline APB and SRB Field Test Kit Results

Table 25: 2017 Water and Sediment APB and SRB Field Test Kit Results

Table 26: 2017 APB and SRB Assay Frequency of Detection (%)

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Table 1. 2017 East Pipeline Location of Biota, [redacted]tes

Site ID	Location Description	[redacted]	Study Zone	Bottom Depth (ft)
E-S1	Biota site	[redacted]	A	71
E-S2	Biota site	[redacted]	B	144
E-S3	Biota site	[redacted]	C	194
E-AOI1	Area of Interest	[redacted]	C	194
E-S4	Biota site	[redacted]	D	216
E-AOI2	Area of Interest	[redacted]	D	216
E-S5	Biota site	[redacted]	D	229
E-S6	Biota site	[redacted]	C	175
E-S7	Biota site	[redacted]	B	149
E-AOI3	Area of Interest	[redacted]	A	107
E-AOI4	Area of Interest	[redacted]	A	102
E-AOI5	Area of Interest	[redacted]	A	103
E-AOI6	Area of Interest	[redacted]	A	82
E-S8	Biota site	[redacted]	A	81
E-AOI7	Area of Interest	[redacted]	A	81
E-AOI8	Area of Interest	[redacted]	A	81
E-AOI9	Area of Interest	[redacted]	A	82
E-AOI10	Area of Interest	[redacted]	A	77
E-AS1	Additional Site	[redacted]	A	74
E-AOI11	Area of Interest	[redacted]	A	72
E-AS2	Additional Site	[redacted]	A	75

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details): E-S3 and E-AOI1; E-S4 and E-AOI2; E-S8 and E-AOI7

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

Table 1. 2017 West Pipeline Location of Biota, [redacted]Sites

Site ID	Location Description	[redacted]	Study Zone	Bottom Depth (ft)
W-S1	Biota site	[redacted]	A	77
W-S2	Biota site	[redacted]	B	128
W-S3	Biota site	[redacted]	C	188
W-S4	Biota site	[redacted]	D	234
W-AOI1	Area of Interest	[redacted]	D	234
W-S5	Biota site	[redacted]	D	245
W-AOI2	Area of Interest	[redacted]	D	201
W-AS1	Additional Site	[redacted]	D	196
W-S6	Biota site	[redacted]	C	178
W-AOI3	Area of Interest	[redacted]	C	178
W-S7	Biota site	[redacted]	B	129
W-AOI4	Area of Interest	[redacted]	B	129
W-AOI5	Area of Interest	[redacted]	A	100
W-AOI6	Area of Interest	[redacted]	A	90
W-S8	Biota site	[redacted]	A	80
W-AOI7	Area of Interest	[redacted]	A	80

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details): W-S4 and W-AOI1; W-S6 and W-AOI3; W-S7 and W-AOI4; W-S8 and W-AOI7

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

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Table 2. 2017 East Pipeline Water Chemistry Mea

Site ID	Location Description	Study Zone	Bottom Depth (ft)
E-S3 E-AOI1	Biota site Area of Interest	C	194
E-AS3	Water/Sediment	B	137
E-S8 E-AOI7	Biota site Area of Interest	A	81
E-AOI8	Area of Interest	A	81
E-10	Water/Sediment	A	83

Sampling at the following Biota sampling locations and Areas each other (see Section 2.5.3.2 of Report for further details): E-S3 and E-AOI1; E-S8 and E-AOI7

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

Table 2. 2017 West Pipeline Water Chemistry Me

Site ID	Location Description	Study Zone	Bottom Depth (ft)
W-S4 W-AOI1	Biota site Area of Interest	D	234
W-AOI6	Area of Interest	A	90

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details): E-S3 and E-AOI1; E-S8 and E-AOI7

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

Table 3. 2017 Water and Sediment Collection Loca

Site ID	Location Description	Study Zone	Bottom Depth (ft)
E-AS3	Water/Sediment	B	137
E-10	Water/Sediment	A	83

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Table 4. 2017 East Pipeline Sample Collection Summary

Site ID	GEI	Study Zone	Bottom Depth (ft)	Bottom Water Temperature (°F)	Mussel Colonization	Biota Samples	Opportunistic Samples	Notes
E-S1	Biota site	A	71	65	Heavy	6	1	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
E-S2	Biota site	B	144	55	Moderate	6	0	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
E-S3	Biota site	C	194	42	Heavy	6	0	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
E-AOI1	Area of Interest	C	194	42	Moderate	4	0	No holiday observed; Samples retained per Work Plan
E-S4	Biota site	D	216	42	Heavy	6	0	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
E-AOI2	Area of Interest	D	216	42	None	4	0	No holiday observed; Samples retained per Work Plan
E-S5	Biota site	D	229	50	Heavy	6	0	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
E-S6	Biota site	C	175	44	Heavy	8	0	-
E-S7	Biota site	B	149	-	Heavy	8	0	-
E-AOI3	Area of Interest	A	107	50	Sparse	0	0	No holiday observed; Samples not evaluated per Work Plan Addendum A*
E-AOI4	Area of Interest	A	102	-	Sparse	0	0	No holiday observed; Samples not evaluated per Work Plan Addendum A*
E-AOI5	Area of Interest	A	103	50	Sparse	0	0	No holiday observed; Samples not evaluated per Work Plan Addendum A*
E-AOI6	Area of Interest	A	82	-	Sparse	0	1	No holiday observed; Samples not evaluated per Work Plan Addendum A*
E-S8	Biota site	A	81	52	Heavy	8	0	-
E-AOI7	Area of Interest	A	81	52	Sparse	4	0	Holiday identified
E-AOI8	Area of Interest	A	81	55	Sparse	0	0	No holiday observed; Samples not evaluated per Work Plan Addendum A*
E-AOI9	Area of Interest	A	82	55	Moderate	0	1	No holiday observed; Samples not evaluated per Work Plan Addendum A*
E-AOI10	Area of Interest	A	77	-	Sparse	0	1	No holiday observed; Samples not evaluated per Work Plan Addendum A*
E-AS1	Additional Site	A	74	-	Sparse	4	0	Holiday identified; Samples collected prior to identification - sample location within 3 ft of Holiday
E-AOI11	Area of Interest	A	72	-	Sparse	0	1	No holiday observed; Samples not evaluated per Work Plan Addendum A*
E-AS2	Additional Site	A	75	-	Sparse	4	1	Holiday identified; Samples collected prior to identification - sample location within 3 ft of Holiday

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details): E-S3 and E-AOI1; E-S4 and E-AOI2; E-S8 and E-AOI7

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

All biota samples were analyzed; half of them were analyzed for biota community (see Section 2.7.2 of Report), with the other half used for APB/SRB field test kits and Census qPCR DNA analysis (see Section 2.7.1 and 2.7.3 of Report)

"Opportunistic samples" category includes: Material of Interest (MOI), presumed calcium deposits, and presumed detached coating

*Addendum A (pg 3) - "If it is determined that there are no Holidays at the Area of Interest, the Biota samples that were collected will be properly disposed of per MDNR permit requirements."

Table 4. 2017 West Pipeline Sample Collection Summary

Site ID	Location Description	Study Zone	Bottom Depth (ft)	Bottom Water Temperature (°F)	Mussel Colonization	Biota Samples	Opportunistic Samples	Notes
W-S1	Biota site	A	77	67	Moderate	8	0	-
W-S2	Biota site	B	128	52	Heavy	6	0	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
W-S3	Biota site	C	188	50	Heavy	8	0	-
W-S4	Biota site	D	234	42	Heavy	8	0	-
W-AOI1	Area of Interest	D	234	42	Sparse	4	1	No holiday observed; Samples retained per Work Plan
W-S5	Biota site	D	245	50	Heavy	6	0	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
W-AOI2	Area of Interest	D	201	45	Sparse	0	1	No holiday observed; Samples not evaluated per Work Plan Addendum A*
W-AS1	Additional Site	D	196	43	Sparse	4	0	Holiday identified
W-S6	Biota site	C	178	42	Heavy	6	0	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
W-AOI3	Area of Interest	C	178	42	Sparse	4	0	No holiday observed; Samples retained per Work Plan
W-S7	Biota site	B	129	45	Heavy	8	0	-
W-AOI4	Area of Interest	B	129	45	Moderate	4	0	No holiday observed; Samples retained per Work Plan
W-AOI5	Area of Interest	A	100	55	Sparse	0	1	No holiday observed; Samples not evaluated per Work Plan Addendum A*
W-AOI6	Area of Interest	A	90	58	Sparse	0	0	No holiday observed; Samples not evaluated per Work Plan Addendum A*
W-S8	Biota site	A	80	55	Sparse	6	0	Bottom of pipe not accessible - could not be sampled; 6 samples instead of 8
W-AOI7	Area of Interest	A	80	55	Sparse	4	0	No holiday observed; Samples retained per Work Plan

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details): W-S4 and W-AOI1; W-S6 and W-AOI3; W-S7 and W-AOI4; W-S8 and W-AOI7

Table contents are represented in a north to south manner from top to bottom

All biota samples were analyzed; half of them were analyzed for biota community (see Section 2.7.2 of Report), with the other half used for APB/SRB field test kits and Census qPCR DNA analysis (see Section 2.7.1 and 2.7.3 of Report)

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

"Opportunistic samples" category includes: Material of Interest (MOI), presumed calcium deposits, and presumed detached coating

*Addendum A (pg 3) - "If it is determined that there are no Holidays at the Area of Interest, the Biota samples that were collected will be properly disposed of per MDNR permit requirements."

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Table 5. 2017 Water and Sediment Sample Collection Summary

Site ID	Location Description	Study Zone	Bottom Depth (ft)	Sample Type			
				Surface Water	Mid-column Water	Bottom Water	Sediment
E-AS3	Water/Sediment	B	137	1	1	1	2
E-10	Water/Sediment	A	83	1	1	1	2

Sediment sample counts include replicate samples from each location (Section 2.5.5); a duplicate sediment sample for QA/QC purposes was generated at E-10

Table 6. 2017 East Pipeline Biota Thickness Measurement (mm)

Site ID	Pipe End	Zone	Mussel colonization	Sample depth (ft)	Biota Thickness 1	Biota Thickness 2	Biota Thickness 3	Minimum	Mean	Maximum	GeoMean	Std. Deviation
E-S6	South	C	Heavy	175	12.1	18.2	12.1	12.1	14.1	18.2	13.9	3.5
E-S7	South	B	Heavy	149	20.2	20.2	14.1	14.1	18.2	20.2	17.9	3.5
E-S8	South	A	Heavy	81	26.3	26.3	23.2	23.2	25.3	26.3	25.2	1.8

All thickness measures and relative statistics are represented in millimeters (mm)

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

Table 7. 2017 East Pipeline Biota Sample Dry Weight (g) Summary Statistics by Study Zone and Pipeline Position

Study Zone	*n*	Sum						Mean				
		Periphyton	Macroinvertebrate	Mussel	Inorganic	Total Biomass	Total*	Periphyton	Macroinvertebrate	Mussel	Inorganic	Biomass
A	3	0.4	0.0	26.6	0.7	26.9	27.7	0.1	0.0	8.9	0.2	9.0
B	3	0.0	0.0	3.36	119.6	3.3	123.0	0.0	0.0	1.1	39.9	1.1
C	3	0.0	0.0	56.3	25.9	56.3	82.2	0.0	0.0	18.8	8.6	18.8
D	3	0.0	0.0	31.8	0.1	31.8	31.9	0.0	0.0	10.6	0.03	10.6
D	3	0.0	0.001	59.5	1.5	59.5	61.0	0.0	0.0	19.8	0.5	19.8
C	4	0.0	0.0	65.5	1.3	65.5	66.8	0.0	0.0	16.4	0.3	16.4
B	4	0.0	0.0	91.8	5	91.8	96.8	0.0	0.0	23.0	1.2	23.0
A	4	0.2	0.006	99.2	0.3	99.4	99.7	0.1	0.002	24.8	0.1	24.9

*Sum of Total Biomass and Inorganic material dry weight

Inorganic material = sediment/sand

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Table 8. 2017 East Pipeline Biota Site Sample Mussel Mass [g; Wet Weight (Dry Weight)]

n	Minimum	Mean	Maximum
27	0.38 (0.02)	35.08 (16.07)	107.71 (46.98)

Table 9. 2017 East Pipeline Biota Site Sample Mussel Density (Mussels/ft^2) by Study Zone and Pipeline Position

Study Zone	*n*	Mean Density of Size Class / ft^2				Mean Dry Weight (g) of Size / ft^2					
		Large (>10 mm)	Medium (5-10 mm)	Small (<5 mm)	Mean Density All Classes	Large (>10 mm)	Medium (5-10 mm)	Small (<5 mm)	Mussel Shell Fragments	Mean Dry Weight Mussels Only	Mean Dry Weight Mussels + Fragments
A	3	95.5	3.8	7.6	106.9	51.9	0.1	0.0	49.5	52.0	101.5
B	3	7.6	3.8	0.0	11.4	3.3	0.1	0.0	9.3	3.4	12.7
C	3	229.2	15.3	3.8	248.3	119.6	0.4	0.0	94.8	120.0	214.8
D	3	210.1	68.8	68.8	347.7	74.8	0.7	0.1	46.1	75.6	121.7
D	3	255.9	114.6	68.8	439.3	127.0	4.4	0.2	95.5	131.6	227.1
C	4	232.0	17.2	5.7	254.9	142.4	0.1	0.0	45.0	142.5	187.5
B	4	452.6	60.2	25.8	538.6	205.2	0.5	0.1	57.2	205.8	263.0
A	4	398.2	108.9	85.9	593.0	187.5	1.5	0.2	95.1	189.2	284.3

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

Table 10. 2017 East Pipeline Biota Site Sample Mussel Mass by Study Zone [g; Wet Weight (Dry Weight)]

Study Zone	*n*	Minimum	Mean	Maximum
A	3	15.10 (7.60)	17.04 (8.86)	19.92 (10.74)
B	3	0.55 (0.02)	1.84 (1.11)	4.03 (2.42)
C	3	22.98 (11.48)	37.32 (18.75)	48.21 (24.06)
D	6	9.40 (4.29)	32.51 (15.22)	54.27 (24.42)
C	4	0.38 (0.34)	34.33 (16.36)	54.60 (25.99)
B	4	30.28 (12.27)	54.46 (22.95)	83.37 (36.77)
A	4	5.35 (2.40)	57.07 (24.80)	107.71 (46.98)

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

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Table 11. 2017 East Pipeline Biota Site Sample Mussel Mass by Study Zone and Pipeline Position [g; Wet Weight (Dry Weight)]

Study Zone	Pipeline Position	*n*	Wet Weight (Dry Weight)
A	Top	1	16.09 (8.23)
	East	1	19.92 (10.74)
	West	1	15.10 (7.60)
	Bottom	-	-
B	Top	1	4.03 (2.42)
	East	1	0.95 (0.87)
	West	1	0.55 (0.02)
	Bottom	-	-
C	Top	1	40.78 (20.72)
	East	1	22.98 (11.48)
	West	1	48.21 (24.06)
	Bottom	-	-
D	Top	2	9.41 - 28.66 (4.29 - 14.21)*
	East	2	38.05 - 54.27 (17.33 - 24.42)*
	West	2	22.47 - 56.09 (10.23 - 20.82)*
	Bottom	-	-
C	Top	1	46.40 (21.50)
	East	1	54.60 (25.99)
	West	1	35.96 (17.63)
	Bottom	1	0.38 (0.34)
B	Top	1	30.28 (12.27)
	East	1	61.88 (25.54)
	West	1	83.37 (36.77)
	Bottom	1	42.31 (17.24)
A	Top	1	5.35 (2.40)
	East	1	107.71 (46.98)
	West	1	67.44 (30.78)
	Bottom	1	47.76 (19.04)

*n = 2, reported as a range of results

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

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Table 12. 2017 West Pipeline Biota Thickness Measurements (mm)

Site ID	Pipe End	Study Zone	Mussel colonization	Sample depth (ft)	Biota Thickness 1	Biota Thickness 2	Biota Thickness 3	Minimum	Mean	Maximum	GeoMean	Std. Deviation
W-S1	North	A	Moderate	77	20.2	18.2	19.2	18.2	19.2	20.2	19.2	1.0
W-S3	North	C	Heavy	188	16.2	17.2	15.2	15.2	16.2	17.2	16.1	1.0
W-S4	N/A	D	Heavy	234	16.2	16.2	20.2	16.2	17.5	20.2	17.4	2.3
W-S7	South	B	Heavy	129	8.1	14.1	12.1	8.1	11.5	14.1	11.2	3.1

All thickness measures and relative statistics are represented in millimeters (mm)

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

Table 13. 2017 West Pipeline Biota Site Sample Dry Weight (g) Summary Statistics by Study Zone and Pipeline Position

Study Zone	*n*	Sum						Mean				
		Periphyton	Macroinvertebrate	Mussel	Inorganic	Total Biomass	Total*	Periphyton	Macroinvertebrate	Mussel	Inorganic	Biomass
A	4	0.1	0.0	14.3	0.2	14.3	14.5	0.01	0.0	3.6	0.05	3.6
B	3	0.0	0.0	69.8	5.4	69.8	75.2	0.0	0.0	23.3	1.8	23.3
C	4	0.0	0.0	59.8	0.6	59.8	60.4	0.0	0.0	15.0	0.1	15.0
D	4	0.0	0.0	60.1	0.5	60.1	60.6	0.0	0.0	15	0.1	15.0
D	3	0.0	0.0	30.1	0.1	30.1	30.2	0.0	0.0	10	0.03	10.0
C	3	0.0	0.0	38.2	0.1	38.2	38.4	0.0	0.0	12.7	0.04	12.7
B	4	0.0	0.002	83.7	0.6	83.7	84.3	0.0	0.001	20.9	0.1	20.9
A	3	0.02	0.0	0.5	2	0.6	2.6	0.01	0.0	0.2	0.7	0.2

*Sum of Total Biomass and Inorganic material dry weight

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Table 14. 2017 West Pipeline Biota Site Sample Mussel Mass [g; Wet Weight (Dry Weight)]

n	Minimum	Mean	Maximum
28	0.00 (0.00)	28.53 (12.73)	66.54 (29.11)

Table 15. 2017 West Pipeline Mussel Density (Mussels/ft^2) by Study Zone and Pipeline Position

Study Zone	*n*	Mean Number of Size Class / ft^2				Mean Dry Weight (g) of Size / ft^2					
		Large (>10 mm)	Medium (5-10 mm)	Small (<5 mm)	Mean Density All Classes	Large (>10 mm)	Medium (5-10 mm)	Small (<5 mm)	Mussel Shell Fragments	Mean Dry Weight Mussels Only	Mean Dry Weight Mussels + Fragments
A	4	85.9	57.3	11.5	154.7	29.4	0.5	0.0	10.9	29.9	40.8
B	3	404.9	84.0	38.2	527.1	187.2	1.0	0.1	78.3	188.3	266.6
C	4	220.6	51.6	54.4	326.6	101.5	0.5	0.1	69.3	102.1	171.4
D	4	249.2	77.3	25.8	352.3	108.2	0.7	0.1	63.0	109.0	172.0
D	3	194.8	68.8	61.1	324.7	75.8	0.7	0.2	38.2	76.7	114.9
C	3	194.8	95.5	156.6	446.9	102.0	0.9	0.2	42.8	103.1	145.9
B	4	386.7	48.7	80.2	515.6	158.7	0.4	0.1	80.6	159.2	239.8
A	3	7.6	0.0	0.0	7.6	1.3	0.0	0.0	0.7	1.3	2.0

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

Table 16. 2017 West Pipeline Biota Site Sample Mussel Mass by Study Zone [g; Wet Weight (Dry Weight)]

Study Zone	*n*	Minimum	Mean	Maximum
A	4	0.00 (0.00)	7.79 (3.57)	23.52 (10.96)
B	3	46.64 (19.83)	52.82 (23.26)	58.09 (26.90)
C	4	20.82 (11.05)	31.25 (14.96)	47.24 (20.78)
D	7	0.00 (0.00)	28.88 (12.88)	66.54 (29.11)
C	3	15.93 (5.72)	31.44 (12.74)	48.82 (19.52)
B	4	30.18 (14.33)	46.57 (20.93)	66.21 (28.68)
A	3	0.00 (0.00)	0.47 (0.18)	1.21 (0.44)

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

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Table 17. 2017 West Pipeline Biota Site Sample Mussel Mass by Study Zone and Pipeline Position [g; Wet Weight (Dry Weight)]

Study Zone	Pipeline Position	*n*	Wet Weight (Dry Weight)
A	Top	1	0.00 (0.00)
	East	1	5.07 (1.98)
	West	1	2.58 (1.35)
	Bottom	1	23.52 (10.96)
B	Top	1	53.72 (23.05)
	East	1	46.64 (19.83)
	West	1	58.09 (26.90)
	Bottom	-	-
C	Top	1	20.82 (11.05)
	East	1	25.65 (13.24)
	West	1	47.24 (20.78)
	Bottom	1	31.29 (14.76)
D	Top	2	0.00 - 1.36 (0.00 - 0.94)*
	East	2	33.69 - 66.54 (15.18 - 29.11)*
	West	2	35.40 - 56.17 (14.88 - 25.01)*
	Bottom	1	9.04 (5.01)
C	Top	1	29.59 (12.99)
	East	1	48.82 (19.52)
	West	1	15.93 (5.72)
	Bottom	-	-
B	Top	1	37.14 (18.07)
	East	1	52.76 (22.63)
	West	1	66.21 (28.68)
	Bottom	1	30.18 (14.33)
A	Top	1	0.00 (0.00)
	East	1	0.18 (0.09)
	West	1	1.21 (0.44)
	Bottom	-	-

*n = 2, reported as a range of results

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

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Table 18. 2017 East Pipeline Area of Interest and Additional Sites Mussel Mass with Paired Adjacent Samples [g; Wet Weight (Dry Weight)]

n		Min		Mean		Max	
AOI/AS	Adjacent	AOI/AS	Adjacent	AOI/AS	Adjacent	AOI/AS	Adjacent
5	5	0.00 (0.00)	9.29 (4.42)	14.16 (5.15)	24.24 (13.90)	49.48 (25.75)	48.87 (25.29)

Table 18. 2017 West Pipeline Area of Interest and Additional Sites Mussel Mass with Paired Adjacent Samples [g; Wet Weight (Dry Weight)]

n		Min		Mean		Max	
AOI/AS	Adjacent	AOI/AS	Adjacent	AOI/AS	Adjacent	AOI/AS	Adjacent
5	5	0.00 (0.00)	0.00 (0.00)	3.30 (1.53)	39.32 (17.40)	6.92 (3.64)	67.25 (27.01)

Table 19. 2017 East Pipeline Area of Interest and Additional Sites Mussel Mass with Paired Adjacent Samples by Study Zone [g; Wet Weight (Dry Weight)]

Study Zone	*n*		Min		Mean		Max	
	AOI/AS	Adjacent	AOI/AS	Adjacent	AOI/AS	Adjacent	AOI/AS	Adjacent
A	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-
C	1	1	49.48 (25.75)	9.87 (4.42)	49.48 (25.75)	9.87 (4.42)	49.48 (25.75)	9.87 (4.42)
D	1	1	0.00 (0.00)	9.29 (4.79)	0.00 (0.00)	9.29 (4.79)	0.00 (0.00)	9.29 (4.79)
C	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-
A	3	3	0.00 (0.00)	21.34 (13.66)	7.11 (0.00)	34.02 (20.10)	21.34 (0.00)	48.87 (25.29)

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

Table contents are represented in a north to south manner from top to bottom

Table 19. 2017 West Pipeline Area of Interest and Additional Sites Mussel Mass with Paired Adjacent Samples by Study Zone [g; Wet Weight (Dry Weight)]

Study Zone	*n*		Min		Mean		Max	
	AOI/AS	Adjacent	AOI/AS	Adjacent	AOI/AS	Adjacent	AOI/AS	Adjacent
A	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-
C	-	-	-	-	-	-	-	-
D	2	2	0.00 (0.00)	44.07 (18.34)	3.46 (1.43)	46.73 (21.02)	6.92 (2.86)	49.39 (23.70)
C	1	1	0.00 (0.00)	35.90 (17.96)	0.00 (0.00)	35.90 (17.96)	0.00 (0.00)	35.90 (17.96)
B	1	1	6.74 (3.64)	67.25 (27.01)	6.74 (3.64)	67.25 (27.01)	6.74 (3.64)	67.25 (27.01)
A	1	1	2.85 (1.18)	0.00 (0.00)	2.85 (1.18)	0.00 (0.00)	2.85 (1.18)	0.00 (0.00)

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

Table contents are represented in a north to south manner from top to bottom

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Table 20. 2017 Areas of Interest, Additional Sites and Paired Adjacent Sample Dry Weights (g)

Pipeline	Zone	Site Type	Periphyton	Macroinvertebrate	Mussel	Total Biomass	Inorganic	Total*
East	C	Area of Interest	0.0	0.0	25.7	25.7	7.8	33.6
		Adjacent	0.0	0.0	4.4	4.4	0.0	4.4
	D	Area of Interest	0.0	0.0	0.0	0.0	0.001	0.001
		Adjacent	0.0	0.0	4.8	4.8	0.03	4.8
	A	Area of Interest	0.0	0.0	0	0	0.2	0.2
		Adjacent	2.6	0.002	21.3	24.0	0.5	24.5
		Additional Site	0.0	0.0	0.0	0.0	0.5	0.5
		Adjacent	0.01	0.0	13.67	13.7	0.02	13.7
		Additional Site	0.02	0.0	0	0.016	0.03	0.05
		Adjacent	2.3	0.0	25.3	27.5	3.2	30.7
West	D	Area of Interest	0.0	0.0	0.0	0.0	0.04	0.04
		Adjacent	0.0	0.001	23.7	23.7	1.4	25.1
	D	Additional Site	0.0	0.0	2.9	2.9	0.4	3.3
		Adjacent	0.0	0.0	18.3	18.3	0.7	19.1
	C	Area of Interest	0.0	0.0	0.0	0.0	0.0	0.0
		Adjacent	0.0	0.0	18.0	18.0	0.2	18.2
	B	Area of Interest	0.0	0.001	3.6	3.6	8.8	12.5
		Adjacent	0.0	0.001	27.0	27.0	0.04	27.1
	A	Area of Interest	0.01	0.001	1.2	1.2	0.3	1.5
		Adjacent	0.0	0.0	0.0	0.0	0.0	0.0

*Sum of Total Biomass and Inorganic material (sediment/sand) dry weight

Table contents are represented in a north to south manner from top to bottom by pipeline

Table 21. 2017 East Pipeline Bottom Water Chemistry Measurements

Site ID	Date	Depth (ft)	Temperature (°C)	Specific Conductance (µS/cm)	pH	ORP (mV)	Turbidity (FNU)	DO (% sat)	DO (mg/L)
E-S3 E-AOI1	9/8/2017	193	8.9	209.7	8.0	101.2	0.62	95.6	11.07
EAS-3*	12/15/2017	118	3.1	234.3	8.43	56.1	0.10	90.1	12.09
E-S8 E-AOI7	9/5/2017	76	12.99	227.6	8.1	59.9	0.21	94.4	9.94
E-AOI8	9/6/2017	78	12.42	226.6	8.24	74.7	0.22	93.3	9.96
E-10*	12/13/2017	70	3.57	220.6	8.2	167.8	1.95	94.2	12.48

*Water chemistry meter attached to dive bell - readings were taken near, but not on bottom

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details): E-S3 and E-AOI1; E-S8 and E-AOI7

Table 21. 2017 West Pipeline Bottom Water Chemistry Measurements

Site ID	Date	Depth (ft)	Temperature (°C)	Specific Conductance (µS/cm)	pH	ORP (mV)	Turbidity (FNU)	DO (% sat)	DO (mg/L)
W-S4 W-AOI1	9/7/2017	234	7.59	204.5	8.06	79.4	0.22	95.1	11.37
W-AOI6	9/6/2017	88	10.9	218.8	8.131082	84.2	1.35	93.9	10.38131

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details): W-S4 and W-AOI1

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Table 22. 2017 APB and SRB Field Test Kit QA/QC Results

Sample ID	Sample Date	Pipeline	Depth Zone	Sample depth (ft)	Material Sampled	BioSan Acid Production Category	BioSan Sulfate Reducer Production Category
TAPH2OB	8/22/2017				Tap water, sample container, seive, mesh	Strong	Generally insignificant
LAKEH2OB	8/22/2017	-	-	-	Lake surface water from sprayer, sample container, seive, mesh	Strong	Generally insignificant
SSLAKEH2OB	8/26/2017	-	-	178	Lake bottom water, sample container, seive, mesh	Strong	Generally insignificant
DIH2OB	8/27/2017	-	-	-	Distilled water, sample container, seive, mesh	Strong	Generally insignificant
BOTH2OB	9/7/2017	-	-	-	Bottled water (Enon Springs) - swabs directly into water	No production	Heavy
LAKEH2OB2	9/7/2017	-	-	-	Lake surface water from sprayer-swabs directly into water	No production	Generally insignificant
SSLAKEH2OB2	9/7/2017	-	-	201	Lake bottom water-swabs directly into water	Strong	Generally insignificant
SSLAKEH2OB2DUP						Strong	Generally insignificant
MBOTH2OB	9/7/2017	-	-	-	Bottled water (Enon Springs), mesh-swabs held under mesh	Strong	Generally insignificant
MLAKEH2OB	9/7/2017	-	-	-	Lake surface water from sprayer, mesh-swabs held under mesh	Medium	Generally insignificant
TAPH2OB2	9/8/2017	-	-	-	Tap water-swabs directly into water	Medium	Generally insignificant
DIH2OB2	9/8/2017	-	-	-	Distilled water-swabs directly into water	No production	Generally insignificant
SSLAKEH2OB3	9/8/2017	East	C	194	Lake bottom water-swabs directly into water	No production	Generally insignificant
GDIH2OB	9/8/2017	-	-	-	Distilled water, nitrile glove	No production	Generally insignificant
GDIH2OBDUP						No production	Heavy
TENTATMB	9/8/2017	-	-	-	Sample processing tent air	No production	Generally insignificant
TENTATMBDUP						No production	Generally insignificant
SSLAKEH2OB4	9/8/2017	West	B	129	Lake bottom water-swabs directly into water	No production	Generally insignificant
SSLAKEH2OB4DUP						Strong	Generally insignificant
LAKEH2OB4	9/8/2017	-	-	3	Dipped bottle lake surface water-swabs directly into water	No production	Generally insignificant
LAKEH2OB4DUP						Strong	Generally insignificant
DIH2OB3	9/9/2017	-	-	-	Distilled water, sample container	Strong	Generally insignificant
DWNISBLK01	12/13/2017	-	-	-	Distilled water, Niskin water sampler	No production	Generally insignificant
DWNISBLK01DUP						Weak	Generally insignificant
DWVDBLK02	12/13/2017	-	-	-	Distilled water, Van Dorn water sampler	No production	Generally insignificant
DWVDBLK02DUP						Weak	Generally insignificant
DWBSBLK03	12/13/2017	-	-	-	Distilled water, biota/sediment sampler	Medium	Generally insignificant
DWBSBLK03DUP						Medium	Generally insignificant
STWBLK04	12/13/2017	-	-	-	Sterile water	No production	Generally insignificant
STWBLK04DUP						No production	Generally insignificant
STWVDBLK05	12/13/2017	-	-	-	Sterile water, Van Dorn water sampler	No production	Generally insignificant
STWVDBLK05DUP						No production	Generally insignificant
STWBSBLK06	12/13/2017	-	-	-	Sterile water, biota/sediment sampler	No production	Generally insignificant
STWBSBLK06DUP						No production	Generally insignificant
DWNISBLK07	12/14/2017	-	-	-	Distilled water, Niskin water sampler	Weak	Generally insignificant
DWNISBLK07DUP						Medium	Generally insignificant
DWVDBLK08	12/14/2017	-	-	-	Distilled water, Van Dorn water sampler	Weak	Generally insignificant
DWVDBLK08DUP						No production	Generally insignificant
DWBSBLK09	12/14/2017	-	-	-	Distilled water, biota/sediment sampler	Medium	Generally insignificant
DWBSBLK09DUP						Weak	Generally insignificant
STWBSBLK10	12/14/2017	-	-	-	Sterile water, biota/sediment sampler	No production	Generally insignificant
STWBSBLK10DUP						No production	Generally insignificant
STWBLK11	12/14/2017	-	-	-	Sterile water	No production	Generally insignificant
STWBLK11DUP						No production	Generally insignificant
STWNISBLK12	12/14/2017	-	-	-	Sterile water, Niskin water sampler	No production	Generally insignificant
STWNISBLK12DUP						No production	Generally insignificant

"DUP" = represents a duplicate taken concurrently from the same sample as the initial (aka "parent") sample, that is shown in the preceding row

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Table 23. 2017 East Pipeline APB and SRB Field Test Kit Results

Site ID	Study Zone	Sample depth (ft)	Pipeline position	Sample ID	Material Sampled	BioSan Acid Production Category	BioSan Sulfate Reducer Production Category
E-S1	A	71	Top	EPZANT10	Biota sample	Strong	Heavy
			East	EPZANE09	Biota sample	Strong	Heavy
			West	EPZANW07	Biota sample	Strong	Heavy
E-S2	B	144	Top	EPZBNT06	Biota sample	Strong	Heavy
			East	EPZBNE02	Biota sample	Strong	Heavy
			West	EPZBNW05	Biota sample	Strong	Heavy
E-S3	C	194	Top	EPZCNT10	Biota sample	Strong	Heavy
			East	EPZCNE02	Biota sample	Strong	Heavy
			West	EPZCNW07	Biota sample	Strong	Heavy
E-AOI1	C	194	West	EPZCNW05	Biota sample	Strong	Heavy
			West	EPZCNW14	Biota sample	Strong	Heavy
E-S4	D	216	West	EPZDW11	Biota sample	Strong	Heavy
			East	EPZDE08	Biota sample	Strong	Heavy
			Top	EPZDT04	Biota sample	Strong	Heavy
E-AOI2	D	216	West	EPZDW03	Biota sample	Strong	Heavy
			West	EPZDW12	Biota sample	Strong	Heavy
E-S5	D	229	Top	EPZDT05	Biota sample	Strong	Heavy
			West	EPZDW10	Biota sample	Strong	Heavy
			East	EPZDE09	Biota sample	Strong	Heavy
E-S6	C	175	Top	EPZCST07	Biota sample	Strong	Heavy
			Bottom	EPZCST02	Biota sample	Strong	Heavy
			East	EPZCST01	Biota sample	Strong	Heavy
			West	EPZCSW04	Biota sample	Strong	Moderate-Heavy
E-S7	B	149	East	EPZBSE07	Biota sample	Strong	Heavy
			West	EPZBSW12	Biota sample	Strong	Heavy
			Bottom	EPZBSB06	Biota sample	Strong	Heavy
			Top	EPZBST11	Biota sample	Strong	Heavy
E-AOI6	A	82	West	170905-EAOI6DC	Presumed detached coating	Strong	Heavy
E-S8	A	81	Top	EPZAST03	Biota sample	Strong	Heavy
			East	EPZASE05	Biota sample	Strong	Heavy
			West	EPZASW06	Biota sample	Strong	Heavy
			Bottom	EPZASB07	Biota sample	Strong	Heavy
E-AOI7	A	81	West	EPZASW11	Biota sample	Strong	Heavy
			West	EPZASW10	Biota sample	Strong	Heavy
E-AOI9	A	82	West	170906-EAOI9MOI	Material of interest	Strong	Heavy
E-AOI10	A	77	West	170906-EAOI10MOI	Material of interest	Strong	Heavy
E-AS1	A	74	West	EPZASW02	Biota sample	Strong	Heavy
			West	EPZASW11	Biota sample	Strong	Heavy
E-AOI11	A	72	Top	170824-EAOI11DC	Presumed detached coating	Strong	Heavy
E-AS2	A	75	West	EPZASW11	Biota sample	Strong	Heavy
			West	EPZASW04	Biota sample	Strong	Heavy
			West	EPZASW04DUP	Biota sample	Strong	Heavy
			West	EPZASW07CD	Presumed calcium deposit	Strong	Heavy

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details):

E-S3 and E-AOI1; E-S4 and E-AOI2; E-S8 and E-AOI7

Table contents are represented in a north to south manner from top to bottom

Table 24. 2017 West Pipeline APB and SRB Field Test Kit Results

Site ID	Study Zone	Sample depth (ft)	Pipeline position	Sample ID	Material Sampled	BioSan Acid Production Category	BioSan Sulfate Reducer Production Category
W-S1	A	77	Top	WPZANT12	Biota sample	Strong	Heavy
			Bottom	WPZANB05	Biota sample	Strong	Heavy
			East	WPZANE11	Biota sample	Strong	Heavy
			West	WPZANW04	Biota sample	Strong	Heavy
W-S2	B	128	Top	WPZBNT10	Biota sample	Strong	Heavy
			East	WPZBNE09	Biota sample	Strong	Heavy
			West	WPZBNW02	Biota sample	Strong	Heavy
W-S3	C	188	Top	WPZCNT03	Biota sample	Strong	Heavy
			Bottom	WPZCNB01	Biota sample	Strong	Heavy
			East	WPZCNE05	Biota sample	Strong	Heavy
			West	WPZCNW10	Biota sample	Strong	Heavy
W-S4	D	234	Top	WPZDT04	Biota sample	Strong	Heavy
			East	WPZDE07	Biota sample	Strong	Heavy
			East	WPZDE07DUP	Biota sample	Strong	Heavy
			West	WPZDW10	Biota sample	Strong	Heavy
			Bottom	WPZDTB12	Biota sample	Strong	Heavy
W-AOI1	D	234	East	WPZDTE01	Biota sample	Strong	Heavy
			East	WPZDTE06	Biota sample	Strong	Heavy
			East	170907-WAOI1MOI	Material of interest	Strong	Heavy
W-S5	D	245	Top	WPZDT05	Biota sample	Strong	Heavy
			East	WPZDE06	Biota sample	Strong	Heavy
			West	WPZDW09	Biota sample	Strong	Heavy
W-AOI2	D	201	West	170907-WAOI2CD	Presumed calcium deposit	Strong	Heavy
W-AS1	D	201	Top	WPZDT06	Biota sample	Strong	Heavy
			Top	WPZDT04	Biota sample	Strong	Heavy
W-S6	C	178	Top	WPZCST12	Biota sample	Strong	Heavy
			West	WPZCSW04	Biota sample	Strong	Heavy
			East	WPZCSE06	Biota sample	Strong	Heavy
W-AOI3	C	178	West	WPZCSW01	Biota sample	Strong	Heavy
			West	WPZCSW02	Biota sample	Strong	Heavy
W-S7	B	129	Top	WPZBST04	Biota sample	Strong	Heavy
			East	WPZBSE06	Biota sample	Strong	Heavy
			West	WPZBSW12	Biota sample	Strong	Heavy
			Bottom	WPZBSB07	Biota sample	Strong	Heavy
W-AOI4	B	129	East	WPZBSE13	Biota sample	Strong	Heavy
			East	WPZBSE03	Biota sample	Strong	Heavy
W-AOI5	A	100	East	170821-WAOI5DC	Presumed detached coating	Strong	Heavy
W-S8	A	80	Top	WPZAST08	Biota sample	Strong	Heavy
			East	WPZASE03	Biota sample	Strong	Heavy
			West	WPZASW12	Biota sample	Strong	Heavy
W-AOI7	A	80	Top	WPZAST01	Biota sample	Strong	Heavy
			Top	WPZAST02	Biota sample	Strong	Heavy

Sampling at the following Biota sampling locations and Areas of Interest occurred within 10-30 feet of each other (see Section 2.5.3.2 of Report for further details):

W-S4 and W-AOI1; W-S6 and W-AOI3; W-S7 and W-AOI4; W-S8 and W-AOI7

Table contents are represented in a north to south manner from top to bottom

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Table 25. 2017 Water and Sediment APB and SRB Field Test Kit Results

Site ID	Study Zone	Sample Depth (ft)	Sample ID	Material Sampled	BioSan Acid Production Category	BioSan Sulfate Reducer Production Category
E-AS3	B	1	EPZBS-WS-01	Surface water	No production	Generally insignificant
		70	EPZBS-WM-06	Mid-column water	No production	Generally insignificant
		137	EPZBS-WB-05	Bottom water	No production	Generally insignificant
		137	EPZBS-S1-04	Sediment - replicate #1	Strong	Heavy
		137	EPZBS-S2-05	Sediment - replicate #2	Strong	Heavy
E-10	A	1	EPZAS-WS-02	Surface water	No production	Generally insignificant
		42	EPZAS-WM-04	Mid-column water	Medium	Generally insignificant
		87	EPZAS-WB-03	Bottom water	Weak	Generally insignificant
		87	EPZAS-S1-01	Sediment - replicate #1	Strong	Heavy
		87	EPZAS-S1-03	Sediment - replicate #1 duplicate	Strong	Heavy
		87	EPZAS-S2-02	Sediment - replicate #2	Strong	Heavy

Table 26. 2017 APB and SRB Assay Frequency of Detection (%)

Bacteria Assay	Biota (n=70)	Sediment (n=4)	Water (n=6)
APS-1	90.0	100.0	100.0
APS-2	98.6	100.0	100.0
APS-3	88.6	100.0	83.3
APS-4	0.0	0.0	0.0
APS-5	0.0	0.0	0.0
APS-6	0.0	0.0	0.0
APS-7	0.0	0.0	0.0
AGN-1	8.6	25.0	50.0
AGN-2	30.0	25.0	100.0
AGN-3	1.4	0	50.0
AGN-7	8.6	25.0	0.0
AGN-8	0.0	0	0.0

Results below detection limits not included

APS = SRB assays; AGN = APB assays

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Appendices

Appendix A: 2017 Biota Sampling Checklist

Appendix B: 2017 Biota Investigation Work Plan Addendums

Appendix C: 2017 Representative Photographs of Biota, Water and Sediment Collection Efforts

Appendix D: 2017 BioSan APB and SRB Field Test Kit Instructions

Appendix E: 2017 GEI Denver Lab Standard Operating Procedures: Evaluation of Line 5 Samples

Appendix F: 2017 GEI Laboratory Analyses

Appendix G: 2017 Microbial Insights Standard Operating Procedures for DNA Extraction and qPCR: Evaluation of Line 5 Samples

Appendix H: 2017 GEI Field Data Sheets

Appendix I: 2017 GEI Line 5 Daily Field Activity Logs

Appendix J: 2017 GEI Chain-of-Custody Forms

Appendix K: 2017 Phycotech Laboratory Analyses

Appendix L: 2017 GEI Lab Statistical Analyses Tables for Biota Samples

Appendix M: 2017 Water Chemistry Measurements

Appendix N: 2017 Microbial Insights Biota, Water, and Sediment Census qPCR DNA Analysis Results and Lab Report

Appendix O: ATS Line 5 Pipeline Byssal Thread Investigation Report of Findings

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Appendix A

2017 Biota Sampling Checklist

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16 Biota Sites Sampling Checklist

Date: **Time:** **Location ID:** **Depth (ft) @ pipeline:**

Crew initials:

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☐	
Random-select number (1-100), ROV navigates that distance in feet along pipeline		☐	
Slow pan of pipeline by ROV			
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☐	
Identify relative level of mussel colonization via footage from ROV		☐	
	Use chart to confirm mussel density	☐	
	Video/snapshot of comparison to mussel density reference card	☐	
Diver descends to ROV position on pipeline		☐	
Biota thickness measures via flexible tape		☐	
	Measure 1 at site where pipeline was first touched by diver	☐	
	Measure 2 approx. 3' north or south from measure 1	☐	
	Measure 3 approx. 3' north or south from measure 2	☐	
Clean pipe measures			
	Remove all attached material then measure circumference at the 3 biota thickness measure sites	☐	
Biota sampling		☐	
	Diver walk upcurrent slighlty from last measurement site	☐	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☐	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☐	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☐	
	Repeat paired sampling on the other areas of pipeline	☐	
	Verify collection of 8 samples (or 6 if pipeline is buried)	☐	
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for ecological lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

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7 Areas of Interest at Biota Sites Sampling Checklist - *for use at 7 Biota Sites Coinciding with Area of Interest*

Date: **Time:** **Location ID:** **Depth (ft) @ pipeline:**

Crew initials:

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☐	
ROV arrival at AOI, slow pan of pipeline with ROV		☐	
	Focus on Area of Interest	☐	
	Evaluate for other Area(s) of Interest, holidays, maintenance signs	☐	
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☐	
Identify relative level of mussel colonization			
	Use chart to identify mussel density at Area of Interest	☐	
	Video/snapshot of comparison to mussel density reference card	☐	
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☐	
	Video/snapshot of comparison to mussel density reference card	☐	
Biota sampling @ Area of Interest		☐	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☐	
	Collect one sample from Area of Interest	☐	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if AOI is small, receive confirmation from topside	☐	
	Repeat paired sampling 3 feet upcurrent of Area of Interest, verify collection of 4 total samples	☐	
Random-select number (10-30), ROV navigates that distance in feet along pipeline		☐	
	Proceed into current that distance (in feet) and touch pipeline	☐	
Slow pan of pipeline by ROV and/or diver		☐	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☐	
Identify relative level of mussel colonization		☐	
	Use chart to identify mussel density	☐	
	Video/snapshot of comparison to mussel density reference card	☐	
Biota thickness measures via flexible tape		☐	
	Measure 1 at site where pipeline was first touched	☐	
	Measure 2 approx. 3' north or south from measure 1	☐	
	Measure 3 approx. 3' north or south from measure 2	☐	
Clean pipe measures		☐	
	Remove all attached material then measure circumference at 3 biota thickness measure sites	☐	
Biota sampling		☐	
	Diver walk upcurrent slighlty from last measurement site	☐	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☐	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☐	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☐	
	Repeat paired sampling on the other areas of pipeline	☐	
	Confirm collection of 8 samples (or 6 if pipeline is buried)	☐	
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for ecological lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers		
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

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11 Areas of Interest, 3 "Additional Sites" (non-Biota Sites) Checklist

Date: **Time:** **Location ID:** **Depth (ft) @ pipeline:**

Crew Initials:

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☐	
ROV arrival at AOI, slow pan of pipeline with ROV		☐	
	Focus on Area of Interest	☐	
	Evaluate for other Area(s) of Interest, holidays, maintenance signs	☐	
	If Holiday is identified, incorporate Holiday Biota sampling protocol and checklist. Biota sampling only if Holiday found.	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☐	
Identify relative level of mussel colonization			
	Use chart to identify mussel density at Area of Interest	☐	
	Video/snapshot of comparison to mussel density reference card	☐	
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☐	
	Video/snapshot of comparison to mussel density reference card	☐	

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Holiday Area Biota Sampling Checklist - only fill out if Holiday Area is found

Date: **Time:** **Location ID:** **Depth (ft) @ pipeline:**

Crew Initials:

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☐	
ROV arrival at potential Holiday Area		☐	
Slow pan of pipeline		☐	
	Focus on Holiday Area	☐	
	Evaluate for Area(s) of interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☐	
Identify relative level of mussel colonization		☐	
	Use chart to identify mussel density at Holiday Area	☐	
	Video/snapshot of comparison to mussel density reference card	☐	
	Use chart to identify mussel density 3 feet upcurrent of Holiday Area	☐	
	Video/snapshot of comparison to mussel density reference card	☐	
Biota sampling @ Holiday Area		☐	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☐	
	Collect one sample from Holiday Area	☐	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if Holiday Area is small, receive confirmation from topside	☐	
	Repeat paired sampling 3 feet upcurrent of Holiday Area, verify collection of 4 total samples	☐	
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for ecological lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

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Appendix B

2017 Biota Investigation Work Plan Addendums

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ENBRIDGE

Biota Investigation Work Plan: Addendum A

The following amendments to procedures set forth in the Biota Investigation Work Plan (Work Plan) were approved by the EPA via emails on August 11, August 15, August 16, and August 21, 2017.

Section 3.2 Coating Inspections

Revision to Work Plan:

An Elcometer magnetic coating gauge will be used to measure the thickness of the coating. The effective range of the Elcometer magnetic coating thickness gauge is from 25mils (thousandths of an inch) to 250mils. Where the thickness of the coating is greater than 250mils, the reading at that point will be recorded as “greater than 250mils”. Where a reading of less than 25mils is obtained, the Polatrak Cathodic Protection (CP) tool will be used to determine whether a CP measurement is possible at this location. The Polatrak tool requires a direct metal-to-metal contact between the tip of the Polatrak tool and exterior wall of the pipe. If definitive CP readings are obtained the area will be considered a Holiday and the requirements in the Work Plan for a Holiday will be followed. If definitive CP readings are not obtained, the coating thickness at this point will be recorded as greater than 0 but less than 25mils.

Rationale for Change:

Due to potential difficulties using Ultrasonic Testing (UT) to determine coating thickness on bituminous coating underwater, the project team has identified an alternative means to measure the coating thickness. An Elcometer magnetic coating gauge will be used to measure the thickness of the coating instead of UT as outlined in Revision 2 of the Work Plan.

Section 3.5.2 Biota Measurements

Revision to Work Plan

To avoid potential bias, upon ROV arrival at a Biota sampling locations not pre-defined as an Area of Interest, the crew will generate a randomly- generated number (ranging from 1 - 100 feet). The ROV will then proceed into the current (or to the north) that given distance and the diver will be lowered to the ROV location to commence Biota measurements.

Rationale for Change:

The purpose of this change is to use the time required to travel the randomly-generated distance at the surface, rather than at depths where the diver has a limited amount of time to be submerged and complete the work.

Section 3.5.3 Biota Sampling

Revision to Work Plan

In addition to placing the biota on ice after recovering the samples, ethanol will also be applied to the samples to comply with DNR permitting, which requires euthanization of invasive species such as quagga and/or zebra mussels.

One of the paired samples will be considered a “Biota” sample, which will be submitted to the GEI ecological laboratory for analysis. The other sample from each pair is considered a “Bacterial” sample, in which the sample will be evaluated APB and SRB “test kits” manufactured by Biosan Laboratories for analysis “in the field.” The remainder of the “Bacterial” sample will be submitted to the Microbial Insights laboratory for storage. Mussels will be removed from the sample prior to submission to Microbial Insights as biofilm/periphyton is the target substrate for storage, rather than mussels. Ethanol will only be applied to the “Biota” sample and will not need to be applied to the “bacterial” samples.

Rationale for Change:

Addition of detail to the Work Plan due to DNR permit requirements.

Section 3.5.3.1 Biota Sampling at Areas of Interest

Revision to Work Plan

A total of seven (7) representative locations are selected for the Biota sampling at Areas of Interest – 3 on the East pipeline and 4 on the West pipeline. Paired sampling at the Area of Interest will occur. Following this, a number between10-30 will be randomly-selected. The diver will move up current (or whichever direction is safest for the diver if the current is perpendicular to the pipelines) that many feet to arrive at the randomly-selected position and biota sampling (6-8 samples around the pipeline) will occur at this location.

Rationale for Change:

The purpose of this change is to ensure that biota sampling is conducted at randomly-selected sites while minimizing the extent to which a diver is required to walk along the lake bed. Randomly-selecting a number between10-30 is within the range a diver can safely walk without using up too much bottom time.

Section 3.5.3.2 Biota Sampling at Any Holiday Found

Revision to Work Plan

Once the Remote Operated Vehicle identifies the Area of Interest at which various measurements will be taken, the diver on first approaching the pipe will collect four biota samples as identified in Figure 9 of the BIWP. If it is determined that there are no Holidays at the Area of Interest, the Biota samples that were collected will be properly disposed of per MDNR permit requirements. If, however, a Holiday is found at the Area of Interest the Biota samples taken from that location will be retained and analyzed as described in the Work Plan.

Rationale for Change:

This change is suggested as it is not possible to determine if any holidays might exist in the coating before the surface of the pipe is cleaned prior to undertaking the work described in the BIWP. If in the process of cleaning the pipe to take the various measurements as described Section 3.2 a Holiday is identified that would require the diver to then take such Biota samples. However in the process of cleaning the pipe as well as moving around the pipe silt and other materials are stirred up. By collecting Biota samples first it will minimize any extraneous silt or other materials being collected in these samples versus collecting the Biota samples after the pipe is cleaned.

Figures 1, 2, and 3

Revision to Work Plan

The following table with the approximate (+/-50ft) Global Positioning System (GPS) locations of each Area of Interest and Additional Site will be used by the general contractor to successfully locate the previously identified Areas of Interest and Additional Sites. The locations of Areas of Interest and Additional Sites shown on Figures 1, 2 and 3 of the Work Plan (Revision 2: May 18, 2017) are schematic representations only and not to be used for specifically locating the sites.

Actuals	Location	Description
Between E-74 & E-71	[redacted]	Area of Interest
Between E-77 & E-26	[redacted]	Area of Interest
Between E-24 & E-25	[redacted]	Area of Interest
E-30	[redacted]	Area of Interest
E-35	[redacted]	Area of Interest
Between E-33 & E-34B	[redacted]	Area of Interest
E-39	[redacted]	Area of Interest
Near E-48	[redacted]	Area of Interest

Actuals	Location	Description
Near E-70	[redacted]	Area of Interest
Between E-02 & E76	[redacted]	Area of Interest
E-01B-B	[redacted]	Area of Interest
Between W-10 & W-11	[redacted]	Area of Interest
W-12A	[redacted]	Area of Interest
Between W-15 & W-16	[redacted]	Area of Interest
W-35	[redacted]	Area of Interest
W-70	[redacted]	Area of Interest
W-68	[redacted]	Area of Interest
Between W-56 & W-54	[redacted]	Area of Interest
E-74	[redacted]	Additional Site
E-72	[redacted]	Additional Site
W-68A	[redacted]	Additional Site

Rationale for Change:

Figures 1, 2 and 3 included in the test plan were provided to show the general locations for all Areas of Interest and Additional Sites. After performing initial dives, it was determined that some of the marked locations in the figures of the Areas of Interest and Additional Sites did not fully correlate with the listed pipe spans. The table with the approximate (+/-50ft) Global Positioning System (GPS) locations of each Area of Interest and Additional Site is being provided to supplement and correct Figures 1, 2 and 3 of the Biota Investigation Work Plan (Revision 2: May 18, 2017). The GPS coordinates listed will be used by the general contractor to successfully locate the previously identified Areas of Interest and Additional Sites.

Figure 7

Revision to Work Plan

The lid and shape of the sample apparatus outlined in Figure 7 may be modified.

Rationale for Change:

To preserve the sample integrity during the sample collection activities.

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Biota Investigation Work Plan: Addendum B

Background and Rationale for this Addendum

The bacteria testing using the BioSan equipment conducted in accordance with the BIWP (Section 4.2) included testing on non-biota sample "blanks" (e.g. tap water), some of which showed unexpected levels of culturable bacteria. These results bring into question the sensitivity of the full test result data set regarding bacteria levels. As such, Enbridge, in consultation with external environmental experts, wishes to conduct additional sampling and testing in order to obtain more reliable and useful test results. The scope of this additional work for the BIWP (Section 4.2) is described below:

Additional Sampling and Testing of Lake Water and Bottom Sediments, and Genetic Bacterial Enumeration of Previously Collected Samples

The collection of additional bacterial samples (lake water and bottom sediment) will help establish background levels of bacteria, and will provide additional context to the biota samples collected from the Line 5 dual pipelines. Water and bottom sediments will be collected in conjunction with on-going barge operations. Integration logistics between barge operations and these additional sampling efforts are being developed with maintenance operations. As such, specific sampling locations and depths for water and sediment will be predicated by the barge work locations. Water and sediment samples will be collected at each site as described in the next section. Additionally, genetic bacterial analysis (quantitative polymerase chain reaction – qPCR) will be performed on both the new samples as well as the preserved biota samples from the original BIWP. In contrast with the BioSan culturing technique that may inconsistently incubate different bacterial strains, qPCR allows a more refined discrimination of bacterial population *as it existed* in the native environment. This can more precisely enumerate bacterial strains.

Water Sampling

Water samples will be collected at near surface (~ two feet of depth), approximate mid-depth, and near bottom for a total of three (3) water samples per location. Bottom water samples will be collected using a Niskin sampler (as with previous bottom water samples). All other water samples will be collected using a Van Dorn sampler. Samples will be shipped overnight to Microbial Insights for DNA extraction, qPCR testing and storage.

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Bottom sediments sampling

Sediment samples will be collected from the lake bed. Samples will be collected in pairs, adjacent to each other, to provide replicate data. The sampling technique will be finalized based on feedback from Ballard Marine; it is expected that sediment sampling containers will be developed using PVC pipe or lexan-type tubing similar to systems used for sediment coring. Sediment would be sampled to a depth of approximately two inches. Sediment samples will be shipped overnight to Microbial Insights for DNA extraction, qPCR testing and storage. Greater sediment depth may need to be sampled pending confirmation on sediment volume requirements for all lab work.

APB and SRB field testing

BioSan APB and SRB field test kits will be used on each water and sediment sample following BioSan test kit protocol. APB and SRB blanks will also be generated (in duplicate) daily at the rate of no less than one set of blanks per ten investigative water or sediment samples. Types of blanks will include, but not limited to, equipment blanks (Van Dorn and Niskin samplers, sediment sampling equipment, etc.), and water blanks (i.e., distilled). Decontamination procedures recommended by Microbial Insights are consistent with those employed during the initial sampling effort (i.e., wash with non-phosphate detergent followed by rinse with distilled water). Microbial Insights advised an ethanol rinse may be beneficial for additional decontamination (i.e., wash with non-phosphate detergent, rinse with distilled water, rinse with ethanol, rinse with distilled water). This will be added to the decontamination process for equipment blanks.

Field documentation

Efforts will be documented to the same level as that of biota sampling efforts. Field data sheets will be utilized for each sample site, all samples will be photographed with time-stamp, and a field notebook will be maintained to document all efforts. It is anticipated that a daily field log would be transmitted to Leggette, Brashears, and Graham, Inc. and Enbridge on a daily basis.

Results reporting

Data generated through these efforts shall be evaluated and summarized. Summaries will include, but not limited to, figures depicting sediment sampling and water sampling locations, and the associated results from the APB/SRB test kits and qPCR testing. This information will be included in the BIWP report.

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Appendix C

2017 Representative Photographs of Biota, Water and Sediment Collection Efforts

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Photo 1. DR03 - Tugboat steaming barge to pipeline location

Photo 2. Tugboat positioning barge prior to anchoring

Photo 3. Barge Deck - Dive shacks located in Conex boxes (left); Sample processing tent (right)

Photo 4. Sample processing tent

Photo 5. ROV units prior to deployment; support vessel in background

Photo 6. View of ROV operation station from within the dive shack

Photo 7. Heavy mussel colonization on the west pipe position

Photo 8. View of pipeline biota colonization

Photo 9. Round Gobies foraging proximal to the pipeline

Photo 10. Pre-dive visual inspection footage

Photo 11. Diver performing biota thickness measurements

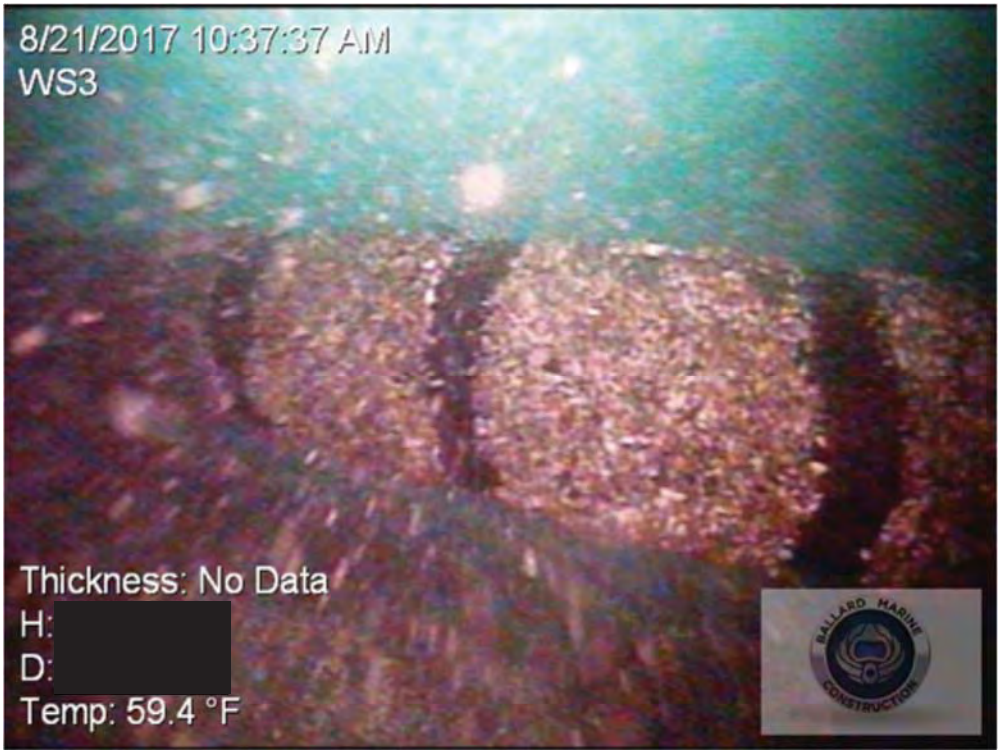

Photo 12. View of pipeline following biota thickness measurements

Photo 13. Dive bell prior to dive operations; support vessel in background

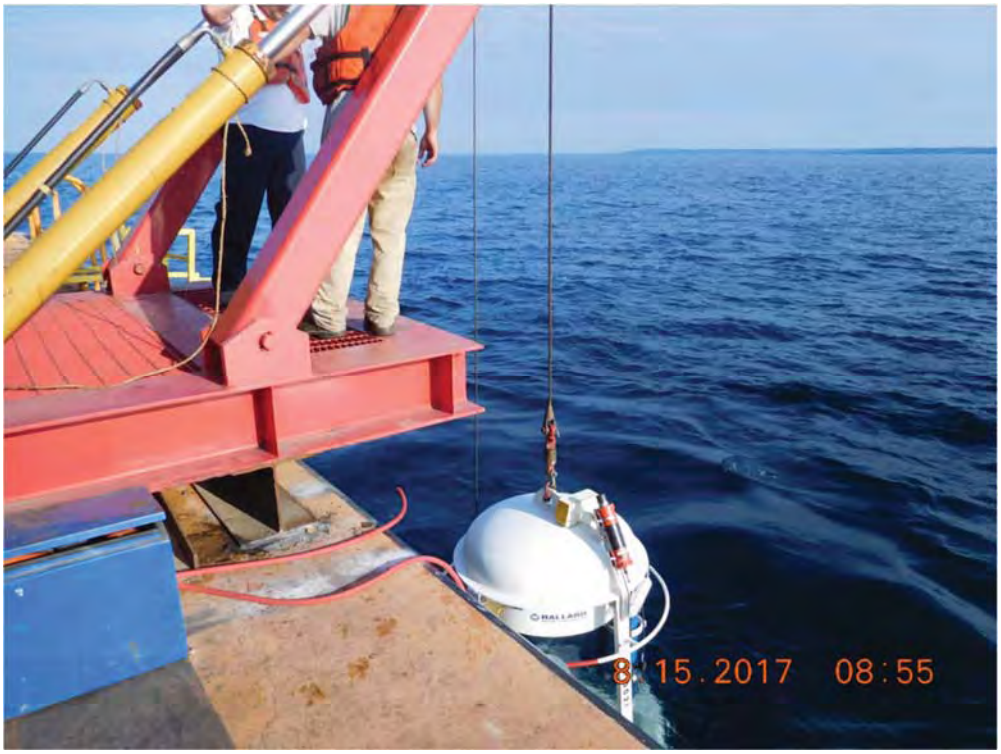

Photo 14. Dive bell lowering into water prior to dive commencement

Photo 15. Dive crew preparing diver - note video camera mounted on diver's helmet

Photo 16. Diver descending to sampling location

Photo 17. Biota sampling devices

Photo 18. Tool crib utilized to transport biota sampling devices

Photo 19. Tool crib lowering into water prior to sampling

Photo 20. Diver inspecting pipeline at a biota sampling site

Photo 21. Diver collecting a biota sample

Photo 22. Diver collecting a biota sample - note inorganic matter (sand/sediment) visible at this site

Photo 23. Sampling location following paired biota sample collection

Photo 24. Tool crib with water chemistry probe attached to lid

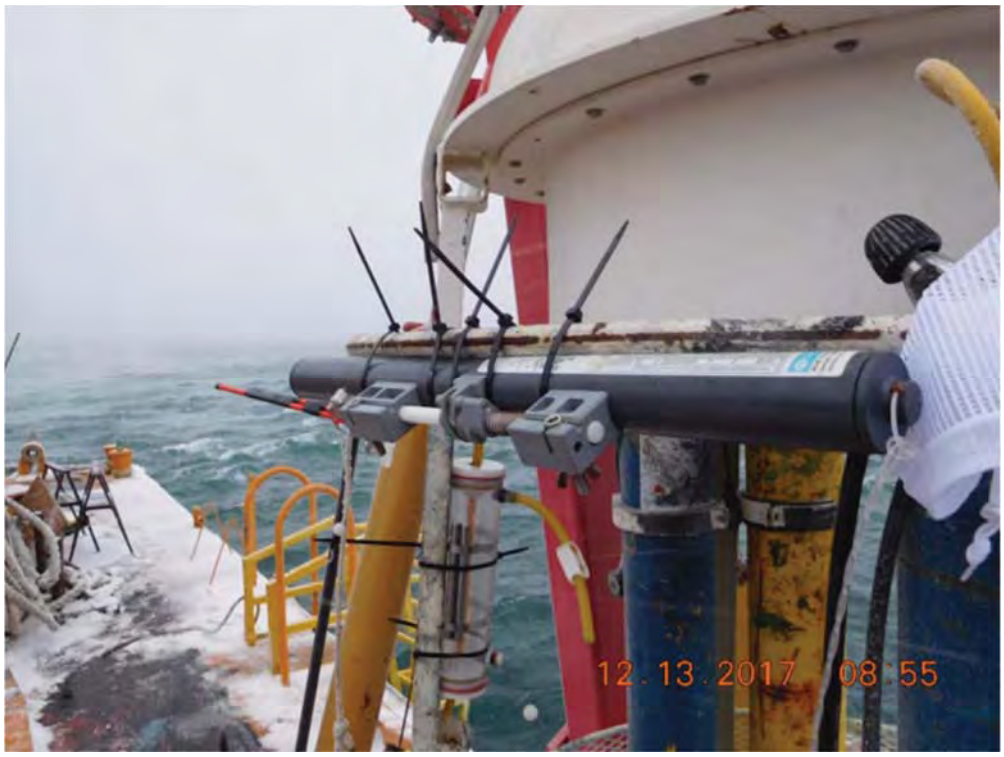

Photo 25. Dive bell with Niskin and Van Dorn water samplers attached during December water and sediment effort

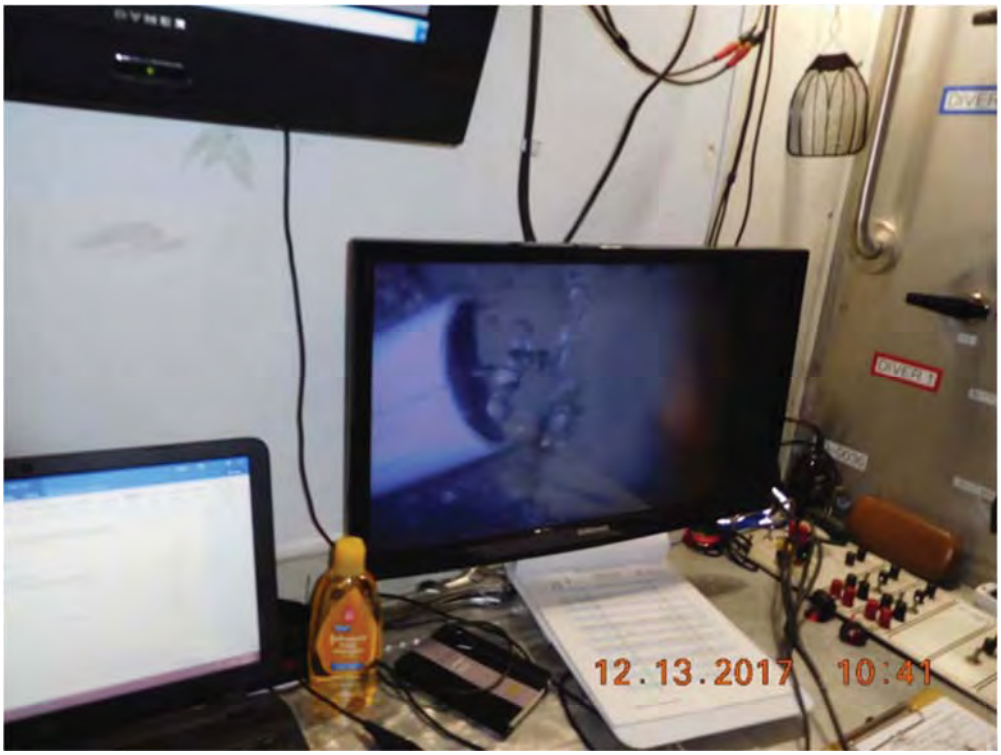

Photo 26. Collection of a sediment sample during December water and sediment effort

Photo 27. Sediment sample homogenization during December water and sediment effort

Photo 28. APB field test kit swab of a biota sample

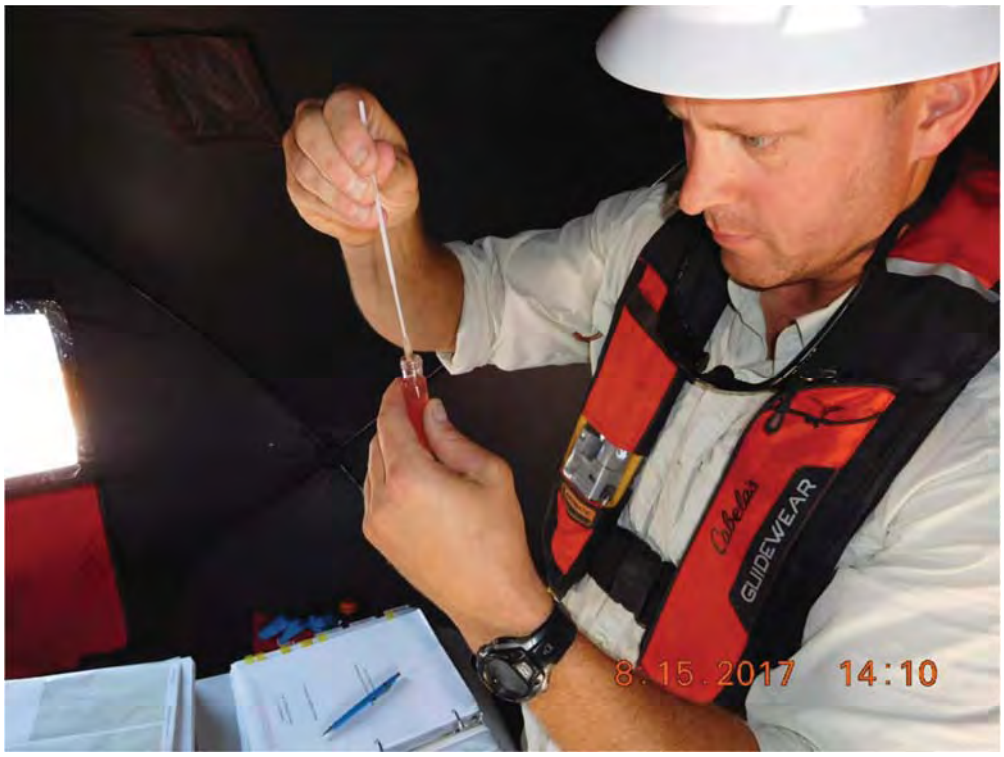

Photo 29. APB field test kit agar tube inoculation

Photo 30. SRB field test kit swab of a biota sample

Photo 31. SRB field test kit agar tube inoculation

Photo 32. SRB field test kit agar tube mineral oil application

Photo 33. APB and SRB field test kit tube placement into incubator

Photo 34. Removal of periphyton from Quagga mussels for DNA extraction

Photo 35. Periphyton sample (bagged). Some periphyton samples lacked sufficient mass for DNA extraction

Photo 36. Biota sample exhibiting varying age classes of mussels present on pipeline

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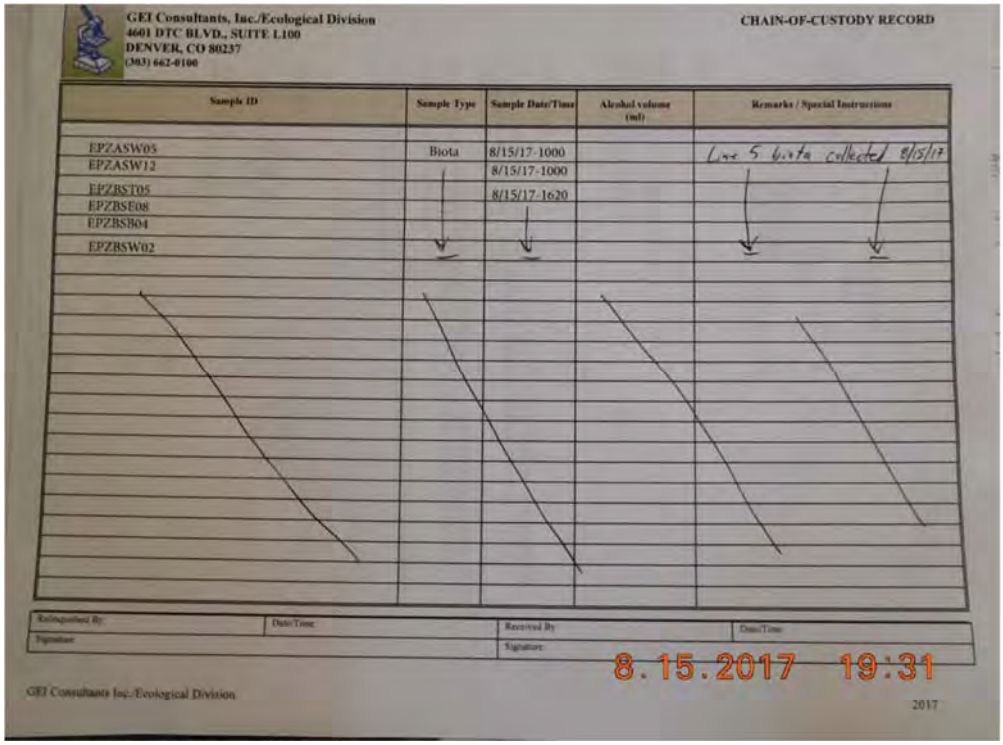
Photo 37. Biota sample dewatering on 254 micron mesh bolt cloth and 580 micron mesh sieve

Photo 38. Biota samples yielding minimal sample mass

Photo 39. Biota samples drying after collection

Photo 40. Field-based facility sample handling and processing station



GEI Consultants, Inc./Ecological Division
4601 DTC BLVD., SUITE L100
DENVER, CO 80237
(303) 662-0100

CHAIN-OF-CUSTODY RECORD

Sample ID	Sample Type	Sample Date/Time	Alcohol volume (ml)	Remarks / Special Instructions
EPZASW05	Biota	8/15/17-1000		Line 5 biota collected 8/15/17
EPZASW12		8/15/17-1000		
EPZBST05		8/15/17-1620		
EPZBSF08				
EPZBSB04				
EPZBSW02				

Relinquished By:	Date/Time	Received By	Date/Time
Signature:		Signature:	

8.15.2017 19:31

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2017

Photo 41. Example of a Chain of Custody form used during shipment to laboratories

Photo 42. Samples prepared with chain of custody form prior to overnight shipment to laboratory

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Photo 43. APB field test kit reference vial and sample exhibiting color change indicative of APB production

Photo 44. SRB field test kit reference vial and sample exhibiting color change indicative of SRB production

Photo 45. Material of Interest sample collected from E-S1

Photo 46. Calcium magnesium carbonate sample collected from E-AS2

Photo 47. Calcium magnesium carbonate sample collected from E-AS2

Photo 48. Presumed dislodged coating sample collected from E-AOI11

Photo 49. Presumed dislodged coating sample collected from E-AOI6

Photo 50. Material of Interest sample collected from E-AOI9

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Photo 51. Material of Interest sample collected from E-AOI10

Photo 52. Material of Interest sample collected from W-AOI5

Photo 53. Material of Interest sample collected from W-AOI1

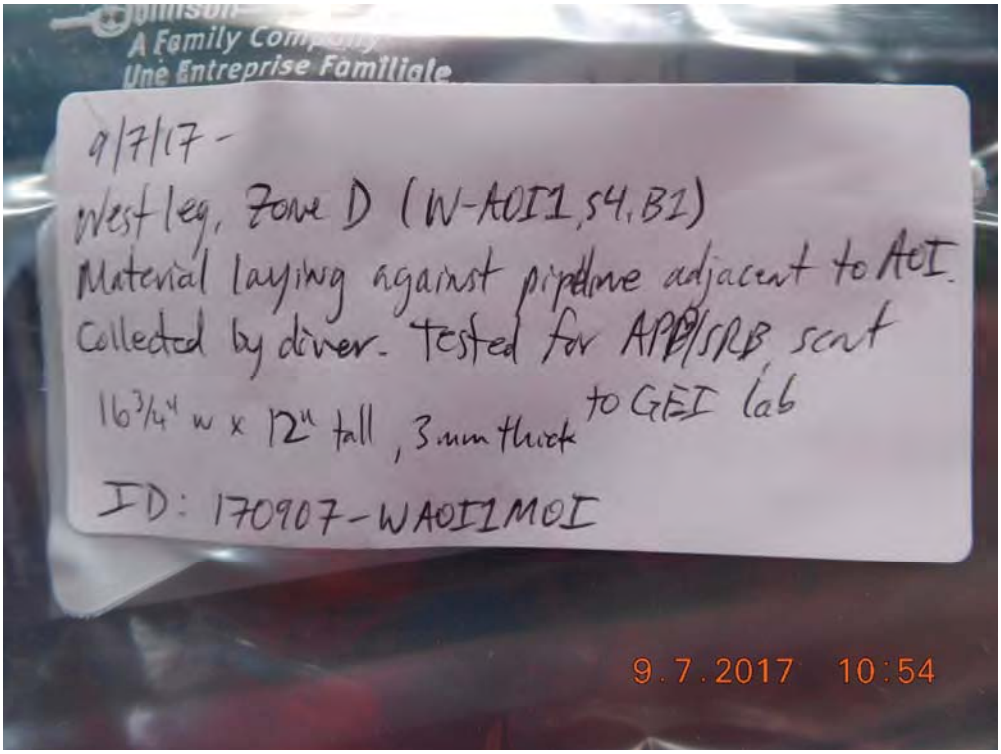

Photo 54. Material of Interest sample collected from W-AOI1 sample label

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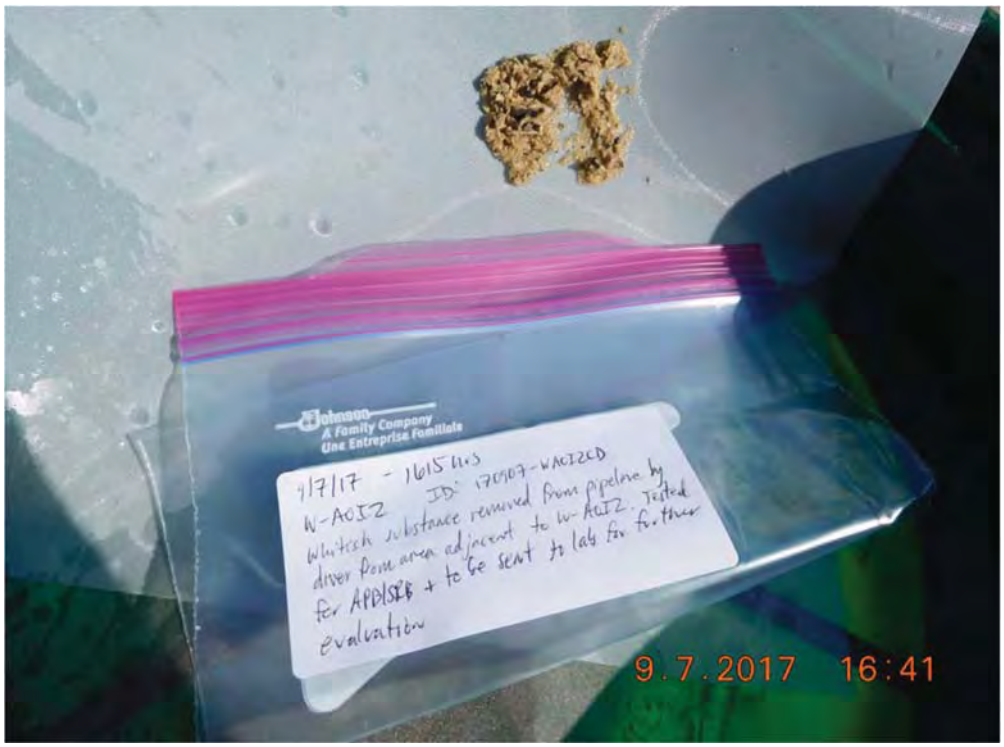

Photo 55. Calcium magnesium carbonate sample collected from W-AOI2

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Appendix D

2017 BioSan APB and SRB Field Test Kit Instructions

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SANICHECK® APB

Field Test Kit for Detecting Acid Producing Bacteria (APB)

INSTRUCTIONS

1. Disinfect hands with an alcohol wipe before handling any of the test kit components.
2. Open one Agar Tube and place screw cap side up on a clean, dry surface.
3. Remove sterile Sample Applicator Swab from the envelope (do not touch the swab side).
4. Insert Sample Applicator Swab into the liquid sample for approximately 10 seconds. For solid samples, use the Sample Applicator directly to swab the surface.
5. Transfer Sample Applicator into the Agar Tube by inserting it slowly into the agar to reach the bottom of the tube.
6. Slowly and carefully remove Sample Applicator from the Agar Tube. Discard used Sample Applicator.
7. Replace screw cap on Agar Tube.
8. Incubate samples for 1-5 days at 30°C.
9. Examine tubes daily for color change.
   - Color change from **red to yellow** in the Agar Tube indicates acid production. Note: any portion of the Agar Tube turning yellow indicates acid production.
   - Strong acid producers even at very low numbers can change the color overnight.
   - Slow acid producers require longer time for color change development depending on the type and number of acid producers present in the sample.
   - Visually check Agar Tubes daily for color change from red to yellow.
   - Use the evaluation chart provided below to estimate the amount of acid production due to the growth of acid producing bacteria.

Evaluation Chart for Acid Production
due to the Growth of Acid Producing Bacteria

Appearance of Yellow	Acid Production
Day 1 – Day 2	Strong
Day 3 – Day 4	Medium
Day 5	Weak

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SANI-CHECK® SRB

Test System for Counting Sulfate Reducing Bacteria

DESCRIPTION OF TEST

Anaerobic sulfate reducing bacteria are ubiquitous in the environment. They are found in secondary oil recover effluents, estuarine waters, deep wells, cooling waters, metalworking fluids, water-based hydraulic fluids, and petroleum based products that in some way become contaminated with water. The growth of sulfate reducing bacteria can be responsible for fouling, objectionable hydrogen sulfide odors, corrosion of metals, and pitting of concrete. It is essential that these organisms be monitored and controlled to prevent the damage caused by their metabolic activities.

The SANI-CHECK SRB test kit contains tubes of culture media that are specifically formulated to promote the growth of anaerobic sulfate reducing bacteria. The medium contains reducing agents that maintain a low oxidation reduction potential and thus allows for maximal growth. When the organisms grow in this medium, sulfate is reduced to sulfide and a black precipitate of iron sulfide is formed. The degree of blackening through the medium is directly proportional to the amount of sulfate reducer growth.

SANI-CHECK SRB is designed to be used in areas where little or no formal laboratory facilities are available. Each test kit contains the following materials for 25 tests: 25 SANI-CHECK SRB tubes, 25 identification labels, 25 applicators, one bottle mineral oil, one sample vial with cap, one alligator clip, and one instruction sheet.

Collection of Sample

Oily Sample
Microorganisms are unable to grow in the absence of water. In contaminated oil/water systems, the organisms will be found at the interface and in the water layer. Therefore, it is important that sampling be done from these locations. A sample vial is included with SANI-CHECK SRB. The vial should be filled with a freshly collected sample that has only a minimal oil layer on its surface. Excess oil can be skimmed from the surface of the sample with the enclosed dropper.

Water and Other Samples
No special sampling precautions are necessary. The sample may be tested using the provided vial or any other suitable container.

DIRECTIONS FOR USE

1. Open a SANI-CHECK SRB tube by peeling off the protective seal and removing the cap. Grip an applicator with the alligator clip and insert applicator into liquid sample. Immerse for approximately 5 seconds, withdraw, and drain excess fluid by running applicator along the inner lip of vial or other sample container. [Dry surfaces may be sampled by pre-wetting the applicator with tap water and swabbing a representative portion of the test area.]
2. Holding applicator with clip, insert into tube of agar, taking care to center it as much as possible. Push the applicator into the tube until it is about even with the surface of the agar.
3. Add 2-3 drops of mineral oil to the tube and cap the tube.
4. Incubate the tube at 30°C or within 3°C of the sample environment if the temperature is greater than 30°C.
5. Observe the tube regularly for results and compare to the chart below.

	Sulfate Reducers/ml*				
Days of Incubation:	1	2	3	4	5
TUBE APPEARANCE					
completely black	$\geq 10^6$	10^6 - 10^5	10^5 - 10^4	10^4 - 10^3	10^3 - 10^2
narrow zone of black around applicator center	10^6 - 10^5	10^5 - 10^4	10^4 - 10^3	10^3 - 10^2	10^2 - 10^1
no reaction	$<10^5$	$<10^4$	$<10^3$	$<10^2$	$<10^1$

*Figures shown have been calculated by Biosan Laboratories using anaerobic plate counts and a pure culture of *Desulfovibrio desulfuricans* [ATCC #7757]

≥ greater than or equal to
< less than

Interpretation of Quantitative Results

Sulfate Reducers/ml	Interpretation
10^5 (100,000) or more/ml	Heavy
10^3-10^4 (1,000-10,000)/ml	Moderate
10^2-10^3 (100-1,000)/ml	Low
10^1-10^2 (10-100)/ml	Very Low
10^1 (10) or less/ml	Generally Insignificant

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Appendix E

**2017 GEI Denver Lab Standard Operating Procedures:
Evaluation of Line 5 Samples**

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Standard Operating Procedures

Enbridge Mussel Project

GEI Consultants, Inc.
Ecological Division
4601 DTC Boulevard, Suite 900
Denver, CO 80237

Effective: August 2017
Manual Approved by:

Natalie Love
Laboratory Director

Revised February 14, 2018

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1.0 Introduction

GEI Consultants Inc. (GEI), Denver, Colorado, performs a wide variety of macrobiotic analyses for client samples. The ecological laboratory's scope of work (Section 4.1 Biota Investigation Work Plan, Revision 2: May 18, 2017, Enbridge 2017) entailed qualitatively evaluating each sample received and separating the larger biota (e.g. mussels) from smaller biota (e.g. benthic macroinvertebrate, periphyton and planktonic algae/zooplankton). Qualitative wet weights of the entire sample mass and its components along with quantitative dry weights of the mussel, benthic macroinvertebrate, and periphyton components were obtained. Following the separation of the biota components, each sample contained inorganic material (e.g. sand/grit) and some samples contain material of interest (MOI). Therefore, two additional categories were created to account for these remaining dry weight components.

Notably, the Biota Investigation Work Plan identified "macrophytes" as a biological component to identify and process; however, the term "periphyton" has been substituted herein because it more appropriately described the plant matter contained in the samples. The term macrophyte is primarily used for visual field assessments when the entire plant structure can be evaluated. While some algae, such as charophytes or cladophora spp. may be characterized as macrophytes (i.e., large plants), the biota samples required microscopic analysis to separate plant fragments to identify cell structure. Thus, the term periphyton (i.e., algae attached to substrate) more appropriately described the samples processed.

Each mussel encountered was identified and enumerated. All mussels were measured for length, width, and height of the base and sorted by size class. Benthic macroinvertebrate, periphyton and planktonic algae/zooplankton were identified to the lowest practical level. Because the microscopic planktonic algae/zooplankton required a greater level of taxonomic capabilities, a subset of samples were sent to PhycoTech, St. Joseph, Michigan, to identify and determine presence/absence of planktonic algae/zooplankton.

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2.0 Sample Receiving

Benthic samples (46.57 cm^2 area) are collected from selected areas of interest and each sample is filtered through Nitex mesh (290µm) and carefully enclosed with a zip-tie to contain the benthic sample. Each sample is placed in a Ziploc bag and preserved with approximately 150 mL of 70% ethanol to euthanize all mussels and to preserve the sample. Samples are shipped to GEI's laboratory in Denver, CO for analysis. Upon receipt of samples, a laboratory technician ensures the data recorded on the Chain of Custody form (COC) matches the data recorded on the samples received, then signs and dates the COC and stores it in the project folder. A copy of the sampling permit and authorization letter to receive dead invasive mussels, which is sent with each sample set, is stamped with the date of sample receipt and placed in the project folder.

The technician assigns each sample a unique GEI sample identification (ID) number and records each sample on an internal laboratory log in sheet. The unique ID number is comprised of the first two letters of the project name, month and year sample arrived in the laboratory, and the sample number (e.g., EN817-2 indicating the second sample received in August of 2017). Record the sample log number on the sample bag and any other components of the sample (i.e., benthic macroinvertebrate, periphyton and planktonic algae/zooplankton, or inorganic fraction). After sample analysis, each component is stored in a separate vial or Ziploc bag, depending on the size of the component. Each label contains the samples' site information, the GEI log number, the sample date, and the dry weight of the material. The label is placed on the vial or Ziploc bag in a prominent location.

Example of label:

Enbridge- Periphyton
Sample ID: EPZASW12
GEI Log #: EN817-2
Sample Date: 8/15/2017
Dry weight (g): 0.0046

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3.0 Sample Analysis

3.1 Laboratory Equipment and Electronic Benchsheet

To obtain the wet and dry weights of each component, the same enclosed scale is calibrated daily and used throughout the duration of the project. A clean, dry, tared glass jar with a lid is used to minimize balance drift due to the evaporation of alcohol. To account for any measurement bias that the glass jar may introduce, the same process is used for all dry weight analyses. After sample receiving (see Section 2.0), analyze the samples in the order received.

Values are reported to the 4th decimal place (highest precision allowed by the balance) and recorded in an electronic benchsheet using MS Excel. The benchsheet contains the following: Sample Information, Wet/Dry Weight, Mussel Identification, Macro & Peri Identification, Planktonic Identification, and Mussel QA tabs.

3.2 Initial Weight of Sample

The sample consists of a Ziploc bag, containing a 290µm mesh bag that encapsulates the benthic sample. A zip tie encloses the mesh into a bag. Notably, the first ten samples received were processed using 64µm mesh, which was used in lieu of the 290µm mesh due to material shipping delays. Place the mesh bag containing the sample over a bucket to allow excess alcohol to drain from the sample bag for 5 minutes. Store the original Ziploc bag with the remaining preservative for future analysis of microscopic biota, and dispose of the excess alcohol that dripped from the mesh bag according to standard laboratory procedures. Remove the zip tie and place the mesh bag in a tared, clean, dry glass jar with a lid and record the initial wet weight of the entire sample in the electronic benchsheet.

3.3 Sample Sorting

Sample analysis occurs in a clean, dry, tray large enough to contain the entire sample. Remove the mussels and fragments from the mesh bag and place them into separate sorting dishes. Separate any benthic macroinvertebrates, periphyton, or inorganic materials from the sample and place the sample fraction into a separate sorting dish for each component.

3.4 Macroinvertebrate, Periphyton, Inorganic Materials Wet Weights

Using labeled 2 dram, tared vials, perform separate wet weight measurements on the subcomponents – benthic macroinvertebrates, periphyton, or inorganic materials – found in a sample. Record the sample component wet weight in the electronic bench sheet.

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Label each vial, as described above, and preserve the subcomponent with 70% alcohol until identification is performed.

3.5 Total Mussel Wet Weight

Using a clean, tared glass jar with a lid, record the wet weight for each mussel size class and the fragments in the electronic benchsheet. Weigh the mesh and any inorganic material left in the sample and record the wet weight in the electronic benchsheet. Return the mesh and inorganic material into the original Ziploc bag for microscopic analyses.

3.6 Mussel Identification

In addition to utilizing a qualified technician to process the samples, use the literature in Section 7.2 to aid in the species identification of each mussel [Quagga mussels (*Dreissena rostiformes bugensis*), and Zebra mussels (*Dreissena polymorpha*)].

3.7 Mussel Wet Weights by Size Class

Measure each mussel using a digital caliper, or if too small, using a grid with 1mm divisions. Record measurements for length, width, and height of the base for each mussel, along with mussel ID (either Quagga mussel or Zebra mussel). Consider any mussels less than 6mm in length as juveniles and record identification at genus level. Juvenile mussels cannot reliably be identified to species; therefore, the juvenile weights are recorded as quagga mussel juveniles (i.e., small size class) because this is the dominant taxa observed in all samples. Place the mussel in the appropriate size class tray.

The three size classes established by Miller & Lei (1993) were used to categorize each specimen: mussels over 10 millimeter (mm) in length were categorized as ‘large size class’, between 5-10mm in length were categorized as a ‘medium size class’, and less than 5mm in length were categorized as ‘small size class’. Weigh the Zebra mussels separate from the Quagga mussels.

Use a tared, dry, glass jar with lid to obtain wet weights for the individual size classes for each sample. Record the wet weights of each size class in the electronic benchsheet.

3.8 Mussel Dry Weights by Size Class

Each size class is placed in a baking tray for approximately 2 hours at 110°C or until a constant weight is reached (APHA, 1981, Mackie & Claudi, 2009). Small and medium size classes require less drying time due to the size of the specimens, while the large size class may require additional time. Check the drying oven frequently to ensure that each sample is drying properly.

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Measure the dry weight for each size class using a lidded glass jar and record the weights in the electronic benchsheet. Store the dried mussels for each sample size class in a separate Ziploc bag and label accordingly (See section 2.0).

3.9 Macroinvertebrate and Periphyton Identification

Retrieve the benthic macroinvertebrate and periphyton vials that were processed in Section 3.4 and identify each taxon to the lowest practicable level using a binocular dissecting microscope set at 40X. See sections 7.1 and 7.3 for source materials for the identification process.

3.10 Macroinvertebrate, Periphyton, Inorganic Material Dry Weights

The drying process will destroy the sample in terms of being able to identify the biota subcomponent, so confirm that the benthic macroinvertebrates have been identified. Place the organisms in an aluminum dish and dry at 103°C or until the weight remains consistent (Weber, 1983). Record the dry weight in the electronic benchsheet.

Confirm that the periphyton have been identified, then dry the periphyton at 105°C for 1-2 hours or until the weight remains consistent (Sullivan, 2013). Notably, the periphyton biomass consists primarily of filamentous green algae, and once the filaments are teased apart, negligible amounts of mussel fragments, macroinvertebrates, and inorganic material remain in the periphyton subcomponent. The periphyton dry weight includes these negligible amounts of other components, and the components are excluded from their appropriate category for ID and weight. Record the dry weight in the electronic benchsheet.

Allow the inorganic material to air dry for 2 days or until the weight remains consistent. Record the dry weight in the electronic benchsheet.

Store the dried specimens and inorganic material in air-tight, labeled vials with no preservative added.

3.11 Planktonic Algae and Zooplankton Analysis

To prepare the samples selected for microscopic planktonic algae/zooplankton analysis, filter the remaining liquids from the original Ziploc bag containing the mesh and any preservative (See Section 3.2) through a Nitex mesh (64µm) using a vacuum pump set a low pressure (<10 PSI). Clean the mesh with 70% ethanol to collect any remaining debris on the mesh. Place the Nitex mesh in a beaker and rinse with 70% ethanol until clean. Let the sample settle in the beaker for 2+ hours. Using a 1mL plastic pipet, collect a 5mL aliquot from the settled materials at the bottom of the beaker and place into a labeled vial.

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Complete a COC and send the vials in a well-packaged box to the subcontractor, PhycoTech, for planktonic algae and zooplankton analysis.

PhycoTech, will identify as many taxon, to the lowest practicable level, in 15 minutes of visual scope time per sample to provide presence/absence data for planktonic algae and zooplankton observed in each sample.

3.12 Inorganic Material and Mesh Analysis

Retrieve the original sample bag from Section 3.2. Carefully, pour the contents from the bag through the mesh. Discard the liquid portion. Allow the mesh and any inorganic material to air dry in a tray for 2 days or until a consistent weight is achieved.

Using a tared, clean jar, record the dry weight of the combined mesh and inorganic material. Scrape or brush the inorganic material off the mesh and collect in a weigh boat. Record the dry weights of both the inorganic material and the cleaned mesh in the electronic benchsheet.

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4.0 Quality Assurance Analysis

4.1 Dry Weight QA

Randomly select 10% of the samples analyzed. The QA analyst will replicate the dry weight measurements on the mussel components using a lidded, tared glass jar for all mussel groups. Notably, the dry weights for the benthic macroinvertebrate and periphyton samples are very small and remeasuring the samples for QA analysis was not practicable. Record the QA data separate from the original data to ensure data integrity. Calculate the percent similarity, accept a percent similarity of 90% or higher.

4.2 Sample QA

A certified benthic macroinvertebrate taxonomist will monitor the technician from sample set up through the sample analysis to ensure sample integrity throughout the process. The sample QA is performed on 10% of the samples analyzed. The QA analyst will monitor and verify all weights, sizes, for these samples and ensure that the samples are correctly labeled.

4.3 Mussel Identification QA

Using the same samples from Section 4.1, the taxonomist will re-identify the Dreissenid mussels to ensure proper identification using the references in Section 7.2.

4.4 Macroinvertebrate and Periphyton QA

An experienced aquatic biologist will identify macroinvertebrates to the lowest practicable taxonomic level, and eight randomly selected samples will be re-identified by a certified benthic macroinvertebrate taxonomist to ensure data quality.

An experienced aquatic biologist will identify periphyton to the lowest practicable taxonomic level and confirm the characteristics with available online resources for taxa observed in Lake Michigan.

4.5 Data QA

Establish whether there are any discrepancies between the information on the COC, the information in the GEI log-in sheets, and the electronic benchsheet to ensure all information is recorded accurately.

The electronic benchsheet is divided into multiple tabs. The “Sample Information” tab that provides metadata on each sample as collected in the field and contains the

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GEI Log # used to track the sample through the laboratory. The “Wet-Dry Weights” tab is evaluated to ensure all weights were correctly recorded (i.e. none of the values are inappropriately higher than would be expected for a parameter). Weight data are also evaluated to ensure the percent difference between the mussels before and after the organisms were cleaned of excess byssal threads and other materials are less than 20% for all samples. The change in wet weight to dry weight was also evaluated to ensure the change was within 45-65% for all samples. All other data in the “Weights” tab are QA’d to ensure correct reporting.

The “Mussel Identification” tab was reviewed to ensure class sizes were recorded appropriately and to ensure consistency throughout the data set. The “Macro & Peri Identification” tab was reviewed to ensure information was accurately recorded.

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5.0 Data Reporting

Preparation of the benchsheet entails: Performing a final data QA of the data to ensure accurate and complete data, and reporting all weights to three decimal places instead of four to account for balance accuracy. After the data for macroinvertebrates, periphyton, and planktonic algae/zooplankton receives a final QA the entire data spreadsheet is sent to the Project Manager.

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6.0 Sample Storage

Combine all components of the sample in a large, labeled Ziploc bag. The Ziploc bag will include: the bags of dried mussels segregated by size class, a bag containing the dried mesh and any inorganic material, and vials containing benthic macroinvertebrate, periphyton, inorganic material, or material of interest. Store the samples in a dry, cool place until requested from the client.

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7.0 Literature Used for Identification/ Dry Weight

7.1 Benthic Macroinvertebrates

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7.2 Dreissenid Mussels

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7.3 Periphyton

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Appendix F

2017 GEI Laboratory Analyses

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General Sample Information

Project Name	Site Name	GEI Log #	Collection Date	Pipeline Leg (E or W)	Zone	North or South (N/A for Zone D)	Pipeline position (top, bottom, north, south)	Sample Type	Sample Site ID (aka "ITP ID")	Paired AOI-Add Site + Adjacent sample	AOI-Add Site/Adjacent	Qualitative Sample Wet Weight (Minus water prior to EtOH Preservation) (g)	Volume of EtOH added (mL)	Received Date	Mussels Present
Enbridge	EPZASW05	EN817-1	8/15/2017	East	A	South	West	Additional Site	E-AS1	1	Additional Site	8.1	30	8/17/2017	N
Enbridge	EPZASW12	EN817-2	8/15/2017	East	A	South	West	Additional Site	E-AS1	1	Adjacent	44.6	80	8/17/2017	Y
Enbridge	EPZASW01	EN817-36	8/24/2017	East	A	South	West	Additional Site	E-AS2	2	Adjacent	90.2	Not Recorded	8/28/2017	Y
Enbridge	EPZASW02	EN817-37	8/24/2017	East	A	South	West	Additional Site	E-AS2	2	Additional Site	1.8	50	8/28/2017	N
Enbridge	WPZDT11	EN817-38	8/25/2017	West	D	N/A	Top	Additional Site	W-AS1	3	Additional Site	12.6	50	8/29/2017	Y
Enbridge	WPZDT02	EN817-39	8/25/2017	West	D	N/A	Top	Additional Site	W-AS1	3	Adjacent	64.7	100	8/29/2017	Y
Enbridge	EPZDW06	EN817-43	8/26/2017	East	D	N/A	West	Area of Interest	E-AOI2	4	Adjacent	15	50	8/29/2017	Y
Enbridge	EPZDW01	EN817-44	8/26/2017	East	D	N/A	West	Area of Interest	E-AOI2	4	Area of Interest	1.5	50	8/29/2017	N
Enbridge	WPZCSW08	EN817-47	8/26/2017	West	C	South	West	Area of Interest	W-AOI3	5	Area of Interest	1.5	50	8/29/2017	N
Enbridge	WPZCSW03	EN817-49	8/26/2017	West	C	South	West	Area of Interest	W-AOI3	5	Adjacent	55.3	90	8/29/2017	Y
Enbridge	WPZAST06	EN817-53	8/29/2017	West	A	South	Top	Area of Interest	W-AOI7	6	Adjacent	1.7	50	8/31/2017	N
Enbridge	WPZAST09	EN817-54	8/29/2017	West	A	South	Top	Area of Interest	W-AOI7	6	Area of Interest	6.6	50	8/31/2017	Y
Enbridge	EPZASW02	EN817-62	9/5/2017	East	A	South	West	Area of Interest	E-AOI7	7	Adjacent	71.5	100	9/7/2017	Y
Enbridge	EPZASW10	EN817-63	9/5/2017	East	A	South	West	Area of Interest	E-AOI7	7	Area of Interest	2.1	50	9/7/2017	N
Enbridge	WPZDE02	EN817-70	9/7/2017	West	D	N/A	East	Area of Interest	W-AOI1	8	Area of Interest	2.8	50	9/11/2017	N
Enbridge	WPZDE03	EN817-71	9/7/2017	West	D	N/A	East	Area of Interest	W-AOI1	8	Adjacent	73.6	100	9/11/2017	Y
Enbridge	EPZCNW08	EN817-77	9/8/2017	East	C	North	West	Area of Interest	E-AOI1	9	Adjacent	14.5	75	9/12/2017	Y
Enbridge	EPZCNW03	EN817-78	9/8/2017	East	C	North	West	Area of Interest	E-AOI1	9	Area of Interest	86.1	100	9/12/2017	Y
Enbridge	WPZBSE08	EN817-83	9/8/2017	West	B	South	East	Area of Interest	W-AOI4	10	Adjacent	86.7	150	9/12/2017	Y
Enbridge	WPZBSE09	EN817-84	9/8/2017	West	B	South	East	Area of Interest	W-AOI4	10	Area of Interest	22.5	50	9/12/2017	Y
Enbridge	EPZCSW05	EN817-10	8/16/2017	East	C	South	West	Biota Site	E-S6	-	-	51.7	100	8/20/2017	Y
Enbridge	EPZANW08	EN817-11	8/19/2017	East	A	North	West	Biota Site	E-S1	-	-	22.3	80	8/22/2017	Y
Enbridge	EPZANE03	EN817-12	8/19/2017	East	A	North	East	Biota Site	E-S1	-	-	30.4	100	8/22/2017	Y
Enbridge	EPZANT02	EN817-13	8/19/2017	East	A	North	Top	Biota Site	E-S1	-	-	24.6	100	8/22/2017	Y
Enbridge	EPZBNW12	EN817-14	8/19/2017	East	B	North	West	Biota Site	E-S2	-	-	6.2	100	8/22/2017	Y
Enbridge	EPZBNE04	EN817-15	8/19/2017	East	B	North	East	Biota Site	E-S2	-	-	151.2	150	8/22/2017	N
Enbridge	EPZBNT01	EN817-16	8/19/2017	East	B	North	Top	Biota Site	E-S2	-	-	7.7	75	8/22/2017	Y
Enbridge	WPZANT01	EN817-17	8/19/2017	West	A	North	Top	Biota Site	W-S1	-	-	1.9	75	8/22/2017	N
Enbridge	WPZANE02	EN817-18	8/19/2017	West	A	North	East	Biota Site	W-S1	-	-	9.2	75	8/22/2017	Y
Enbridge	WPZANB09	EN817-19	8/19/2017	West	A	North	Bottom	Biota Site	W-S1	-	-	33.4	125	8/22/2017	Y
Enbridge	WPZANW08	EN817-20	8/19/2017	West	A	North	West	Biota Site	W-S1	-	-	7.2	75	8/22/2017	Y
Enbridge	EPZDT02	EN817-21	8/20/2017	East	D	N/A	Top	Biota Site	E-S5	-	-	40.9	100	8/22/2017	Y
Enbridge	EPZDE01	EN817-22	8/20/2017	East	D	N/A	East	Biota Site	E-S5	-	-	78.9	150	8/22/2017	Y
Enbridge	EPZDW08	EN817-23	8/20/2017	East	D	N/A	West	Biota Site	E-S5	-	-	61.4	100	8/22/2017	Y
Enbridge	WPZDT10	EN817-24	8/20/2017	West	D	N/A	Top	Biota Site	W-S5	-	-	1.7	50	8/22/2017	N
Enbridge	WPZDE12	EN817-25	8/20/2017	West	D	N/A	East	Biota Site	W-S5	-	-	47	150	8/22/2017	Y
Enbridge	WPZDW03	EN817-26	8/20/2017	West	D	N/A	West	Biota Site	W-S5	-	-	50.7	150	8/22/2017	Y
Enbridge	WPZCNT04	EN817-27	8/21/2017	West	C	North	Top	Biota Site	W-S3	-	-	30.8	50	8/23/2017	Y
Enbridge	WPZCNB09	EN817-28	8/21/2017	West	C	North	Bottom	Biota Site	W-S3	-	-	45.4	50	8/23/2017	Y
Enbridge	WPZCNW06	EN817-29	8/21/2017	West	C	North	West	Biota Site	W-S3	-	-	68	100	8/23/2017	Y
Enbridge	EPZBST05	EN817-3	8/15/2017	East	B	South	Top	Biota Site	E-S7	-	-	44.7	100	8/17/2017	Y
Enbridge	WPZBNT01	EN817-30	8/21/2017	West	B	North	Top	Biota Site	W-S2	-	-	71.6	100	8/23/2017	Y
Enbridge	WPZBNE11	EN817-31	8/21/2017	West	B	North	East	Biota Site	W-S2	-	-	64.2	150	8/23/2017	Y
Enbridge	WPZBNW04	EN817-32	8/21/2017	West	B	North	West	Biota Site	W-S2	-	-	87.7	150	8/23/2017	Y
Enbridge	WPZCNE11	EN817-33	8/21/2017	West	C	North	East	Biota Site	W-S3	-	-	38.6	50	8/23/2017	Y
Enbridge	EPZASW07CD	EN817-34	8/24/2017	East	A	South	West	Additional Site	E-AS2	-	-	NA	50	8/28/2017	N
Enbridge	170824-EAOI11DC	EN817-35	8/24/2017	East	A	South	Top	Area of Interest	E-AOI11	-	-	NA	50	8/28/2017	Y
Enbridge	EPZBSE08	EN817-4	8/15/2017	East	B	South	East	Biota Site	E-S7	-	-	84.3	100	8/17/2017	Y
Enbridge	EPZDE09	EN817-40	8/26/2017	East	D	N/A	East	Biota Site	E-S4	-	-	53.6	100	8/29/2017	Y
Enbridge	EPZDT02	EN817-41	8/26/2017	East	D	N/A	Top	Biota Site	E-S4	-	-	15.2	50	8/29/2017	Y
Enbridge	EPZDW10	EN817-42	8/26/2017	East	D	N/A	West	Biota Site	E-S4	-	-	34.7	75	8/29/2017	Y
Enbridge	WPZCSE09	EN817-45	8/26/2017	West	C	South	East	Biota Site	W-S6	-	-	61.8	100	8/29/2017	Y
Enbridge	WPZCSW11	EN817-46	8/26/2017	West	C	South	West	Biota Site	W-S6	-	-	22.3	75	8/29/2017	Y
Enbridge	WPZCST07	EN817-48	8/26/2017	West	C	South	Top	Biota Site	W-S6	-	-	39.7	75	8/29/2017	Y
Enbridge	EPZBSB04	EN817-5	8/15/2017	East	B	South	Bottom	Biota Site	E-S7	-	-	59.8	100	8/17/2017	Y
Enbridge	WPZAST04	EN817-50	8/29/2017	West	A	South	Top	Biota Site	W-S8	-	-	1.6	50	8/31/2017	N
Enbridge	WPZASE07	EN817-51	8/29/2017	West	A	South	East	Biota Site	W-S8	-	-	5.8	50	8/31/2017	Y
Enbridge	WPZASW11	EN817-52	8/29/2017	West	A	South	West	Biota Site	W-S8	-	-	3.9	50	8/31/2017	Y
Enbridge	EPZANMOI	EN817-55	8/19/2017	East	A	North	East	Biota Site	E-S1	-	-	2.3	NA	8/29/2017	NA-On Hold
Enbridge	170821-WAOI5DC	EN817-56	8/21/2017	West	A	South	West	Area of Interest	W-AOI5	-	-	60.1	150	8/29/2017	NA-On Hold
Enbridge	170905-EAOI6DC	EN817-57	9/5/2017	East	A	South	West	Area of Interest	E-AOI6	-	-	NA	NA	9/7/2017	Y- On Hold
Enbridge	EPZAST09	EN817-58	9/5/2017	East	A	South	Top	Biota Site	E-S8	-	-	8.5	50	9/7/2017	Y
Enbridge	EPZASE08	EN817-59	9/5/2017	East	A	South	East	Biota Site	E-S8	-	-	136	200	9/7/2017	Y
Enbridge	EPZBSW02	EN817-6	8/15/2017	East	B	South	West	Biota Site	E-S7	-	-	107.6	100	8/17/2017	Y
Enbridge	EPZASW04	EN817-60	9/5/2017	East	A	South	West	Biota Site	E-S8	-	-	88.4	100	9/7/2017	Y
Enbridge	EPZASB01	EN817-61	9/5/2017	East	A	South	Bottom	Biota Site	E-S8	-	-	60.5	50	9/7/2017	Y
Enbridge	170906-EAOI9MOI	EN817-64	9/6/2017	East	A	South	-	Area of Interest	E-AOI9	-	-	NA	NA	9/11/2017	NA-On Hold
Enbridge	170906-EAOI10MOI	EN817-65	9/6/2017	East	A	South	-	Area of Interest	E-AOI10	-	-	NA	NA	9/11/2017	NA-On Hold
Enbridge	WPZDT08	EN817-66	9/7/2017	West	D	N/A	Top	Biota Site	W-S4	-	-	4.8	50	9/11/2017	Y
Enbridge	WPZDE11	EN817-67	9/7/2017	West	D	N/A	East	Biota Site	W-S4	-	-	92.3	150	9/11/2017	Y
Enbridge	WPZDW09	EN817-68	9/7/2017	West	D	N/A	West	Biota Site	W-S4	-	-	80	150	9/11/2017	Y
Enbridge	WPZDB05	EN817-69	9/7/2017	West	D	N/A	Bottom	Biota Site	W-S4	-	-	15.7	50	9/11/2017	Y
Enbridge	EPZCST08	EN817-7	8/16/2017	East	C	South	Top	Biota Site	E-S6	-	-	76.0	100	8/20/2017	Y
Enbridge	170907-WAOI1MOI	EN817-72	9/7/2017	West	D	N/A	West	Area of Interest	W-AOI1	-	-	NA	1500	9/11/2017	Y
Enbridge	170907-WAOI2CD	EN817-73	9/7/2017	West	D	N/A	West	Area of Interest	W-AOI2	-	-	NA	NA	9/11/2017	NA-On Hold
Enbridge	EPZCNT13	EN817-74	9/8/2017	East	C	North	Top	Biota Site	E-S3	-	-	92	100	9/12/2017	Y
Enbridge	EPZCNE11	EN817-75	9/8/2017	East	C	North	East	Biota Site	E-S3	-	-	35.7	100	9/12/2017	Y
Enbridge	EPZCNW06	EN817-76	9/8/2017	East	C	North	West	Biota Site	E-S3	-	-	68.7	100	9/12/2017	Y
Enbridge	WPZBST11	EN817-79	9/8/2017	West	B	South	Top	Biota Site	W-S7	-	-	55.7	100	9/12/2017	Y
Enbridge	EPZCSE03	EN817-8	8/16/2017	East	C	South	East	Biota Site	E-S6	-	-	78.0	150	8/20/2017	Y
Enbridge	WPZBSE10	EN817-80	9/8/2017	West	B	South	East	Biota Site	W-S7	-	-	69.1	100	9/12/2017	Y
Enbridge	WPZBSW14	EN817-81	9/8/2017	West	B	South	West	Biota Site	W-S7	-	-	91.5	150	9/12/2017	Y
Enbridge	WPZBSB01	EN817-82	9/8/2017	West	B	South	Bottom	Biota Site	W-S7	-	-	47.8	100	9/12/2017	Y
Enbridge	EPZCSB10	EN817-9	8/16/2017	East	C	South	Bottom	Biota Site	E-S6	-	-	7.0	50	8/20/2017	Y

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Mussel Count (Density) and Biomass Per Square Foot

Project Name	Site Name	GEI Log #	Collection Date	Pipeline (East or West)	Zone	North or South (N/A for Zone D)	Pipeline position (top, bottom, north, south)	Location Type	Large (>10mm) Count	Medium (5-10mm) Count	Small (<5mm) Count	Total Count	Quagga Dry Weight Large Size Class >10mm (g)	Quagga Dry Weight Medium Size Class 5-10mm (g)	Quagga Dry Weight Small Size Class <5mm (g)	Fragment Dry Weight (g)	Large Density (#/sq-ft)	Medium Density (#/sq-ft)	Small Density (#/sq-ft)	Total Density (#/sq-ft)	Large Biomass (g/sq-ft)	Medium Biomass (g/sq-ft)	Small Biomass (g/sq-ft)	Fragment Biomass (g/sq-ft)	Total Biomass (g/sq-ft)
Enbridge	EPZASW05	EN817-1	8/15/2017	East	A	South	West	Additional Site	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	EPZCSW05	EN817-10	8/16/2017	East	C	South	West	Biota Site	23	NA	NA	23	12.787	NA	NA	4.839	263.561	0	0	263.561	146.528	0	0	55.451	201.979
Enbridge	EPZANW08	EN817-11	8/19/2017	East	A	North	West	Biota Site	9	NA	NA	9	4.287	NA	NA	3.311	103.132	0	0	103.132	49.125	0	0	37.941	87.067
Enbridge	EPZANE03	EN817-12	8/19/2017	East	A	North	East	Biota Site	9	NA	NA	9	5.300	NA	NA	5.443	103.132	0	0	103.132	60.734	0	0	62.372	123.106
Enbridge	EPZANT02	EN817-13	8/19/2017	East	A	North	Top	Biota Site	7	1	2	10	4.011	0.014	0.004	4.197	80.214	11.459	22.918	114.592	45.963	0.16	0.046	48.094	94.263
Enbridge	EPZBNW12	EN817-14	8/19/2017	East	B	North	West	Biota Site	NA	1	NA	1	NA	0.022	NA	NA	0	11.459	0	11.459	0	0.252	0	0	0.252
Enbridge	EPZBNE04	EN817-15	8/19/2017	East	B	North	East	Biota Site	NA	NA	NA	NA	NA	NA	NA	0.873	0	0	0	0	0	0	0	10.004	10.004
Enbridge	EPZBNT01	EN817-16	8/19/2017	East	B	North	Top	Biota Site	2	NA	NA	2	0.855	NA	NA	1.567	22.918	0	0	22.918	9.798	0	0	17.956	27.754
Enbridge	WPZANT01	EN817-17	8/19/2017	West	A	North	Top	Biota Site	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	WPZANE02	EN817-18	8/19/2017	West	A	North	East	Biota Site	5	10	2	17	1.479	0.076	0.006	0.415	57.296	114.592	22.918	194.806	16.948	0.871	0.069	4.756	22.643
Enbridge	WPZANB09	EN817-19	8/19/2017	West	A	North	Bottom	Biota Site	20	NA	NA	20	8.269	NA	NA	2.687	229.183	0	0	229.183	94.756	0	0	30.791	125.547
Enbridge	EPZASW12	EN817-2	8/15/2017	East	A	South	West	Additional Site	22	4	2	28	9.830	0.038	0.006	3.781	252.101	45.837	22.918	320.856	112.644	0.435	0.069	43.327	156.475
Enbridge	WPZANW08	EN817-20	8/19/2017	West	A	North	West	Biota Site	5	10	2	17	0.530	0.112	0.004	0.707	57.296	114.592	22.918	194.806	6.073	1.283	0.046	8.102	15.504
Enbridge	EPZDT02	EN817-21	8/20/2017	East	D	South	Top	Biota Site	17	7	5	29	8.897	0.900	0.010	4.401	194.806	80.214	57.296	332.316	101.952	10.313	0.115	50.432	162.812
Enbridge	EPZDE01	EN817-22	8/20/2017	East	D	South	East	Biota Site	31	10	9	50	14.595	0.124	0.027	9.675	355.234	114.592	103.132	572.958	167.246	1.421	0.309	110.867	279.844
Enbridge	EPZDW08	EN817-23	8/20/2017	East	D	South	West	Biota Site	19	13	4	36	9.760	0.123	0.011	10.929	217.724	148.969	45.837	412.53	111.841	1.409	0.126	125.237	238.614
Enbridge	WPZDT10	EN817-24	8/20/2017	West	D	South	Top	Biota Site	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	WPZDE12	EN817-25	8/20/2017	West	D	South	East	Biota Site	26	11	8	45	9.768	0.104	0.016	5.296	297.938	126.051	91.673	515.662	111.933	1.192	0.183	60.688	173.996
Enbridge	WPZDW03	EN817-26	8/20/2017	West	D	South	West	Biota Site	25	7	8	40	10.083	0.067	0.028	4.698	286.479	80.214	91.673	458.366	115.543	0.768	0.321	53.835	170.466
Enbridge	WPZCNT04	EN817-27	8/21/2017	West	C	North	Top	Biota Site	10	6	12	28	4.802	0.060	0.021	6.167	114.592	68.755	137.51	320.856	55.027	0.688	0.241	70.669	126.624
Enbridge	WPZCNB09	EN817-28	8/21/2017	West	C	North	Bottom	Biota Site	23	3	3	29	9.276	0.055	0.004	5.420	263.561	34.377	34.377	332.316	106.295	0.63	0.046	62.109	169.08
Enbridge	WPZCNW06	EN817-29	8/21/2017	West	C	North	West	Biota Site	26	1	NA	27	14.132	0.017	NA	6.628	297.938	11.459	0	309.397	161.941	0.195	0	75.951	238.087
Enbridge	EPZBST05	EN817-3	8/15/2017	East	B	South	Top	Biota Site	27	6	NA	33	10.268	0.039	NA	1.962	309.397	68.755	0	378.152	117.663	0.447	0	22.483	140.592
Enbridge	WPZBNT01	EN817-30	8/21/2017	West	B	North	Top	Biota Site	29	5	3	37	14.815	0.068	0.005	8.158	332.316	57.296	34.377	423.989	169.767	0.779	0.057	93.484	264.088
Enbridge	WPZBNE11	EN817-31	8/21/2017	West	B	North	East	Biota Site	33	6	7	46	15.955	0.053	0.011	3.815	378.152	68.755	80.214	527.121	182.831	0.607	0.126	43.717	227.281
Enbridge	WPZBNW04	EN817-32	8/21/2017	West	B	North	West	Biota Site	44	11	NA	55	18.230	0.136	NA	8.537	504.203	126.051	0	630.254	208.9	1.558	0	97.827	308.286
Enbridge	WPZCNE11	EN817-33	8/21/2017	West	C	North	East	Biota Site	18	8	4	30	7.208	0.048	0.009	5.979	206.265	91.673	45.837	343.775	82.598	0.55	0.103	68.514	151.765
Enbridge	EPZASW07CD	EN817-34	8/24/2017	East	A	South	West	Additional Site	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	170824-EAOI11DC	EN817-35	8/24/2017	East	A	South	Top	Area of Interest	1	NA	NA	1	0.441	NA	NA	NA	11.459	0	0	11.459	5.053	0	0	0	5.053
Enbridge	EPZASW01	EN817-36	8/24/2017	East	A	South	West	Additional Site	34	NA	NA	34	15.549	0.056	NA	9.687	389.611	0	0	389.611	178.178	0.642	0	111.005	289.825
Enbridge	EPZASW02	EN817-37	8/24/2017	East	A	South	West	Additional Site	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	WPZDT11	EN817-38	8/25/2017	West	D	South	Top	Additional Site	3	4	12	19	1.532	0.036	0.015	1.273	34.377	45.837	137.51	217.724	17.555	0.413	0.172	14.588	32.727
Enbridge	WPZDT02	EN817-39	8/25/2017	West	D	South	Top	Additional Site	29	NA	2	31	12.332	NA	0.009	5.999	332.316	0	22.918	355.234	141.314	0	0.103	68.743	210.161
Enbridge	EPZBSE08	EN817-4	8/15/2017	East	B	South	East	Biota Site	38	7	4	49	19.016	0.039	0.015	6.470	435.448	80.214	45.837	561.499	217.907	0.447	0.172	74.141	292.667
Enbridge	EPZDE09	EN817-40	8/26/2017	East	D	North	East	Biota Site	32	11	4	47	10.530	0.119	0.010	6.667	366.693	126.051	45.837	538.58	120.665	1.364	0.115	76.398	198.541
Enbridge	EPZDT02	EN817-41	8/26/2017	East	D	North	Top	Biota Site	5	3	12	20	2.373	0.029	0.021	1.869	57.296	34.377	137.51	229.183	27.193	0.332	0.241	21.417	49.183
Enbridge	EPZDW10	EN817-42	8/26/2017	East	D	North	West	Biota Site	18	4	2	24	6.673	0.026	0.008	3.523	206.265	45.837	22.918	275.02	76.467	0.298	0.092	40.371	117.227
Enbridge	EPZDW06	EN817-43	8/26/2017	East	D	North	West	Area of Interest	4	2	1	7	1.465	0.017	0.001	3.305	45.837	22.918	11.459	80.214	16.788	0.195	0.011	37.873	54.866
Enbridge	EPZDW01	EN817-44	8/26/2017	East	D	North	West	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	WPZCSE09	EN817-45	8/26/2017	West	C	South	East	Biota Site	26	10	3	39	14.265	0.074	0.008	5.168	297.938	114.592	34.377	446.907	163.465	0.848	0.092	59.221	223.625
Enbridge	WPZCSW11	EN817-46	8/26/2017	West	C	South	West	Biota Site	11	1	4	16	4.074	0.026	0.008	1.612	126.051	11.459	45.837	183.346	46.685	0.298	0.092	18.472	65.546
Enbridge	WPZCSW08	EN817-47	8/26/2017	West	C	South	West	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	WPZCST07	EN817-48	8/26/2017	West	C	South	Top	Biota Site	14	14	34	62	8.376	0.147	0.047	4.424	160.428	160.428	389.611	710.468	95.982	1.684	0.539	50.695	148.9
Enbridge	WPZCSW03	EN817-49	8/26/2017	West	C	South	West	Area of Interest	16	1	NA	17	7.920	0.029	NA	10.011	183.346	11.459	0	194.806	90.757	0.332	0	114.718	205.806
Enbridge	EPZBSB04	EN817-5	8/15/2017	East	B	South	Bottom	Biota Site	41	NA	NA	41	12.105	NA	NA	5.139	469.825	0	0	469.825	138.713	0	0	58.889	197.602
Enbridge	WPZAST04	EN817-50	8/29/2017	West	A	South	Top	Biota Site	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	WPZASE07	EN817-51	8/29/2017	West	A	South	East	Biota Site	1	NA	NA	1	0.044	NA	NA	0.046	11.459	0	0	11.459	0.504	0	0	0.527	1.031
Enbridge	WPZASW11	EN817-52	8/29/2017	West	A	South	West	Biota Site	1	NA	NA	1	0.299	NA	NA	0.141	11.459	0	0	11.459	3.426	0	0	1.616	5.042
Enbridge	WPZAST06	EN817-53	8/29/2017	West	A	South	Top	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	WPZAST09	EN817-54	8/29/2017	West	A	South	Top	Area of Interest	2	NA	2	4	0.941	NA	0.002	0.234	22.918	0	22.918	45.837	10.783	0	0.023	2.681	13.487
Enbridge	EPZANMOI	EN817-55	8/19/2017	East	A	North	East	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	170821-WAOI5DC	EN817-56	8/21/2017	West	A	South	West	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	170905-EAOI6DC	EN817-57	9/5/2017	East	A	South	West	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	EPZAST09	EN817-58	9/5/2017	East	A	South	Top	Biota Site	2	NA	NA	2	1.351	NA	NA	1.047	22.918	0	0	22.918	15.481	0	0	11.998	27.479
Enbridge	EPZASE08	EN817-59	9/5/2017	East	A	South	East	Biota Site	64	14	14	92	30.683	0.188	0.024	16.083	733.386	160.428	160.428	1054.242	351.601	2.154	0.275	184.298	538.328
Enbridge	EPZBSW02	EN817-6	8/15/2017	East	B	South	West	Biota Site	52	8	5	65	30.246	0.111	0.014	6.394	595.876	91.673	57.296	744.845	346.594	1.272	0.16	73.27	421.296
Enbridge	EPZASW04	EN817-60	9/5/2017	East	A	South	West	Biota Site	39	8	12	59	18.852	0.112	0.019	11.797	446.907	91.673	137.51	676.09	216.028	1.283	0.218	135.184	352.713
Enbridge	EPZASB01	EN817-61	9/5/2017	East	A	South	Bottom	Biota Site	34	16	4	54	14.547	0.223	0.010	4.263	389.611	183.346	45.837	618.794	166.696	2.555	0.115	48.85	218.217
Enbridge	EPZASW02	EN817-62	9/5/2017	East	A	South	West	Area of Interest	31	NA	NA	31	12.801	NA	NA	8.543	355.234	0	0	355.234	146.689	0	0	97.896	244.584
Enbridge	EPZASW10	EN817-63	9/5/2017	East	A	South	West	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	170906-EAOI9MOI	EN817-64	9/6/2017	East	A	South	-	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	170906-EAOI10MOI	EN817-65	9/6/2017	East	A	South	-	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	WPZDT08	EN817-66	9/7/2017	West	D	North	Top	Biota Site	NA	1	2	3	NA	0.008	0.004	0.931	0	11.459	22.918	34.377	0	0.092	0.046	10.668	10.806
Enbridge	WPZDE11	EN817-67	9/7/2017	West	D	North	East	Biota Site	47	13	4	64	20.675	0.116	0.014	8.305	538.58	148.969	45.837	733.386	236.918	1.329	0.16	95.168	333.576
Enbridge	WPZDW09	EN817-68	9/7/2017	West	D	North	West	Biota Site	31	9	3	43	14.591	0.078	0.011	10.326	355.234	103.132	34.377	492.744	167.201	0.894	0.126	118.327	286.548
Enbridge	WPZDB05	EN817-69	9/7/2017	West	D	North	Bottom	Biota Site	9	4	NA	13	2.514	0.056	NA	2.440	103.132	45.837	0	148.969	28.808	0.642	0	27.96	57.41
Enbridge	EPZCST08	EN817-7	8/16/2017	East	C	South	Top	Biota Site	26	NA	NA	26	16.260	NA	NA	5.243	297.938	0	0	297.938	186.326	0	0	60.08	246.406
Enbridge	WPZDE02	EN817-70	9/7/2017	West	D	North	East	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	WPZDE03	EN817-71	9/7/2017	West	D	North	East	Area of Interest	28	9	13	50	13.708	0.116	0.028	9.852	320.856	103.132	148.969	572.958	157.082	1.329	0.321	112.896	271.628

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Mussel Count (Density) and Biomass Per Square Foot (Continued)

Enbridge	170907-WAOI1MOI	EN817-72	9/7/2017	West	D	North	West	Area of Interest	260	276	193	729	76.791	2.925	0.388	50.254	2979.381	3162.727	2211.617	8353.725	879.96	33.518	4.446	575.868	1493.793
Enbridge	170907-WAOI2CD	EN817-73	9/7/2017	West	D	South	West	Area of Interest	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	0	0	0	0	0
Enbridge	EPZCNT13	EN817-74	9/8/2017	East	C	North	Top	Biota Site	22	1	1	24	12.241	0.016	0.002	8.457	252.101	11.459	11.459	275.02	140.272	0.183	0.023	96.91	237.388
Enbridge	EPZCNE11	EN817-75	9/8/2017	East	C	North	East	Biota Site	12	NA	NA	12	6.669	NA	NA	4.807	137.51	0	0	137.51	76.421	0	0	55.084	131.505
Enbridge	EPZCNW06	EN817-76	9/8/2017	East	C	North	West	Biota Site	26	3	NA	29	12.405	0.097	NA	11.562	297.938	34.377	0	332.316	142.151	1.112	0	132.491	275.753
Enbridge	EPZCNW08	EN817-77	9/8/2017	East	C	North	West	Area of Interest	7	NA	1	8	3.327	NA	0.001	1.089	80.214	0	11.459	91.673	38.125	0	0.011	12.479	50.615
Enbridge	EPZCNW03	EN817-78	9/8/2017	East	C	North	West	Area of Interest	21	NA	NA	21	12.252	NA	NA	13.493	240.642	0	0	240.642	140.398	0	0	154.618	295.016
Enbridge	WPZBST11	EN817-79	9/8/2017	West	B	South	Top	Biota Site	27	1	7	35	10.288	0.004	0.009	7.764	309.397	11.459	80.214	401.07	117.892	0.046	0.103	88.969	207.01
Enbridge	EPZCSE03	EN817-8	8/16/2017	East	C	South	East	Biota Site	32	4	1	37	20.676	0.026	0.001	5.284	366.693	45.837	11.459	423.989	236.93	0.298	0.011	60.55	297.789
Enbridge	WPZBSE10	EN817-80	9/8/2017	West	B	South	East	Biota Site	36	5	11	52	16.117	0.057	0.020	6.438	412.53	57.296	126.051	595.876	184.687	0.653	0.229	73.774	259.344
Enbridge	WPZBSW14	EN817-81	9/8/2017	West	B	South	West	Biota Site	47	8	5	60	19.553	0.065	0.013	9.045	538.58	91.673	57.296	687.549	224.061	0.745	0.149	103.648	328.603
Enbridge	WPZBSB01	EN817-82	9/8/2017	West	B	South	Bottom	Biota Site	25	3	5	33	9.423	0.014	0.004	4.890	286.479	34.377	57.296	378.152	107.98	0.16	0.046	56.035	164.221
Enbridge	WPZBSE08	EN817-83	9/8/2017	West	B	South	East	Area of Interest	48	5	3	56	21.837	0.039	0.010	5.125	550.039	57.296	34.377	641.713	250.234	0.447	0.115	58.728	309.523
Enbridge	WPZBSE09	EN817-84	9/8/2017	West	B	South	East	Area of Interest	14	18	20	52	1.672	0.272	0.024	1.668	160.428	206.265	229.183	595.876	19.16	3.117	0.275	19.114	41.665
Enbridge	EPZCSB10	EN817-9	8/16/2017	East	C	South	Bottom	Biota Site	NA	2	1	3	NA	0.008	0.002	0.328	0	22.918	11.459	34.377	0	0.092	0.023	3.759	3.873

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Mussel Wet and Dry Weights (Total Biomass Results found on Pages F-2, F-3)

Project Name	Site Name	GEI Log #	Sample Date	Drip Time	Initial Wet Weight of Total Sample Minus EtOH (g)	Initial Wet Weight of Mussels Only (g)	Initial Wet Weight of Fragments/ Byssal Threads Only (g)	Quagga Wet Weight Large Size Class >10mm (g)	Quagga Wet Weight Medium Size Class 5-10mm (g)	Quagga Wet Weight Small Size Class <5mm (g)	Zebra Wet Weight (g)	Fragment Wet Weight (g)	Oven Start Date	Oven Start Time	Oven End Date	Oven End Time	Quagga Dry Weight Large Size Class >10mm (g)	Quagga Dry Weight Medium Size Class 5-10mm (g)	Quagga Dry Weight Small Size Class <5mm (g)	Zebra Dry Weight (g)	Fragment Dry Weight (g)	QA Performed
Enbridge	EPZASW05	EN817-1	8/15/2017	(3 min handling, 2 min draining)	7.9670	NA	4.113	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	EPZCSW05	EN817-10	8/16/2017	5 min	40.095	29.988	6.762	29.339	NA	NA	NA	6.617	8/21/2017	3:30 PM	8/21/2017	5:30 PM	12.787	NA	NA	NA	4.839	N
Enbridge	EPZANW08	EN817-11	8/19/2017	5 min	24.003	10.912	4.708	10.632	NA	NA	NA	4.466	8/22/2017	11:40 AM	8/22/2017	12:44 PM	4.287	NA	NA	NA	3.311	N
Enbridge	EPZANE03	EN817-12	8/19/2017	5 min	31.739	13.528	7.189	13.015	NA	NA	NA	6.907	8/22/2017	12:21 PM	8/22/2017	2:21 PM	5.300	NA	NA	NA	5.443	N
Enbridge	EPZANT02	EN817-13	8/19/2017	5 min	26.482	12.025	4.731	10.840	0.020	0.007	NA	5.225	8/22/2017	1:36 PM	8/22/2017	3:30 PM	4.011	0.014	0.004	NA	4.197	N
Enbridge	EPZBNW12	EN817-14	8/19/2017	5 min	9.249	0.547	NA	NA	0.547	NA	NA	NA	8/22/2017	2:15 PM	8/22/2017	3:15 PM	NA	0.022	NA	NA	NA	N
Enbridge	EPZBNE04	EN817-15	8/19/2017	5 min	140.86	NA	0.954	NA	NA	NA	NA	0.954	8/22/2017	2:35 PM	8/22/2017	3:30 PM	NA	NA	NA	NA	0.873	N
Enbridge	EPZBNT01	EN817-16	8/19/2017	5 min	11.506	2.133	2.157	2.050	NA	NA	NA	1.979	8/22/2017	3:08 PM	8/22/2017	4:38 PM	0.855	NA	NA	NA	1.567	Y
Enbridge	WPZANT01	EN817-17	8/19/2017	5 min	6.679	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	WPZANE02	EN817-18	8/19/2017	5 min	13.084	4.625	0.913	4.258	0.150	0.007	NA	0.657	8/22/2017	4:13 PM	8/22/2017	5:30 PM	1.479	0.076	0.006	NA	0.415	N
Enbridge	WPZANB09	EN817-19	8/19/2017	5 min	32.79	20.725	4.505	19.316	NA	NA	NA	4.199	8/23/2017	9:41 AM	8/23/2017	11:41 AM	8.269	NA	NA	NA	2.687	N
Enbridge	EPZASW12	EN817-2	8/15/2017	10+	36.578	23.293	4.490	25.207	0.082	<0.001	NA	6.555	8/18/2017	10:00 AM	8/18/2017	12:45 AM	9.830	0.038	0.006	NA	3.781	N
Enbridge	WPZANW08	EN817-20	8/19/2017	5 min	10.516	1.885	1.128	1.364	0.322	0.005	NA	0.886	8/23/2017	10:36 AM	8/23/2017	12:30 PM	0.530	0.112	0.004	NA	0.707	N
Enbridge	EPZDT02	EN817-21	8/20/2017	5 min	39.667	23.363	7.112	21.907	0.189	0.016	NA	6.552	8/23/2017	11:37 AM	8/23/2017	1:30 PM	8.897	0.900	0.010	NA	4.401	N
Enbridge	EPZDE01	EN817-22	8/20/2017	5 min	73.852	44.939	14.011	39.368	0.323	0.043	NA	14.536	8/23/2017	1:38 PM	8/23/2017	3:30 PM	14.595	0.124	0.027	NA	9.675	N
Enbridge	EPZDW08	EN817-23	8/20/2017	5 min	56.69	28.346	16.943	26.014	0.256	0.024	NA	15.890	8/23/2017	2:50 PM	8/23/2017	4:50 PM	9.760	0.123	0.011	NA	10.929	N
Enbridge	WPZDT10	EN817-24	8/20/2017	5 min	6.225	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	WPZDE12	EN817-25	8/20/2017	5 min	44.064	28.127	8.056	26.071	0.227	0.031	NA	7.365	8/23/2017	3:40 AM	8/23/2017	5:30 PM	9.768	0.104	0.016	NA	5.296	N
Enbridge	WPZDW03	EN817-26	8/20/2017	5 min	46.943	30.499	7.351	28.470	0.163	0.046	NA	6.721	8/24/2017	11:42 AM	8/24/2017	1:42 PM	10.083	0.067	0.028	NA	4.698	N
Enbridge	WPZCNT04	EN817-27	8/21/2017	5 min	28.866	12.471	9.652	11.451	0.134	0.040	NA	9.193	8/24/2017	1:01 PM	8/24/2017	3:01 PM	4.802	0.060	0.021	NA	6.167	N
Enbridge	WPZCNB09	EN817-28	8/21/2017	5 min	43.232	24.321	8.887	22.793	0.135	0.013	NA	8.352	8/24/2017	1:47 PM	8/24/2017	3:47 PM	9.276	0.055	0.004	NA	5.420	N
Enbridge	WPZCNW06	EN817-29	8/21/2017	5 min	59.762	38.563	10.878	36.949	0.032	NA	NA	10.260	8/24/2017	2:45 PM	8/24/2017	4:45 PM	14.132	0.017	NA	NA	6.628	Y
Enbridge	EPZBST05	EN817-3	8/15/2017	5 min	37.94	27.815	3.227	27.493	0.153	NA	NA	2.634	8/18/2017	2:08 PM	8/18/2017	4:00 PM	10.268	0.039	NA	NA	1.962	N
Enbridge	WPZBNT01	EN817-30	8/21/2017	5 min	66.441	44.324	11.579	42.524	0.126	0.007	NA	11.064	8/24/2017	3:25 PM	8/24/2017	5:25 PM	14.815	0.068	0.005	NA	8.158	N
Enbridge	WPZBNE11	EN817-31	8/21/2017	5 min	59.905	43.849	5.187	41.738	0.090	0.023	NA	4.788	8/25/2017	1:05 PM	8/25/2017	3:05 PM	15.955	0.053	0.011	NA	3.815	N
Enbridge	WPZBNW04	EN817-32	8/21/2017	5 min	79.319	50.973	12.932	45.813	0.322	NA	NA	11.950	8/25/2017	2:05 PM	8/25/2017	4:05 AM	18.230	0.136	NA	NA	8.537	Y
Enbridge	WPZCNE11	EN817-33	8/21/2017	5 min	34.649	17.506	9.156	16.680	0.105	0.018	NA	8.842	8/25/2017	3:10 PM	8/25/2017	5:10 PM	7.208	0.048	0.009	NA	5.979	N
Enbridge	EPZASW07CD	EN817-34	8/24/2017	5 min	6.054	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	170824-EAOI11DC	EN817-35	8/24/2017	5 min	16.792	0.5290	NA	0.529	NA	NA	NA	NA	8/28/2017	3:38 PM	8/28/2017	5:00 PM	0.441	NA	NA	NA	NA	N
Enbridge	EPZASW01	EN817-36	8/24/2017	5 min	77.075	40.317	11.973	36.980	0.099	NA	NA	11.791	8/29/2017	11:58 AM	8/29/2017	2:00 PM	15.549	0.056	NA	NA	9.687	N
Enbridge	EPZASW02	EN817-37	8/24/2017	5 min	6.857	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	WPZDT11	EN817-38	8/25/2017	5 min	15.629	5.453	1.867	5.119	0.122	0.027	NA	1.649	8/29/2017	12:55 PM	8/29/2017	3:00 PM	1.532	0.036	0.015	NA	1.273	N
Enbridge	WPZDT02	EN817-39	8/25/2017	5 min	56.248	34.732	11.563	34.334	NA	0.010	NA	9.722	8/29/2017	2:01 PM	8/29/2017	4:00 PM	12.332	NA	0.009	NA	5.999	N
Enbridge	EPZBSE08	EN817-4	8/15/2017	5 min	72.024	53.051	10.618	51.675	0.094	0.021	NA	10.087	8/18/2017	3:21 PM	8/18/2017	5:30 PM	19.016	0.039	0.015	NA	6.470	N
Enbridge	EPZDE09	EN817-40	8/26/2017	5 min	51.6	30.996	10.3	28.209	0.274	0.014	NA	9.548	8/29/2017	3:15 PM	8/29/2017	5:15 PM	10.530	0.119	0.010	NA	6.667	N
Enbridge	EPZDT02	EN817-41	8/26/2017	5 min	17.157	7	2.976	6.604	0.062	0.029	NA	2.710	8/30/2017	10:18 AM	8/30/2017	12:20 PM	2.373	0.029	0.021	NA	1.869	N
Enbridge	EPZDW10	EN817-42	8/26/2017	5 min	32.858	18.05	5.873	16.963	0.060	0.012	NA	5.436	8/30/2017	11:18 AM	8/30/2017	1:20 PM	6.673	0.026	0.008	NA	3.523	N
Enbridge	EPZDW06	EN817-43	8/26/2017	5 min	16.888	4.419	5.344	4.205	0.041	0.004	NA	5.042	8/30/2017	12:01 PM	8/30/2017	2:00 PM	1.465	0.017	0.001	NA	3.305	Y
Enbridge	EPZDW01	EN817-44	8/26/2017	5 min	5.99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	WPZCSE09	EN817-45	8/26/2017	5 min	60.441	43.026	8.544	40.744	0.173	0.015	NA	7.883	8/30/2017	1:25 PM	8/30/2017	3:25 PM	14.265	0.074	0.008	NA	5.168	N
Enbridge	WPZCSW11	EN817-46	8/26/2017	5 min	24.383	14.017	2.711	13.400	0.065	0.017	NA	2.447	8/30/2017	2:55 PM	8/30/2017	4:55 PM	4.074	0.026	0.008	NA	1.612	N
Enbridge	WPZCSW08	EN817-47	8/26/2017	5 min	7.027	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	WPZCST07	EN817-48	8/26/2017	5 min	39.769	24.592	6.898	23.037	0.244	0.083	NA	6.225	8/31/2017	11:35 AM	8/31/2017	1:40 PM	8.376	0.147	0.047	NA	4.424	N
Enbridge	WPZCSW03	EN817-49	8/26/2017	5 min	48.733	20.495	16.701	19.659	0.081	NA	NA	16.162	8/31/2017	12:15 PM	8/31/2017	2:15 PM	7.920	0.029	NA	NA	10.011	N
Enbridge	EPZBSB04	EN817-5	8/15/2017	5 min	50.554	35.047	7.83	34.529	NA	NA	NA	7.783	8/18/2017	4:11 PM	8/18/2017	6:11 PM	12.105	NA	NA	NA	5.139	N
Enbridge	WPZAST04	EN817-50	8/29/2017	5 min	6.206	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	WPZASE07	EN817-51	8/29/2017	5 min	10.516	0.103	0.118	0.100	NA	NA	NA	0.084	9/1/2017	11:15AM	9/1/2017	12:30 PM	0.044	NA	NA	NA	0.046	N
Enbridge	WPZASW11	EN817-52	8/29/2017	5 min	7.593	0.99	0.318	0.920	NA	NA	NA	0.293	9/1/2017	11:55 AM	9/1/2017	1:00 PM	0.299	NA	NA	NA	0.141	N
Enbridge	WPZAST06	EN817-53	8/29/2017	5 min	6.847	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	WPZAST09	EN817-54	8/29/2017	5 min	9.968	2.719	0.244	2.608	NA	0.002	NA	0.242	9/1/2017	1:10 PM	9/1/2017	3:00 PM	0.941	NA	0.002	NA	0.234	Y
Enbridge	EPZANMOI	EN817-55	8/19/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	17082-WAOI5DC	EN817-56	8/21/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	170905-EAOI6DC	EN817-57	9/5/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	EPZAST09	EN817-58	9/5/2017	5 min	14.055	3.966	1.603	3.882	NA	NA	NA	1.471	9/7/2017	1:11 PM	9/7/2017	3:00 PM	1.351	NA	NA	NA	1.047	N
Enbridge	EPZASE08	EN817-59	9/5/2017	5 min	131.255	88.339	23.716	84.675	0.399	0.049	NA	22.586	9/7/2017	3:15 PM	9/7/2017	5:15 PM	30.683	0.188	0.024	NA	16.083	N
Enbridge	EPZBSW02	EN817-6	8/15/2017	5 min	96.159	77.335	10.412	73.299	0.226	0.022	NA	9.821	8/18/2017	5:13 PM	8/18/2017	7:13 PM	30.246	0.111	0.014	NA	6.394	N
Enbridge	EPZASW04	EN817-60	9/5/2017	5 min	84.878	53.558	18.111	50.561	0.219	0.028	NA	16.633	9/8/2017	12:45 PM	9/8/2017	3:45 PM	18.852	0.112	0.019	NA	11.797	N
Enbridge	EPZASB01	EN817-61	9/5/2017	5 min	60.717	42.122	7.447	40.328	0.453	0.022	NA	6.954	9/8/2017	2:05 PM	9/8/2017	4:40 PM	14.547	0.223	0.010	NA	4.263	N
Enbridge	EPZASW02	EN817-62	9/5/2017	5 min	62.938	35.242	10.754	33.525	NA	NA	NA	10.728	9/11/2017	2:15 PM	9/11/2017	4:15 PM	12.801	NA	NA	NA	8.543	N
Enbridge	EPZASW10	EN817-63	9/5/2017	5 min	6.034	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	170906-EAOI9MOI	EN817-64	9/6/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	170906-EAOI10MOI	EN817-65	9/6/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	WPZDT08	EN817-66	9/7/2017	5 min	7.948	0.022	1.47	NA	0.009	0.006	NA	1.342	9/12/2017	10:45 AM	9/12/2017	12:30 PM	NA	0.008	0.004	NA	0.931	Y
Enbridge	WPZDE11	EN817-67	9/7/2017	5 min	87.654	57.913	13.726	53.999	0.231	0.023	NA	12.288	9/12/2017	12:26 PM	9/12/2017	2:26 PM	20.675	0.116	0.014	NA	8.305	N
Enbridge	WPZDW09	EN817-68	9/7/2017	5 min	72.758	42.77	16.018	40.711	0.178	0.011	NA	15.266	9/12/2017	2:00 PM	9/12/2017	4:00 PM	14.591	0.078	0.011	NA	10.326	N
Enbridge	WPZDB05	EN817-69	9/7/2017	5 min	17.608	5.62	3.973	5.245	0.124	NA	NA	3.667	9/12/2017	2:35 PM	9/12/2017	4:35 PM	2.514	0.056	NA	NA	2.440	N
Enbridge	EPZCST08	EN817-7	8/16/2017	5 min	57.519	38.198	8.591	38.131	NA	NA	NA	8.272	8/21/2017	11:35 AM	8/21/2017	1:35 PM	16.260	NA	NA	NA	5.243	N
Enbridge	WPZDE02	EN817-70	9/7/2017	5 min	7.463	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	WPZDE03	EN817-71	9/7/2017	5 min	68.311	38.785	13.277	36.409	0.224	0.056	NA	12.697	9/14/2017	12:15 PM	9/14/2017	2:30 PM	13.708	0.116	0.028	NA	9.852	N
Enbridge	170907-WAOI1MOI	EN817-72	9/7/2017	NA-Large mat of rubber, no mesh	800	206	77	181.989	3.933	0.489	NA	76.675	9/15/2017	10:10 AM	9/15/2017	2:30 PM	76.791	2.925	0.388	NA	50.254	N
Enbridge	170907-WAOI2CD	EN817-73	9/7/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	N
Enbridge	EPZCNT13	EN817-74	9/8/2017	5 min	85.764	32.813	10.886	30.282	0.042	0.003	NA	10.456	9/18/2017	9:33 AM	9/18/2017	12:00 PM	12.241	0.016	0.002	NA	8.457	N
Enbridge	EPZCNE11	EN817-75	9/8/2017	5 min	35.1	17.865	6.266	16.955	NA	NA	NA	6.025	9/18/2017	11:45 AM	9/18/2017	1:45 PM	6.669	NA	NA	NA	4.807	N
Enbridge	EPZCNW06	EN817-76	9/8/2017	5 min	61.922	34.873	16.383	32.171	0.223	NA	NA	15.815	9/18/2017	12:30 PM	9/18/2017	2:30 PM	12.405	0.097	NA	NA	11.562	N
Enbridge	EPZCNW08	EN817-77	9/8/2017	5 min	17.071	8.486	1.495	8.413	NA	0.002	NA	1.456	9/19/2017	10:40 AM	9/19/2017	1:00 PM	3.327	NA	0.001	NA	1.089	N
Enbridge	EPZCNW03	EN817-78	9/8/2017	5 min	77.988	33.765	17.036	32.726	NA	NA	NA	16.754	9/19/2017	11:45 AM	9/19/2017	2:00 PM	12.252	NA	NA	NA	13.493	N
Enbridge	WPZBST11	EN817-79	9/8/2017	5 min	51.355	26.659	11.765	25.865	0.006	0.011	NA	11.258	9/19/2017	12:30 PM	9/19/2017	3:00 PM	10.288	0.004	0.009	NA	7.764	N
Enbridge	EPZCSE03	EN817-8	8/16/2017	5 min	64.729	50.287	7.462	47.702	0.055	0.016	NA	6.828	8/21/2017	1:30 PM	8/21/2017	3:30 PM	20.676	0.026	0.001	NA	5.284	N
Enbridge	WPZBSE10	EN817-80	9/8/2017	5 min	67.455	45.472	10.177	43.354	0.131	0.038	NA	9.233	9/19/2017	1:50 PM	9/19/2017	3:50 PM	16.117	0.057	0.020	NA	6.438	N
Enbridge	WPZBSW14	EN817-81	9/8/2017	5 min	81.479	55.432	14.349	52.815	0.139	0.019	NA	13.233	9/25/2017	12:15 PM	9/25/2017	2:15 PM	19.553	0.065	0.013	NA	9.045	Y
Enbridge	WPZBSB01	EN817-82	9/8/2017	5 min	42.538	24.006	7.809	22.884	0.023	0.005	NA	7.268	9/25/2017	1:38 PM	9/25/2017	3:38 PM	9.423	0.014	0.004	NA	4.890	Y
Enbridge	WPZBSE08	EN817-83	9/8/2017	5 min	81.379	61.822	8.004	59.705	0.075	0.011	NA	7.457	9/25/2017	2:35 PM	9/25/2017	4:35 PM	21.837	0.039	0.010	NA	5.125	Y
Enbridge	WPZBSE09	EN817-84	9/8/2017	5 min	21.744	4.918	2.399	3.992	0.551	0.034	NA	2.162	9/25/2017	3:20 PM	9/25/2017	5:20 PM	1.672	0.272	0.024	NA	1.668	Y
Enbridge	EPZCSB10	EN817-9	8/16/2017	5 min	5.446	NA	0.404	NA	0.008	0.002	NA	0.369	8/21/2017	3:30 PM	8/21/2017	4:15 PM	NA	0.008	0.002	NA	0.328	Y

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Biota and Inorganic Material Wet and Dry Weights

Project Name	Site Name	GEI Log #	Sample Date	Drip Time	Initial Wet Weight of Total Sample Minus EtOH (g)	Initial Wet Weight of Periphyton/ Macroinvertebrate (g)	Oven Start Date	Oven Start Time	Oven End Date	Oven End Time	QA Performed	Macroinvertebrate Wet Weight (g)	Oven Start Date	Oven Start Time	Oven End Date	Oven End Time	Macroinvertebrate Dry Weight (g)	Periphyton Wet Weight (g)	Macrophyte Wet Weight (g)	Oven Start Date	Oven Start Time	Oven End Date	Oven End Time	Periphyton Dry Weight (g)	MOI Wet Weight (g)	MOI Type	MOI Dry Weight (g)	Wet Weight of Mesh Plus Inorganic Material (g)	Inorganic Material Dry Weight (g)	Mesh Dry Weight (g)
Enbridge	EP2ASW05	EN817-1	8/15/2017	(3 min handling, 2 min draining)	7.9670	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.050	Coating	0.050	3.854	0.419	3.885
Enbridge	EP2CSW05	EN817-10	8/16/2017	5 min	40.095	NA	8/21/2017	3:30 PM	8/21/2017	5:30 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.921	NA	0.955
Enbridge	EP2ANW08	EN817-11	8/19/2017	5 min	24.003	0.125	8/22/2017	11:40 AM	8/22/2017	12:44 PM	N	NA	NA	NA	NA	NA	NA	0.125	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.049	0.005	Coating	0.005	5.432	<0.001	5.450
Enbridge	EP2ANB03	EN817-12	8/19/2017	5 min	31.739	0.331	8/22/2017	12:21 PM	8/22/2017	2:21 PM	N	NA	NA	NA	NA	NA	NA	0.331	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.143	0.712	Coating	0.462	5.406	0.369	5.328
Enbridge	EP2ANT02	EN817-13	8/19/2017	5 min	26.482	0.549	8/22/2017	1:36 PM	8/22/2017	3:30 PM	N	NA	NA	NA	NA	NA	NA	0.549	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.182	0.095	Coating	0.075	5.375	<0.001	5.387
Enbridge	EP2BNW12	EN817-14	8/19/2017	5 min	9.349	NA	8/22/2017	2:15 PM	8/22/2017	3:15 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.130	Coating	2.293	5.451	0.005	5.424
Enbridge	EP2BNE04	EN817-15	8/19/2017	5 min	140.86	NA	8/22/2017	2:35 PM	8/22/2017	3:30 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	138.888	117.335	5.413
Enbridge	EP2BNT01	EN817-16	8/19/2017	5 min	11.506	NA	8/22/2017	3:08 PM	8/22/2017	4:38 PM	Y	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.656	<0.001	5.520
Enbridge	WP2ANT01	EN817-17	8/19/2017	5 min	6.679	0.003	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	0.003	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	<0.001	0.013	Coating	0.011	5.545	<0.001	5.471
Enbridge	WP2ANE02	EN817-18	8/19/2017	5 min	13.084	0.121	8/22/2017	4:13 PM	8/22/2017	5:30 PM	N	NA	NA	NA	NA	NA	NA	0.121	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.021	NA	NA	NA	5.520	0.066	5.531
Enbridge	WP2ANB09	EN817-19	8/19/2017	5 min	32.79	NA	8/23/2017	9:41 AM	8/23/2017	11:41 AM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.569	0.002	5.486
Enbridge	EP2ASW12	EN817-2	8/15/2017	30+	36.578	0.006	8/18/2017	10:00 AM	8/18/2017	12:45 AM	N	NA	NA	NA	NA	NA	NA	0.006	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.005	NA	NA	NA	3.827	0.025	3.748
Enbridge	WP2ANW08	EN817-20	8/19/2017	5 min	10.516	0.068	8/23/2017	10:36 AM	8/23/2017	12:30 PM	N	NA	NA	NA	NA	NA	NA	0.068	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.031	0.117	Coating	0.086	5.611	0.024	5.606
Enbridge	EP2DT02	EN817-21	8/20/2017	5 min	39.667	NA	8/23/2017	11:37 AM	8/23/2017	1:30 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.664	0.018	5.659
Enbridge	EP2DE01	EN817-22	8/20/2017	5 min	73.852	0.005	8/23/2017	1:38 PM	8/23/2017	3:30 PM	N	0.005	10/23/2017	1:30 PM	10/23/2017	2:30 PM	<0.001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.213	1.512	5.396
Enbridge	EP2DW08	EN817-23	8/20/2017	5 min	56.69	NA	8/23/2017	2:50 PM	8/23/2017	4:50 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.645	<0.001	5.501
Enbridge	WP2DT10	EN817-24	8/20/2017	5 min	6.225	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.225	0.088	5.423
Enbridge	WP2DE12	EN817-25	8/20/2017	5 min	44.064	NA	8/23/2017	3:40 AM	8/23/2017	5:30 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.460	0.012	5.439
Enbridge	WP2DW03	EN817-26	8/20/2017	5 min	46.943	NA	8/24/2017	11:42 AM	8/24/2017	1:42 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.508	<0.001	5.490
Enbridge	WP2CNT04	EN817-27	8/21/2017	5 min	28.866	NA	8/24/2017	1:01 PM	8/24/2017	3:01 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.460	<0.001	5.431
Enbridge	WP2CNB09	EN817-28	8/21/2017	5 min	43.232	NA	8/24/2017	1:47 PM	8/24/2017	3:47 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.524	0.411	5.479
Enbridge	WP2CNW06	EN817-29	8/21/2017	5 min	59.762	NA	8/24/2017	2:45 PM	8/24/2017	4:45 PM	Y	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.119	Coating	0.092	5.621	0.041	5.573
Enbridge	EP2BST05	EN817-3	8/15/2017	5 min	37.94	NA	8/18/2017	2:08 PM	8/18/2017	4:00 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.776	2.531	1.891
Enbridge	WP2BNT05	EN817-30	8/21/2017	5 min	66.441	NA	8/24/2017	3:25 PM	8/24/2017	5:25 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.192	0.537	5.613
Enbridge	WP2BNE11	EN817-31	8/21/2017	5 min	59.905	NA	8/25/2017	1:05 PM	8/25/2017	3:05 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.622	<0.001	5.534
Enbridge	WP2BNW04	EN817-32	8/21/2017	5 min	79.319	NA	8/25/2017	2:05 PM	8/25/2017	4:05 AM	Y	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.680	4.830	5.571
Enbridge	WP2CNE11	EN817-33	8/21/2017	5 min	34.649	NA	8/25/2017	3:10 PM	8/25/2017	5:10 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.569	0.046	5.466
Enbridge	EP2ASW07CD	EN817-34	8/24/2017	5 min	6.054	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.204	Calcium deposit	NA	5.677	On hold	On hold
Enbridge	170824-EAO11DC	EN817-35	8/24/2017	5 min	16.792	NA	8/28/2017	3:38 PM	8/28/2017	5:00 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10.340	Coating	6.522	5.459	On hold	On hold
Enbridge	EP2ASW01	EN817-36	8/24/2017	5 min	77.075	3.373	8/29/2017	11:58 AM	8/29/2017	2:00 PM	N	NA	NA	NA	NA	NA	NA	3.373	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	2.252	NA	NA	NA	10.847	3.171	5.397
Enbridge	EP2ASW02	EN817-37	8/24/2017	5 min	6.857	0.074	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	0.074	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.036	0.020	Coating	0.013	5.447	0.019	5.396
Enbridge	WP2DT11	EN817-38	8/25/2017	5 min	15.629	NA	8/29/2017	12:55 PM	8/29/2017	3:00 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.030	Coating	0.021	6.151	0.414	5.357
Enbridge	WP2DT02	EN817-39	8/25/2017	5 min	56.248	NA	8/29/2017	2:01 PM	8/29/2017	4:00 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.730	0.736	5.580
Enbridge	EP2BE08	EN817-4	8/15/2017	5 min	72.024	NA	8/18/2017	3:21 PM	8/18/2017	5:30 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.642	1.029	1.821
Enbridge	EP2DE09	EN817-40	8/26/2017	5 min	5.16	NA	8/29/2017	3:15 PM	8/29/2017	5:15 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.558	0.004	5.437
Enbridge	EP2DT02	EN817-41	8/26/2017	5 min	17.157	NA	8/30/2017	10:18 AM	8/30/2017	12:20 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.587	0.043	5.548
Enbridge	EP2DW10	EN817-42	8/26/2017	5 min	12.858	NA	8/30/2017	11:18 AM	8/30/2017	1:20 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.866	0.047	5.785
Enbridge	EP2DW06	EN817-43	8/26/2017	5 min	16.888	NA	8/30/2017	12:01 PM	8/30/2017	2:00 PM	Y	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.688	0.034	5.653
Enbridge	EP2DW01	EN817-44	8/26/2017	5 min	5.99	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.990	0.001	5.541
Enbridge	WP2CSE09	EN817-45	8/26/2017	5 min	60.441	NA	8/30/2017	1:25 PM	8/30/2017	3:25 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.110	Coating	0.100	5.663	0.019	5.655
Enbridge	WP2CSW11	EN817-46	8/26/2017	5 min	24.383	NA	8/30/2017	2:55 PM	8/30/2017	4:55 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.490	0.007	5.498
Enbridge	WP2CSW08	EN817-47	8/26/2017	5 min	7.027	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.027	NA	5.570
Enbridge	WP2CST07	EN817-48	8/26/2017	5 min	39.769	NA	8/31/2017	11:35 AM	8/31/2017	1:40 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.686	0.001	5.630
Enbridge	WP2CSW03	EN817-49	8/26/2017	5 min	48.733	NA	8/31/2017	12:15 PM	8/31/2017	2:15 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.120	Coating	0.081	5.674	0.112	5.490
Enbridge	EP2BSB04	EN817-5	8/15/2017	5 min	50.554	NA	8/18/2017	4:11 PM	8/18/2017	6:11 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.800	0.002	1.946
Enbridge	WP2AST04	EN817-50	8/29/2017	5 min	6.206	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.206	NA	5.334
Enbridge	WP2ASE07	EN817-51	8/29/2017	5 min	10.516	0.059	9/1/2017	11:35 AM	9/1/2017	12:30 PM	N	NA	NA	NA	NA	NA	NA	0.059	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.012	0.192	Coating	0.122	7.255	1.994	5.379
Enbridge	WP2ASW11	EN817-52	8/29/2017	5 min	7.983	0.024	9/1/2017	11:55 AM	9/1/2017	1:00 PM	N	NA	NA	NA	NA	NA	NA	0.024	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.012	0.463	Coating	0.313	5.397	0.016	5.404
Enbridge	WP2AST06	EN817-53	8/29/2017	5 min	6.847	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.847	NA	5.378
Enbridge	WP2AST09	EN817-54	8/29/2017	5 min	9.968	0.021	9/1/2017	1:10 PM	9/1/2017	3:00 PM	Y	<0.001	10/23/2017	1:30 PM	10/23/2017	2:30 PM	<0.001	0.021	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.012	0.326	Coating	0.225	5.594	0.112	5.484
Enbridge	EP2ANW03	EN817-55	8/19/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	On hold	On hold
Enbridge	170812-WAO51DC	EN817-56	8/21/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	On hold	On hold
Enbridge	170905-EAO16DC	EN817-57	9/5/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	On hold	On hold
Enbridge	EP2AST09	EN817-58	9/5/2017	5 min	14.055	0.033	9/7/2017	1:11 PM	9/7/2017	3:00 PM	N	<0.001	10/23/2017	1:30 PM	10/23/2017	2:30 PM	<0.001	0.036	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.007	NA	NA	NA	5.488	0.095	5.367
Enbridge	EP2ASE08	EN817-59	9/5/2017	5 min	131.255	0.281	9/7/2017	3:15 PM	9/7/2017	5:15 PM	N	0.004	10/23/2017	1:30 PM	10/23/2017	2:30 PM	<0.001	0.277	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.122	NA	NA	NA	5.504	0.095	5.444
Enbridge	EP2BSW02	EN817-6	8/15/2017	5 min	96.159	NA	8/18/2017	5:13 PM	8/18/2017	7:13 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.673	1.414	1.811
Enbridge	EP2ASW04	EN817-60	9/5/2017	5 min	84.878	0.272	9/8/2017	12:45 PM	9/8/2017	3:45 PM	N	0.019	10/23/2017	1:30 PM	10/23/2017	2:30 PM	0.004	0.271	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	0.077	0.060	Coating	0.047	5.499	0.014	5.497
Enbridge	EP2ASB01	EN817-61	9/5/2017	5 min	60.717	NA	9/8/2017	2:05 PM	9/8/2017	4:40 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.344	0.019	5.334
Enbridge	EP2ASW02	EN817-62	9/5/2017	5 min	62.938	4.847	9/11/2017	2:15 PM	9/11/2017	4:15 PM	N	0.010	10/23/2017	1:30 PM	10/23/2017	2:30 PM	0.002	4.737	NA	12/6/2017	9:00 AM	12/6/2017	11:15 AM	2.604	0.266	Coating	0.235	5.670	0.289	5.501
Enbridge	EP2ASW10	EN817-63	9/5/2017	5 min	6.084	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.300	Coating	0.186	5.831	0.007	5.561
Enbridge	170906-EAO9MOI	EN817-64	9/6/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	On hold	On hold
Enbridge	170906-EAO10MOI	EN817-65	9/6/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	On hold	On hold
Enbridge	WP2DT08	EN817-66	9/7/2017	5 min	7.948	NA	9/12/2017	10:45 AM	9/12/2017	12:30 PM	Y	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.452	0.335	5.398
Enbridge	WP2DE11	EN817-67	9/7/2017	5 min	87.654	NA	9/12/2017	12:26 PM	9/12/2017	2:26 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.166	Coating	0.119	5.537	NA	5.529
Enbridge	WP2DW09	EN817-68	9/7/2017	5 min	72.758	NA	9/12/2017	2:00 PM	9/12/2017	4:00 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.580	0.014	5.567
Enbridge	WP2DB05	EN817-69	9/7/2017	5 min	17.608	NA	9/12/2017	2:35 PM	9/12/2017	4:35 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.590	0.033	5.546
Enbridge	EP2CST08	EN817-7	8/16/2017	5 min	57.519	NA	8/21/2017	11:35 AM	8/21/2017	1:35 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.058	0.022	2.197
Enbridge	WP2DE02	EN817-70	9/7/2017	5 min	7.463	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.043	Coating	0.028	6.144	0.008	5.666
Enbridge	WP2DE03	EN817-71	9/7/2017	5 min	68.311	<0.001	9/14/2017	12:15 PM	9/14/2017	2:30 PM	N	<0.001	10/23/2017	1:30 PM	10/23/2017	2:30 PM	<0.001	NA	NA	NA	NA	NA	NA	NA	0.712	Coating	0.548	6.607	0.896	5.681
Enbridge	170907-WAO13MOI	EN817-72	9/7/2017	NA-Large mat of rubber, no mesh	800	0.020	9/15/2017	10:10 AM	9/15/2017	2:30 PM	N	0.020	10/23/2017	1:30 PM	10/23/2017	2:30 PM	0.009	NA	NA	NA	NA	NA	NA	NA	600.000	Coating	On hold	NA	On hold	On hold
Enbridge	170907-WAO12CD	EN817-73	9/7/2017	NA- On hold for Enbridge	NA	NA	NA	NA	NA	NA	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Calcium deposit	NA	NA	On hold	On hold
Enbridge	EP2CNT13	EN817-74	9/8/2017	5 min	85.764	NA	9/18/2017	9:33 AM	9/18/2017	12:00 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.186	Coating	0.159	33.004	25.052	5.591
Enbridge	EP2CNE11	EN817-75	9/8/2017	5 min	35.1	NA	9/18/2017	11:45 AM	9/18/2017	1:45 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.933	0.330	5.476
Enbridge	EP2CNW06	EN817-76	9/8/2017	5 min	61.922	NA	9/18/2017	12:30 PM	9/18/2017	2:30 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.136	Coating	0.125	5.729	0.260	5.585
Enbridge	EP2CNW08	EN817-77	9/8/2017	5 min	17.071	NA	9/19/2017	10:40 AM	9/19/2017	1:00 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.485	NA	5.481
Enbridge	EP2CNW03	EN817-78	9/8/2017	5 min	77.988	NA	9/19/2017	11:45 AM	9/19/2017	2:00 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	21.573	7.837	5.480
Enbridge	WP2BST11	EN817-79	9/8/2017	5 min	51.355	NA	9/19/2017	12:30 PM	9/19/2017	3:00 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.627	0.368	5.485
Enbridge	EP2CSE03	EN817-8	8/16/2017	5 min	64.729	NA	8/21/2017	1:30 PM	8/21/2017	3:30 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.170	0.058	1.820
Enbridge	WP2BSE10	EN817-80	9/8/2017	5 min	67.455	NA	9/19/2017	1:50 PM	9/19/2017	3:50 PM	N	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.032	Coating	0.027	5.558	<0.001	5.545
Enbridge	WP2BSW14	EN817-81	9/8/2017	5 min	81.479	0.003	9/25/2017	12:15 PM	9/25/2017	2:15 PM	Y	0.003	10/23/2017	1:30 PM	10/23/2017	2:30 PM	<0.001	NA	NA	NA	NA	NA	NA	NA	0.012	Coating	0.011	5.532	0.041	5.529
Enbridge	WP2BSB01	EN817-82	9/8/2017	5 min	42.538	0.004	9/25/2017	1:38 PM	9/25/2017	3:38 PM	Y	0.004	10/23/2017	1:30 PM	10/23/2017	2:30 PM	<0.001	NA	NA	NA	NA	NA	NA	NA	0.140	Coating	0.073	5.626	0.044	5.571
Enbridge	WP2BSE08	EN817-83	9/8/2017	5 min	81.379	0.009	9/25/2017	2:35 PM	9/25/2017	4:35 PM	Y	0.009	10/23/2017	1:30 PM	10/23/2017	2:30 PM	<0.001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.482	0.040	5.441
Enbridge	WP2BSE09	EN817-84	9/8/2017	5 min	21.744	0.005	9/25/2017	3:20 PM	9/25/2017	5:20 PM	Y	0.005	10/23/2017	1:30 PM	10/23/2017	2:30 PM	<0.001	NA	NA	NA	NA	NA	NA	NA	10.193	Coating	8.830	2.741	0.009	2.739
Enbridge	EP2CSB30	EN817-9	8/16/2017	5 min	5.446	NA	8/21/2017	3:30 PM	8/21/2017	4:15 PM	Y	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.796	Coating	1.234	1.805	NA	1.696

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Macrophyte and Periphyton Identification

Project Name	Site Name	GEI Log #	Taxon Group; Family Level (Periphyton/ Macroinvertebrate)	Lowest Practicable Taxon	Comments
Enbridge	EPZASW12	EN817-2	Periphyton	Cladophora sp.	The sample also contained MOI
Enbridge	EPZANW08	EN817-11	Periphyton	Cladophora sp.	The sample also contained mussel fragments and byssal threads
Enbridge	EPZANE03	EN817-12	Periphyton	Cladophora sp.	The sample also contained mussel fragments, 3 juvenile mussels, MOI, and sand
Enbridge	EPZANT02	EN817-13	Periphyton	Cladophora sp.	The sample also contained mussel fragments and tissue, byssal threads, 2 Mysidae shrimp, 1 chironomidae, 1 amphipod
Enbridge	WPZANT01	EN817-17	Periphyton	Cladophora sp.	The sample also contained MOI
Enbridge	WPZANE02	EN817-18	Periphyton	Cladophora sp.	The sample also contained mussel fragments, 3 juvenile mussels, byssal threads, 1 chironomidae, MOI, sand
Enbridge	WPZANW08	EN817-20	Periphyton	Cladophora sp.	The sample also contained mussel fragments, byssal threads, and MOI
Enbridge	WPZANW08	EN817-20	Periphyton	Rhodophyceae	The sample also contained mussel fragments, byssal threads, and MOI
Enbridge	EPZDE01	EN817-22	Amphipod	Echinogammarus ischnus	
Enbridge	EPZASW01	EN817-36	Periphyton	Cladophora sp.	The sample also contained mussel fragments, 9 juvenile mussels, byssal threads, 1 caddisfly casing, sand
Enbridge	EPZASW02	EN817-37	Periphyton	Cladophora sp.	The sample also contained MOI
Enbridge	WPZASE07	EN817-51	Periphyton	Cladophora sp.	The sample also contained mussel fragments, byssal threads, MOI, and sand
Enbridge	WPZASW11	EN817-52	Periphyton	Cladophora sp.	The sample also contained mussel fragments, byssal threads, and MOI
Enbridge	WPZAST09	EN817-54	Isopod	Caecidotea gn.	
Enbridge	WPZAST09	EN817-54	Periphyton	Cladophora sp.	The sample also contained mussel fragments and MOI
Enbridge	EPZAST09	EN817-58	Periphyton	Cladophora sp.	The sample also contained mussel fragments
Enbridge	EPZAST09	EN817-58	Isopod	Lirceus gn.	
Enbridge	EPZASE08	EN817-59	Amphipod	Gammarus sp.	
Enbridge	EPZASE08	EN817-59	Amphipod	Echinogammarus ischnus	
Enbridge	EPZASE08	EN817-59	Periphyton	Cladophora sp.	The sample also contained mussel fragments, byssal threads, and 10 juvenile mussels
Enbridge	EPZASW04	EN817-60	Periphyton	Cladophora sp.	The sample also contained mussel fragments and 8 juvenile mussels
Enbridge	EPZASW04	EN817-60	Periphyton	Rhodophyceae	The sample also contained mussel fragments and 8 juvenile mussels
Enbridge	EPZASW04	EN817-60	Amphipod	Echinogammarus ischnus	
Enbridge	EPZASW02	EN817-62	Amphipod	Echinogammarus ischnus	
Enbridge	EPZASW02	EN817-62	Periphyton	Cladophora sp.	The sample also contained mussel fragments, 6 juvenile mussels, byssal threads, 1 chironomidae, 3 Mysidae shrimp, MOI, and sand
Enbridge	WPZDE03	EN817-71	Chironomid	Procladius gn.	
Enbridge	170907-WAOI1MOI	EN817-72	Amphipod	Gammaridae	Note on Gammaridae ID: No posterior end, likely Echinogammarus ischnus
Enbridge	170907-WAOI1MOI	EN817-72	Amphipod	Echinogammarus ischnus	
Enbridge	170907-WAOI1MOI	EN817-72	Isopod	Caecidotea gn.	
Enbridge	WPZBSW14	EN817-81	Isopod	Caecidotea gn.	
Enbridge	WPZBSB01	EN817-82	Isopod	Caecidotea gn.	
Enbridge	WPZBSE08	EN817-83	Amphipod	Echinogammarus ischnus	
Enbridge	WPZBSE09	EN817-84	Isopod	Caecidotea gn.	

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Mussel Identification

Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZASW12	EN817-2	Adult, Quagga	30	14	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	30	15	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	23	12	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	30	13	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	24	14	9	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	29	14	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	26	13	11	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	24	14	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	28	14	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	22	14	9	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	21	12	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	25	14	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	24	14	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	24	16	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	28	15	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	30	16	12	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	30	14	11	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	20	13	10	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	11	13	9	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	18	11	5	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	14	10	6	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	11	6	4	Large
Enbridge	EPZASW12	EN817-2	Adult, Quagga	9	5	4	Medium
Enbridge	EPZASW12	EN817-2	Adult, Quagga	8	4	3	Medium
Enbridge	EPZASW12	EN817-2	Adult, Quagga	7	5	2	Medium
Enbridge	EPZASW12	EN817-2	Juvenile	6	3	2	Medium
Enbridge	EPZASW12	EN817-2	Juvenile	3	2	1	Small
Enbridge	EPZASW12	EN817-2	Juvenile	2	1	1	Small
Enbridge	EPZBST05	EN817-3	Juvenile	5	3	1	Medium
Enbridge	EPZBST05	EN817-3	Juvenile	6	4	2	Medium
Enbridge	EPZBST05	EN817-3	Juvenile	6	4	1	Medium
Enbridge	EPZBST05	EN817-3	Juvenile	6	4	1	Medium
Enbridge	EPZBST05	EN817-3	Adult, Quagga	7	4	2	Medium
Enbridge	EPZBST05	EN817-3	Juvenile	5	3	2	Medium
Enbridge	EPZBST05	EN817-3	Adult, Quagga	29	17	10	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	23	13	10	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	24	13	9	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	23	12	7	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	23	12	8	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	17	12	8	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	22	14	10	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	28	16	10	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	25	15	10	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	25	13	9	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	23	12	7	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	23	13	8	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	23	13	8	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	25	13	9	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	25	15	8	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	26	14	8	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	27	16	10	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	23	13	10	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	22	13	8	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	21	11	8	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZBST05	EN817-3	Adult, Quagga	21	11	6	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	22	12	7	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	21	13	8	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	17	9	7	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	12	6	4	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	15	9	7	Large
Enbridge	EPZBST05	EN817-3	Adult, Quagga	18	13	7	Large
Enbridge	EPZBSE08	EN817-4	Juvenile	6	4	2	Medium
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	7	4	2	Medium
Enbridge	EPZBSE08	EN817-4	Juvenile	5	3	2	Medium
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	7	5	3	Medium
Enbridge	EPZBSE08	EN817-4	Juvenile	4	4	1	Small
Enbridge	EPZBSE08	EN817-4	Juvenile	5	3	2	Medium
Enbridge	EPZBSE08	EN817-4	Juvenile	3	2	1	Small
Enbridge	EPZBSE08	EN817-4	Juvenile	4	2	1	Small
Enbridge	EPZBSE08	EN817-4	Juvenile	5	3	1	Medium
Enbridge	EPZBSE08	EN817-4	Juvenile	6	3	2	Medium
Enbridge	EPZBSE08	EN817-4	Juvenile	4	3	2	Small
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	16	10	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	27	15	10	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	25	14	10	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	25	15	10	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	20	11	8	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	25	15	8	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	15	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	16	10	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	15	10	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	28	15	10	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	22	13	8	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	28	16	12	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	15	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	15	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	32	16	11	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	28	15	11	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	28	16	11	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	27	16	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	22	13	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	30	16	10	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	15	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	27	17	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	25	13	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	14	8	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	14	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	24	14	8	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	25	16	10	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	29	16	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	24	14	7	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	23	13	10	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	25	15	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	15	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	22	13	7	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	24	13	8	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	26	15	12	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	24	15	7	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	25	14	9	Large
Enbridge	EPZBSE08	EN817-4	Adult, Quagga	18	11	6	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	27	16	11	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	21	11	7	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	25	12	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	23	13	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	21	12	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	21	13	9	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	21	13	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	25	13	9	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	20	12	7	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	26	16	9	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	29	15	11	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	24	14	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	19	13	5	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	22	12	7	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	23	11	7	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	21	12	7	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	22	12	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	22	14	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	22	12	7	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	19	12	6	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	27	16	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	23	13	9	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	20	11	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	20	12	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	24	13	9	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	27	16	9	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	17	9	7	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	22	12	9	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	20	12	6	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	23	13	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	24	15	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	22	12	8	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	19	11	6	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	18	9	7	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	19	10	5	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	19	10	7	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	17	11	7	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	20	12	6	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	15	9.5	5	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	16	8	5	Large
Enbridge	EPZBSB04	EN817-5	Adult, Quagga	24	14	6	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	28	16	11	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	23	14	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	23	14	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	25	14	10	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	27	15	12	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	15	10	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	16	12	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	15	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	16	11	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	14	10	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	23	13	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	27	15	11	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	22	13	10	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	28	19	11	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	29	17	12	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	24	16	11	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	16	11	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	25	13	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	29	16	13	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	28	15	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	28	15	10	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	25	13	10	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	32	18	11	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	25	15	10	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	25	15	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	24	15	11	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	14	10	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	17	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	24	13	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	15	8	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	25	15	10	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	16	11	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	21	13	8	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	25	15	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	22	13	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	24	12	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	20	12	8	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	24	13	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	22	13	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	18	11	7	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	20	11	8	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	21	12	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	21	13	10	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	22	12	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	21	12	8	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	23	13	7	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	26	16	8	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	25	14	9	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	20	11	7	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	13	8	5	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	13	8	4	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	15	10	5	Large
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	10	5	3	Medium
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	7	4	2	Medium
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	7	5	2	Medium
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	8	5	3	Medium
Enbridge	EPZBSW02	EN817-6	Juvenile	4	3	1	Small
Enbridge	EPZBSW02	EN817-6	Juvenile	4	2	1	Small
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	7	5	2	Medium
Enbridge	EPZBSW02	EN817-6	Adult, Quagga	7	4	2	Medium
Enbridge	EPZBSW02	EN817-6	Juvenile	6	4	2	Medium
Enbridge	EPZBSW02	EN817-6	Juvenile	4	3	2	Small
Enbridge	EPZBSW02	EN817-6	Juvenile	6	3	1	Medium
Enbridge	EPZBSW02	EN817-6	Juvenile	4	3	1	Small
Enbridge	EPZBSW02	EN817-6	Juvenile	4	2	1	Small
Enbridge	EPZCST08	EN817-7	Adult, Quagga	26	14	10	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	33	17	13	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	26	16	10	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	31	17	11	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	30	17	12	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	28	14	9	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZCST08	EN817-7	Adult, Quagga	30	17	12	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	28	16	10	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	30	18	10	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	28	17	9	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	25	14	9	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	25	13	10	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	26	15	10	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	26	16	10	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	25	14	7	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	25	14	10	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	22	14	9	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	24	14	10	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	25	16	11	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	20	11	7	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	26	15	7	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	22	13	8	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	23	13	8	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	14	7	5	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	20	12	5	Large
Enbridge	EPZCST08	EN817-7	Adult, Quagga	12	7	4	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	32	19	14	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	24	14	9	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	28	16	13	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	27	15	10	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	30	16	10	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	27	16	12	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	26	15	7	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	28	16	14	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	30	18	10	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	28	17	11	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	32	18	13	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	18	10	8	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	26	15	8	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	24	14	9	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	29	17	10	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	27	16	13	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	28	15	9	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	30	16	13	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	29	19	11	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	28	17	10	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	29	16	12	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	24	14	10	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	22	12	8	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	18	11	6	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	28	15	9	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	17	10	7	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	19	11	6	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	25	15	10	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	27	17	11	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	22	12	9	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	23	14	7	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	21	11	7	Large
Enbridge	EPZCSE03	EN817-8	Adult, Quagga	7	4	2	Medium
Enbridge	EPZCSE03	EN817-8	Juvenile	6	4	2	Medium
Enbridge	EPZCSE03	EN817-8	Juvenile	5	3	2	Medium
Enbridge	EPZCSE03	EN817-8	Juvenile	6	3	2	Medium

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZCSE03	EN817-8	Juvenile	4	2	1	Small
Enbridge	EPZCSB10	EN817-9	Juvenile	4	2	1	Small
Enbridge	EPZCSB10	EN817-9	Juvenile	6	3	2	Medium
Enbridge	EPZCSB10	EN817-9	Juvenile	5	3	1	Medium
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	26	15	9	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	27	17	10	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	29	17	9	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	28	18	12	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	25	15	12	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	27	15	10	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	27	15	9	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	26	15	8	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	25	14	8	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	24	14	7	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	30	17	11	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	24	13	10	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	28	16	11	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	26	16	13	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	27	15	11	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	24	15	9	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	26	14	9	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	23	13	9	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	22	11	8	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	23	14	10	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	24	15	9	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	21	12	8	Large
Enbridge	EPZCSW05	EN817-10	Adult, Quagga	19	12	8	Large
Enbridge	EPZANW08	EN817-11	Adult, Quagga	26	14	10	Large
Enbridge	EPZANW08	EN817-11	Adult, Quagga	22	14	8	Large
Enbridge	EPZANW08	EN817-11	Adult, Quagga	22	12	9	Large
Enbridge	EPZANW08	EN817-11	Adult, Quagga	24	14	10	Large
Enbridge	EPZANW08	EN817-11	Adult, Quagga	21	12	8	Large
Enbridge	EPZANW08	EN817-11	Adult, Quagga	20	11	9	Large
Enbridge	EPZANW08	EN817-11	Adult, Quagga	20	12	10	Large
Enbridge	EPZANW08	EN817-11	Adult, Quagga	22	13	7	Large
Enbridge	EPZANW08	EN817-11	Adult, Quagga	25	13	9	Large
Enbridge	EPZANE03	EN817-12	Adult, Quagga	25	14	9	Large
Enbridge	EPZANE03	EN817-12	Adult, Quagga	27	15	8	Large
Enbridge	EPZANE03	EN817-12	Adult, Quagga	25	15	11	Large
Enbridge	EPZANE03	EN817-12	Adult, Quagga	27	15	10	Large
Enbridge	EPZANE03	EN817-12	Adult, Quagga	25	15	12	Large
Enbridge	EPZANE03	EN817-12	Adult, Quagga	27	14	10	Large
Enbridge	EPZANE03	EN817-12	Adult, Quagga	23	12	8	Large
Enbridge	EPZANE03	EN817-12	Adult, Quagga	25	14	11	Large
Enbridge	EPZANE03	EN817-12	Adult, Quagga	14	10	6	Large
Enbridge	EPZANT02	EN817-13	Adult, Quagga	24	13	8	Large
Enbridge	EPZANT02	EN817-13	Adult, Quagga	27	15	10	Large
Enbridge	EPZANT02	EN817-13	Adult, Quagga	23	13	7	Large
Enbridge	EPZANT02	EN817-13	Adult, Quagga	27	14	9	Large
Enbridge	EPZANT02	EN817-13	Adult, Quagga	26	15	12	Large
Enbridge	EPZANT02	EN817-13	Adult, Quagga	23	13	10	Large
Enbridge	EPZANT02	EN817-13	Adult, Quagga	24	16	12	Large
Enbridge	EPZANT02	EN817-13	Adult, Quagga	9	5	2	Medium
Enbridge	EPZANT02	EN817-13	Juvenile	4	2	2	Small
Enbridge	EPZANT02	EN817-13	Juvenile	3	2	1	Small
Enbridge	EPZBNW12	EN817-14	Adult, Quagga	9	7	4	Medium

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZBNT01	EN817-16	Adult, Quagga	23	14	10	Large
Enbridge	EPZBNT01	EN817-16	Adult, Quagga	22	14	10	Large
Enbridge	WPZANE02	EN817-18	Adult, Quagga	32	18	14	Large
Enbridge	WPZANE02	EN817-18	Adult, Quagga	13	8	4	Large
Enbridge	WPZANE02	EN817-18	Adult, Quagga	13	8	5	Large
Enbridge	WPZANE02	EN817-18	Adult, Quagga	11	7	4	Large
Enbridge	WPZANE02	EN817-18	Adult, Quagga	12	7	5	Large
Enbridge	WPZANE02	EN817-18	Adult, Quagga	10	5	3	Medium
Enbridge	WPZANE02	EN817-18	Adult, Quagga	10	6	3	Medium
Enbridge	WPZANE02	EN817-18	Adult, Quagga	8	5	3	Medium
Enbridge	WPZANE02	EN817-18	Adult, Quagga	8	4	3	Medium
Enbridge	WPZANE02	EN817-18	Juvenile	6	3	2	Medium
Enbridge	WPZANE02	EN817-18	Juvenile	6	3	2	Medium
Enbridge	WPZANE02	EN817-18	Juvenile	6	3	2	Medium
Enbridge	WPZANE02	EN817-18	Adult, Quagga	8	4	3	Medium
Enbridge	WPZANE02	EN817-18	Adult, Quagga	7	4	2	Medium
Enbridge	WPZANE02	EN817-18	Juvenile	5	2	2	Medium
Enbridge	WPZANE02	EN817-18	Juvenile	4	3	2	Small
Enbridge	WPZANE02	EN817-18	Juvenile	3	2	1	Small
Enbridge	WPZANB09	EN817-19	Adult, Quagga	27	15	11	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	26	15	10	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	30	18	13	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	23	14	10	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	22	13	9	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	25	13	9	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	25	14	10	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	29	16	11	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	25	14	10	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	23	13	8	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	23	13	9	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	25	13	10	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	17	10	7	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	22	12	8	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	18	11	6	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	23	13	9	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	18	10	5	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	19	10	6	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	24	14	6	Large
Enbridge	WPZANB09	EN817-19	Adult, Quagga	18	9	6	Large
Enbridge	WPZANW08	EN817-20	Adult, Quagga	17	10	7	Large
Enbridge	WPZANW08	EN817-20	Adult, Quagga	19	10	6	Large
Enbridge	WPZANW08	EN817-20	Adult, Quagga	16	9	6	Large
Enbridge	WPZANW08	EN817-20	Adult, Quagga	10	6	3	Medium
Enbridge	WPZANW08	EN817-20	Adult, Quagga	9	6	3	Medium
Enbridge	WPZANW08	EN817-20	Adult, Quagga	11	7	4	Large
Enbridge	WPZANW08	EN817-20	Adult, Quagga	9	4	3	Medium
Enbridge	WPZANW08	EN817-20	Adult, Quagga	11	7	4	Large
Enbridge	WPZANW08	EN817-20	Adult, Quagga	7	5	2	Medium
Enbridge	WPZANW08	EN817-20	Adult, Quagga	10	5	3	Medium
Enbridge	WPZANW08	EN817-20	Adult, Quagga	7	4	2	Medium
Enbridge	WPZANW08	EN817-20	Adult, Quagga	8	4	2	Medium
Enbridge	WPZANW08	EN817-20	Adult, Quagga	8	4	2	Medium
Enbridge	WPZANW08	EN817-20	Juvenile	5	3	1	Medium
Enbridge	WPZANW08	EN817-20	Juvenile	5	2	1	Medium
Enbridge	WPZANW08	EN817-20	Juvenile	3	2	1	Small
Enbridge	WPZANW08	EN817-20	Juvenile	3	2	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZDT02	EN817-21	Adult, Quagga	25	16	10	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	30	15	10	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	29	15	10	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	30	17	11	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	30	17	12	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	27	17	13	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	28	16	11	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	25	15	11	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	28	16	11	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	28	17	11	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	21	12	9	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	26	15	9	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	16	9	6	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	13	7	5	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	15	9	6	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	12	7	5	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	11	7	4	Large
Enbridge	EPZDT02	EN817-21	Adult, Quagga	10	6	3	Medium
Enbridge	EPZDT02	EN817-21	Adult, Quagga	8	5	3	Medium
Enbridge	EPZDT02	EN817-21	Adult, Quagga	8	5	2	Medium
Enbridge	EPZDT02	EN817-21	Adult, Quagga	8	5	2	Medium
Enbridge	EPZDT02	EN817-21	Juvenile	5	3	1	Medium
Enbridge	EPZDT02	EN817-21	Juvenile	6	4	2	Medium
Enbridge	EPZDT02	EN817-21	Juvenile	4	2	1	Small
Enbridge	EPZDT02	EN817-21	Juvenile	6	3	1	Medium
Enbridge	EPZDT02	EN817-21	Juvenile	4	2	1	Small
Enbridge	EPZDT02	EN817-21	Juvenile	4	2	1	Small
Enbridge	EPZDT02	EN817-21	Juvenile	4	3	1	Small
Enbridge	EPZDT02	EN817-21	Juvenile	3	2	1	Small
Enbridge	EPZDE01	EN817-22	Adult, Quagga	26	15	12	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	28	18	11	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	28	17	12	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	26	15	9	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	26	15	11	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	29	16	11	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	28	17	9	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	26	16	11	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	31	17	13	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	21	13	9	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	25	14	10	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	25	16	11	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	20	12	9	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	30	16	9	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	28	16	12	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	24	13	9	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	28	15	10	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	26	15	7	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	27	15	10	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	24	14	9	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	20	11	7	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	20	12	7	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	20	12	8	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	16	9	6	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	17	10	6	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	19	12	8	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	27	17	10	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZDE01	EN817-22	Adult, Quagga	30	15	8	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	26	15	10	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	22	13	9	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	11	8	4	Large
Enbridge	EPZDE01	EN817-22	Adult, Quagga	10	6	3	Medium
Enbridge	EPZDE01	EN817-22	Adult, Quagga	10	5	3	Medium
Enbridge	EPZDE01	EN817-22	Adult, Quagga	10	6	4	Medium
Enbridge	EPZDE01	EN817-22	Adult, Quagga	9	4	2	Medium
Enbridge	EPZDE01	EN817-22	Juvenile	6	4	2	Medium
Enbridge	EPZDE01	EN817-22	Juvenile	6	3	1	Medium
Enbridge	EPZDE01	EN817-22	Juvenile	4	3	1	Small
Enbridge	EPZDE01	EN817-22	Juvenile	4	3	1	Small
Enbridge	EPZDE01	EN817-22	Adult, Quagga	9	5	2	Medium
Enbridge	EPZDE01	EN817-22	Juvenile	5	3	2	Medium
Enbridge	EPZDE01	EN817-22	Juvenile	5	2	1	Medium
Enbridge	EPZDE01	EN817-22	Juvenile	5	3	1	Medium
Enbridge	EPZDE01	EN817-22	Juvenile	4	3	1	Small
Enbridge	EPZDE01	EN817-22	Juvenile	3	2	1	Small
Enbridge	EPZDE01	EN817-22	Juvenile	3	2	1	Small
Enbridge	EPZDE01	EN817-22	Juvenile	3	2	1	Small
Enbridge	EPZDE01	EN817-22	Juvenile	3	2	1	Small
Enbridge	EPZDE01	EN817-22	Juvenile	3	2	1	Small
Enbridge	EPZDE01	EN817-22	Juvenile	3	2	1	Small
Enbridge	EPZDW08	EN817-23	Adult, Quagga	26	14	11	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	27	17	11	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	27	16	12	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	27	16	10	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	26	15	10	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	27	14	10	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	28	16	13	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	31	19	11	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	27	16	9	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	26	15	12	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	27	14	10	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	31	17	12	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	17	10	7	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	26	15	12	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	23	13	8	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	29	17	10	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	17	10	5	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	16	9	5	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	11	7	3	Large
Enbridge	EPZDW08	EN817-23	Adult, Quagga	10	6	3	Medium
Enbridge	EPZDW08	EN817-23	Juvenile	6	4	2	Medium
Enbridge	EPZDW08	EN817-23	Adult, Quagga	9	6	3	Medium
Enbridge	EPZDW08	EN817-23	Juvenile	6	5	2	Medium
Enbridge	EPZDW08	EN817-23	Juvenile	6	4	1	Medium
Enbridge	EPZDW08	EN817-23	Juvenile	6	4	2	Medium
Enbridge	EPZDW08	EN817-23	Juvenile	6	4	2	Medium
Enbridge	EPZDW08	EN817-23	Adult, Quagga	7	4	2	Medium
Enbridge	EPZDW08	EN817-23	Juvenile	6	3	2	Medium
Enbridge	EPZDW08	EN817-23	Juvenile	4	3	1	Small
Enbridge	EPZDW08	EN817-23	Juvenile	5	3	2	Medium
Enbridge	EPZDW08	EN817-23	Juvenile	5	3	1	Medium
Enbridge	EPZDW08	EN817-23	Juvenile	4	2	1	Small
Enbridge	EPZDW08	EN817-23	Juvenile	4	2	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZDW08	EN817-23	Juvenile	5	3	2	Medium
Enbridge	EPZDW08	EN817-23	Juvenile	4	2	1	Small
Enbridge	EPZDW08	EN817-23	Juvenile	5	2	1	Medium
Enbridge	WPZDE12	EN817-25	Adult, Quagga	29	17	11	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	30	16	11	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	28	18	12	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	20	14	9	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	25	15	10	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	29	16	12	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	24	13	9	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	23	13	10	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	24	14	9	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	23	14	11	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	27	15	9	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	25	15	9	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	22	13	9	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	20	11	8	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	20	13	8	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	21	10	7	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	21	12	9	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	18	12	8	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	20	12	7	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	24	12	10	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	20	12	8	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	27	13	8	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	16	9	6	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	13	8	4	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	14	8	5	Large
Enbridge	WPZDE12	EN817-25	Juvenile	4	2	1	Small
Enbridge	WPZDE12	EN817-25	Juvenile	4	2	1	Small
Enbridge	WPZDE12	EN817-25	Adult, Quagga	9	5	4	Medium
Enbridge	WPZDE12	EN817-25	Adult, Quagga	12	7	4	Large
Enbridge	WPZDE12	EN817-25	Adult, Quagga	9	4	3	Medium
Enbridge	WPZDE12	EN817-25	Adult, Quagga	9	6	3	Medium
Enbridge	WPZDE12	EN817-25	Adult, Quagga	9	5	3	Medium
Enbridge	WPZDE12	EN817-25	Juvenile	6	3	2	Medium
Enbridge	WPZDE12	EN817-25	Juvenile	6	3	2	Medium
Enbridge	WPZDE12	EN817-25	Juvenile	6	3	2	Medium
Enbridge	WPZDE12	EN817-25	Juvenile	5	3	1	Medium
Enbridge	WPZDE12	EN817-25	Juvenile	5	3	2	Medium
Enbridge	WPZDE12	EN817-25	Juvenile	5	3	2	Medium
Enbridge	WPZDE12	EN817-25	Juvenile	4	3	1	Small
Enbridge	WPZDE12	EN817-25	Juvenile	5	3	1	Medium
Enbridge	WPZDE12	EN817-25	Juvenile	4	2	1	Small
Enbridge	WPZDE12	EN817-25	Juvenile	4	3	1	Small
Enbridge	WPZDE12	EN817-25	Juvenile	4	2	1	Small
Enbridge	WPZDE12	EN817-25	Juvenile	4	3	1	Small
Enbridge	WPZDE12	EN817-25	Juvenile	2	1	1	Small
Enbridge	WPZDW03	EN817-26	Adult, Quagga	28	17	13	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	26	16	9	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	27	15	9	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	29	17	10	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	25	14	9	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	23	13	7	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	30	19	12	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	28	16	10	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZDW03	EN817-26	Adult, Quagga	24	14	9	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	25	15	9	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	27	15	10	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	28	17	11	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	25	15	10	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	29	17	10	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	23	14	9	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	22	14	8	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	28	16	8	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	22	13	8	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	26	14	10	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	21	13	9	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	23	13	7	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	18	11	7	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	16	9	6	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	13	9	4	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	11	7	3	Large
Enbridge	WPZDW03	EN817-26	Adult, Quagga	10	4	2	Medium
Enbridge	WPZDW03	EN817-26	Adult, Quagga	7	4	2	Medium
Enbridge	WPZDW03	EN817-26	Adult, Quagga	8	4	2	Medium
Enbridge	WPZDW03	EN817-26	Juvenile	4	3	2	Small
Enbridge	WPZDW03	EN817-26	Juvenile	4	3	1	Small
Enbridge	WPZDW03	EN817-26	Juvenile	5	3	2	Medium
Enbridge	WPZDW03	EN817-26	Juvenile	6	4	2	Medium
Enbridge	WPZDW03	EN817-26	Juvenile	4	2	2	Small
Enbridge	WPZDW03	EN817-26	Juvenile	4	3	1	Small
Enbridge	WPZDW03	EN817-26	Juvenile	3	2	1	Small
Enbridge	WPZDW03	EN817-26	Juvenile	4	2	1	Small
Enbridge	WPZDW03	EN817-26	Juvenile	3	2	1	Small
Enbridge	WPZDW03	EN817-26	Juvenile	6	3	1	Medium
Enbridge	WPZDW03	EN817-26	Juvenile	6	4	2	Medium
Enbridge	WPZDW03	EN817-26	Juvenile	4	2	1	Small
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	31	17	11	Large
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	29	16	11	Large
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	23	13	9	Large
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	29	17	9	Large
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	24	14	10	Large
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	27	15	9	Large
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	22	12	8	Large
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	28	15	10	Large
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	17	10	8	Large
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	11	6	5	Large
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	7	4	2	Medium
Enbridge	WPZCNT04	EN817-27	Juvenile	6	4	2	Medium
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	9	6	3	Medium
Enbridge	WPZCNT04	EN817-27	Adult, Quagga	7	4	2	Medium
Enbridge	WPZCNT04	EN817-27	Juvenile	5	3	1	Medium
Enbridge	WPZCNT04	EN817-27	Juvenile	4	3	2	Small
Enbridge	WPZCNT04	EN817-27	Juvenile	4	3	2	Small
Enbridge	WPZCNT04	EN817-27	Juvenile	4	2	1	Small
Enbridge	WPZCNT04	EN817-27	Juvenile	5	3	1	Medium
Enbridge	WPZCNT04	EN817-27	Juvenile	3	2	1	Small
Enbridge	WPZCNT04	EN817-27	Juvenile	3	2	1	Small
Enbridge	WPZCNT04	EN817-27	Juvenile	4	3	1	Small
Enbridge	WPZCNT04	EN817-27	Juvenile	4	2	1	Small
Enbridge	WPZCNT04	EN817-27	Juvenile	3	2	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZCNT04	EN817-27	Juvenile	2	2	1	Small
Enbridge	WPZCNT04	EN817-27	Juvenile	2	1	1	Small
Enbridge	WPZCNT04	EN817-27	Juvenile	1	1	1	Small
Enbridge	WPZCNT04	EN817-27	Juvenile	2	1	1	Small
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	28	15	7	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	25	15	6	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	26	13	8	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	26	14	9	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	26	15	11	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	30	19	12	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	25	15	10	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	26	15	9	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	26	16	9	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	30	17	13	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	20	11	8	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	22	13	7	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	26	15	9	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	24	12	8	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	21	12	7	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	23	13	8	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	21	13	7	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	26	15	11	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	23	13	7	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	20	11	8	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	19	10	7	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	10	6	3	Medium
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	11	10	4	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	12	7	4	Large
Enbridge	WPZCNB09	EN817-28	Adult, Quagga	9	5	3	Medium
Enbridge	WPZCNB09	EN817-28	Juvenile	4	3	1	Small
Enbridge	WPZCNB09	EN817-28	Juvenile	5	4	2	Medium
Enbridge	WPZCNB09	EN817-28	Juvenile	3	2	1	Small
Enbridge	WPZCNB09	EN817-28	Juvenile	3	2	1	Small
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	29	17	10	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	21	13	8	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	26	15	10	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	31	16	12	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	30	17	10	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	25	14	11	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	24	14	11	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	25	14	9	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	23	13	8	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	30	19	13	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	26	17	11	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	28	16	9	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	23	14	8	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	24	15	10	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	25	15	10	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	24	15	10	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	24	15	12	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	25	14	11	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	27	17	11	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	22	13	8	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	25	13	9	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	26	15	10	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	23	14	9	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	26	15	9	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	29	16	9	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	20	12	6	Large
Enbridge	WPZCNW06	EN817-29	Adult, Quagga	10	5	2	Medium
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	24	13	8	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	28	15	10	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	26	15	9	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	28	15	8	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	27	15	9	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	27	14	9	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	29	16	10	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	31	17	11	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	21	13	9	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	29	15	11	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	27	16	11	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	30	16	12	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	26	14	10	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	28	14	9	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	24	13	10	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	23	14	10	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	23	13	8	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	26	14	9	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	25	14	10	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	22	13	8	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	24	12	8	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	27	14	11	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	28	17	12	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	26	14	9	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	20	12	10	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	24	15	10	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	23	13	8	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	21	11	8	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	17	10	7	Large
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	10	6	3	Medium
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	8	5	2	Medium
Enbridge	WPZBNT01	EN817-30	Adult, Quagga	8	5	2	Medium
Enbridge	WPZBNT01	EN817-30	Juvenile	6	3	2	Medium
Enbridge	WPZBNT01	EN817-30	Juvenile	6	4	2	Medium
Enbridge	WPZBNT01	EN817-30	Juvenile	3	2	1	Small
Enbridge	WPZBNT01	EN817-30	Juvenile	3	2	1	Small
Enbridge	WPZBNT01	EN817-30	Juvenile	2	1	1	Small
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	24	15	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	27	17	13	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	24	14	9	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	25	14	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	21	12	9	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	21	12	7	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	31	17	11	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	24	15	9	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	22	12	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	21	11	8	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	23	13	8	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	29	14	11	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	24	14	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	23	14	8	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	24	12	10	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	26	15	11	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	23	14	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	23	13	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	24	14	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	25	14	9	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	24	13	9	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	22	12	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	22	12	9	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	23	13	7	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	25	14	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	22	13	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	27	14	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	24	14	9	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	26	15	11	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	24	16	10	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	15	8	5	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	14	8	4	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	11	9	4	Large
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	9	5	2	Medium
Enbridge	WPZBNE11	EN817-31	Adult, Quagga	7	4	2	Medium
Enbridge	WPZBNE11	EN817-31	Juvenile	6	4	2	Medium
Enbridge	WPZBNE11	EN817-31	Juvenile	6	3	1	Medium
Enbridge	WPZBNE11	EN817-31	Juvenile	6	3	2	Medium
Enbridge	WPZBNE11	EN817-31	Juvenile	4	3	1	Small
Enbridge	WPZBNE11	EN817-31	Juvenile	4	3	2	Small
Enbridge	WPZBNE11	EN817-31	Juvenile	5	3	2	Medium
Enbridge	WPZBNE11	EN817-31	Juvenile	3	2	1	Small
Enbridge	WPZBNE11	EN817-31	Juvenile	4	3	1	Small
Enbridge	WPZBNE11	EN817-31	Juvenile	3	2	1	Small
Enbridge	WPZBNE11	EN817-31	Juvenile	2	1	1	Small
Enbridge	WPZBNE11	EN817-31	Juvenile	2	1	1	Small
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	27	15	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	26	17	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	25	13	10	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	25	15	11	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	30	17	12	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	28	16	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	27	17	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	22	14	6	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	25	15	10	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	25	14	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	22	12	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	19	11	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	21	12	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	22	12	6	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	18	10	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	24	14	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	23	13	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	26	14	10	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	24	14	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	34	19	13	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	24	14	10	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	23	14	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	23	13	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	26	15	10	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	23	13	9	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	23	14	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	22	13	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	23	14	10	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	25	14	10	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	24	14	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	24	14	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	25	15	10	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	25	14	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	24	14	9	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	24	13	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	24	13	10	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	22	13	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	22	13	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	22	12	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	21	13	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	19	10	6	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	20	12	8	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	14	8	3	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	12	7	3	Large
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	10	6	3	Medium
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	8	5	2	Medium
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	10	4	3	Medium
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	7	3	2	Medium
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	7	4	2	Medium
Enbridge	WPZBNW04	EN817-32	Adult, Quagga	8	5	2	Medium
Enbridge	WPZBNW04	EN817-32	Juvenile	6	4	2	Medium
Enbridge	WPZBNW04	EN817-32	Juvenile	6	3	2	Medium
Enbridge	WPZBNW04	EN817-32	Juvenile	5	3	2	Medium
Enbridge	WPZBNW04	EN817-32	Juvenile	5	3	2	Medium
Enbridge	WPZBNW04	EN817-32	Juvenile	5	3	2	Medium
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	23	14	10	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	23	13	9	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	25	14	7	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	29	16	10	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	25	15	9	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	26	14	8	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	25	15	11	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	21	13	9	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	25	15	8	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	23	14	9	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	23	14	8	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	20	12	8	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	22	13	8	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	27	16	8	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	23	13	8	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	27	17	8	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	24	13	7	Large
Enbridge	WPZCNE11	EN817-33	Adult, Quagga	11	7	4	Large
Enbridge	WPZCNE11	EN817-33	Juvenile	6	4	2	Medium
Enbridge	WPZCNE11	EN817-33	Juvenile	6	4	2	Medium
Enbridge	WPZCNE11	EN817-33	Juvenile	5	3	1	Medium
Enbridge	WPZCNE11	EN817-33	Juvenile	5	4	2	Medium
Enbridge	WPZCNE11	EN817-33	Juvenile	5	3	2	Medium
Enbridge	WPZCNE11	EN817-33	Juvenile	5	3	2	Medium
Enbridge	WPZCNE11	EN817-33	Juvenile	5	3	1	Medium
Enbridge	WPZCNE11	EN817-33	Juvenile	4	3	2	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZCNE11	EN817-33	Juvenile	5	4	2	Medium
Enbridge	WPZCNE11	EN817-33	Juvenile	4	3	1	Small
Enbridge	WPZCNE11	EN817-33	Juvenile	3	2	1	Small
Enbridge	WPZCNE11	EN817-33	Juvenile	2	2	1	Small
Enbridge	70824-EAOI11D	EN817-35	Adult, Quagga	19	13	12	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	22	14	10	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	25	14	10	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	27	14	12	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	28	14	12	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	24	14	10	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	20	12	8	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	17	11	9	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	23	12	9	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	19	11	9	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	19	11	9	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	21	12	10	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	18	10	9	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	23	15	12	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	20	10	8	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	17	10	8	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	16	10	8	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	18	11	9	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	28	14	11	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	24	13	11	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	21	11	9	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	21	11	9	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	26	15	12	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	24	14	11	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	22	12	11	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	22	13	8	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	23	12	10	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	24	13	10	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	27	14	11	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	21	12	9	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	21	12	9	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	24	13	10	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	14	8	6	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	16	10	5	Large
Enbridge	EPZASW01	EN817-36	Adult, Quagga	17	9	8	Large
Enbridge	WPZDT11	EN817-38	Adult, Quagga	27	14	11	Large
Enbridge	WPZDT11	EN817-38	Adult, Quagga	26	14	10	Large
Enbridge	WPZDT11	EN817-38	Adult, Quagga	26	14	10	Large
Enbridge	WPZDT11	EN817-38	Adult, Quagga	10	6	3	Medium
Enbridge	WPZDT11	EN817-38	Adult, Quagga	8	6	2	Medium
Enbridge	WPZDT11	EN817-38	Adult, Quagga	8	5	2	Medium
Enbridge	WPZDT11	EN817-38	Juvenile	5	4	2	Medium
Enbridge	WPZDT11	EN817-38	Juvenile	4	2	1	Small
Enbridge	WPZDT11	EN817-38	Juvenile	4	2	1	Small
Enbridge	WPZDT11	EN817-38	Juvenile	4	2	1	Small
Enbridge	WPZDT11	EN817-38	Juvenile	3	2	1	Small
Enbridge	WPZDT11	EN817-38	Juvenile	2	1	1	Small
Enbridge	WPZDT11	EN817-38	Juvenile	3	2	1	Small
Enbridge	WPZDT11	EN817-38	Juvenile	3	2	1	Small
Enbridge	WPZDT11	EN817-38	Juvenile	4	3	1	Small
Enbridge	WPZDT11	EN817-38	Juvenile	3	1	1	Small
Enbridge	WPZDT11	EN817-38	Juvenile	3	2	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZDT11	EN817-38	Juvenile	2	1	1	Small
Enbridge	WPZDT11	EN817-38	Juvenile	2	1	1	Small
Enbridge	WPZDT02	EN817-39	Adult, Quagga	28	15	10	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	24	13	8	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	25	14	9	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	25	15	9	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	22	14	9	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	27	13	10	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	27	16	10	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	24	15	10	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	24	14	10	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	24	14	9	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	28	16	9	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	22	13	8	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	26	14	9	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	27	15	11	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	25	16	10	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	22	15	9	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	21	12	8	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	26	14	10	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	26	14	10	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	26	15	8	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	22	12	8	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	22	13	8	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	24	13	8	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	23	13	7	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	20	13	7	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	22	13	9	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	25	13	8	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	22	12	8	Large
Enbridge	WPZDT02	EN817-39	Adult, Quagga	12	8	5	Large
Enbridge	WPZDT02	EN817-39	Juvenile	4	3	1	Small
Enbridge	WPZDT02	EN817-39	Juvenile	4	3	1	Small
Enbridge	EPZDE09	EN817-40	Adult, Quagga	22	14	10	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	27	16	10	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	23	13	8	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	25	13	9	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	24	14	8	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	24	14	9	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	25	15	8	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	27	16	11	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	30	18	12	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	26	15	10	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	25	14	9	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	21	13	7	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	25	14	10	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	23	14	9	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	23	13	8	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	24	13	8	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	19	11	7	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	18	11	7	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	20	11	6	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	19	10	7	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	21	11	8	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	26	16	10	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	18	10	6	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZDE09	EN817-40	Adult, Quagga	18	10	7	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	16	10	6	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	10	6	3	Medium
Enbridge	EPZDE09	EN817-40	Adult, Quagga	16	10	7	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	20	12	7	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	25	16	11	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	20	12	8	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	19	11	7	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	13	8	4	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	15	9	5	Large
Enbridge	EPZDE09	EN817-40	Adult, Quagga	9	5	3	Medium
Enbridge	EPZDE09	EN817-40	Juvenile	6	4	2	Medium
Enbridge	EPZDE09	EN817-40	Adult, Quagga	7	4	3	Medium
Enbridge	EPZDE09	EN817-40	Juvenile	6	4	2	Medium
Enbridge	EPZDE09	EN817-40	Juvenile	5	3	2	Medium
Enbridge	EPZDE09	EN817-40	Juvenile	5	3	2	Medium
Enbridge	EPZDE09	EN817-40	Juvenile	5	3	2	Medium
Enbridge	EPZDE09	EN817-40	Juvenile	6	4	2	Medium
Enbridge	EPZDE09	EN817-40	Juvenile	4	3	1	Small
Enbridge	EPZDE09	EN817-40	Juvenile	5	2	1	Medium
Enbridge	EPZDE09	EN817-40	Juvenile	5	3	1	Medium
Enbridge	EPZDE09	EN817-40	Juvenile	4	3	1	Small
Enbridge	EPZDE09	EN817-40	Juvenile	3	2	1	Small
Enbridge	EPZDE09	EN817-40	Juvenile	3	2	1	Small
Enbridge	EPZDT02	EN817-41	Adult, Quagga	25	14	9	Large
Enbridge	EPZDT02	EN817-41	Adult, Quagga	27	15	10	Large
Enbridge	EPZDT02	EN817-41	Adult, Quagga	26	15	11	Large
Enbridge	EPZDT02	EN817-41	Adult, Quagga	17	11	7	Large
Enbridge	EPZDT02	EN817-41	Adult, Quagga	27	15	9	Large
Enbridge	EPZDT02	EN817-41	Adult, Quagga	8	5	3	Medium
Enbridge	EPZDT02	EN817-41	Juvenile	4	3	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	5	3	1	Medium
Enbridge	EPZDT02	EN817-41	Juvenile	2	1	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	5	3	1	Medium
Enbridge	EPZDT02	EN817-41	Juvenile	3	2	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	4	2	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	3	2	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	2	1	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	3	2	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	4	2	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	4	2	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	3	2	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	4	2	1	Small
Enbridge	EPZDT02	EN817-41	Juvenile	3	2	1	Small
Enbridge	EPZDW10	EN817-42	Adult, Quagga	27	16	11	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	26	15	11	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	26	15	10	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	27	17	10	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	28	17	11	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	31	17	11	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	27	15	9	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	24	14	9	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	19	11	9	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	19	10	7	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	21	12	7	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	19	11	7	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZDW10	EN817-42	Adult, Quagga	20	13	8	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	17	11	6	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	20	12	7	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	14	9	6	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	15	9	5	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	13	7	4	Large
Enbridge	EPZDW10	EN817-42	Adult, Quagga	7	4	3	Medium
Enbridge	EPZDW10	EN817-42	Adult, Quagga	7	5	2	Medium
Enbridge	EPZDW10	EN817-42	Juvenile	5	3	1	Medium
Enbridge	EPZDW10	EN817-42	Juvenile	4	3	1	Small
Enbridge	EPZDW10	EN817-42	Juvenile	5	3	1	Medium
Enbridge	EPZDW10	EN817-42	Juvenile	3	2	1	Small
Enbridge	EPZDW06	EN817-43	Adult, Quagga	21	12	9	Large
Enbridge	EPZDW06	EN817-43	Adult, Quagga	26	15	12	Large
Enbridge	EPZDW06	EN817-43	Adult, Quagga	25	16	9	Large
Enbridge	EPZDW06	EN817-43	Adult, Quagga	14	9	6	Large
Enbridge	EPZDW06	EN817-43	Adult, Quagga	7	4	2	Medium
Enbridge	EPZDW06	EN817-43	Juvenile	6	4	2	Medium
Enbridge	EPZDW06	EN817-43	Juvenile	3	2	1	Small
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	28	16	13	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	30	18	12	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	25	14	11	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	34	17	13	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	32	17	11	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	26	15	9	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	25	14	9	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	29	17	11	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	23	16	11	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	27	17	11	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	25	14	10	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	28	15	10	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	27	15	10	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	23	14	8	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	22	13	9	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	24	14	9	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	20	12	8	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	28	15	10	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	25	15	8	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	24	14	9	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	19	12	8	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	19	11	5	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	18	11	6	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	17	11	7	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	17	10	6	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	12	8	4	Large
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	7	6	3	Medium
Enbridge	WPZCSE09	EN817-45	Juvenile	6	5	2	Medium
Enbridge	WPZCSE09	EN817-45	Adult, Quagga	8	5	2	Medium
Enbridge	WPZCSE09	EN817-45	Juvenile	6	3	2	Medium
Enbridge	WPZCSE09	EN817-45	Juvenile	6	3	2	Medium
Enbridge	WPZCSE09	EN817-45	Juvenile	5	3	2	Medium
Enbridge	WPZCSE09	EN817-45	Juvenile	5	3	2	Medium
Enbridge	WPZCSE09	EN817-45	Juvenile	6	4	2	Medium
Enbridge	WPZCSE09	EN817-45	Juvenile	6	4	2	Medium
Enbridge	WPZCSE09	EN817-45	Juvenile	5	3	1	Medium
Enbridge	WPZCSE09	EN817-45	Juvenile	3	2	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZCSE09	EN817-45	Juvenile	4	3	1	Small
Enbridge	WPZCSE09	EN817-45	Juvenile	4	3	1	Small
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	24	13	10	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	26	16	9	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	27	18	10	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	24	14	10	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	23	15	9	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	25	13	9	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	22	13	10	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	23	14	10	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	23	13	9	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	20	12	7	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	16	9	7	Large
Enbridge	WPZCSW11	EN817-46	Adult, Quagga	10	6	3	Medium
Enbridge	WPZCSW11	EN817-46	Juvenile	4	3	2	Small
Enbridge	WPZCSW11	EN817-46	Juvenile	4	3	1	Small
Enbridge	WPZCSW11	EN817-46	Juvenile	3	2	1	Small
Enbridge	WPZCSW11	EN817-46	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Adult, Quagga	26	14	9	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	29	16	11	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	28	14	9	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	27	16	11	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	29	17	12	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	25	14	9	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	28	15	9	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	29	17	12	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	26	14	9	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	27	15	9	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	30	17	12	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	29	15	10	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	18	10	7	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	14	8	6	Large
Enbridge	WPZCST07	EN817-48	Adult, Quagga	10	7	4	Medium
Enbridge	WPZCST07	EN817-48	Adult, Quagga	10	7	3	Medium
Enbridge	WPZCST07	EN817-48	Adult, Quagga	8	4	2	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	6	3	2	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	6	3	2	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	6	4	2	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	6	4	2	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	5	3	2	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	5	4	2	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	6	3	1	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	4	3	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	5	3	2	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	5	3	1	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	5	3	2	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	4	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	4	3	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	4	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	4	3	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	2	1	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	4	3	2	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	4	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	1	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	2	1	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	4	2	2	Small
Enbridge	WPZCST07	EN817-48	Juvenile	5	3	2	Medium
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	4	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	2	1	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	2	1	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	2	1	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	2	1	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	2	1	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	4	2	2	Small
Enbridge	WPZCST07	EN817-48	Juvenile	4	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	3	2	1	Small
Enbridge	WPZCST07	EN817-48	Juvenile	2	1	1	Small
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	28	15	8	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	26	15	8	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	28	17	10	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	27	14	11	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	24	14	10	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	23	13	7	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	26	13	8	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	26	16	8	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	29	16	11	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	22	14	10	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	24	13	9	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	26	14	8	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	28	16	10	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	29	18	12	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	25	16	9	Large
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	9	6	3	Medium
Enbridge	WPZCSW03	EN817-49	Adult, Quagga	26	15	8	Large
Enbridge	WPZASE07	EN817-51	Adult, Quagga	11	6	3	Large
Enbridge	WPZASW11	EN817-52	Adult, Quagga	21	12	9	Large
Enbridge	WPZAST09	EN817-54	Adult, Quagga	24	13	10	Large
Enbridge	WPZAST09	EN817-54	Adult, Quagga	22	12	9	Large
Enbridge	WPZAST09	EN817-54	Juvenile	3	2	1	Small
Enbridge	WPZAST09	EN817-54	Juvenile	2	1	1	Small
Enbridge	EPZAST09	EN817-58	Adult, Quagga	22	13	11	Large
Enbridge	EPZAST09	EN817-58	Adult, Quagga	28	16	12	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	25	14	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	28	14	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	23	12	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	24	13	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	26	15	12	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	28	16	12	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	25	15	9	Large

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Enbridge	EPZASE08	EN817-59	Adult, Quagga	25	14	12	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	27	13	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	25	15	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	28	14	8	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	12	8	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	26	16	14	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	12	8	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	11	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	28	15	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	12	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	29	15	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	24	15	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	13	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	18	10	8	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	13	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	27	14	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	27	14	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	27	16	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	26	15	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	21	14	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	24	13	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	13	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	14	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	21	10	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	25	14	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	26	14	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	12	8	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	21	12	8	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	26	14	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	30	16	13	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	28	15	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	27	15	12	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	26	15	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	26	15	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	11	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	23	15	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	25	14	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	29	15	12	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	26	15	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	23	14	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	24	13	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	14	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	24	14	11	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	22	14	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	21	13	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	21	12	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	26	14	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	21	12	8	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	25	13	9	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	23	13	10	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	21	11	8	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	17	11	8	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	17	9	7	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	16	10	8	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	14	9	6	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	12	7	5	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZASE08	EN817-59	Adult, Quagga	10	6	4	Medium
Enbridge	EPZASE08	EN817-59	Adult, Quagga	11	7	4	Large
Enbridge	EPZASE08	EN817-59	Adult, Quagga	7	5	2	Medium
Enbridge	EPZASE08	EN817-59	Adult, Quagga	10	7	4	Medium
Enbridge	EPZASE08	EN817-59	Adult, Quagga	10	6	4	Medium
Enbridge	EPZASE08	EN817-59	Adult, Quagga	10	5	3	Medium
Enbridge	EPZASE08	EN817-59	Adult, Quagga	8	5	3	Medium
Enbridge	EPZASE08	EN817-59	Adult, Quagga	7	4	3	Medium
Enbridge	EPZASE08	EN817-59	Adult, Quagga	7	5	3	Medium
Enbridge	EPZASE08	EN817-59	Juvenile	6	4	2	Medium
Enbridge	EPZASE08	EN817-59	Juvenile	6	4	2	Medium
Enbridge	EPZASE08	EN817-59	Juvenile	5	3	2	Medium
Enbridge	EPZASE08	EN817-59	Juvenile	3	3	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	4	2	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	3	2	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	4	3	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	5	3	2	Medium
Enbridge	EPZASE08	EN817-59	Juvenile	4	3	2	Small
Enbridge	EPZASE08	EN817-59	Juvenile	5	3	1	Medium
Enbridge	EPZASE08	EN817-59	Juvenile	4	2	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	5	2	1	Medium
Enbridge	EPZASE08	EN817-59	Juvenile	4	2	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	4	2	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	3	2	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	2	1	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	2	2	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	2	1	1	Small
Enbridge	EPZASE08	EN817-59	Juvenile	4	3	2	Small
Enbridge	EPZASE08	EN817-59	Juvenile	2	1	1	Small
Enbridge	EPZASW04	EN817-60	Adult, Quagga	27	15	11	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	25	14	13	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	28	17	12	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	25	15	10	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	21	13	9	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	21	14	10	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	22	13	11	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	26	15	10	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	30	17	11	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	29	16	12	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	29	18	13	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	26	14	10	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	24	15	10	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	25	14	9	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	25	15	11	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	22	12	10	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	24	14	10	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	26	16	11	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	21	12	9	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	24	13	11	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	24	13	10	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	25	15	12	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	20	12	9	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	23	13	10	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	21	11	10	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	27	15	11	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	21	12	12	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZASW04	EN817-60	Adult, Quagga	22	13	9	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	23	15	11	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	20	12	9	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	17	9	6	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	15	9	7	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	17	10	7	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	19	12	9	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	21	13	9	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	25	13	9	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	25	14	9	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	15	8	5	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	21	12	8	Large
Enbridge	EPZASW04	EN817-60	Adult, Quagga	10	8	4	Medium
Enbridge	EPZASW04	EN817-60	Adult, Quagga	10	7	3	Medium
Enbridge	EPZASW04	EN817-60	Juvenile	6	4	3	Medium
Enbridge	EPZASW04	EN817-60	Adult, Quagga	7	5	3	Medium
Enbridge	EPZASW04	EN817-60	Adult, Quagga	7	5	3	Medium
Enbridge	EPZASW04	EN817-60	Juvenile	6	4	2	Medium
Enbridge	EPZASW04	EN817-60	Juvenile	5	3	2	Medium
Enbridge	EPZASW04	EN817-60	Juvenile	4	2	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	5	3	2	Medium
Enbridge	EPZASW04	EN817-60	Juvenile	4	3	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	4	2	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	4	2	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	2	1	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	3	2	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	3	2	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	3	2	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	3	2	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	3	2	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	2	2	1	Small
Enbridge	EPZASW04	EN817-60	Juvenile	2	1	1	Small
Enbridge	EPZASB01	EN817-61	Adult, Quagga	26	14	11	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	28	16	9	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	23	12	8	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	27	16	11	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	27	14	10	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	27	15	10	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	26	16	11	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	23	12	8	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	24	13	9	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	26	16	12	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	27	15	11	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	24	14	10	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	20	12	8	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	27	15	11	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	25	15	10	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	24	13	9	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	26	14	9	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	23	12	10	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	22	12	8	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	26	15	8	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	22	14	10	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	28	14	9	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	28	15	11	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	23	13	9	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZASB01	EN817-61	Adult, Quagga	19	10	7	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	17	10	6	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	20	10	7	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	21	13	9	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	16	9	7	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	15	8	6	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	16	9	6	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	17	9	7	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	17	10	6	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	15	6	4	Large
Enbridge	EPZASB01	EN817-61	Adult, Quagga	10	5	3	Medium
Enbridge	EPZASB01	EN817-61	Adult, Quagga	10	6	3	Medium
Enbridge	EPZASB01	EN817-61	Adult, Quagga	10	6	4	Medium
Enbridge	EPZASB01	EN817-61	Adult, Quagga	9	6	3	Medium
Enbridge	EPZASB01	EN817-61	Adult, Quagga	9	5	3	Medium
Enbridge	EPZASB01	EN817-61	Adult, Quagga	8	6	3	Medium
Enbridge	EPZASB01	EN817-61	Adult, Quagga	7	5	2	Medium
Enbridge	EPZASB01	EN817-61	Adult, Quagga	7	4	2	Medium
Enbridge	EPZASB01	EN817-61	Adult, Quagga	9	4	2	Medium
Enbridge	EPZASB01	EN817-61	Adult, Quagga	7	4	2	Medium
Enbridge	EPZASB01	EN817-61	Juvenile	6	4	2	Medium
Enbridge	EPZASB01	EN817-61	Juvenile	6	4	2	Medium
Enbridge	EPZASB01	EN817-61	Juvenile	5	3	2	Medium
Enbridge	EPZASB01	EN817-61	Juvenile	5	3	1	Medium
Enbridge	EPZASB01	EN817-61	Juvenile	4	3	1	Small
Enbridge	EPZASB01	EN817-61	Juvenile	5	3	1	Medium
Enbridge	EPZASB01	EN817-61	Juvenile	4	3	2	Small
Enbridge	EPZASB01	EN817-61	Juvenile	5	3	2	Medium
Enbridge	EPZASB01	EN817-61	Juvenile	4	3	1	Small
Enbridge	EPZASB01	EN817-61	Juvenile	3	2	1	Small
Enbridge	EPZASW02	EN817-62	Adult, Quagga	31	18	13	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	25	13	8	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	27	15	11	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	27	15	10	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	26	14	10	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	22	12	9	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	25	14	9	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	27	15	11	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	25	15	10	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	22	12	9	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	26	14	10	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	23	12	9	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	23	13	9	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	21	12	8	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	23	13	9	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	20	11	8	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	21	11	10	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	23	14	9	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	24	13	10	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	21	13	9	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	21	12	8	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	21	12	9	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	21	13	9	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	21	12	8	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	19	11	7	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	18	10	6	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZASW02	EN817-62	Adult, Quagga	17	10	8	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	17	10	8	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	16	9	6	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	12	8	5	Large
Enbridge	EPZASW02	EN817-62	Adult, Quagga	15	9	5	Large
Enbridge	WPZDT08	EN817-66	Juvenile	6	4	2	Medium
Enbridge	WPZDT08	EN817-66	Juvenile	4	3	1	Small
Enbridge	WPZDT08	EN817-66	Juvenile	4	3	1	Small
Enbridge	WPZDE11	EN817-67	Adult, Quagga	26	14	9	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	23	13	8	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	22	13	8	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	27	17	12	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	25	14	10	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	28	16	11	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	26	15	10	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	26	17	10	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	33	20	13	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	26	15	9	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	28	16	9	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	24	14	8	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	25	15	13	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	21	11	8	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	26	17	11	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	23	12	9	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	20	12	10	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	29	16	11	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	29	16	12	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	24	13	9	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	25	15	9	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	25	13	8	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	27	15	11	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	28	15	9	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	26	16	10	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	27	15	12	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	26	15	9	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	21	13	9	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	27	16	11	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	26	14	8	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	24	13	8	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	27	17	12	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	25	15	9	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	19	12	6	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	25	15	11	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	21	12	8	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	22	14	8	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	21	12	8	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	20	12	7	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	17	10	6	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	16	9	5	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	14	8	6	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	19	11	6	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	13	8	5	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	15	8	5	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	14	8	5	Large
Enbridge	WPZDE11	EN817-67	Adult, Quagga	9	5	3	Medium
Enbridge	WPZDE11	EN817-67	Adult, Quagga	11	6	4	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZDE11	EN817-67	Juvenile	6	5	2	Medium
Enbridge	WPZDE11	EN817-67	Adult, Quagga	7	4	3	Medium
Enbridge	WPZDE11	EN817-67	Adult, Quagga	7	4	3	Medium
Enbridge	WPZDE11	EN817-67	Juvenile	6	4	3	Medium
Enbridge	WPZDE11	EN817-67	Juvenile	5	3	2	Medium
Enbridge	WPZDE11	EN817-67	Juvenile	5	3	2	Medium
Enbridge	WPZDE11	EN817-67	Juvenile	6	4	2	Medium
Enbridge	WPZDE11	EN817-67	Juvenile	5	3	1	Medium
Enbridge	WPZDE11	EN817-67	Juvenile	5	3	1	Medium
Enbridge	WPZDE11	EN817-67	Juvenile	5	3	1	Medium
Enbridge	WPZDE11	EN817-67	Juvenile	6	3	2	Medium
Enbridge	WPZDE11	EN817-67	Juvenile	4	3	1	Small
Enbridge	WPZDE11	EN817-67	Juvenile	5	3	2	Medium
Enbridge	WPZDE11	EN817-67	Juvenile	4	3	2	Small
Enbridge	WPZDE11	EN817-67	Juvenile	4	2	1	Small
Enbridge	WPZDE11	EN817-67	Juvenile	3	2	1	Small
Enbridge	WPZDW09	EN817-68	Adult, Quagga	27	16	11	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	29	19	14	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	27	15	11	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	29	18	12	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	25	14	9	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	25	15	8	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	24	13	9	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	32	16	11	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	29	19	12	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	25	15	10	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	25	14	12	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	24	15	9	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	24	14	10	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	24	15	9	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	28	17	12	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	24	14	8	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	27	16	10	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	25	14	9	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	27	17	10	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	30	18	11	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	25	16	10	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	25	15	10	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	23	12	8	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	22	14	9	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	20	11	9	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	28	15	10	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	24	12	9	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	24	13	10	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	16	10	6	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	13	8	5	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	15	9	5	Large
Enbridge	WPZDW09	EN817-68	Adult, Quagga	10	5	3	Medium
Enbridge	WPZDW09	EN817-68	Juvenile	6	5	3	Medium
Enbridge	WPZDW09	EN817-68	Adult, Quagga	7	5	3	Medium
Enbridge	WPZDW09	EN817-68	Juvenile	6	4	2	Medium
Enbridge	WPZDW09	EN817-68	Adult, Quagga	7	4	2	Medium
Enbridge	WPZDW09	EN817-68	Adult, Quagga	7	4	2	Medium
Enbridge	WPZDW09	EN817-68	Juvenile	5	3	2	Medium
Enbridge	WPZDW09	EN817-68	Juvenile	4	2	1	Small
Enbridge	WPZDW09	EN817-68	Juvenile	5	3	2	Medium

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZDW09	EN817-68	Juvenile	5	3	1	Medium
Enbridge	WPZDW09	EN817-68	Juvenile	3	2	1	Small
Enbridge	WPZDW09	EN817-68	Juvenile	3	2	1	Small
Enbridge	WPZDB05	EN817-69	Adult, Quagga	24	15	11	Large
Enbridge	WPZDB05	EN817-69	Adult, Quagga	22	14	9	Large
Enbridge	WPZDB05	EN817-69	Adult, Quagga	25	16	10	Large
Enbridge	WPZDB05	EN817-69	Adult, Quagga	20	12	5	Large
Enbridge	WPZDB05	EN817-69	Adult, Quagga	22	13	9	Large
Enbridge	WPZDB05	EN817-69	Adult, Quagga	20	12	7	Large
Enbridge	WPZDB05	EN817-69	Adult, Quagga	16	10	5	Large
Enbridge	WPZDB05	EN817-69	Adult, Quagga	20	12	8	Large
Enbridge	WPZDB05	EN817-69	Adult, Quagga	11	7	4	Large
Enbridge	WPZDB05	EN817-69	Adult, Quagga	8	5	4	Medium
Enbridge	WPZDB05	EN817-69	Adult, Quagga	8	5	3	Medium
Enbridge	WPZDB05	EN817-69	Adult, Quagga	8	4	3	Medium
Enbridge	WPZDB05	EN817-69	Juvenile	6	4	2	Medium
Enbridge	WPZDE03	EN817-71	Adult, Quagga	28	15	9	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	31	17	11	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	27	16	10	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	25	14	9	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	29	15	11	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	27	14	11	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	26	15	11	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	28	17	11	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	26	15	10	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	29	16	11	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	24	14	9	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	29	16	10	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	32	16	11	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	29	16	10	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	23	15	12	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	25	15	9	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	22	14	11	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	24	14	11	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	26	15	10	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	25	14	8	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	25	13	10	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	21	11	8	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	22	12	9	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	19	13	8	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	25	14	9	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	17	10	7	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	11	7	5	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	12	8	5	Large
Enbridge	WPZDE03	EN817-71	Adult, Quagga	9	6	3	Medium
Enbridge	WPZDE03	EN817-71	Adult, Quagga	9	5	3	Medium
Enbridge	WPZDE03	EN817-71	Adult, Quagga	7	4	2	Medium
Enbridge	WPZDE03	EN817-71	Juvenile	6	4	2	Medium
Enbridge	WPZDE03	EN817-71	Juvenile	6	3	2	Medium
Enbridge	WPZDE03	EN817-71	Juvenile	5	3	2	Medium
Enbridge	WPZDE03	EN817-71	Juvenile	6	3	2	Medium
Enbridge	WPZDE03	EN817-71	Juvenile	4	3	2	Small
Enbridge	WPZDE03	EN817-71	Juvenile	4	3	1	Small
Enbridge	WPZDE03	EN817-71	Juvenile	5	3	2	Medium
Enbridge	WPZDE03	EN817-71	Juvenile	5	3	2	Medium
Enbridge	WPZDE03	EN817-71	Juvenile	4	3	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZDE03	EN817-71	Juvenile	4	3	1	Small
Enbridge	WPZDE03	EN817-71	Juvenile	3	2	1	Small
Enbridge	WPZDE03	EN817-71	Juvenile	2	2	1	Small
Enbridge	WPZDE03	EN817-71	Juvenile	3	2	1	Small
Enbridge	WPZDE03	EN817-71	Juvenile	4	2	1	Small
Enbridge	WPZDE03	EN817-71	Juvenile	4	3	1	Small
Enbridge	WPZDE03	EN817-71	Juvenile	4	2	1	Small
Enbridge	WPZDE03	EN817-71	Juvenile	3	2	1	Small
Enbridge	WPZDE03	EN817-71	Juvenile	4	3	1	Small
Enbridge	WPZDE03	EN817-71	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	15	12	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	15	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	29	16	13	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	30	18	12	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	16	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	15	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	29	15	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	29	16	12	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	15	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	20	12	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	12	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	16	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	16	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	16	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	13	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	12	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	15	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	14	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	12	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	16	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	28	17	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	28	16	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	16	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	20	11	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	11	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	12	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	30	16	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	8	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	29	14	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	16	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	15	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	16	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	14	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	15	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	15	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	15	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	15	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	14	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	31	18	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	16	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	30	16	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	12	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	15	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	20	11	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	14	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	17	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	11	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	16	12	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	15	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	30	17	12	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	14	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	29	18	13	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	28	16	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	14	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	12	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	10	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	15	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	29	15	12	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	29	15	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	11	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	15	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	15	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	20	12	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	15	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	12	9	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	12	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	20	11	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	11	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	20	12	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	12	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	15	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	16	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	12	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	13	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	12	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	12	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	13	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	29	16	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	14	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	12	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	27	16	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	26	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	29	15	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	23	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	13	10	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	12	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	19	10	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	24	14	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	15	11	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	14	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	19	11	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	9	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	11	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	19	12	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	13	9	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	12	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	19	11	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	20	12	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	22	11	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	20	12	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	9	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	11	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	11	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	11	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	11	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	25	13	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	19	12	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	9	6	Large

REDACTED SUBMITTAL - PUBLIC COPY

Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	11	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	21	11	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	11	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	11	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	9	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	11	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	19	11	8	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	10	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	19	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	9	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	9	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	10	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	10	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	9	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	15	9	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	15	9	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	19	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	18	9	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	9	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	9	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	9	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	15	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	8	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	11	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	8	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	15	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	16	9	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	7	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	15	9	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	15	9	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	8	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	8	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	7	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	15	9	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	9	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	15	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	9	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	4	Large

REDACTED SUBMITTAL - PUBLIC COPY

Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	17	10	7	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	15	8	6	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	6	3	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	3	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	15	9	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	13	7	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	3	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	14	8	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	8	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	7	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	7	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	8	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	7	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	8	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	5	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	7	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	6	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	7	4	Medium

REDACTED SUBMITTAL - PUBLIC COPY

Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	7	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	12	7	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	5	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	7	3	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	5	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	3	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	11	6	4	Large
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	7	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	7	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	7	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	10	6	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium

REDACTED SUBMITTAL - PUBLIC COPY

Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	6	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	5	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	6	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	4	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	9	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	5	3	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	5	3	Medium

REDACTED SUBMITTAL - PUBLIC COPY

Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	1	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	5	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	8	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	5	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Adult, Quagga	7	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	2	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	1	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	1	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	2	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	1	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	5	3	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	6	4	2	Medium
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	1	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	2	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	4	3	2	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	1	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	1	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	3	2	1	Small
Enbridge	0907-WAOI1M	EN817-72	Juvenile	1	1	1	Small
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	25	14	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	29	15	11	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	32	18	11	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	25	13	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	27	14	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	28	15	11	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	22	13	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	25	15	10	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	24	13	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	25	14	8	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	27	15	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	25	16	10	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	28	15	10	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	24	13	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	23	13	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	24	13	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	23	13	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	23	12	8	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	24	13	10	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	20	12	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	23	14	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	23	13	9	Large
Enbridge	EPZCNT13	EN817-74	Adult, Quagga	8	5	3	Medium
Enbridge	EPZCNT13	EN817-74	Juvenile	3	2	1	Small
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	27	17	9	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	30	17	13	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	29	15	11	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	24	13	7	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	29	17	11	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	22	14	9	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	22	12	10	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	28	15	12	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	25	15	12	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	24	13	8	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	24	13	9	Large
Enbridge	EPZCNE11	EN817-75	Adult, Quagga	22	11	6	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	24	13	8	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	27	15	10	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	33	18	12	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	24	12	7	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	28	15	11	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	22	13	8	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	21	12	7	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	23	13	10	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	27	15	8	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	27	15	10	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	28	15	10	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	25	12	9	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	24	13	8	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	26	14	9	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	25	14	8	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	24	13	11	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	23	14	8	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	26	14	11	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	28	16	9	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	27	14	11	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	22	13	9	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	23	14	8	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	24	13	8	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	19	11	8	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	23	13	8	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	16	11	7	Large
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	10	5	4	Medium
Enbridge	EPZCNW06	EN817-76	Adult, Quagga	10	6	4	Medium
Enbridge	EPZCNW06	EN817-76	Juvenile	5	3	2	Medium
Enbridge	EPZCNW08	EN817-77	Adult, Quagga	26	15	8	Large
Enbridge	EPZCNW08	EN817-77	Adult, Quagga	27	15	12	Large
Enbridge	EPZCNW08	EN817-77	Adult, Quagga	26	13	9	Large
Enbridge	EPZCNW08	EN817-77	Adult, Quagga	25	14	7	Large
Enbridge	EPZCNW08	EN817-77	Adult, Quagga	27	14	10	Large
Enbridge	EPZCNW08	EN817-77	Adult, Quagga	23	12	8	Large
Enbridge	EPZCNW08	EN817-77	Adult, Quagga	22	12	8	Large
Enbridge	EPZCNW08	EN817-77	Juvenile	4	2	1	Small
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	26	14	11	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	26	13	11	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	28	16	11	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	23	13	9	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	26	13	9	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	24	15	13	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	26	15	12	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	31	18	11	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	27	16	10	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	27	15	11	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	30	16	11	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	29	16	12	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	25	14	11	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	27	15	10	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	24	14	13	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	22	13	8	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	25	14	9	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	26	16	8	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	26	15	11	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	14	9	6	Large
Enbridge	EPZCNW03	EN817-78	Adult, Quagga	13	9	5	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	24	14	9	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	21	12	8	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	25	15	8	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	24	13	9	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	22	13	8	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	22	14	9	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	24	14	10	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZBST11	EN817-79	Adult, Quagga	22	13	11	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	23	13	10	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	23	12	8	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	20	12	8	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	25	14	9	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	24	15	11	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	22	13	8	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	24	12	9	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	24	15	10	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	25	14	10	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	24	12	10	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	19	11	7	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	22	12	8	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	22	13	7	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	22	12	8	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	20	12	7	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	17	10	7	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	21	11	8	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	16	9	6	Large
Enbridge	WPZBST11	EN817-79	Adult, Quagga	17	10	6	Large
Enbridge	WPZBST11	EN817-79	Juvenile	5	3	2	Medium
Enbridge	WPZBST11	EN817-79	Juvenile	4	2	1	Small
Enbridge	WPZBST11	EN817-79	Juvenile	4	2	1	Small
Enbridge	WPZBST11	EN817-79	Juvenile	3	2	1	Small
Enbridge	WPZBST11	EN817-79	Juvenile	3	2	1	Small
Enbridge	WPZBST11	EN817-79	Juvenile	3	2	1	Small
Enbridge	WPZBST11	EN817-79	Juvenile	1	1	1	Small
Enbridge	WPZBST11	EN817-79	Juvenile	2	2	1	Small
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	27	17	11	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	27	17	10	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	22	13	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	27	14	8	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	29	16	10	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	24	13	11	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	25	15	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	28	16	11	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	24	13	8	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	20	12	8	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	24	15	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	23	13	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	21	11	7	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	22	12	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	26	14	10	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	26	15	10	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	24	14	10	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	25	12	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	30	18	11	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	24	14	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	23	14	10	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	22	12	8	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	23	12	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	20	11	6	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	26	16	10	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	23	13	8	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	23	14	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	24	13	8	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	17	10	7	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	18	11	8	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	24	15	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	25	13	9	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	19	10	8	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	21	12	7	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	19	11	7	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	18	11	7	Large
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	10	6	4	Medium
Enbridge	WPZBSE10	EN817-80	Adult, Quagga	8	5	3	Medium
Enbridge	WPZBSE10	EN817-80	Juvenile	6	4	2	Medium
Enbridge	WPZBSE10	EN817-80	Juvenile	6	4	2	Medium
Enbridge	WPZBSE10	EN817-80	Juvenile	5	3	1	Medium
Enbridge	WPZBSE10	EN817-80	Juvenile	4	3	2	Small
Enbridge	WPZBSE10	EN817-80	Juvenile	4	3	1	Small
Enbridge	WPZBSE10	EN817-80	Juvenile	4	3	2	Small
Enbridge	WPZBSE10	EN817-80	Juvenile	4	2	1	Small
Enbridge	WPZBSE10	EN817-80	Juvenile	4	2	1	Small
Enbridge	WPZBSE10	EN817-80	Juvenile	3	2	1	Small
Enbridge	WPZBSE10	EN817-80	Juvenile	4	2	1	Small
Enbridge	WPZBSE10	EN817-80	Juvenile	4	2	1	Small
Enbridge	WPZBSE10	EN817-80	Juvenile	3	2	1	Small
Enbridge	WPZBSE10	EN817-80	Juvenile	2	2	1	Small
Enbridge	WPZBSE10	EN817-80	Juvenile	1	1	1	Small
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	25	17	14	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	28	16	11	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	26	14	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	15	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	15	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	25	14	8	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	23	14	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	15	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	25	14	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	25	13	8	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	23	13	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	15	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	20	12	8	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	22	13	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	27	15	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	25	15	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	14	11	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	26	14	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	26	14	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	13	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	22	13	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	17	11	7	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	23	12	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	25	14	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	14	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	25	13	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	23	12	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	26	15	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	22	15	11	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	22	12	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	14	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	21	12	10	Large

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	21	12	8	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	23	15	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	21	13	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	13	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	21	12	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	14	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	23	13	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	22	13	8	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	24	15	10	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	22	13	9	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	21	11	8	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	21	12	8	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	19	11	8	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	12	7	4	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	11	6	4	Large
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	10	6	3	Medium
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	8	4	3	Medium
Enbridge	WPZBSW14	EN817-81	Adult, Quagga	8	4	3	Medium
Enbridge	WPZBSW14	EN817-81	Juvenile	6	3	2	Medium
Enbridge	WPZBSW14	EN817-81	Juvenile	5	3	2	Medium
Enbridge	WPZBSW14	EN817-81	Juvenile	5	3	2	Medium
Enbridge	WPZBSW14	EN817-81	Juvenile	5	3	2	Medium
Enbridge	WPZBSW14	EN817-81	Juvenile	5	3	2	Medium
Enbridge	WPZBSW14	EN817-81	Juvenile	4	2	1	Small
Enbridge	WPZBSW14	EN817-81	Juvenile	4	2	1	Small
Enbridge	WPZBSW14	EN817-81	Juvenile	3	1	1	Small
Enbridge	WPZBSW14	EN817-81	Juvenile	3	1	1	Small
Enbridge	WPZBSW14	EN817-81	Juvenile	4	2	1	Small
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	29	17	12	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	25	16	11	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	27	17	10	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	27	16	11	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	26	15	10	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	25	15	9	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	29	15	10	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	24	15	9	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	24	13	10	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	24	14	8	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	27	16	10	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	24	14	11	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	24	14	11	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	23	16	9	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	23	16	9	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	22	13	9	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	20	12	8	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	23	13	8	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	22	13	8	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	19	12	8	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	17	10	8	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	19	12	8	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	19	11	7	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	18	10	7	Large
Enbridge	WPZBSB01	EN817-82	Adult, Quagga	18	10	7	Large
Enbridge	WPZBSB01	EN817-82	Juvenile	5	3	2	Medium
Enbridge	WPZBSB01	EN817-82	Juvenile	5	3	2	Medium
Enbridge	WPZBSB01	EN817-82	Juvenile	5	3	2	Medium

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZBSB01	EN817-82	Juvenile	3	2	1	Small
Enbridge	WPZBSB01	EN817-82	Juvenile	3	2	1	Small
Enbridge	WPZBSB01	EN817-82	Juvenile	3	2	1	Small
Enbridge	WPZBSB01	EN817-82	Juvenile	2	1	1	Small
Enbridge	WPZBSB01	EN817-82	Juvenile	2	1	1	Small
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	28	17	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	27	16	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	29	17	13	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	26	13	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	25	15	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	27	15	11	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	25	14	11	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	25	15	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	28	16	11	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	26	14	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	24	15	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	21	13	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	23	13	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	23	13	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	27	16	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	25	14	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	25	15	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	25	15	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	23	13	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	27	16	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	21	11	8	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	21	13	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	22	12	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	22	13	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	27	16	11	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	26	15	11	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	27	13	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	28	16	11	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	28	15	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	24	14	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	28	15	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	28	16	11	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	26	16	11	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	26	15	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	26	12	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	25	13	11	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	25	14	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	25	14	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	22	13	10	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	21	11	8	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	22	13	8	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	22	13	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	24	14	8	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	23	13	9	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	16	10	8	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	14	7	5	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	13	7	4	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	13	8	5	Large
Enbridge	WPZBSE08	EN817-83	Adult, Quagga	7	4	2	Medium
Enbridge	WPZBSE08	EN817-83	Juvenile	6	4	2	Medium
Enbridge	WPZBSE08	EN817-83	Juvenile	6	3	2	Medium

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Enbridge	WPZBSE08	EN817-83	Juvenile	6	3	2	Medium
Enbridge	WPZBSE08	EN817-83	Juvenile	5	3	2	Medium
Enbridge	WPZBSE08	EN817-83	Juvenile	4	3	1	Small
Enbridge	WPZBSE08	EN817-83	Juvenile	3	2	1	Small
Enbridge	WPZBSE08	EN817-83	Juvenile	3	2	1	Small
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	18	11	8	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	17	10	8	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	16	9	7	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	17	10	8	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	18	10	7	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	18	10	8	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	13	8	6	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	12	9	5	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	14	9	6	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	11	7	3	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	12	7	4	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	12	7	4	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	11	6	4	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	12	8	4	Large
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	10	6	4	Medium
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	9	6	3	Medium
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	10	6	4	Medium
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	9	5	3	Medium
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	9	6	3	Medium
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	9	5	3	Medium
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	9	5	3	Medium
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	8	5	3	Medium
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	8	4	3	Medium
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	7	4	3	Medium
Enbridge	WPZBSE09	EN817-84	Adult, Quagga	7	4	3	Medium
Enbridge	WPZBSE09	EN817-84	Juvenile	6	4	3	Medium
Enbridge	WPZBSE09	EN817-84	Juvenile	6	3	2	Medium
Enbridge	WPZBSE09	EN817-84	Juvenile	5	2	3	Medium
Enbridge	WPZBSE09	EN817-84	Juvenile	5	3	2	Medium
Enbridge	WPZBSE09	EN817-84	Juvenile	5	3	2	Medium
Enbridge	WPZBSE09	EN817-84	Juvenile	5	3	2	Medium
Enbridge	WPZBSE09	EN817-84	Juvenile	5	3	2	Medium
Enbridge	WPZBSE09	EN817-84	Juvenile	4	3	2	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	4	2	2	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	4	2	2	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	4	2	2	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	3	2	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	3	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	3	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	3	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	3	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	3	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	3	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	2	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	2	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	2	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	2	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	2	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	2	1	1	Small
Enbridge	WPZBSE09	EN817-84	Juvenile	1	1	1	Small

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Project Name	Site Name	GEI Log #	Identification Zebra, Adult, Quagga Adult, Juveniles, Fragment	Length (mm)	Width (mm) Widest part of shell	Width of base (mm)	Size Class (Quagga Only) >10 mm Large, 5-10 mm Medium, <5 mm Small
Enbridge	WPZBSE09	EN817-84	Juvenile	1	1	1	Small

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2017 Biota Investigation Duplicate Sample ID

Sample ID	GEI Log #	Microbial Sample ID	Date sampled	Pipeline	Study Zone	Pipe End	Site ID	Location Description	Latitude	Longitude
EPZDT02	EN817-21	-	20-Aug-17	East	D	-	E-S5	Biota site	[redacted]	
EPZDT02	EN817-41	-	26-Aug-17	East	D	-	E-S4	Biota site		
EPZASW02	-	066OH-2	15-Aug-17	East	A	SOUTH	E-AS1	Additional Site		
EPZASW02	EN817-37	-	24-Aug-17	East	A	SOUTH	E-AS2	Additional Site		
EPZASW02	EN817-62	-	5-Sep-17	East	A	SOUTH	E-AOI7	Area of Interest		
EPZDW10	-	066OH-23	20-Aug-17	East	D	-	E-S5	Biota site		
EPZDW10	EN817-42	-	26-Aug-17	East	D	-	E-S4	Biota site		
EPZDE09	-	066OH-22	20-Aug-17	East	D	-	E-S5	Biota site		
EPZDE09	EN817-40	-	26-Aug-17	East	D	-	E-S4	Biota site		
EPZASW04	-	066OH-35	24-Aug-17	East	A	SOUTH	E-AS2	Additional Site		
EPZASW04	EN817-60	-	5-Sep-17	East	A	SOUTH	E-S8	Biota site		
WPZDW09	-	066OH-26	20-Aug-17	West	D	-	W-S5	Biota site		
WPZDW09	EN817-68	-	7-Sep-17	West	D	-	W-S4	Biota site		
WPZDE06	-	066OH-25	20-Aug-17	West	D	-	W-S5	Biota site		
WPZDE06	-	066OH-63	7-Sep-17	West	D	-	W-AOI1	Area of Interest		
EPZASW11	-	066OH-1	15-Aug-17	East	A	SOUTH	E-AS1	Additional Site		
EPZASW11	-	066OH-34	24-Aug-17	East	A	SOUTH	E-AS2	Additional Site		
EPZASW11	-	066OH-57	5-Sep-17	East	A	SOUTH	E-AOI7	Area of Interest		
WPZDT04	-	066OH-37	25-Aug-17	West	D	-	W-AS1	Additional Site		
WPZDT04	-	066OH-58	7-Sep-17	West	D	-	W-S4	Biota site		

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2017 East and West Pipeline Opportunistic Samples

Pipeline	Site ID	Sample ID	Depth Zone	Sample depth (ft)	Material Collected
East	E-AOI6	170905-EAOI6DC	A	82	Presumed detached coating
	E-AOI9	170906-EAOI9MOI	A	82	Material of interest
	E-AOI10	170906-EAOI10MOI	A	77	Material of interest
	E-AOI11	170824-EAOI11DC	A	72	Presumed detached coating
	E-AS2	EPZASW07CD	A	75	see ATS 2018
West	W-AOI1	170907-WAOI1MOI	D	234	Material of interest
	W-AOI2	170907-WAOI2CD	D	201	see ATS 2018
	W-AOI5	170821-WAOI5DC	A	100	Presumed detached coating

Table contents are represented in a north to south manner from top to bottom

"Study Zone" depth ranges (ft): A = 50 - 100; B = 100 - 150; C = 150 - 200; D = >200

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Appendix G

2017 Microbial Insights Standard Operating Procedures for DNA Extraction and qPCR: Evaluation of Line 5 Samples

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microbialinsights
10515 Research Drive
Knoxville, TN 37932

STANDARD OPERATING PROCEDURE

Extraction of DNA from Environmental samples (Matrix—Soil, Water, BioFlo, Beads)

SOP Number:	MI SOP-DNAEXT
Revision Number:	1.2
Effective Date:	07/06/2010
Revision Date:	04/12/2016

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1.0 Purpose

The purpose of this standard operating procedure (SOP) is to describe the activities involved in the preparation, handling, documentation, and extraction of nucleic acids of samples collected from soil, water or BioFlo filters.

2.0 Scope and Application

The extraction process involves both chemical and mechanical lysis of cells to release chromosomal and plasmid nucleic acids. After the extraction, Microbial Insights, Inc. (MI) uses these products in a variety of analyses.

3.0 Sample Collection, Preservation, and Holding Times

Samples should be collected in field following Microbial Insights, Inc. (MI) standard operating procedure for sample collection. All groundwaters will be filtered the day they arrive and extracted the same day of receipt. If waters come in late a corrective action form will be filled out and the filters will be frozen at -20C until the remaining extraction process can be completed the following day. All soils, solids and Bio-Flo filters will preferably be extracted the day samples arrive. If this is not possible, samples will be held at -20C until extractions can be completed. DNA extracts will then be held at -20ºC for at least 1 year in case there is a need for additional analysis.

4.0 Equipmet and Supplies

- [redacted] DNA extraction kit [redacted]
- Micropipetters (Gilson P-10, P-100, P-1000) and appropriate sterile tips (ART). [See pipet calibration and maintenance in calibration log.]
- Sartorius AG Analytical scale, Model BP310. (Sartorius) [See scale calibration and maintenance in calibration log]
- Sterile spatulas and transfer paper.
- Microcentrifuge Eppendorf model #5415D.

[redacted]

5.0 Reagents

[redacted]

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[redacted]

6.0 Testing Procedure

6.1 Sample Preparation:

6.1.1 Soil samples
Use a flame sterilized spatula to place 0.25 to 0.50g soil into the labeled [redacted] Tube.

6.1.2 Water/filter samples
Use flame sterilized tweezers to place the cut filter into the labeled [redacted] Tube.

6.1.3 Bead Samples
Use flame sterilized tweezers to pick out 20 beads into the labeled [redacted] Tube.

6.2 Extraction process

6.2.1. Prior to adding samples label 2ml bead tubes with sample name and number. For every extraction set a blank tube must be labeled with the date and "x" to indicate this tube as the extraction blank for that set. For every full rack of extractions (15 samples) an extraction blank is performed. Add samples as described in sample preparation section. Next add [redacted] Tube.

6.2.2 Check [redacted]. If [redacted] is precipitated, heat solution to 60°C until dissolved before use. Add [redacted] Tube. Place [redacted] Tubes onto the [redacted] Vortex Adapter at maximum speed for 10 minutes.

6.2.3 While tubes are vortexing, label 1 [redacted] tube for each sample as well as the blank and 4- 2ml tubes for each sample and blank with sample name and number. Be sure that the final tube is labeled legibly with the entire sample name as this is the final tube in the process and will be used for long term storage. To the first tube, add [redacted]. To the second, add [redacted]. Shake [redacted] and add [redacted] to the third tube.

[redacted] After removing Bead Tubes from Vortex, place them in the centrifuge at 10,000 x g for 1 minute. Note: Do not exceed 10,000 x g or tubes may break. For clay soils, you may need

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to centrifuge the tubes longer to pellet all the debris and obtain maximal supernatant. Centrifuge for [redacted] for clay soils or if your soil is not completely pelleted after [redacted]

6.2.5 Transfer the supernatant to the 2ml tube containing [redacted]. Vortex the tube [redacted] for 5 minutes.

6.2.6 Place tubes in the centrifuge at 10,000 x g at room temperature for 1 minute.

6.2.7 Transfer all of the supernatant to the tube containing [redacted], being careful not to disturb the pellet. Vortex for 5 seconds and incubate at 4°C for 5 minutes.

6.2.8 Centrifuge at room temperature for 1 minute at 10,000 x g.

6.2.9 Being careful not to disturb the pellet, transfer up to, but not more than, [redacted] supernatant to a clean [redacted]. Mix well.

6.2.10 Load approximately [redacted] onto a [redacted] and centrifuge at 10,000 x g for 1 minute. Discard the flow through and add an additional [redacted] of supernatant to the [redacted] and centrifuge at 10,000 x g for 1 minute. Repeat with the remaining supernatant. (A total of three loads for each sample processed are required.)

6.2.11 Add [redacted] and centrifuge at room temperature for 1 minute at 10,000 x g.

6.2.12 Discard flow through and centrifuge again at room temperature for 1 minute at 10,000 x g.

6.2.13 Transfer the filter a clean, labeled [redacted]. Add 100µls of [redacted] directly to the center of the filter. Spin at 10,000 x g for 1 minute. For soil samples, spin at 10,000 x g for 3 minutes. Check tube to be sure that there are 100µls of eluted DNA then discard the filter. Store the extracted DNA at 4ºC for up to 6 months. Transfer to -20ºC for long term storage.

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7.0 Quality Control

7.0 An extraction blank is processed with each extraction set to ensure no cross contamination of samples or solutions.

7.1 Ongoing calibration checks and maintenance of the instruments must be documented in the appropriate logbook.

7.2 The Laboratory Director has the responsibility to ensure that this procedure is performed by an employee who has been properly trained in accordance to MI SOP Train and has the required experience to process the samples.

7.3 All deviations from this SOP must be documented in a Nonconformance Report (NCR) or an equivalent system (i.e., database).

7.4 A tiered system of verification, consisting of two levels with successive checks performed by different people. This approach should include (at a minimum) 100% review by the analyst and a 100% verification review by a technically qualified supervisor. The final review will verify that the data package is complete.

8.0 Laboratory Sample Folders

Extraction date, extraction volume, technician initials, and DNA kit information for each sample will be logged in at the time of extraction in the worksheet attached in each sample folder.

9.0 Document Corrections

Changes or corrections on any laboratory documentation will be made by crossing out the erroneous item with a single line and writing the new information above the crossed-out item. The person correcting the information should initial and date the correction. The original entry, although erroneous, must remain legible beneath the cross-out line. All information will be recorded using black or blue indelible ink.

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microbialinsights
10515 Research Drive
Knoxville, TN 37932

STANDARD OPERATING PROCEDURE

Quantitative Polymerase Chain Reaction (qPCR)

SOP Number:	DNA-qPCR
Revision Number:	1.3
Effective Date:	01/10/2006
Revision Date:	03/08/2017

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10.0 Tables, Diagrams, and Flowcharts ..... N/A

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1.0 Purpose

The purpose of this standard operating procedure (SOP) is to describe the activities involved in the preparation, handling, documentation, and analysis of samples collected from a variety of matrices (water, soil, bio-traps, etc) to enumerate target populations using quantitative Real-Time polymerase chain reaction or qPCR.

2.0 Scope and Application

Quantitative Real-Time polymerase chain reaction (qPCR) is used to enumerate target populations of microorganisms. Microbial Insights, Inc. (MI) uses qPCR to target organisms associated with the remediation of a multitude of priority pollutants as well as organisms important for microbial source tracking, and microbial induced corrosion.

3.0 Sample Collection, Preservation, and Holding Times

Samples are collected following the standard operating procedure developed by Microbial Insights, Inc (MI). DNA extraction and RNA extraction are performed following the extraction standard operating procedure developed by Microbial Insights, Inc. DNA is stored in 1/10 Tris-EDTA(TE) at 4ºC while RNA is stored in reagent specific to RNA extraction protocol at -80ºC after cDNA is prepared. RNA samples are converted to cDNA following (SOP-RNA ext) prior to the quantitative PCR analysis.

4.0 Equipment and Supplies

- 96-well plate, 384 well plate (Life Technologies).
- Micropipettes (Gilson P-10, P-100, P-1000) and Eppendorf, and appropriate sterile tips (ART). [see calibration listed in calibration log]
- Applied Biosystems SDS 7000 or 7300 instrument, Life Technologies QuantStudio instrument. [see calibration listed in calibration log]
- Sterile 0.5ml thin wall strip tubes and optical clear caps (Life Technologies)

5.0 Reagents and Positive Controls

5.1 [redacted] DNA polymerase and master mix for Taqman assays ([redacted])

5.2 [redacted] for SYBR Green assays

5.3 Sterile filtered (0.2mM) nanopure, organic-free, deionized water.

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5.4 Forward and Reverse primers/Probe: these are gene/assay specific [redacted]. See notes section for primer handling. Final concentration of probe and primers: [redacted] or adjusted as needed for each primer set. Probes are only used in Taqman assays.

5.5 Positive and Negative Control DNA: Positive DNA is either purchased from ATCC, synthesized from [redacted], or extracted and purified in-house from pure isolates. The amount of DNA used in all assays is [redacted] For negative controls, water is added in place of template DNA.

5.6 [redacted] Reaction Buffer for SYBR green assays ([redacted]

5.7 $MgCl_2$ Stock Solution [redacted] for SYBR green assay

5.8 DNTP's [redacted]

5.9 [redacted] DNA Polymerase [redacted]

5.10 SYBR green [redacted] Probes [redacted]

6.0 Procedure

6.1 Preparation of Stock Primer

6.1.1 It is necessary to re-suspend and dilute the primers [redacted] before use in the PCR reaction. This procedure is done when new primers are received and both working stocks and solution stocks should be prepared at this time. The label on the tube will provide the concentration.

6.1.2 To the stock tube, aseptically add [redacted] and vortex the tube for 1 minute to re-suspend the primer. Centrifuge for 1 minute at 14,000 rpm to remove any solution from the lid then allow the tube to sit at room temperature for 5 minutes to ensure complete dissolution. This provides the solution stock.

6.1.3 To make the working stock to be used in each reaction, add the amount of nanomoles of the stock solution (listed on the stock tube) to a clean 1.5ml tube and bring this volume up to 1ml with sterile 1X TE buffer.

6.2 Mixing Reagents-Taqman Assays

6.2.1 Prepare a master mix including the appropriate amounts of each of the following: PCR water, [redacted] PCR mix, Primers (forward and reverse) and Probe. The appropriate amounts are listed in the MI master mix sheets prepared for each primer/probe combination.

6.2.2 Add [redacted] of master mix to each well of the 96 well plate, 384 well plate, or strip tube. Add [redacted] of template DNA/cDNA to the appropriate wells. Add [redacted] of positive control DNA to the

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appropriate wells. Add [redacted] of PCR water to the negative control wells. Follow MI SOP Robot for set up of reaction plates.

6.2.1 Spin the plate in the centrifuge at 3000 rpm for 3 minutes to be sure all mix is in the bottom of the tube and that no bubbles are present.

6.2.2 The plate of samples is then placed in either the ABI QuantStudio (384-well or 96-well) or 7300. The conditions of each assay will vary depending upon the primer/probe combination.

6.2.3 Upon completion of the run, export the data to an Excel worksheet and upload to LIMS which will determine the number of target molecules, using an equation derived from standard curves of known numbers of target molecules.

6.2.4 Standard curves are developed from a serial dilution of a known concentration of the positive control organism. At least 4 dilutions will be used for each curve and the R^2 of each equation must be at least 0.95.

6.3 Mixing Reagents-SYBR green Assays

6.3.1 Prepare a master mix including the appropriate amounts of each of the following ingredients: PCR water, [redacted]. Mix the appropriate amounts are listed in the excel sheets prepared for each primer combination.

6.3.2 Add [redacted] of master mix to each well of the 96 well plate, 384 well plate, or strip tube. Add [redacted] of template DNA/cDNA to the appropriate wells. Add [redacted] of positive control DNA to the appropriate wells. Add [redacted] of PCR water to the negative control wells. Follow MI SOP Robot for set up of the reaction plate.

6.3.3 Spin the plate in the centrifuge at 3000 rpm for 3 minutes to be sure all mix is in the bottom of the tube and that no bubbles are present.

6.3.4 The plate of samples is then placed in either the ABI Quant Studio or 7300 following the conditions specific for the assay of interest.

6.3.5 Upon completion of the run, export the data to an Excel worksheet, then determine the number of target molecules, using an equation derived from standard curves of known numbers of target molecules. The standard curves are developed from a serial dilution of a known concentration of the positive control organism. At least 4 dilutions will be used for each curve and the R^2 of each equation must be at least 0.95.

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7.0 Quality Control

7.1 For quality control of the amplification process, positive and negative controls are always performed. The positive control must have a CT value +/- 20% of the known CT in order to meet the acceptance criteria. Corrective action rerun assay and check reagents. The extraction blank from each set is also amplified to ensure no cross contamination of samples or solutions during the extraction process.

7.2 Ongoing calibration checks and maintenance of the instruments must be documented in the appropriate logbook.

7.3 The Laboratory Director has the responsibility to ensure that this procedure is performed by an employee who has been properly trained in its use and has the required experience to process the samples.

7.4 All deviations from this SOP must be documented in a Nonconformance Report (NCR) or using an equivalent system (i.e., database).

8.0 Analytical Report

8.1 All data regarding quantities are entered into a data report using the laboratory information management systems (LIMS).

8.2 All documentation pertinent to a project will be placed in the "project folder" identified with the unique LIMS Project number. Hardcopy records, data sheets, and soft copy reports will be stored for a period of three years.

9.0 Document Corrections

Changes or corrections on any laboratory documentation will be made by crossing out the erroneous item with a single line and initialing (by the person performing the correction) and dating the correction.
The original item, although erroneous, must remain legible beneath the cross-out line. The new information should be written clearly above the crossed-out erroneous item. All information will be recorded using black or blue indelible ink.

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Appendix H

2017 GEI Field Data Sheets

Test Dive – 8/14/17 34' south of anchor @ E-71

Line 5 field data sheet

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Date: 8 / 14 /2017 **Time:** 1400 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** _____ **Long W:** _____ – Need to get N, GPS on ROV

Pipeline zone and water depth range:

- ☐ A-North, "**AN**" (50-100') ☐ B-North, "**BN**" (100-150') ☐ C-North, "**CN**" (150-200') ☐ "D" (> 200')
- ☒ A-South, "**AS**" (50-100') ☐ B-South, "**BS**" (50-100') ☐ C-South, "**CS**" (150-200') ☐ Other:

Sample ID Key

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **B** (bottom) **E** (east) **W** (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

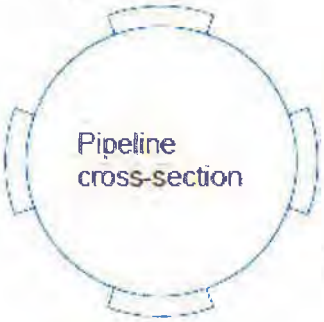
Sample IDs (list below)

EPZASE03
EPZASE07
EPZASE09
EPZASE12

Sample 1 = 03 (container w/ #3 on outside)
2 = 07
3 = 09
4 = 12

Container #'s: _____ & _____

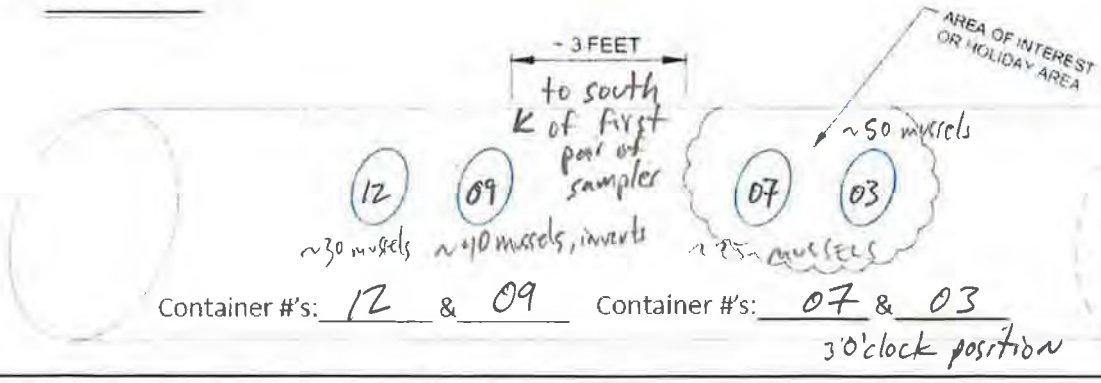
Container #'s: _____ & _____



Container #'s: ~~03~~ & ~~07~~ ~3 o'clock position ~~4"-6" south of 1st sample~~ (see below)

RH 8/14/17

Container #'s: _____ & _____



72' depth

Container #'s: 12 & 09 Container #'s: 07 & 03
3 o'clock position

Notes (also indicate if additional notes are on reverse side of form):

- Heavy mussel colonization, multiple layers of biota
- AOI sample pairs @ east side, ~3 o'clock position
- Qualitative observations of mussel density, biota layers, etc. made during ROV inspection and during dive
- Appeared to be 95+% quaggas, if not more. Didn't look @ every mussel but brief inspection found only shells of zebra mussels but none live.

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Test Run 8/14/ [illegible]

- heavy mussel colonization, numerous gobies
- 6 o'clock buried so wouldn't sample on bottom
- Will end up being a 10 sample test run
  - 4 simulated AOI
  - 6 " biota

Test Dive objectives - discussed pre-dive

- Paired samples @ hypothetical AOI
- " " upcurrent from hypothetical AOI
- CP + coating readings per Trish

Things to watch out for / discuss

- umbilical rubbing sampling area
- slow/static view of sampling rite after collection
- Static view of Container ID

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Line 5 field data sheet

Date: 8 / 14 /2017 **Time:** 1655 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** _____ **Long W:** _____

Pipeline zone and water depth range:

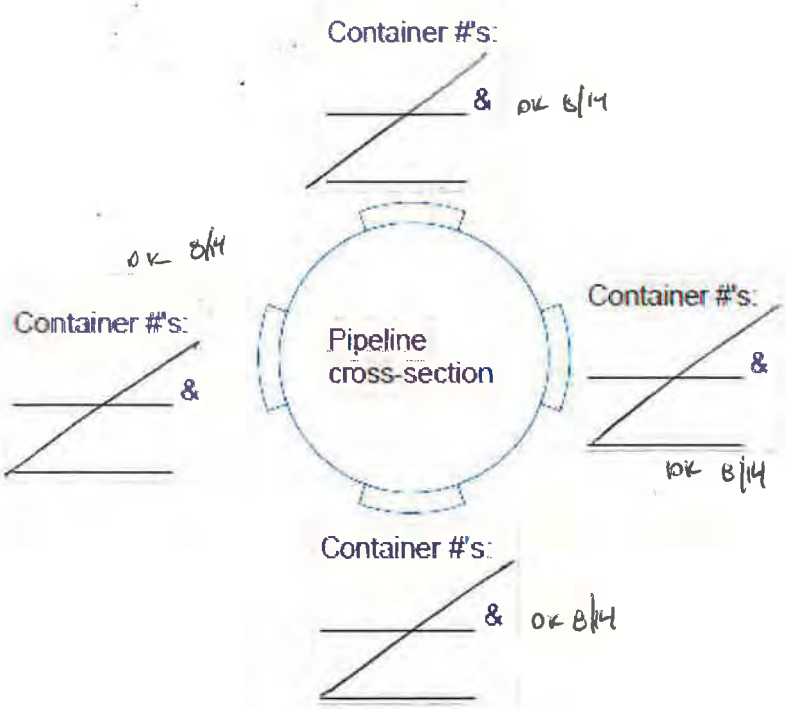
☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☒ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** (50-100') ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

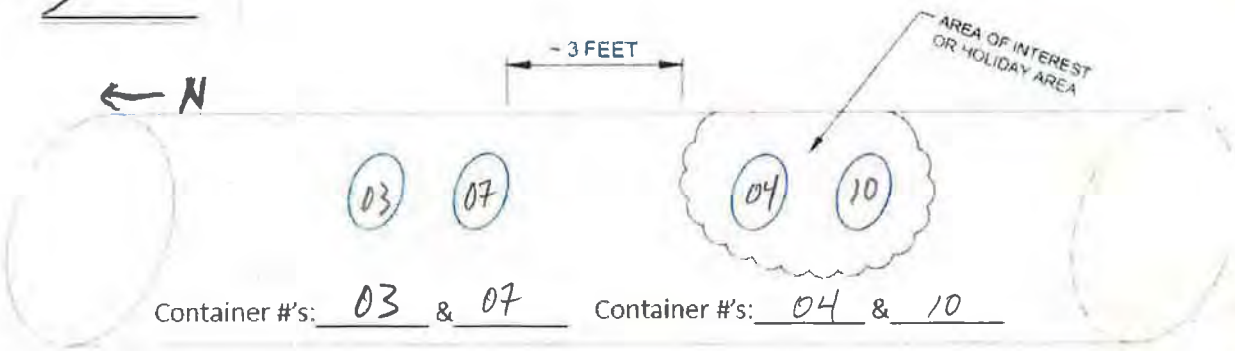
Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09



Container #04 - 2 o'clock, AOI
" #10 - " " (to South)

Container #07 - same position but in undisturbed area ~3' North

Container #03 - To north 6" of 07



Container #'s: 03 & 07 Container #'s: 04 & 10

Notes (also indicate if additional notes are on reverse side of form):

1825 - BALLARD MARINE LEAD INFORMED DIVE/BIOTA TEAM ENGINE ISSUES WERE HAULING OPERATIONS - DIVER PULLED AND SAMPLES LEFT IN PLACE IN RETRIEVAL CRATE - SAMPLES TO BE RETAKEN UPON RETURN TO LOCATION

1st "official" (non-test) dive/sampling

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11 Areas of Interest, 3 "Additional Sites" (non-Biota Sites) Checklist

Date: 8/14/17 Time: 1715 Location ID: EP, Zone A, between E-77 + E-72 Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☒	
	Focus on Area of Interest	☒	
	Evaluate for other **Area(s)** of **Interest, holidays,** maintenance **signs**	☒	Known maintenance area
	If Holiday is identified, incorporate Holiday Biota sampling protocol and **checklist.** Biota **sampling only** if Holiday found.	☐	Could not confirm - had to pull diver due to engine power loss on tug
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple layers present north of AOI, but not w/in AOI
Identify relative level of mussel colonization			
	Use chart to **identify** mussel **density** at Area of Interest	☒	Sparse w/in AOI,
	Video/snapshot of comparison to mussel **density** reference card	☐	Video taken during ~~dive~~ pre-dive ROV ops
	Use chart to **identify** mussel **density** 3 feet **upcurrent** of Area of Interest	☒	
	Video/snapshot of **comparison** to mussel **density** reference card	☐	see above

- Between E-77 and E-72
- Very long AOI due to previous cleaning/maintenance activities. Top of pipeline
- CP, coating measures not taken due to power loss on tug engine.
- Also see notes on Holiday Area Checklist

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Holiday Area Biota Sampling Checklist - only fill out if Holiday Area is found

Date: 8/14/17 Time: 1715 Location ID: EP, Zone A, between E-77 + E-72 Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at potential Holiday Area		☒	
Slow pan of pipeline		☒	
	Focus on Holiday Area	☐	Unable to verify/find holiday
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☒	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Apparent ~~single~~ multiple layer w/in AOI, multiple north of AOI
Identify relative level of mussel colonization		☒	
	Use chart to identify mussel density at Holiday Area	☒	
	Video/snapshot of comparison to mussel density reference card	☐	
	Use chart to identify mussel density 3 feet upcurrent of Holiday Area	☒	
	Video/snapshot of comparison to mussel density reference card	☐	
Biota sampling @ Holiday Area		☐	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☐	N/A - Did not confirm Holiday Area but paired sampling in AOI and undisturbed area north of AOI prior to pulling diver due to tug engine issues.
	Collect one sample from Holiday Area	☐	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if Holiday Area is small, receive confirmation from topside	☐	
	Repeat paired sampling 3 feet upcurrent of Holiday Area, verify collection of 4 total samples	☐	
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	- SAMPLES LEFT IN PLACE (AT DEPTH) IN RETRIEVAL CRATE - TO BE RE-SAMPLED UPON RETURN
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

East leg ~~AOI #10~~ - between E77 + E72 RH 8/25/17 correction. Site sampled [illegible] (Additional Site #1) Symbols juxtaposed on Figure in WP

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Line 5 field data sheet

Date: 08 / 15 /2017 **Time:** ~~0900~~ 1000 hrs RH 8/15/17 **Crew initials:** RH/DK

Pipeline: East or West (circle) **Lat N:** _____ **Long W:** _____ (see notes below)

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☒ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** ~~(50-100')~~ 100-150' DK 8/15 ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key ITP Site ID: ~~E-AOI10~~

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Sample IDs (list below)

EPZASW02
05
11
12

- COLLECTION DEPTH: 74 ft
- BIOTA COLONIZATION LEVEL: Sparse on top of pipeline, dense on bottom (heavy) (0627 video time)
- ROV VIDEO FEED BIOTA: 0627, 0628 "SNAPSHOT" TIME
- COLONIZATION LAYERS: DK 8/15 ~~single~~ on top of pipe, w/in AOI, multiple multiple outside AOI + on sides beneath AOI

Container #'s: ___ & ___

Not a biota sampling site so these don't apply

Pipeline cross-section

Container #'s: ___ & ___

Container #'s: ___ & ___

Sample 1 – Container 02 - APB/SRB
2 – 05 - GEI lab
3 – 11 - APB/SRB
4 – 12 - GEI lab

Container #'s: ___ & ___

N. end AOI 10 East S. end
N [redacted]
W

Mid-point of ~~AOI~~
N. [redacted]
W.

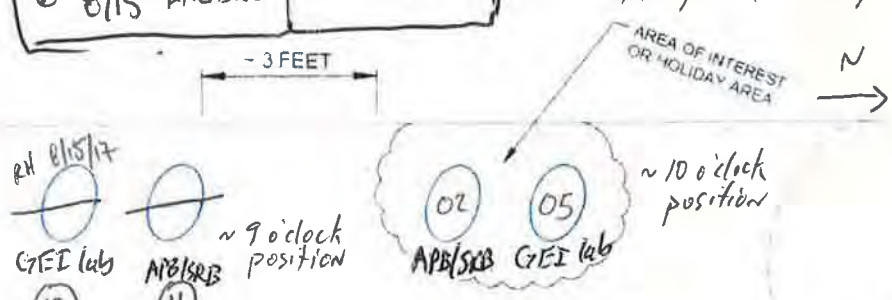
Samples taken here

(46' from N. end)
S. end ~~AOI~~ 10 East, S. end
N [redacted]
W

~~EPA~~ RH 8/15/17

APB/SRB incubator start 1420 hrs @ 8/15 EPZASW02	EPZASW11 APB/SRB start time @ 1436

0642 hrs video feed, some mussels still remained on pipe in sampling areas - can't avoid this, they break during sampling



Container #'s: 12 & 11 Container #'s: _____ & _____

Notes (also indicate if additional notes are on reverse side of form): RH 8/15/17

- Goal to collect samples from ~~opposite side that abandoned samples from yesterday collected~~ see bullet below. 40 ft pipeline sections
- Goby footage predating mussels time stamp approx 0509 hrs.
- Samples to be collected @ mid-point of AOI to be more representative - discussed + concurred w/ Gary, Jim S., etc.
  - ↳ Undisturbed samples collected 3 ft. to side, within footprint of AOI but beneath AOI in undisturbed area. This was discussed w/ Gary + Enbridge.
  - ↳ wanted samples from mid-point of AOI vs. end to be more representative of overall AOI

8/15/17

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-also use for 11 Non-biota AOIs + Additional sites

Holiday Area Biota Sampling Checklist ~~-only fill out if Holiday Area is found-~~ RH 8/15/17

Date: 8/15/17 Time: 1000 Location ID: AS-1 Depth (ft) @ pipeli[redacted]

Crew initials: RH DK East leg, ~~AOI #10~~, between E77 + E72

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☑	
ROV arrival at potential Holiday Area	AOI / ADDITIONAL SITE	☑	
Slow pan of pipeline	OK 8/15	☐	
	Focus on ~~Holiday Area~~ AOI	☑	
	Evaluate for **Area(s)** of **interest, holidays,** maintenance **signs**	☑	
	Confirm, and identify if possible, if multiple **layers** of biota are present	☑	~ 3-9 O'CLOCK TOP of PIPE - SINGLE ~ 3-9 O'CLOCK BOTTOM of PIPE - MULTIPLE
Identify relative level of mussel colonization		☑	
	Use chart to **identify** mussel **density** ~~at Holiday Area~~ OK 8/15	☑	- 3-9 O'CLOCK TOP - SPARSE - 3-9 O'CLOCK BOTTOM - DENSE
	Video/snapshot of **comparison** to mussel **density** reference card	☑	VIDEO FEED TIME 0627 + 0628
	Use chart to identify mussel density 3 feet upcurrent ~~of Holiday Area~~ OK 8/16	☑	DENSE MUSSEL COLONIZATION OUTSIDE AOI
	Video/snapshot of comparison to mussel **density** reference card	☑	ROV FOOTAGE
Biota sampling ~~@ Holiday Area~~ OK 8/15		☐	
	Hold first sample **container** in front of camera to distinguish sample ID, receive confirmation from topside	☑	AOI: #2 + #5 UNDISTURBED: #11 - #12
	Collect one sample from ~~Holiday Area~~ AOI OK 8/15	☑	CONTAINER #2
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if ~~Holiday Area~~ AOI is small, receive confirmation from topside OK 8/15	☑	CONTAINER #5
	Repeat paired sampling 3 feet upcurrent of ~~Holiday Area~~ AOI, verify collection of 4 total samples OK 8/15	☑	CONTAINERS #11 + #12
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take **representative photos (time-stamped)** of sample handling	☐	
	Transport samples to secure, limited access facility for processing and **sample shipment**	☐	

- Holiday observed w/in 3' of ~~AOI~~ samples collected at this location. Holiday on top of pipeline, running perpendicular to pipe. AOI samples were taken at approx. 10 o'clock position.
- Pre-dive ROV flyover did not indicate any apparent holiday(s). Holiday was discovered through cleaning of pipe during inspection.
- Cleaning of pipe during inspection precluded any potential further sample collection @ that location.

RH 8/25/17 - Correction: Site sampled was Additional Site #1.

Biota site - East leg, zone B south

Line 5 field data sheet

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Date: 8 / 15 /2017 **Time:** 1600 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☐ A-South, **"AS"** (50-100') ☒ B-South, **"BS"** ~~(50-100')~~ 100-150' DK 8/15 ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key ITP Site ID: E-57

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Sample IDs (list below)

EPZBSW T 11 RH 8/15/17
E 07
B 06
W 12
APB/SRB

EPZBST 05
E 08
B 04
W 02
GEI lab

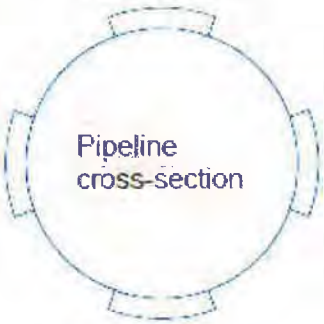
- Sampling video feed starting ~ 1200 hrs (time incorrect on) monitor
- Samples taken @ 1620 hrs (approx)

- No holiday found at sampling sites
- Biota thickness + clean pipe measures taken

Container #'s: 05 & 11 ✓

West

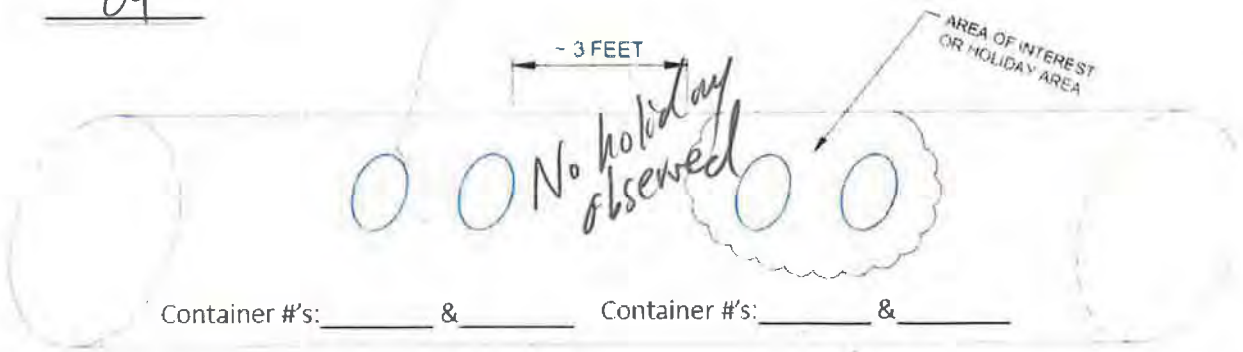
Container #'s: 02 & 12 ✓



East

Container #'s: 08 & 07 ✓

Container #'s: 06 & 04 ✓



Container #'s:_____ &_____ Container #'s:_____ &_____

Notes (also indicate if additional notes are on reverse side of form):

- Random designation of samples w/ Gary. Set 1 (06, 07, 11, 12) for APB/SRB, Set 2 to GEI.

Biota site - east leg, Zone B south *East C-7"

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16 Biota Sites Sampling Checklist

Date: 8/15/17 Time: 1600 Location ID: East leg, Zone B south Depth (ft) @ pipeli [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
Random-select number (1-100), ROV navigates that distance in feet along pipeline		☒	Random # 93'
Slow pan of pipeline by ROV			
	Evaluate for Area(s) of Interest, **holidays**, maintenance **signs**	☒	See video starting @ 1111
	If **Holiday** is identified, **incorporate Holiday** Biota sampling protocol	☒	None observed
	Confirm, and identify if possible, if multiple layers of biota are present	☒	multiple present, biofilm, mussels
Identify relative level of mussel colonization via footage from ROV		☒	
	Use chart to confirm mussel density	☒	Heavy - 1111 video time, Some areas 11-12 o'clock
	Video/snapshot of comparison to mussel density reference card	☒	" " " " are patchy.
Diver descends to ROV position on pipeline		☒	
Biota thickness measures via flexible tape		☐	
	Measure 1 at site where pipeline was first touched by diver	☒	12" N of sample site - 5' 11.5" - (71.5")
	Measure 2 approx. ~~3'~~ north or south from measure 1	☒	RH 8/15/17 ~~5' 10.75"~~ 5' 10" (70")
	Measure 3 approx. ~~3'~~ north or south from measure 2	☒	5' 9.5" (69.5")
Clean pipe measures			(66.5") (65") (66")
	Remove all attached material then measure circumference at the 3 biota thickness measure sites	☒	1: 5' 6.5" 2: 5' 5" 3: 5' 6"
Biota sampling		☒	
	Diver walk upcurrent slighlty from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	Video ~ 1200 hrs on monitor
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from **topside**	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Verify collection of 8 samples (or 6 if pipeline is buried)	☒	
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of **pipeline they** were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, **assign** before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and **sample shipment**	☐	

RH 8/15/17 - 3' N was correct ~~1'N~~ " " " " ~~1'N~~

12, W, bottom, E

measures to north of biota samples

coords @ biota site:

N [redacted]

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Line 5 field data sheet ~~Biota~~ Biota ↓ by ETH Bft (top/bottom, under pipeline)

Date: 08 / 16 /2017 **Time:** 1015 hrs **Crew initials:** RH DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, "**AN**" (50-100') ☐ B-North, "**BN**" (100-150') ☐ C-North, "**CN**" (150-200') ☐ "D" (> 200')

☐ A-South, "**AS**" (50-100') ☐ B-South, "**BS**" ~~(50-100')~~ 100-150' OK 8/15 ☐ C-South, "**CS**" (150-200') ☐ Other:

Sample ID Key ITP site ID: E-56

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Sample IDs (list below)

EPZCST 08, EPZCSE 03, EPZCSB 10, EPZCSW 05 } GEI lab

EPZCST 07, EPZCSE 01, EPZCSB 02, EPZCSW 04 } APB/SRB

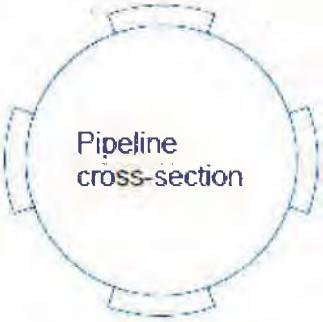
RH 8/16/17 ~~N~~ (Top)

Container #'s: 07 ✓ & 08 ✓ GEI

mussels: Heavy
Biota layers: multiple
Diver on bottom @ 1015, sample collection starting ~ 1018

W

Container #'s: 04 ✓ & 05 ✓ GEI

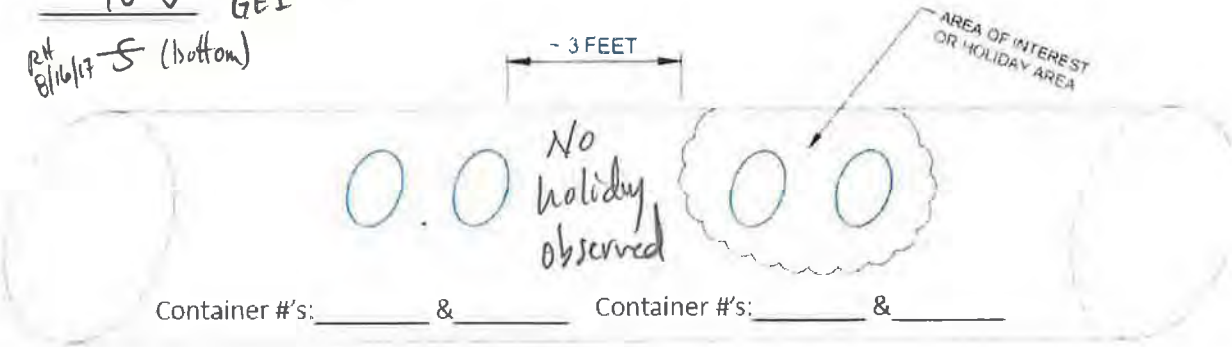


E

Container #'s: 01 ✓ & 03 ✓ GEI

Container #'s: 02 ✓ & 10 ✓ GEI

RH 8/16/17 ~~S~~ (bottom)



Notes (also indicate if additional notes are on reverse side of form):

- Heavy mussel colonization but some patchy areas w/ little/no mussels but overall heavy mussels.
- Sample container 10 (bottom) – Material of interest (non-biota) was found in sample. GEI eco lab to hold material of interest following biota evaluation. Discussed w/ Dave + Gary.
- Sample workup after

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RH 8/16/17

16 Biota Sites Sampling Checklist

Date: 08-16-17 Time: 1015 Location ID: Eastleg, zone C south, biota site by E16 Depth (ft) @ pipeline: [redacted]

Crew initials: RH/DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	44°F water temp @ bottom
Random-select number (1-100), ROV navigates that distance in feet along pipeline		☒	Random # = 23 per App, 23' south of initial footage starting 0452
Slow pan of pipeline by ROV			
Confirmation done by diver after ROV inspection	Evaluate for **Area(s)** of Interest, holidays, maintenance signs	☒	
	If Holiday is **identified, incorporate** Holiday Biota **sampling protocol**	☒	No holiday observed
	Confirm, and identify if possible, if **multiple layers** of biota are **present**	☒	Multiple
Identify relative level of mussel colonization via footage from ROV		☒	Video Feed time 0452 (start) - TV monitor time
	Use chart to confirm mussel **density**	☒	Heavy
	Video/snapshot of comparison to mussel density reference card	☒	Pic of ROV feed on TV, plus video footage 0452
Diver descends to ROV position on pipeline		☒	
Biota thickness measures via flexible tape		☒	See measurement area @ TV monitor time 0630
	Measure 1 at site where **pipeline** was first touched **by** diver	☒	1' from sample area, 5' 8" (68")
	Measure 2 **approx.** 3' north or south from measure 1	☒	5'9" (69")
	Measure 3 approx. 3' north or south from measure 2	☒	5'9" (69")
Clean pipe measures			
	Remove all attached material then measure circumference at the 3 biota thickness measure sites	☒	Measures: 1) 5'5" (65") 2) 5'4.5" (64.5") 3) 5'6" (66")
Biota sampling		☒	Collection starting ~1018, video monitor time 0610
	Diver walk **upcurrent slighlty** from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first **sample,** receive confirmation from **topside**	☒	
	Repeat paired sampling on the other areas of **pipeline**	☒	
	Verify collection of 8 samples (or 6 if pipeline is buried)	☒	
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of **pipeline they** were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for **SRB/APB, assign** before transfer to **ziploc**	☒	Set 1 to GEI lab - coin flip by Gary
	Transfer biota into individual **ziplocs containing** ethanol, label **ziploc**	☒	Ethanol added after ww taken
	Place ziplocs into coolers	☒	
	Take **representative photos (time-stamped)** of **sample** handling	☒	
	Transport samples to secure, limited access facility for processing and **sample shipment**	☒	

- Initial ROV touchdown site N [redacted] W

Sampling site coords N [redacted] W

- Random number 23'
- 44°F water @ initial ROV touchdown. No water temp available until today.

Biota Site

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Line 5 field data sheet

Date: 8 / 19 /2017 **Time:** ~0830 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

- ☒ A-North, "AN" (50-100')
- ☐ B-North, "BN" (100-150')
- ☐ C-North, "CN" (150-200')
- ☐ "D" (> 200')
- ☐ A-South, "AS" (50-100')
- ☐ B-South, "BS" ~~(50-100')~~ 100-150' DK 8/15
- ☐ C-South, "CS" (150-200')
- ☐ Other:

Sample ID Key ITP ID: E-S1

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Sample IDs (list below)

EPZANT 02 GET Sample
~~EPZAN 09~~ RH 8/19/17
EPZANE 03
EPZANW 08

EPZANT 10
EPZANE 09
EPZANW 07 } APB/SRB

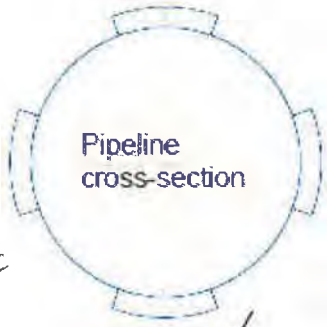
North

Container #'s: 10 & 02 ✓ GEI

- Biota layers: multiple
- Mussel colonization: Heavy
- 71'
- Container order: 07, 08, 10, 02, 03, 09
- Unofficial temp @ bell 65°F - unclear if correct/accurate - oven thermometer, - it is correct, verified
- 3 samples GEI / 3 APB/SRB

Container #'s: 07 & 08 ✓ GEI

West

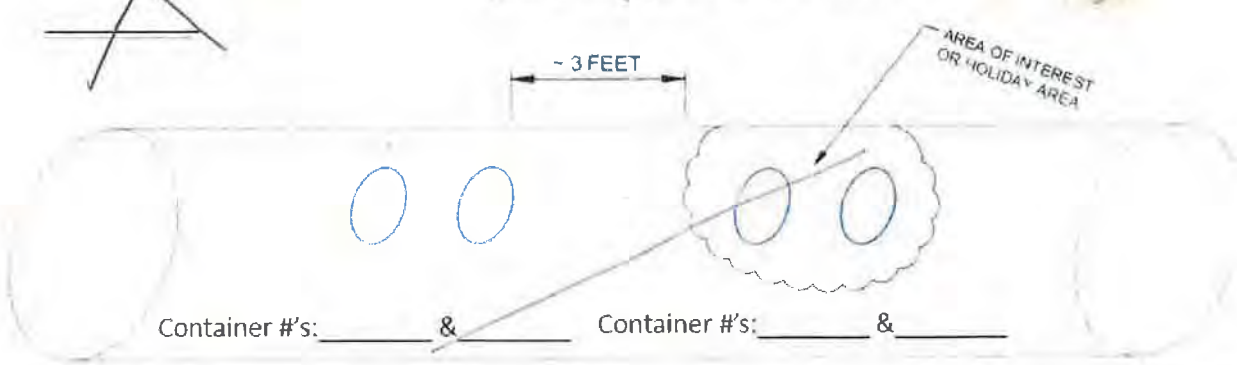


Container #'s: 03 ✓ & GEI 09

East

contained additional material of interest consistent w/ appearance of material in Notes box below.

Container #'s: & Buried pipeline



Container #'s: _____ & _____ Container #'s: _____ & _____

Notes (also indicate if additional notes are on reverse side of form):

- Random # 52' - moved actual area ~1-2' to avoid rocky area + disturb less detritus on lake bed. Agreement by ITP given biota is consistent throughout general area + randomly selected to 52'.
- Black pieces from ~3 o'clock + 9 o'clock recovered. Appear to be same material recovered in sample from 8/17/17. ↳ material of interest. Photograph + hold for Enbridge per discussion w/ Luke + Gary. Too little material for anything else
- Pics taken of mussels, etc. w/ material of interest - see pics from 1030 hrs 8/19/17

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16 Biota Sites Sampling Checklist

Date: 8/19/17 Time: ~0830 Location ID: East leg, Zone A North Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK [redacted]

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	Video feed starting ~0625 monitor time
Random-select number (1-100), ROV navigates that distance in feet along pipeline		☒	Random # 52,
Slow pan of pipeline by ROV			
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☒	
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☐	No holiday observed
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple present - 0844 monitor time
Identify relative level of mussel colonization via footage from ROV		☒	
	Use chart to confirm mussel density	☒	Heavy, gobies abundant
	Video/snapshot of comparison to mussel density reference card	☒	0844 video feed
Diver descends to ROV position on pipeline		☒	
Biota thickness measures via flexible tape		☐	
	Measure 1 at site where pipeline was first touched by diver	☐	N/A - pipeline buried
	Measure 2 approx. 3' north or south from measure 1	☐	
	Measure 3 approx. 3' north or south from measure 2	☐	
Clean pipe measures			
	Remove all attached material then measure circumference at the 3 biota thickness measure sites	☐	N/A - pipeline buried
Biota sampling		☐	
	Diver walk upcurrent slighlty from last measurement site	☐	N/A - No measurements, buried pipeline
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	0913 video feed - 2 sample areas shown
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Verify collection of 8 samples (or 6 if pipeline is buried)	☒	6 samples
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☒	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☒	
	Place ziplocs into coolers	☒	
	Take representative photos (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and sample shipment	☒	

- Pipeline buried, no 6 o'clock samples. 3 + 9 o'clock positions may be tough to get as well.
- See FOS sheet re: black (small) pieces recovered.
- Inform GEI lab to hold material of interest

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Biota Site — Samples on barge deck

144'

Line 5 field data sheet

Date: 8 / 19 /2017 **Time:** 1155 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☒ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☐ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** ~~(50-100')~~ 100-150' RK 8/15 ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key ITP ID: E-S2

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Sample IDs (list below)

EPZBNT 01
EPZBNE 04
EPZBNW 12
} GEI

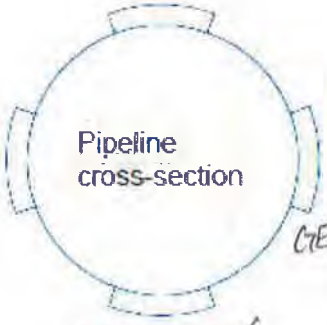
EPZBNT 06
EPZBNE 02
EPZBNW 05
↑ APB/SRB

Significant sand deposition on top ~~to~~ of pipeline RH 8/19/17

North

Container #'s: 01 GEI & 06

- Biota layers: Multiple
- Mussel colonization: moderate but lower end, almost sparse
- Container order: 01, 06, 05, 12, ~~02, 04~~ 04, 02 RH, 8/19/17
- Water temp 55° F @ bell



Container #'s: 05 & 12 GEI

West

Container #'s: 02 & GEI 04 1st sample on east side

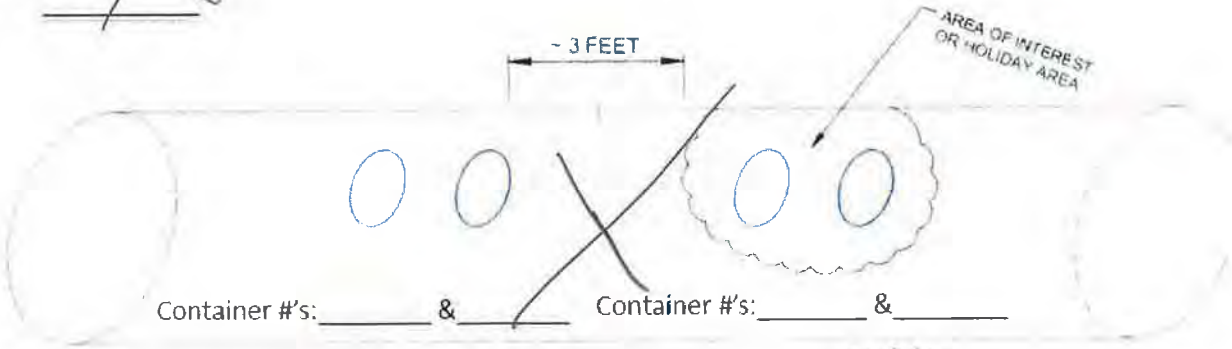
East

Significant sand deposition, east nearly buried. Best attempts will be made to collect.

(Devoid of substantial periphyton, mussels, etc. Very little material observed on pipeline)

Container #'s: ~~____ & ____~~ Buried

↓ Very little sample mass/volume, all sand, much of which affixed to SRB/APB swabs.



RH 8/19/17

Notes (also indicate if additional notes are on reverse side of form):

- Compass heading on ROV + TV monitor still inversed.
- No holiday observed.
- Significant sand deposition, fewer mussels. Some sand in samples wouldn't be in contact w/ pipeline but no way to differentiate.
- Sample ~~0~~ 12 (west side) primarily "Material of interest"

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Biota Site

16 Biota Sites Sampling Checklist

Date: 8/19/17 Time: 1155 Location ID: East leg, Zone B North Depth (ft) @ pipel[redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
Random-select number (1-100), ROV navigates that distance in feet along pipeline		☒	56
Slow pan of pipeline by ROV			
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☒	
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☒	No holiday observed
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple, gobies present
Identify relative level of mussel colonization via footage from ROV		☒	
	Use chart to confirm mussel density	☒	Moderate - lower end of moderate, almost sparse
	Video/snapshot of comparison to mussel density reference card	☒	1045 hrs
Diver descends to ROV position on pipeline		☒	
Biota thickness measures via flexible tape		☐	N/A - buried pipeline
	Measure 1 at site where pipeline was first touched by diver	☐	
	Measure 2 approx. 3' north or south from measure 1	☐	
	Measure 3 approx. 3' north or south from measure 2	☐	
Clean pipe measures			
	Remove all attached material then measure circumference at the 3 biota thickness measure sites	☐	
Biota sampling		☐	
	Diver walk upcurrent slighlty from last measurement site	☐	N/A - buried pipeline
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	1131 hrs, see also 1134 for verification of sampled area
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Verify collection of 8 samples (or 6 if pipeline is buried)	☒	6 samples - pipeline buried
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☒	Note: very minimal mass/volume in some samples, primarily sand. See FOS sheet
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☒	
	Place ziplocs into coolers	☒	
	Take representative photos (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and sample shipment	☒	

- Pipeline buried on bottom + partially on east side
- Note: compass heading on ROV + TV monitor still inversed.

Biota dive

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(77')

Line 5 field data sheet

Date: 8/19/2017 **Time:** 1530 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N** [redacted]

Pipeline zone and water depth range:

- [x] A-North, **"AN"** (50-100')
- [ ] B-North, **"BN"** (100-150')
- [ ] C-North, **"CN"** (150-200')
- [ ] "D" (> 200')
- [ ] A-South, **"AS"** (50-100')
- [ ] B-South, **"BS"** ~~(50-100')~~ 100-150' DK 8/15
- [ ] C-South, **"CS"** (150-200')
- [ ] Other:

Sample ID Key ITP Site ID: W-S1

Sample IDs (list below)

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

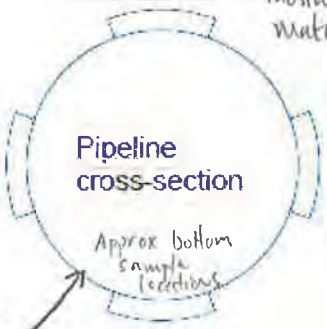
Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

TOP

Biota layers: Multiple
Mussel colonization: Moderate but lower end of range
Container order: 09, 05, 01, 12, 04, 08, 11, 02
Water temp 67°F

Container #'s:
01 & (GEI)
12 – minimal mass, mostly sand + material of interest

Container #'s:
04 ~~09~~ RH 8/19/17 &
(GEI) 08 ~~05~~ RH 8/19/17
West



Container #'s:
11 &
02 (GEI)
East

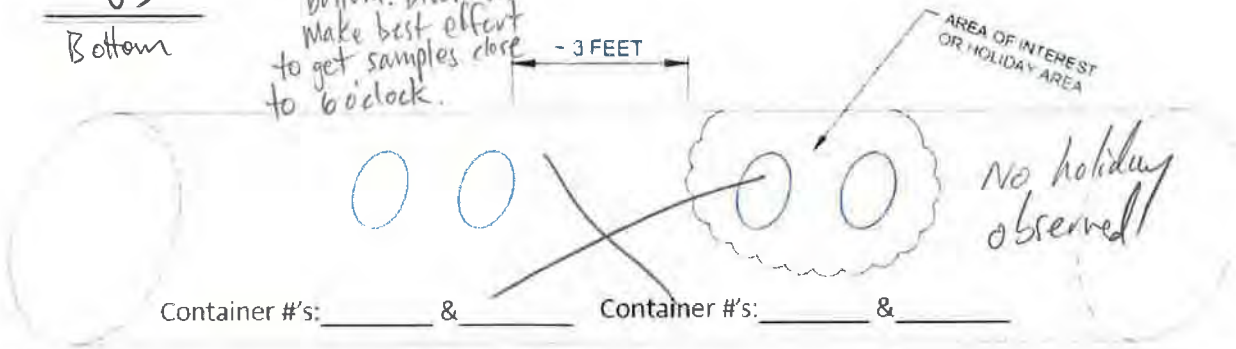
Container #'s:
09 (GEI) &
05
Bottom

Bottom not very accessible as p.line is less than 1' off bottom. Diver will make best effort to get samples close to 6 o'clock.

IDs:

WPZANT 01
WPZANE 02
WPZANB 09
WPZANW 08
} GEI Samples

WPZANT 12
WPZANE 11
WPZANB 05
WPZANW 04
} APB/SRB



Notes (also indicate if additional notes are on reverse side of form):

- Using backup ROV (Video Ray) due to camera issues w/ primary. Lat/longs will be off diver, who was fixed w/ transponder
- Samples on bottom collected first (# 09, 05)
- No holiday observed upon inspection of sample locations.
- Gary com-flip-Set 1 for SRB/APB
- Some samples very minimal mass/volume

Biota dive

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16 Biota Sites Sampling Checklist

Date: 8/19/17 Time: 1530 Location ID: Depth (ft) @ pipeli[redacted]

Crew initials: RA, DK West leg, Zone A North [redacted]

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	Backup ROV - camera issues w/ primary.
Random-select number (1-100), ROV navigates that distance in feet along pipeline		☒	78' N of anchor W65B + W65A
Slow pan of pipeline by ROV			
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☒	
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☒	No holiday observed
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple Water temp (ROV) 67°F
Identify relative level of mussel colonization via footage from ROV		☒	
	Use chart to confirm mussel density	☒	Moderate (lower end) video 1431 hrs
	Video/snapshot of comparison to mussel density reference card	☒	
Diver descends to ROV position on pipeline		☒	
Biota thickness measures via flexible tape		☒	5'9" (69") – Measurement 1
	Measure 1 at site where pipeline was first touched by diver	☒	5'9" (69")
	Measure 2 approx. 3' north or south from measure 1	☒	5'9" (69")
	Measure 3 approx. 3' north or south from measure 2	☒	5' 8.75" (68.75")
Clean pipe measures			
	Remove all attached material then measure circumference at the 3 biota thickness measure sites	☒	1) 5'4" (64") 2) 5'4.5" (64.5") 3) 5'4" (64")
Biota sampling		☒	
	Diver walk upcurrent slighlty from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	Bottom samples taken ~ 7-8 o'clock b/c pipeline only ~1' off bottom.
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Verify collection of 8 samples (or 6 if pipeline is buried)	☒	
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☒	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☒	
	Place ziplocs into coolers	☒	
	Take representative photos (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and sample shipment	☒	

° Pipe only ~1' off bottom so bottom samples at 7-8 o'clock range as 6 was not accessible

[redacted]

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Line 5 field data sheet

Date: 8 / 20 /2017 **Time:** 1155 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☒ "D" (> 200')

☐ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** ~~(50-100')~~ 100-150' DK 8/5 ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key ITP ID: ~~W-S5~~ RH 8/20/17 E-S5

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

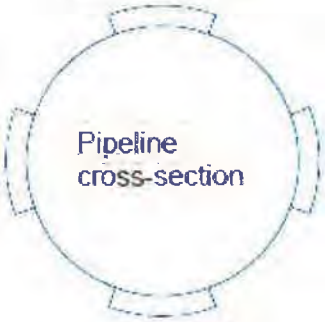
Sample IDs (list below)

GEI samples
~~EPZD02~~ RH 8/20/17
EPZDE01
~~EPZDW10~~ EPZDW08
RH 8/20/17 ~~EPZD~~ EPZDT02
APB/SRB samples
EPZDT05
EPZDE09
EPZDW10

Top

Container #'s:
GEI 02 &
APB/SRB 05

Container #'s:
GEI 08 &
APB/SRB 10
West

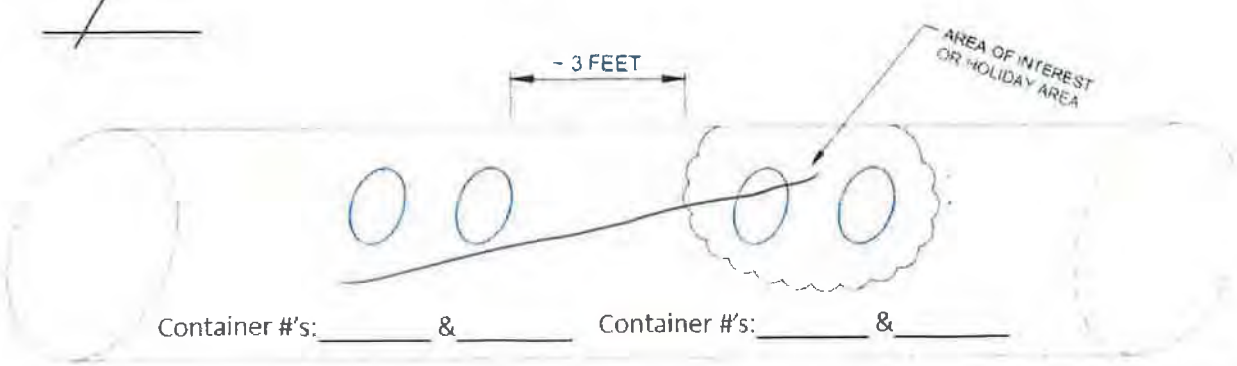


Container #'s:
APB/SRB 09 &
GEI 01 ✓
East

Container #'s:
_____ &
_____

6 o'clock not accessible

Biota layers: Multiple
Mussel colonization: Heavy
Pipeline depth (ft): 229
Water temp (°F): ~~58 57~~ 50 RH 8/20/17
Container order: 02, 05, 08, 10, 09, 01



Container #'s:_____ &_____ Container #'s:_____ &_____

Notes (also indicate if additional notes are on reverse side of form):
- 6 o'clock not accessible, bottom in contact/buried
- Video of what appears to be a "trenched" area (from pipeline install) ~1022-1026 hrs. Big clay walls on either side of pipeline.
- Very little/no macrophytes/periphyton visible
- First two temps off ROV, third (50) off thermometer on bell. Went w/ latter b/c CB said ROVs can give off heat under ops.

Biota Site

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16 Biota Sites Sampling Checklist

Date: 8/20/17 Time: 1155 Location ID: Depth (ft) @ pipeli[redacted]

Crew initials: RH, DK East leg, Zone D

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV **navigates** to **pipeline**		☒	
Random-select number **(1-100)**, ROV **navigates** that distance in feet along pipeline		☒	78 = random #
Slow **pan** of pipeline by ROV			1036 hrs video
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☒	
	If **Holiday** is identified, **incorporate Holiday** Biota sampling protocol	☒	No holiday observed
	Confirm, and **identify** if **possible**, if **multiple layers** of biota are **present**	☒	Multiple
Identify relative level of mussel colonization via **footage** from ROV		☒	
	Use chart to confirm mussel density	☒	Heavy throughout
	Video/snapshot of **comparison** to mussel **density** reference card	☒	1029hrs
Diver descends to ROV position on pipeline		☐	
Biota thickness measures via flexible tape		☐	6 o'clock position not accessible, so
	Measure 1 at site where **pipeline** was first touched by diver	☐	
	Measure 2 **approx.** 3' north or south from measure 1	☐	
	Measure 3 **approx.** 3' north or south from measure 2	☐	No bottom samples + no measurements
Clean pipe measures			
	Remove all attached material then measure circumference at the 3 biota thickness measure sites	☐	
Biota sampling		☒	
	Diver walk upcurrent slighlty from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from **topside**	☒	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Verify collection of 8 samples (or 6 if pipeline is buried)	☒	6 samples
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to **ziploc**	☒	
	Transfer biota into individual **ziplocs** containing ethanol, label ziploc	☒	
	Place ziplocs into coolers	☒	
	Take representative photos (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and **sample shipment**	☒	

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Biota Site

Line 5 field data sheet

245'

Date: 8 / 20 /2017 **Time:** ~~1320~~ 1520 RH 8/20/17 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☒ **"D"** (> 200')

☐ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** ~~(50-100')~~ 100-150' ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key ITP site ID: ~~West S-5~~ W-S-5 DK 8/15 WS-5 (Enbridge ID)

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **B** (bottom) **E** (east) **W** (west)	01, 02……12

RH 8/20/17

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Sample IDs (list below)

GEI samples
WPZDT10
WPZDE12
WPZDW~~09~~03 (WPZDW03) RH 8/20/17

SRB/APB samples
WPZDT05
WPZDE06
WPZDW~~03~~09 (WPZDW09) RH 8/20/17 RH 8/20/17

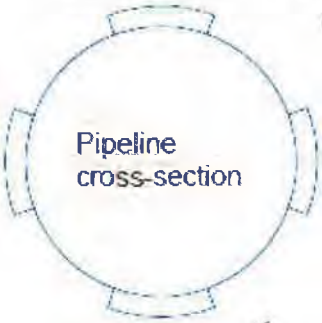
mussel colonization: heavy (overall) ~~but spots on top~~
Biota layers : Multiple
Sample depth (ft): 245
Water temp (F): estimated 50°F
Container order: 03, 09, 05, 10, 06, 12

ROV 57°F + was reading 7° warmer than thermometer on dive bell.

Top

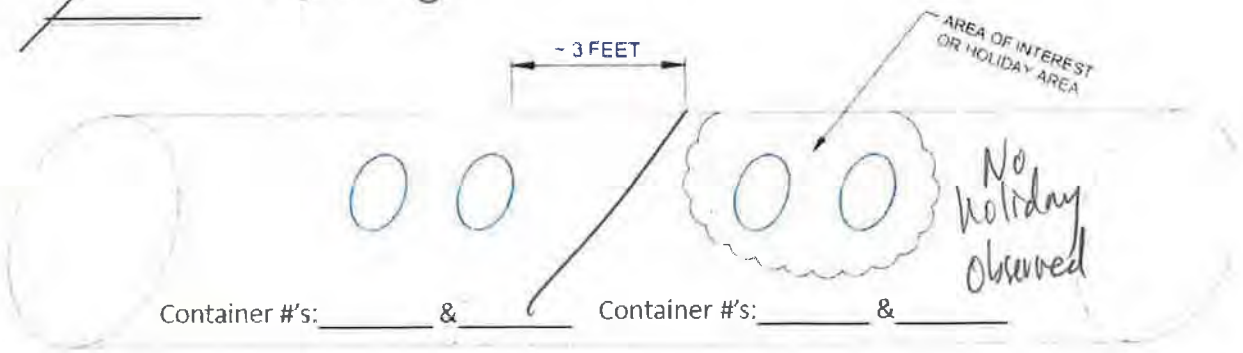
Container #'s: 05 & 10 GEI – minimal mass – very little biota on pipeline @ this sample location

Container #'s: 03 GEI & 09 ✓ ~~GEI~~ West



Container #'s: 06 & 12 GEI East

Container #'s: ~~&~~ Not accessible, lathe, grout bags blocking



No holiday observed

Notes (also indicate if additional notes are on reverse side of form): N 45.81827730 W84.76541754 (Where "S" on Figure 2 is)
• Discussed definition of "Disturbed Area" discussed. Felt initial site (see crossed out GPS coords) may have been "disturbed" so moved according to workplan. Full consensus (Gary, O.B., Luke, Trich).

Biota Site

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16 Biota Sites Sampling Checklist

Date: 8/20/17 Time: ~~1520~~ RH 8/20/17 1520 Location ID: West leg, Zone D Depth (ft) @ pipeline [redacted]

Crew initials: RH, DK (ITP ID: W-S-S)

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
Random-select number (1-100), ROV navigates that distance in feet along pipeline		☒	42 - "Disturbed Area"
Slow pan of pipeline by ROV			See video starting ~ 1400 hrs
	Evaluate for **Area(s)** of Interest, **holidays**, maintenance **signs**	☒	See close up inspection starting ~ 1500 hrs video feed.
	If Holiday is identified, **incorporate Holiday** Biota **sampling protocol**	☒	No holiday observed
	Confirm, and identify if possible, if multiple layers of biota are **present**	☒	Multiple
Identify relative level of mussel colonization via footage from ROV		☒	
	Use chart to confirm mussel **density**	☒	Heavy
	Video/snapshot of comparison to mussel density reference card	☒	1400 hrs video, 1425 hrs
Diver descends to ROV position on pipeline		☐	
Biota thickness measures via flexible tape		☐	N/A Bottom of pipeline is Not accessible
	Measure 1 at site where **pipeline** was first touched **by** diver	☐	
	Measure 2 approx. 3' north or south from measure 1	☐	
	Measure 3 approx. 3' north or south from measure 2	☐	
Clean pipe measures			
	Remove all attached material then measure circumference at the 3 biota thickness measure sites	☐	
Biota sampling		☐	
	Diver walk upcurrent slighlty from last measurement site	☐	N/A - Bottom of pipeline not accessible so no measurement
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	Video @ 1452 hrs
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from **topside**	☒	1454 hrs video feed
	Repeat paired sampling on the other areas of **pipeline**	☒	
	Verify collection of 8 samples (or 6 if pipeline is buried)	☒	6 - pipeline buried
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of **pipeline they** were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, **assign** before transfer to **ziploc**	☒	
	Transfer biota into individual **ziplocs** containing ethanol, label **ziploc**	☒	
	Place ziplocs into coolers	☒	
	Take **representative photos (time-stamped)** of sample handling	☒	
	Transport samples to secure, limited access facility for processing and sample **shipment**	☒	

~~N45.01639109 W84.76538010~~ - Sample location

↳ 1st picked area via random #. It was "disturbed" so had to move to spot w/in 100' that is representative + undisturbed per plan. Samples collected from records on FDS

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Line 5 field data sheet

Date: 8 / 21 /2017 **Time:** 1055 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N** [redacted]

Pipeline zone and water depth range:

- ☐ A-North, **"AN"** (50-100')
- ☐ B-North, **"BN"** (100-150')
- ☒ C-North, **"CN"** (150-200')
- ☐ "D" (> 200')
- ☐ A-South, **"AS"** (50-100')
- ☐ B-South, **"BS"** ~~(50-100')~~ 100-150' DK 8/15
- ☒ C-South, **"CS"** (150-200') RH 8/21/17
- ☐ Other:

Sample ID Key W-S3 ⇒ (ITP Site ID) ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS** RH 8/21/17	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Top

Container #'s:

GEI 04 & ✓

03

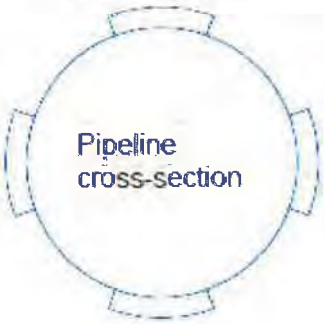
Biota layers: multiple (video 0927), 0951 hrs
Mussels: heavy
Water temp (F): 50°F (on bell)
Sample depth (ft): 188'
Container order: 06, 10, 01, 09, 04, 03, ~~01~~ RH 8/21/17, 05, 11

Container #'s:

GEI 06 ✓ &

10

West



Container #'s:

RH 8/21/17 ~~01~~ 05 &

11 ✓ GEI

East

GEI IDs

04
11
09
06

APB/SRB IDs

03
05
01
10

Container #'s:

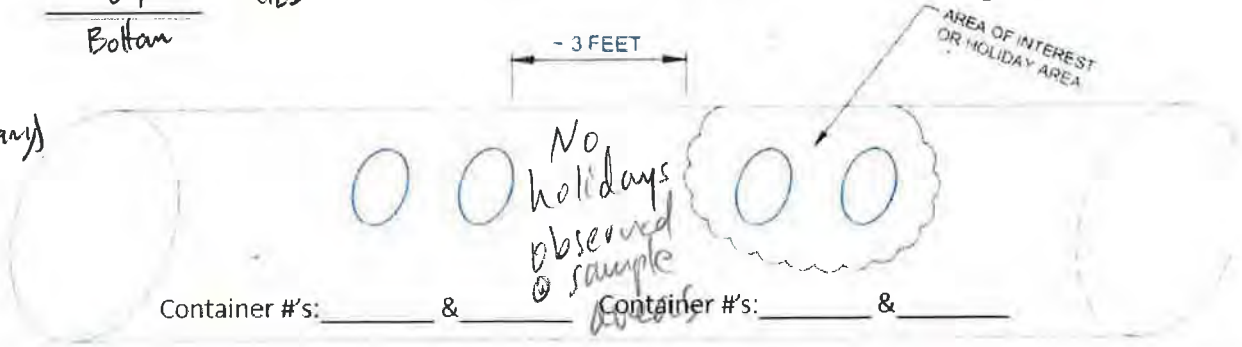
01 &

09 ✓ GEI

Bottom

Biota measurements (if any)
1) 5'9" (69")
2) 5'9" (69")
3) 5'8.75" (68.75")

Clean pipe measurements (if any)
1) 5'5" (65")
2) 5'4.75" (64.75")
3) 5'5" (65")



Container #'s: _____ & _____ Container #'s: _____ & _____

Notes (also indicate if additional notes are on reverse side of form):

- As observed before, there are "patches" w/ little/no biota despite overall heavy mussel colonization. This is an undisturbed area + patchy distribution still observed.

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Zoda Site

188'

16 Biota Sites Sampling Checklist

Date: 8/21/17 Time: 1055 Location ID: West leg, Zone C North (W-S3 ITP ID) Depth (ft) @ pipeli[redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
Random-select number (1-100), ROV navigates that distance in feet along pipeline		☒	22 = random #
Slow pan of pipeline by ROV			
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☒	
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☒	No holidays observed @ sample areas
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple
Identify relative level of mussel colonization via footage from ROV		☒	
	Use chart to confirm mussel density	☒	Heavy 0927 video, 0945-ON
	Video/snapshot of comparison to mussel density reference card	☒	" "
Diver descends to ROV position on pipeline		☒	
Biota thickness measures via flexible tape		☒	
	Measure 1 at site where pipeline was first touched by diver	☒	
	Measure 2 approx. 3' north or south from measure 1	☒	
	Measure 3 approx. 3' north or south from measure 2	☒	
Clean pipe measures			
	Remove all attached material then measure circumference at the 3 biota thickness measure sites	☒	Sampling b/f measurements per usual
Biota sampling		☒	
	Diver walk upcurrent slighlty from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	(1002 -
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	1004 hrs video)
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Verify collection of 8 samples (or 6 if pipeline is buried)	☒	
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

- [redacted] (initial touchdown site w/ ROV)
- Had to go S of this point b/c large "mountain of clay" to north which extended a long way + precluded sampling to north. Would have required lengthy movement N of intended sample site in order to clear the mound + locate area that pipeline isn't buried.
- Coords @ sample site: [redacted]

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Line 5 field data sheet

Date: 8 / 21 /2017 **Time:** 1255 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N** [redacted]

Pipeline zone and water depth range:

☐ A-North, "**AN**" (50-100') ☒ B-North, "**BN**" (100-150') ☐ C-North, "**CN**" (150-200') ☐ "D" (> 200')

☐ A-South, "**AS**" (50-100') ☐ B-South, "**BS**" ~~(50-100')~~ 100-150' DK 8/15 ☐ C-South, "**CS**" (150-200') ☐ Other:

Sample ID Key W-S2

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Sample IDs (list below)

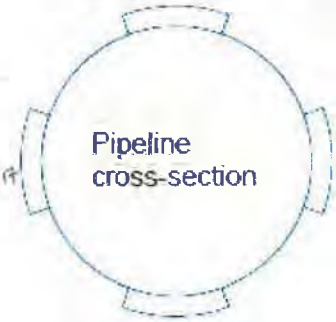
GET IDs
WPZBNT01
WPZBNE11
WPZBNW04

APB/SRB IDs
WPZBNT10
WPZBNE09
WPZBNW02

Top

Container #'s: 10 & 01 GEI

Container #'s: GEI 04 ~~02~~ RH 8/21/17 & 02 West

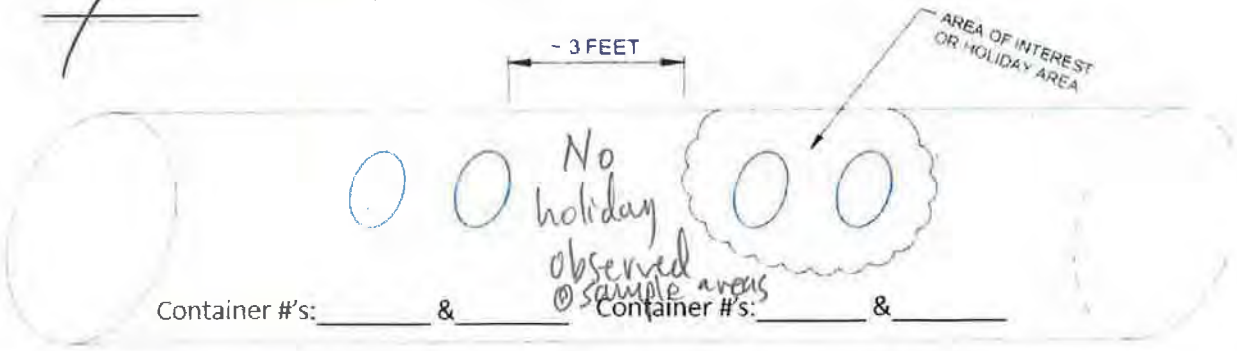


Container #'s: 09 & 11 GEI East

Container #'s: ~~&~~

Bottom inaccessible for samples. Too little room, video ~1150 hrs.

Biota ~~thick~~ layers: multiple
Mussels: heavy
Sample depth (ft): 128'
Water temp (F): ~~62~~ RH 8/21/17 52°F
Container order: ~~02~~ RH 8/21/17 04, 02, 10, 01, 09, 11



Notes (also indicate if additional notes are on reverse side of form):

- "Trenched" area, leaving little/no room for 6 o'clock samples or circumference measurements.
- Circumf. measures will be attempted, but will be discontinued if bottom is disturbed while attempting measurements.
  - couldn't get measurements due to "trenching" of pipeline – bottom would be disturbed.

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16 Biota Sites Sampling Checklist

Date: 8/21/17 Time: 1255 (samples on barge) Location ID: West leg, zone B North ~~TS~~ RH 8/21/17 (W-52) Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
Random-select number (1-100), ROV **navigates** that distance in feet along pipeline		☒	57 - moved 57' N w/ROV
Slow pan of pipeline by ROV			
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☒	
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☒	No holidays observed @ sample area
	Confirm, and **identify if possible, if multiple layers** of biota are **present**	☒	Multiple ↓
Identify relative level of mussel colonization via footage from ROV		☒	1151 hrs video, 1152 hrs
	Use chart to confirm mussel density	☒	
	Video/snapshot of **comparison** to mussel **density** reference card	☒	
Diver descends to ROV position on pipeline		☒	
Biota thickness measures via flexible tape		☒	
	Measure 1 at site where **pipeline** was first touched by diver	☐	Measurements could not be taken at this location b/c pipe was "trenched" + bottom couldn't be accessed without disturbing biota.
	Measure 2 **approx.** 3' north or south from measure 1	☐	
	Measure 3 **approx.** 3' north or south from measure 2	☐	
Clean pipe measures			
	Remove all attached material then measure circumference at the 3 biota thickness measure sites	☐	
Biota sampling		☒	
	Diver walk **upcurrent slighlty** from last measurement site	☐	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired **sampling** on the other areas of **pipeline**	☒	
	Verify collection of 8 **samples (or** 6 if **pipeline** is buried)	☒	6 o'clock inaccessible
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual **ziplocs** containing ethanol, label **ziploc**	☐	
	Place ziplocs into coolers	☐	
	Take **representative** photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and **sample shipment**	☐	

- Initial ROV pos [redacted]
- See FDI sheet for more info. re: circumference measures
- Sample site coords: [redacted]

AOI site

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Line 5 field data sheet

Date: 8/21/2017 **Time:** 1600 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, "**AN**" (50-100') ☐ B-North, "**BN**" (100-150') ☐ C-North, "**CN**" (150-200') ☐ "D" (> 200')

☒ A-South, "**AS**" (50-100') ☐ B-South, "**BS**" ~~(50-100')~~ 100-150' DK 8/15 ☐ C-South, "**CS**" (150-200') ☐ Other:

Sample ID Key ITP Site ID: W-AOI5 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

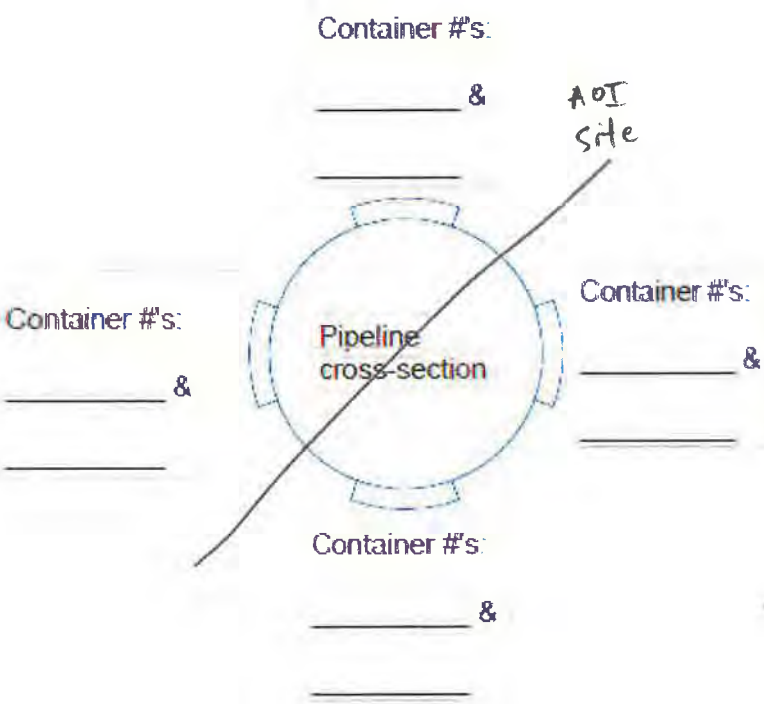
Mussel colonization: sparse w/in AOI, heavy outside AOI

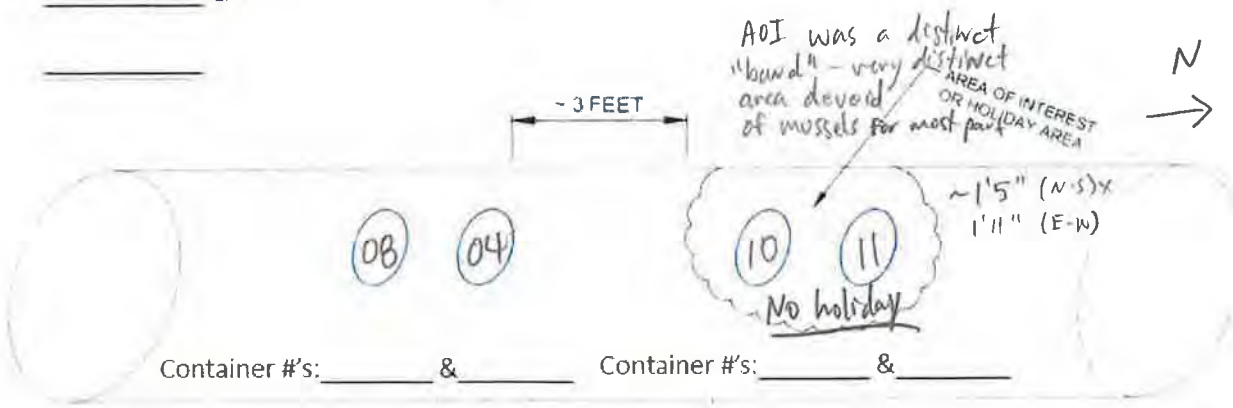
Biota: multiple layers

Depth (ft): ~~101'~~ 100' DK 8/21

Temp (F): 55°

Container order: 10, 11, 08, 04 (AOI)





Notes (also indicate if additional notes are on reverse side of form):

- Per previous discussions samples will be kept only if holiday found
- Material of interest found during inspection, bagged + will be brought up, Enbridge + ITP determined it to be "Dislodged Coating". As such, APB/SRB tests run + sample bagged + labeled. ID: 170821-WAOI5DC
- Will get confirmation as to what else to do w/ Dislodged coating sample
- Thickness measurements taken, all thick enough

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AOI site

11 Areas of Interest, 3 "Additional Sites" (non-Biota Sites) Checklist

Date: 8/21/17 **Time:** 1600 **Location ID:** **Depth (ft) @ pipeline:** [redacted]

Crew initials: RH, DK [illegible] Zone A south (ITP ID: W-AOI5)

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at Area of Interest		☒	
Slow pan of pipeline		☒	
	Focus on AOI/Additional Site	☒	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple: periphyton, mussels, biofilm
Identify relative level of mussel colonization		☐	
	Use chart to identify mussel density within inspection area	☒	Sparse w/in AOI (1511 video), heavy outside
	Video/snapshot of comparison to mussel density reference card	☒	
	Use chart to identify mussel density 3 feet upcurrent of Holiday (where other paired sample is to be taken) if identified	☒	Heavy - video
	Video/snapshot of comparison to mussel density reference card	☐	N/A - Confirming w/ ROV footage
Biota sampling @ AOI/Additional Site		☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect one sample from AOI/Additional Site	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample, receive confirmation from topside	☒	
	Repeat paired sampling 3 feet upcurrent of AOI/Additional Site, verify collection of 4 total samples	☒	
	Clean off/inspection of sampling areas and AOI	☒	
	If holiday is found, keep samples for analysis If no anamolies found, samples disposed of as per, DNR permit	☒	Material of interest found + kept for Enbridge
Topside sample handling			
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

- Coating thickness measures taken - all good
- Material of interest to get unique ID

Additional site #2 on east leg

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Line 5 field data sheet

Date: 8 / 24 /2017 **Time:** 1200 **hrs** **Crew initials:** RH, DK

Pipeline: East or ~~West~~ (circle) RH 8/24/17 **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, "**AN**" (50-100') ☐ B-North, "**BN**" (100-150') ☐ C-North, "**CN**" (150-200') ☐ "D" (> 200')

☒ A-South, "**AS**" (50-100') ☐ B-South, "**BS**" ~~(50-100')~~ (100-150') ☐ C-South, "**CS**" (150-200') ☐ Other:

OK 8/15

ITP ID: (or E-AS2) E-AS2 1 east leg, add. site #2 (if going from N to south)

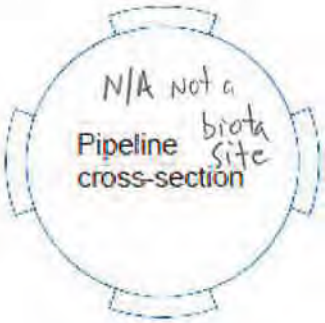
Sample ID Key ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Container #'s: _____ & _____

Container #'s: _____ & _____



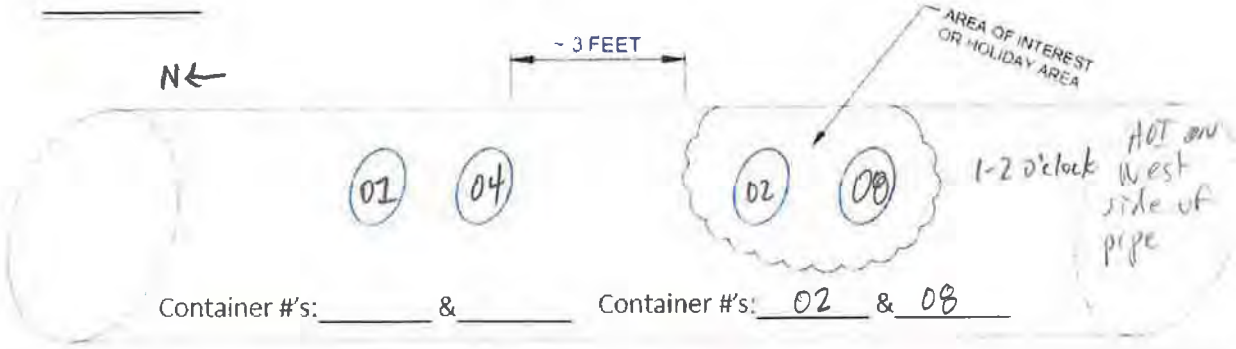
Container #'s: _____ & _____

Container #'s: _____ & _____

* Note: Samples abandoned once confirmed we were sampling wrong location.

Mussel colonization: Sparse, @ AOI
Biota layers: Multiple
Sample depth (ft): 73
Water temp (F):
Container order: 08, 02, 04, 01

Critical issue!
Difficult to confirm holiday (or lack thereof) w/o cleaning pipe off.



(now) **Notes (also indicate if additional notes are on reverse side of form):** General area highly disturbed w/ old anchor pulled out, new anchor installed so sig. biota disturbance. AOI very small so a box approx. 1' square is assumed. Pipeline was in span as recent as a year or so ago, but isn't now. More mussels towards bottom of pipeline but sparse on top + upper sides. Samples collected, trying to verify if paired AOI samples were collected @ known AOI.
- Samples not utilized (disposed per MDNR permit) as was determined that incorrect location was sampled.

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Additional Site

11 Areas of Interest, 3 "Additional Sites" (non-Biota Sites) Checklist

Date: 8/24/17 Time: 1200 hrs Location ID: E-AS2 Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK East leg, Zone A south, ~~E-AOI1~~ RH 8/24/17

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☒	
	Focus on Area of Interest	☒	1115 hrs, 1120
	Evaluate for other **Area(s)** of Interest, **holidays**, maintenance signs	☐	see video 1217 hrs - cleaning/inspecting
	If Holiday is identified, incorporate Holiday Biota sampling protocol and **checklist**. Biota **sampling only** if **Holiday** found.	☐	N/A see notes
	Confirm, and identify if possible, if multiple **layers** of biota are **present**	☐	
Identify relative level of mussel colonization			
	Use chart to **identify** mussel **density** at Area of Interest	☒	1120, 1121
	Video/snapshot of **comparison** to mussel **density** reference card	☒	↓ ↓
	Use chart to identify mussel **density** 3 feet **upcurrent** of Area of Interest	☒	Sparse - see notes on FIX
	Video/snapshot of **comparison** to mussel **density** reference card	☒	1120, 1121

- Posted samples collected but known AOI, potential holiday not observed.
- Note: Samples abandoned once confirmed wrong location was sampled. Disposed of per MDNR requirements.

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Additional Site samples on deck

Line 5 field data sheet

Date: 8/24/2017 **Time:** 1510 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, "AN" (50-100') ☐ B-North, "BN" (100-150') ☐ C-North, "CN" (150-200') ☐ "D" (> 200')

☒ A-South, "AS" (50-100') ☐ B-South, "BS" ~~(50-100')~~ 100-150' DK 8/15 ☐ C-South, "CS" (150-200') ☐ Other:

Sample ID Key ITP site ID: E-AS2 (EAS-2 shown on video feed)

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02.....12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Sample IDs (list below)

GEI
EPZASW02
EPZASW01
EPZASW07CD (calcium deposit)

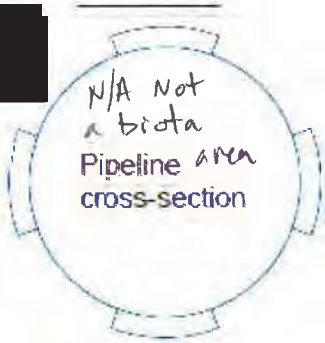
SRB/APB
EPZASW11
EPZASW04
EPZASW07CD (calcium deposit)

#7 container used to attempt to scrape apparent calcium into container for APB/SRB testing. [redacted]

Container #'s: _____ & _____

Biota layers: multiple
mussels : Sparse
Sample depth : 75 ft
Container order : 11, 02, 01, 04

Container #'s: _____ &



Container #'s: _____ &

- CP readings taken at apparent "calcified area" that is suspected to be covering the suspected additional site.
- -248, -290 on anode on anchor (from bolt holding anode down)
  - 844 - 868 from actual anode, not bolt
- CP @ apparent "calcified area" (Not taken)

Video feed: N 148-1

Container #'s: _____ &

* Key issue: during WP development understanding was that AOIs, additional sites would be easily identified. However, this is not the case thus far. Pipeline has had some sort of biota/biofilm that would preclude holiday discovery, AOI verification before cleaning. As such, cleaning/inspection is required. In this case, AOI wasn't found until it was cleaned off.

These taken ~3' away from apparent calcified area that was determined to be the additional site.

See video feed ~1400 hrs, esp. 1407, inspection

No bare pipe found here.

Container #'s: _____ & _____ Container #'s: _____ & _____

Notes (also indicate if additional notes are on reverse side of form): Moved ~44' from original target sample location, latter of which was incorrect. Area had been cleaned in 2012-2014 region thus little mussel/macrophyte growth. Area cleaned off, no bare pipe where samples were taken. Apparent "calcium deposit" found ~3 feet from sample site. This was discovered after cleaning/inspection. Per conversation w/ Gary, Trish - keep samples for evaluation b/c visual survey by ROV + diving dive showed little/no difference in biota community.

OVER

OVER

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RH 8/24/17

8/24/17

- Paired biota samples at presumed additional site + 5 ft. upstream north
- Subsequent inspection revealed no bare pipe @ sampling area.
- However, cleaning/inspection revealed apparent holiday with apparent calcium-like overgrowth within 3' of paired biota sample site.
- Discussed what to do w/ samples:
  - calcium-like area could not be sampled b/c it had been cleaned off/disturbed
  - biota at sampling area + area surrounding apparent holiday was very consistent, RH 8/24/17 ~~[illegible]~~ so much so that apparent holiday appeared no different than proximal areas until it was cleaned off
  - thus, biota @ sampling area likely consistent w/ what may have been found on top of apparent holiday/calcium area.
  - Discussed w/ Gary, Trish, Dave Stafford. Keep samples collected as bare pipe/holiday was assumed under calcium.

Apparent holiday @ E-AS2

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Holiday Area Biota Sampling Checklist - only fill out if Holiday Area is found

Date: 8/24/17 Time: ~~1320~~ 1217 8/24/17 1510 on deck Location ID: East leg, Zone A south (ITP site ID: E-AS2) Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at potential Holiday Area		☒	
Slow pan of pipeline		☐	See Add site ✓list
	Focus on Holiday Area	☐	
	Evaluate for Area(s) of interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☐	
Identify relative level of mussel colonization		☐	
	Use chart to identify mussel density at Holiday Area	☐	
	Video/snapshot of comparison to mussel density reference card	☐	
	Use chart to identify mussel density 3 feet upcurrent of Holiday Area	☐	
	Video/snapshot of comparison to mussel density reference card	☐	
Biota sampling @ Holiday Area		☐	See FDS. Samples were ~3' of apparent holiday w/ apparent calcium-like growth.
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☐	
	Collect one sample from Holiday Area	☐	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if Holiday Area is small, receive confirmation from topside	☐	
	Repeat paired sampling 3 feet upcurrent of Holiday Area, verify collection of 4 total samples	☐	
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

* See FDS Sheet for notes on samples

Additional site
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ITP site ID E-AS2

11 Areas of Interest, 3 "Additional Sites" (non-Biota Sites) Checklist

Date: 8/24/17 **Time:** 1510 samples on deck **Location ID:** **Depth (ft) @ pipeline:** [redacted]

Crew initials: RH, DK East leg, Zone A south

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☒	
	Focus on Area of Interest	☒	
	Evaluate for other Area(s) of Interest, holidays, maintenance signs	☒	
	If Holiday is identified, incorporate Holiday Biota sampling protocol and checklist. Biota sampling only if Holiday found.	☒	Apparent holiday covered by apparent calcium growth
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple
Identify relative level of mussel colonization			
	Use chart to identify mussel density at Area of Interest	☒	Sparse
	Video/snapshot of comparison to mussel density reference card	☒	Video @ ~1400 hrs
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☒	Sparse
	Video/snapshot of comparison to mussel density reference card	☒	~1400 hrs

* See FDS sheet for additional sample notes

Area of Interest

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Line 5 field data sheet

Date: 8 / 24 /2017 **Time:** 1710 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☒ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** ~~(50-100')~~ 100-150' ☐ C-South, **"CS"** (150-200') ☐ Other:

DK 8/15

Sample ID Key JTP site ID E-AOI11

Sample IDs (list below)

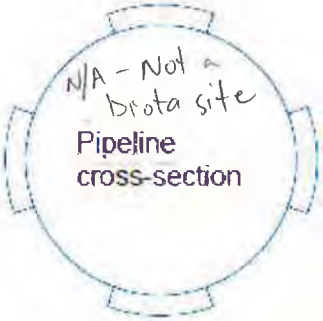
Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **B** (bottom) **E** (east) **W** (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Biota layers: Multiple
mussels: Sparse w/in AOI
Water depth: 12'
Water temp(F):
Container order: 06, 02, 12, 10

Container #'s: _____ & _____

Container #'s: _____ & _____



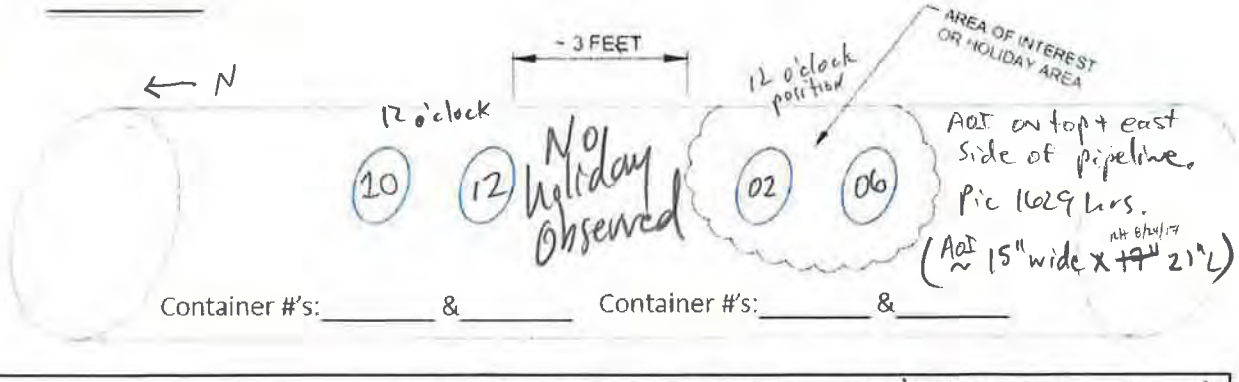
Container #'s: _____ & _____

Container #'s: _____ & _____

- No biota samples analyzed due to no holiday
- APB/SRB on dislodged coating (see notes below) - also sent to GEI lab.

Biota measurements (if any)
1)
2) N/A
3)

Clean pipe measurements (if any)
1)
2) N/A 3)



Notes (also indicate if additional notes are on reverse side of form): Apparent "cracks" or "ridges/bubbles" in coating. 2 samples w/in that area, 2 samples ~ 3' to north of that area. Loose pieces of apparent dislodged coating were collected from ~12 o'clock position

- No holiday so samples disposed of per MDNR permit

* Dislodged coating sample tested for APB/SRB + sent to eco lab. ID: 170824 - ~~EAOI11DE~~ EAOI11DC RH 8/24/17

↳ East leg, AOI #11

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Area of Interest

11 Areas of Interest, 3 "Additional Sites" (non-Biota Sites) Checklist

Date: 8/24/17 Time: 1710 hrs Location ID: Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK East leg, Zone A south (ITP site ID: E-AOI11)

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☒	1547 video
	Focus on Area of Interest	☒	
	Evaluate for other Area(s) of Interest, holidays, maintenance signs	☐	No holiday found/observed
	If Holiday is identified, incorporate Holiday Biota sampling protocol and checklist. ~~Biota sampling only if Holiday found.~~ Reactively	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple: biofilm, periphyton
Identify relative level of mussel colonization			
	Use chart to identify mussel density at Area of Interest	☒	Sparse @ AOI video 1530
	Video/snapshot of comparison to mussel density reference card	☒	ROV
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☒	~~1557~~ video - Heavy 3' to north of AOI
	Video/snapshot of comparison to mussel density reference card	☒	REFER TO ADDITIONAL SHEET

- Dislodged coating sample tested for MPB/SRB + sent to GEI lab
  Sample ID: 170824-EAOI11DC

West leg Additional site (only AS on West leg)

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Line 5 field data sheet

Date: 8 / 25 /2017 **Time:** 1115 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☒ "D" (> 200')

☐ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** ~~(50-100')~~ 100-150' DK 8/15 ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key ITP site ID: W-AS1 (or WAS-1 - unclear which) ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

WPZDT04
WPZDT11 – (GE)
WPZDT02 – (GE)
WPZDT06

Good video footage 0947-0957 incl. view of former anchor hole @ 0956 hrs.

Container #'s: _____ & _____

- Dive/sample collection video feed: 1032-1038
- 13' (ft) measured length of pipe encompassing all calcium areas. Video 1043-1045. 18" tall from "tallest" calcium area. In other words bottom most to top most calcium area.

*Several apparent "calcium" pieces observed in sample

Biota layers: ~~single~~ multiple (biofilm) directly on Additional site features. Multiple outside in undisturbed areas.

Container #'s: _____ & _____

N/A Not a Pipeline cross-section Biota Site

Container #'s: _____ & _____

Mussels: Sparse in proximity of add. site features, heavy in undisturbed areas outside.

Depth (ft): 196' (201' under pipe)
Water temp (F): ~~42°~~ 43° AN 8/23/17
Container order: 04, 11, 02, 06

Container #'s: _____ & _____

*Ballard also capturing screen shots during dives

Biota measurements (if any)
1)
2) N/A
3)

← N

Clean pipe measurements (if any)
1)
2) N/A
3)

Rough "sketch" of calcium sites where taken samples

To be explicit, no mussels observed directly on the calcium. Some right next to it though that could have been captured in samples.

AREA OF INTEREST OR HOLIDAY AREA

multiple "calcified areas" that are presumably covering bare metal but can't be confirmed w/o cleaning/scraping calcified area(s).

Container #'s: _____ & _____ Container #'s: _____ & _____

Notes (also indicate if additional notes are on reverse side of form): • Multiple apparent calcified areas. Paired samples to be taken on top of pipe, directly on a calcified area and other pair in undisturbed area w/in 3' feet. All calcified areas on east side of pipe. Paired samples to north technically still in proximity of Add. site features but in area clearly undisturbed. Entire "Add site footprint" estimated to be ~13' feet in length. Note that as with 8/24/17 p.m dive, bare metal Not observed but potentially under apparent calcium areas, hence the biota samples are being kept for analysis. Holidays confirmed via closer inspection + removal of apparent calcified areas. (per conversation w/ Trish)

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Presumed holidays under apparent entrenched areas

Holiday Area Biota Sampling Checklist - only fill out if Holiday Area is found

Date: 8/25/17 **Time:** 1115 **Location ID:** **Depth (ft) @ pipeline:** [redacted]

Crew initials: RH, DK West leg, Zone D, additional site (W-AS7)

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at potential Holiday Area		☒	
Slow pan of pipeline		☒	
	Focus on Holiday Area	☒	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☒	
	Confirm, and identify if possible, if **multiple layers** of biota are **present**	☒	0947 hrs video - 0955 good video
Identify relative level of mussel colonization		☐	
	Use chart to **identify** mussel **density** at **Holiday** Area	☐	presumed holiday - mussels sparse
	Video/snapshot of **comparison** to mussel **density** reference card	☐	Holidays confirmed via inspection dives
	Use chart to identify mussel density 3 feet upcurrent of Holiday Area	☐	Mussels heavy
	Video/snapshot of **comparison** to **mussel density** reference card	☐	0947 - 0955 hrs
Biota sampling @ Holiday Area (presumed holiday)		☒	
	Hold first **sample** container in front of **camera** to distinguish sample ID, receive confirmation from **topside**	☒	
	Collect one **sample** from **Holiday** Area	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if Holiday Area is small, receive confirmation from topside	☒	
	Repeat paired sampling 3 feet upcurrent of Holiday Area, verify collection of 4 total samples	☒	
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for **SRB/APB, assign** before transfer to **ziploc**	☒	
	Transfer biota into individual ziplocs containing ethanol, label **ziploc**	☒	
	Place ziplocs into coolers	☒	
	Take representative photos (time-stamped) of **sample handling**	☒	
	Transport samples to secure, limited access facility for processing and **sample shipment**	☒	

° Gobies not observed @ such deep depths (~195')

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11 Areas of Interest, 3 "Additional Sites" (non-Biota Sites) Checklist

Date: 8/25/17 Time: Location ID: Depth (ft) @ pipeline:

Crew initials: RH, DK West leg, Zone D, additional site (W-AS1)

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☑	
ROV arrival at AOI, slow pan of pipeline with ROV		☑	
	Focus on Area of Interest	☑	
	Evaluate for other Area(s) of Interest, holidays, maintenance signs	☑	
	If Holiday is identified, incorporate Holiday Biota sampling protocol and checklist. Biota sampling only if Holiday found.	☑	See holiday checklist 0947 0955 video
	Confirm, and identify if possible, if multiple layers of biota are present	☑	
Identify relative level of mussel colonization			
	Use chart to identify mussel density at Area of Interest	☑	Source @ Add. site, heavy in undisturbed areas
	Video/snapshot of comparison to mussel density reference card	☑	outside " "
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☑	Heavy
	Video/snapshot of comparison to mussel density reference card	☑	

* Presumed holidays (bare metal) under apparent calcified areas - holidays confirmed under some of the calcified areas.

Biota + Designated AOI site

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Line 5 field data sheet

Date: 8 / 26 /2017 **Time:** 1030 **hrs** **Crew initials:** RH, DK, SK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☒ "D" (> 200')

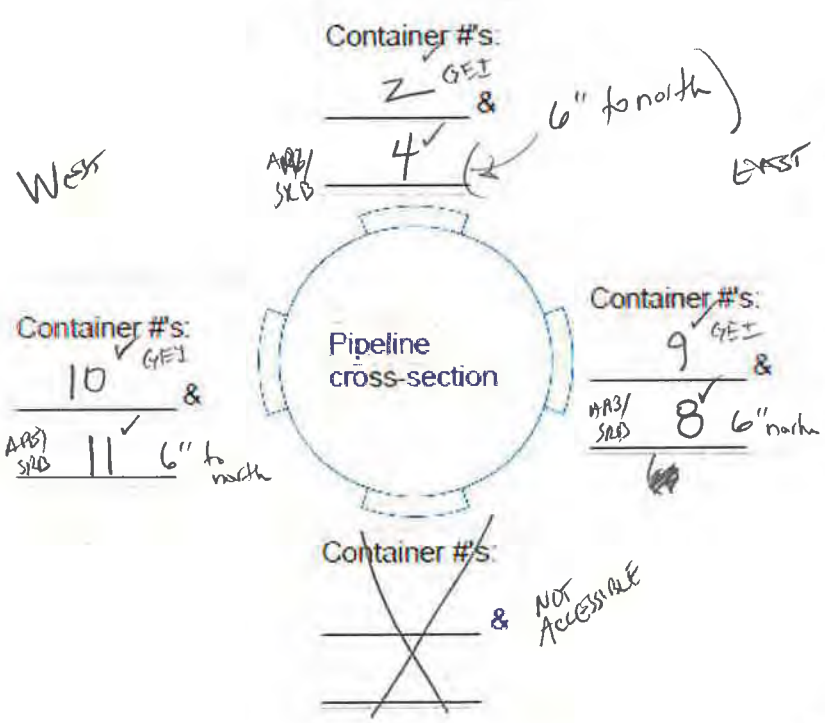
☐ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** ~~(50-100')~~ 100-150' DK 8/15 ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key ITP Site ID: E-AOI-2, S-4, B-2 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

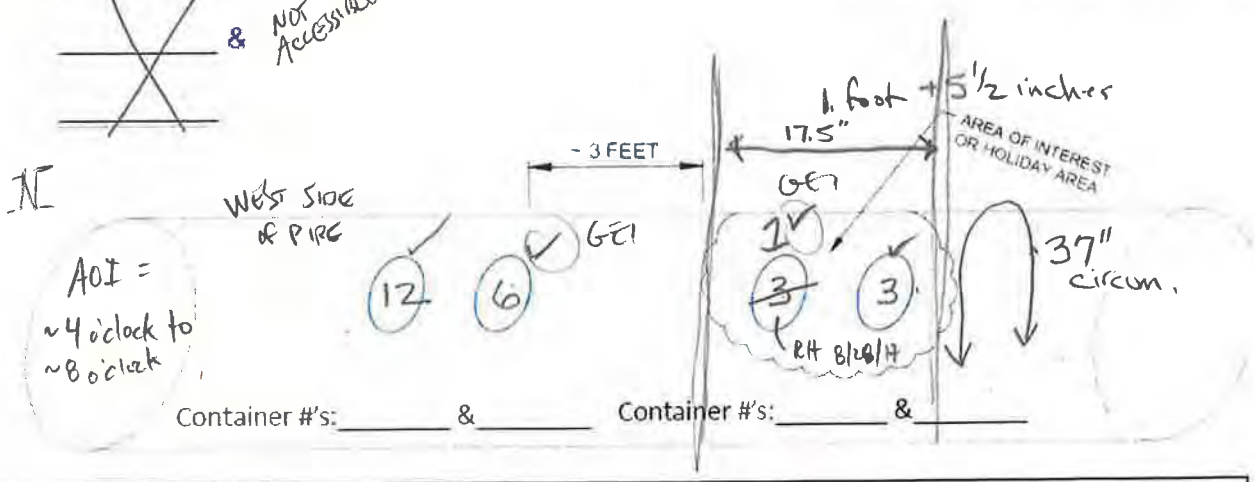
TEMP @ BELL: 42°F



GEI IDS:	Microbial IDS:
EPZDT02	EPZDT04
EPZDE09	EPZDE08
EPZDW10	EPZDW11
EPZDW01	EPZDW03
EPZDW06	EPZDW12

Biota Area; Biota area

Biota layers: ~~Single~~ multiple w/in AOI, multiple outside
Mussels: None w/in AOI, heavy outside
Sample depth(ft): 216'
Water temp(F): 42°F
Container order: 3, 1, 6, 12 [AOI]
2, 4, 10, 11, 9, 8 [Biota]



Notes (also indicate if additional notes are on reverse side of form):

0859 viewed top of pipe @ AOI apparent flap/ridge of paper wrap

AOI - APPARENT STRAIGHT EDGE
MUSSELS APPARENTLY DENSER ON EAST SIDE OF PIPE; DENSER ON LOWER PORTIONS
BOTTOM OF PIPE NOT ACCESSIBLE ; mussels visibly filtering (on pipe & bottom of lake)

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7 Areas of Interest at Biota Sites **Sampling** Checklist - ***for use at 7 Biota Sites Coinciding with Area of Interest***

Date: 8/26/17 Time: 1030 Location ID: Depth (ft) @ pipeline [redacted]

Crew initials: RH, DK, SK East leg, zone D (ITP Site ID: E-AOI-2, S-4, D-2

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☒	0838 video feed ; currently flowing east to west 0857
	Focus on Area of Interest	☒	
	Evaluate for other **Area(s)** of Interest, **holidays**, maintenance **signs**	☒	no holidays observed, can see seam - no holidays; some loose paper on top w/no metal exposed
	If **Holiday** is **identified**, incorporate **Holiday** Biota **sampling protocol**	☐ NA	multiple layers
	Confirm, and **identify** if **possible**, if **multiple layers** of biota are present	☒	~~Single~~ layer w/in AOI
Identify relative level of mussel colonization			
	Use chart to **identify** mussel **density** at Area of Interest	☒	
	Video/snapshot of **comparison** to mussel **density** reference card	☒	0840 hrs video - None w/in AOI, heavy outside AOI
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☒	Heavy outside AOI
	Video/snapshot of **comparison** to mussel **density** reference card	☒	
Biota sampling @ Area of Interest		☐	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from **topside**	☒	45.82151744 84.75908201 - coords for biota site, not AOI
	Collect one **sample** from Area of Interest	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if AOI is small, receive confirmation from topside	☒	
	Repeat paired sampling 3 feet upcurrent of Area of Interest, verify collection of 4 total **samples**	☒	
Random-select number **(10-30)**, ROV **navigates** that distance in feet **along pipeline**		☒	~~May not do this~~ 19 - random number
	Proceed into current that distance (in feet) and touch pipeline	☒	for coords above
Slow pan of pipeline by ROV and/or diver		☒	
	Evaluate for **Area(s)** of Interest, **holidays**, maintenance **signs**	☒	
	Confirm, and identify if **possible**, if multiple layers of biota are present	☒	yes
Identify relative level of mussel colonization		☐	
	Use chart to **identify** mussel **density**	☒	Heavy
	Video/snapshot of **comparison** to mussel **density** reference card	☐	used ROV
Biota thickness measures via flexible tape		☐	
	Measure 1 at site where pipeline was first touched	☐	
	Measure 2 **approx.** 3' north or south from measure 1	☐	NR
	Measure 3 approx. 3' north or south from measure 2	☐	
Clean pipe measures		☐	
	Remove all attached material then measure circumference at 3 biota **thickness measure** sites	☐	NR
Biota sampling	6 samples	☒	
	Diver walk **upcurrent slightly** from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from **topside**	☒	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	didn't on bottom of pipe - not accessible
	Hold second sample container in front of camera, collect sample as close as **possible** to first sample, receive confirmation from **topside**	☒	
	Repeat paired sampling on the other areas of **pipeline**	☒	
	Confirm collection of ~~8 samples~~ (or 6 if pipeline is buried)	☒	only 6 samples
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☒	- Ryan discussed w/ Gary (ITP) Gary flipped so
	Transfer biota into **individual ziplocs** containing ethanol, label ziploc	☒	
	Place **ziplocs** into coolers	☒	
	Take representative photos (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and sample shipment	☒	

Samples taken on west side of pipe

0859 viewed top of pipe @ AOI apparent ridge of paper wrap (ALSO ON FIELD DATA SHEET)

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Biota + designated AOI site

Line 5 field data sheet

Date: 8 / 26 /2017 **Time:** 1435 **hrs** **Crew initials:** RH, DK, SK

Pipeline: East or West (circle) **Lat N** [redacted]

SITE ID: W-AOI3, 36, 32 @ AOI

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☐ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** ~~(50-100')~~ 100 - 150' DK 8/15 ☒ C-South, **"CS"** (150-200') ☐ Other:

BIOTIC SAMPLING: 45.81671491 84.76599389

Sample ID Key ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

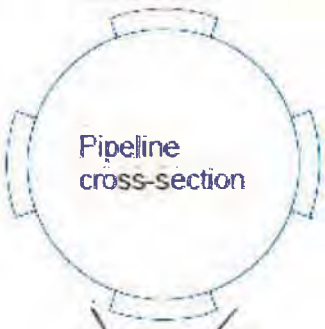
Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Biota layers - multiple outside AOI, ~~single~~ multiple within AOI DK 9/21
current going slightly southwest
Mussel density @ AOI = sparse ; heavy @ Biota
Water depth: 178'
Water temp: 42°F
Sample container sequence: 8, 2, 3, 1 [AOI]
[Biota] = 7, 12, 4, 11, 9, 6
[2:17:51] good video

Container #'s: ✓7 GEI & ✓12 MIC/SRB

WEST

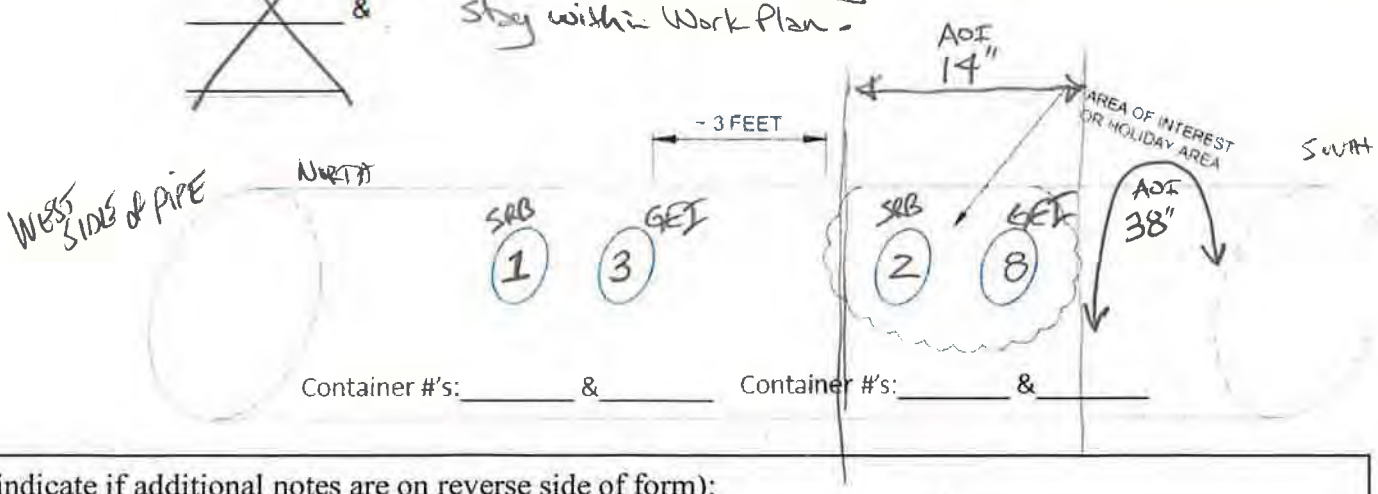
Container #'s: ✓4 MIC/SRB & ✓11 GEI



Container #'s: ✓9 GEI & ✓6 MIC/SRB

~~Container #'s: & ~~

not accessible - discussed moving downcurrent - but didn't to stay within Work Plan.



Container #'s:_____ &_____ Container #'s:_____ &_____

Notes (also indicate if additional notes are on reverse side of form):

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Water sample taken @ 1:52 PM
178'

7 Areas of Interest at Biota Sites Sampling Checklist - *for use at 7 Biota Sites Coinciding with Area of Interest*

Date: 8/26/17 Time: Location ID: W-A013, S6, B2 Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK, SK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☒	
	Focus on Area of Interest	☒	
	Evaluate for other Area(s) of Interest, **holidays**, maintenance **signs**	☒	NO HOLIDAYS OBSERVED
	If Holiday is identified, **incorporate Holiday** Biota sampling protocol	☐ N/A	
	Confirm, and **identify if possible**, if **multiple layers** of biota are present	☒	multiple layers
Identify relative level of mussel colonization			
	Use chart to **identify** mussel **density** at Area of Interest	☒	AOI is SPARSE; outside AOI is heavy
	Video/snapshot of **comparison** to mussel **density** reference card	☒	- see video -
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☒	Heavy
	Video/snapshot of **comparison** to mussel **density** reference card	☒	- see video -
Biota sampling @ Area of Interest		☐	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from **topside**	☒	
	Collect one sample from Area of Interest	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if AOI is small, receive confirmation from **topside**	☒	
	Repeat paired sampling 3 feet upcurrent of Area of Interest, verify collection of 4 total samples	☒	
Random-select number (10-30), ROV navigates that distance in feet along pipeline		☒	~~May not do this~~ 15 is number w/ ROV
	Proceed into current that distance **(in feet)** and touch **pipeline**	☐	Used random number generator and ROV
Slow pan of pipeline by ROV and/or diver		☒	
	Evaluate for Area(s) of **Interest, holidays**, maintenance **signs**	☒	
	Confirm, and identify if **possible**, if **multiple layers** of biota are **present**	☒	Single layer w/in AOI; Multiple outside AOI SK 8/26/17
Identify relative level of mussel colonization		☐	
	Use chart to identify mussel density	☒	Heavy
	Video/snapshot of **comparison** to mussel **density** reference card	☒	- see video
Biota thickness measures via flexible tape		☐	NR
	Measure 1 at site where pipeline was first touched	☐	NR
	Measure 2 **approx.** 3' north or south from measure 1	☐	NR
	Measure 3 approx. 3' north or south from measure 2	☐	NR
Clean pipe measures		☐	NR
	Remove all attached material then measure circumference at 3 biota thickness measure sites	☐	NR
Biota sampling		☒	
	Diver walk **upcurrent slighlty** from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample **ID**, receive confirmation from **topside**	☒	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	ONLY 6 SAMPLES DID NOT ACCESS BOTTOM OF PIPE
	Hold second sample container in front of camera, collect sample as close as **possible** to first **sample**, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of **pipeline**	☒	
	Confirm collection of 8 samples (or 6 if pipeline is buried)	☒	ONLY 6 SAMPLES - bottom of pipe not accessible
Topside sample handling		☒	
	Receive **samples** from diver, **match** containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, **assign** before transfer to **ziploc**	☒	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☒	
	Place ziplocs into coolers	☒	
	Take representative **photos** (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and **sample shipment**	☒	

DISCUSSED ABILITY TO ALSO OBTAIN BIOTA THICKNESS MEASUREMENTS AT AREA DOWNCURRENT OR APART FROM RANDOM # TO ENABLE CIRCUMF. MEASUREMENTS – TRISHA TALKED W/ J.S. – STICK TO WORK PLAN (NO SHIFT TO GET MEASUREMENTS)

ANCHOR 1% SOUTH OF AOI – installed in 2012

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Line 5 field data sheet

Date: 8 / 29 /2017 **Time:** 1804 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) (AOI) **Lat N:** [redacted]

Biota site:

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☒ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** ~~(50-100')~~ 100-150' DK 8/15 ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key Enbridge Site ID (on video monitor) - W-AOI7, S8, B4

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Sample IDs (list below)

WPZAST 09 } AOI
WPZAST 06
WPZAST 04 } Biota
WPZAS E 07
WPZAS W 11

GEI →

APB/ SRB/ Microbial

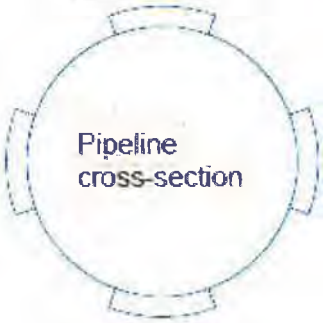
WPZAST 01 } AOI
WPZAST 02
WPZAST 08 } Biota
WPZAS E 03
WPZAS W 12

Top

Container #'s: 08 & 04 GEI

West

Container #'s: 11 GEI & 12



East

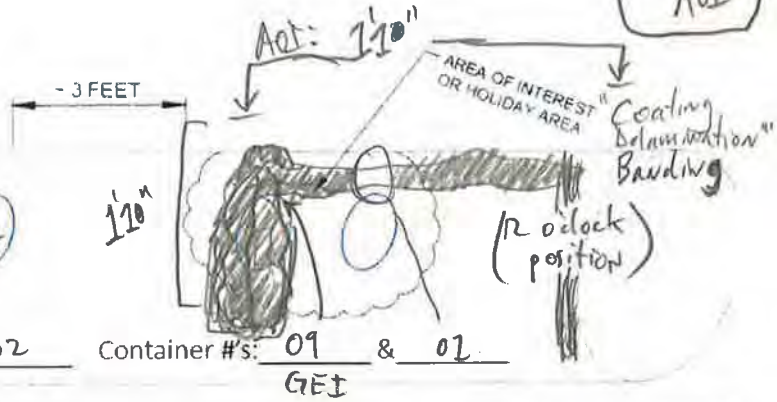
Container #'s: 03 & 07 GEI

Biota layers: multiple
mussels: sparse
Depth (ft): 80'
Water temp (F): 55°
Container order: 09, 01, 02, 06 (AOI)
11, 12, 08, 04, 03, 07 (Biota)

Container #'s: ~~____~~ & N/A - bottom buried

← N

22" x 22" AOI



GEI 06 02

Container #'s: 06 & 02 Container #'s: 09 & 01 GEI

Notes (also indicate if additional notes are on reverse side of form): Significant sand deposition so no bioclock samples, no circumference measurements. Samples will have minimal mass/volume. No holidays observed. Few mussels in samples, all were alive.

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7 Areas of Interest at Biota Sites Sampling Checklist - *for use at 7 Biota Sites Coinciding with Area of Interest*

Date: 8/29/17 Time: 1804 Location ID: Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK West leg, Zone A south (Site ID: W-AOI7, S8, B4 - Enbridge site ID)

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☒	
	Focus on Area of Interest	☒	Lathe/board 1657:40 video
	Evaluate for other Area(s) of Interest, holidays, maintenance signs	☒	No holidays observed
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☒	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple
Identify relative level of mussel colonization			
	Use chart to identify mussel density at Area of Interest	☒	Sparse, possibly some under periphyton
	Video/snapshot of comparison to mussel density reference card	☒	1700 hrs
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☒	Sparse ↓
	Video/snapshot of comparison to mussel density reference card	☒	" within AOI + 3' upcurrent
Biota sampling @ Area of Interest		☐	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	1724 hrs
	Collect one sample from Area of Interest	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if AOI is small, receive confirmation from topside	☒	
	Repeat paired sampling 3 feet upcurrent of Area of Interest, verify collection of 4 total samples	☒	
Random-select number (10-30), ROV navigates that distance in feet along pipeline		☒	~~May not do this~~ 15 = random number
	Proceed into current that distance (in feet) and touch pipeline	☒	
Slow pan of pipeline by ROV and/or diver		☒	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple - biota, periphyton
Identify relative level of mussel colonization		☒	
	Use chart to identify mussel density	☒	sparse 1702 hrs
	Video/snapshot of comparison to mussel density reference card	☒	Sparse ↓
Biota thickness measures via flexible tape		☐	
	Measure 1 at site where pipeline was first touched	☐	
	Measure 2 approx. 3' north or south from measure 1	☐	N/A - bottom buried by sand
	Measure 3 approx. 3' north or south from measure 2	☐	
Clean pipe measures		☐	
	Remove all attached material then measure circumference at 3 biota thickness measure sites	☐	
Biota sampling		☒	
	Diver walk upcurrent slightly from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	ROV lost communication / video
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	during biota sampling
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Confirm collection of ~~8 samples~~ (or 6 if pipeline is buried)	☒	6 - pipeline buried
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☒	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☒	
	Place ziplocs into coolers	☒	
	Take representative photos (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and sample shipment	☒	

AOI sampling

Line 5 field data sheet REDACTED SUBMITTAL - PUBLIC COPY

Date: 8 / 30 /2017 **Time:** 1400 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☒ A-South, **"AS"** (50-100') ☒ B-South, **"BS"** ~~(50-100')~~ 100 - 150' DK 8/15 ☐ C-South, **"CS"** (150-200') ☐ Other:

Zone B south

Sample ID Key ITP ID: E-AOI3 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) B (bottom) E (east) W (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

RH - 8/30/17
Figure 1 symbol showed location in Zone A South. However, 107' @ pipeline so ID will be zone B

Video 1323 hrs, 1331 hrs.

Biota layers: Multiple
Mussels: Sparse @ AOI, heavy outside
Depth: 107'
Temp(F): ~~Estimated 49°F (off ROV)~~ RH 8/30/17 50°F
Container order: 10, 01, (w/in AOI)
08, 11 (outside[N] of AOI)

Container #'s: _____ & _____

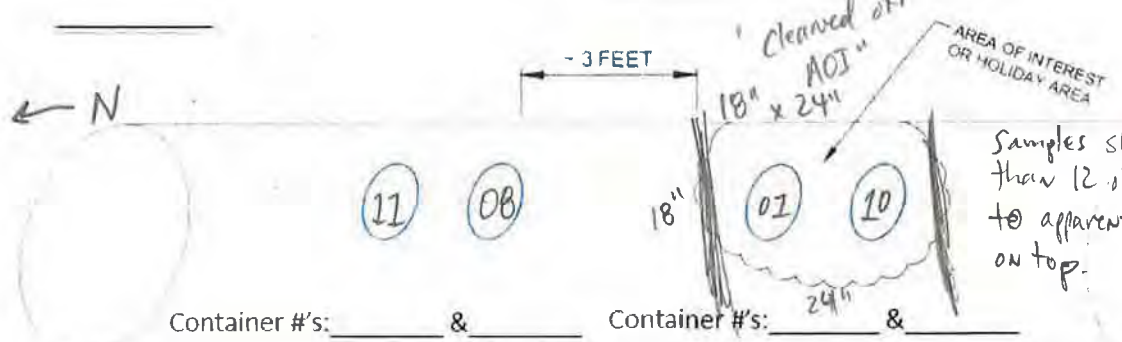
Container #'s: _____ & _____

Container #'s: _____ & _____

Container #'s: _____ & _____

No holiday

Samples to be disposed of per MDNR permit.



Samples slightly lower than 12 o'clock due to apparent scrape on top.

Container #'s: _____ & _____ Container #'s: _____ & _____

Notes (also indicate if additional notes are on reverse side of form): Pipe on lake bed. Cleaned off "band" on pipeline. Heavy mussels outside AOI, sparse within. AOI samples very little biomass/volume.

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11 Areas of Interest, 3 "Additional Sites" (non-Biota Sites) Checklist

Date: 8/30/17 Time: ~~1530~~ 1400 Location ID: East leg, zone A south (E-AOI3) Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☒	
	Focus on Area of Interest	☒	
	Evaluate for other Area(s) of Interest, holidays, maintenance signs	☒	No holiday
	If Holiday is identified, incorporate Holiday Biota sampling protocol and checklist. Biota sampling only if Holiday found.	☒	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	
Identify relative level of mussel colonization			
	Use chart to identify mussel density at Area of Interest	☒	
	Video/snapshot of comparison to mussel density reference card	☒	Sparse @ AOI 1323 hrs
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☒	Heavy to N/S of AOI ↓
	Video/snapshot of comparison to mussel density reference card	☒	

AOI site

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Line 5 field data sheet

Date: 8 / 30 /2017 **Time:** 1530 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☐ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** ~~(50-100')~~ 100-150' or 8/15 ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key ITP ID: E-AOI4 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02.....12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Figure 1 shows symbol in Zone A south. However, depth 102' so Zone B

(Video: 1450-1452, 1458) Biota: Multiple
Mussels: Sparse w/in AOI, heavy outside AOI
Depth(ft): 102'
Temp(F):
Container order: 05, 02, (AOI)
03, 12 (outside AOI)

Container #'s: _____ & _____

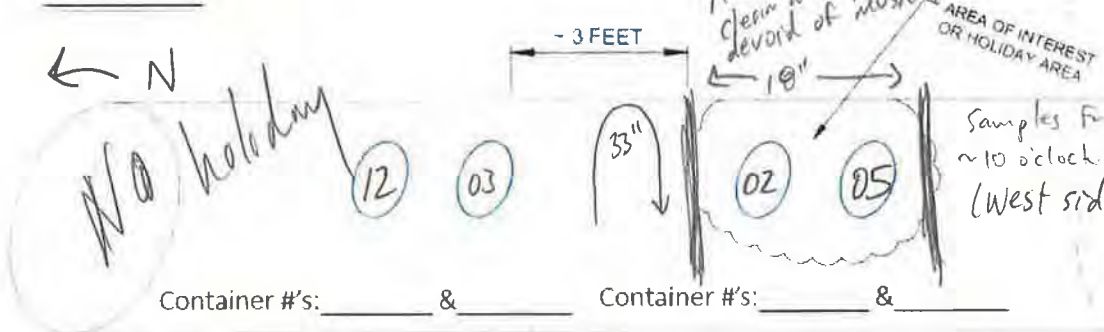
Container #'s: _____ & _____

Container #'s: _____ & _____

Container #'s: _____ & _____

No holiday observed - Samples disposed of per MDNR permit.

Area of Interest - clean area, mostly devoid of mussels etc.



Notes (also indicate if additional notes are on reverse side of form): Similar to AOI3, a "band" of the pipeline is cleaned off relative to surrounding areas. Note, more biota @ ~10 o'clock position where samples were collected as compared to area between 10 + 2 positions, including top of pipe.

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AOI 4

11 Areas of Interest, 3 "Additional Sites" (non-Biota Sites) Checklist

Date: 8/30/17 **Time:** 1530 **Location ID:** **Depth (ft) @ pipeline:** [redacted]

Crew initials: RH, DK East leg JTP: E-AOI4

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	Video start 1450
ROV arrival at AOI, slow pan of pipeline with ROV		☒	
	Focus on Area of Interest	☒	
	Evaluate for other **Area(s)** of Interest, **holidays, maintenance signs**	☐	As with all AOIs, samples proactively collected. Will be analyzed only if holiday found.
	If Holiday is identified, incorporate Holiday Biota sampling protocol and checklist. Biota **sampling only** if **Holiday** found.	☒	
	Confirm, and **identify** if **possible**, if **multiple layers** of biota are **present**	☒	Multiple
Identify relative level of mussel colonization			
	Use chart to **identify** mussel **density** at Area of Interest	☒	Sparse
	Video/snapshot of **comparison** to mussel **density** reference card	☒	1450-1452
	Use chart to **identify** mussel density 3 feet **upcurrent** of Area of Interest	☒	Heavy 1452
	Video/snapshot of **comparison** to mussel **density** reference card	☐	

No holiday observed

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AOI + biota site by F-35

Line 5 field data sheet

Date: 9 / 5 /2017 **Time:** 1225 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, "AN" (50-100') ☐ B-North, "BN" (100-150') ☐ C-North, "CN" (150-200') ☐ "D" (> 200')

☒ A-South, "AS" (50-100') ☐ B-South, "BS" ~~(50-100')~~ 100-150' DK 8/15 ☐ C-South, "CS" (150-200') ☐ Other:

Sample ID Key Site ID: E-AOI7, S8, B3 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Biota sampling ~1145 hrs.

Top

Container #'s:

03 & APB/SRB

09 GEI

Biota layers: multiple
mussels: sparse w/in AOI, heavy outside also heavy @ biota site

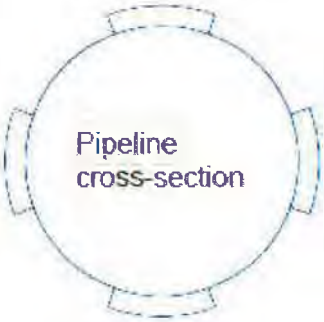
Bottom ~~Sample~~ depth (ft): 81'
Water temp (F): 52
Container order: 10, 12, 11, 02 (AOI)
03, 09, 06, 04, 07, 01, (Biota site)
08, 05

West

Container #'s:

APB/SRB 06 &

GEI 04



East

Container #'s:

08 & GEI

05 APB/SRB

see notes below

APB/SRB samples	GEI samples
EPZASW11 12 } AOI	EPZASW10 } AOI
EPZASW11	EPZASW02
T 03, E 05, B 07, W 06 } Biota	T 09, E 08, B 01, W 04 } Biota

EPZASW10 – also used for APB/SRB due to loss of sample in container 12

Two "similar" in appearance AOIs w/in 5' of each other. Selected the one closest to GPS coords

Container #'s:

07 & APB/SRB

01 GEI

Bottom

N←

Circumference measures: (~1200 hrs)

Pre-cleaned 1): 71"
Cleaned: 64.5"

Pre-cleaned 2): 71"
Cleaned: 64.5"

Pre-cleaned 3): 70.25"
cleaned: 64.5"

~ 3 FEET

29" wide (N-S)

AREA OF INTEREST OR HOLIDAY AREA

Westside GEI 02 APB/SRB 11

APB/SRB ~~12~~ GEI 10

Sample lost during attempted transfer to mesh – minimal material will attempt to get APB/SRB from container #10

34"

Container #'s: _____ & _____ Container #'s: _____ & _____

Notes (also indicate if additional notes are on reverse side of form): Bottom @ biota site appears to be accessible. If so, measures taken from undisturbed area. Possible apparent calcium area but very small. No anomalies @ biota site. Mentioned that there was a desire to get more of the white substance for lab analysis. Trish checked w/ Joe S. via text who said not to remove any of it. Communicated to Trish that Enbridge environment should be made aware of that.

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7 Areas of Interest at Biota Sites Sampling Checklist - *for use at 7 Biota Sites Coinciding with Area of Interest*

Date: 9/5/17 Time: 1225 Location ID: E-AOI7, S8, B3 Depth (ft) @ pipeline: [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☐	
	Focus on Area of Interest	☐	1051 hrs
	Evaluate for other Area(s) of Interest, holidays, maintenance signs	☐	
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple
Identify relative level of mussel colonization			
	Use chart to identify mussel density at Area of Interest	☒	Sparse w/in AOI
	Video/snapshot of comparison to mussel density reference card	☒	1051 hrs
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☒	Heavy
	Video/snapshot of comparison to mussel density reference card	☒	1051 hrs
Biota sampling @ Area of Interest		☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect one sample from Area of Interest	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if AOI is small, receive confirmation from topside	☒	
	Repeat paired sampling 3 feet upcurrent of Area of Interest, verify collection of 4 total samples	☒	
Random-select number (10-30), ROV navigates that distance in feet along pipeline		☒	~~May not do this~~ Random # = 15
	Proceed into current that distance (in feet) and touch pipeline	☒	North via ROV
Slow pan of pipeline by ROV and/or diver		☐	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple
Identify relative level of mussel colonization		☒	
	Use chart to identify mussel density	☒	heavy
	Video/snapshot of comparison to mussel density reference card	☒	~1055
Biota thickness measures via flexible tape		☒	
	Measure 1 at site where pipeline was first touched	☒	71"
	Measure 2 approx. 3' north or south from measure 1	☒	71"
	Measure 3 approx. 3' north or south from measure 2	☒	70.25"
Clean pipe measures		☒	
	Remove all attached material then measure circumference at 3 biota thickness measure sites	☒	1) 64.5" 2) 64.5" 3) 64.5"
Biota sampling		☒	
	Diver walk upcurrent slighlty from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Confirm collection of 8 samples (or 6 if pipeline is buried)	☒	8 samples
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☒	☆ See note on FDS re: loss of sample in container #12. Very minimal mass b/c taken from AOI. Used sample #10 for both APB/SRB + to send to GEI
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☒	
	Place ziplocs into coolers	☒	
	Take representative photos (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and sample shipment	☒	

Gobies abundant

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Line 5 field data sheet

Date: 9 / 5 /2017 **Time:** 1415 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☒ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** (~~50-100'~~) 100-150' DK 8/15 ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key Site ID: E-AOI6 ***Sample IDs (list below)***

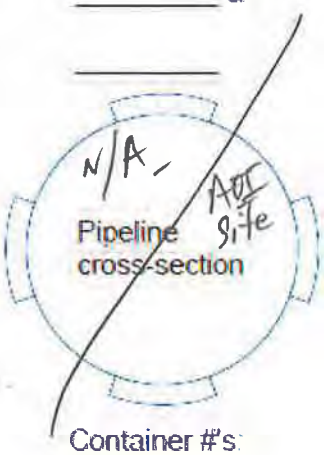
Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

Example Sample ID: ***EPBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Biota layers: multiple - biofilm, periphyton
mussels: sparse w/in AOI, heavy outside
Depth (ft): 82
Water temp:
Container order: 05, 12 (AOI)
11, 07

Container #'s: _____ & _____

Container #'s: _____ & _____

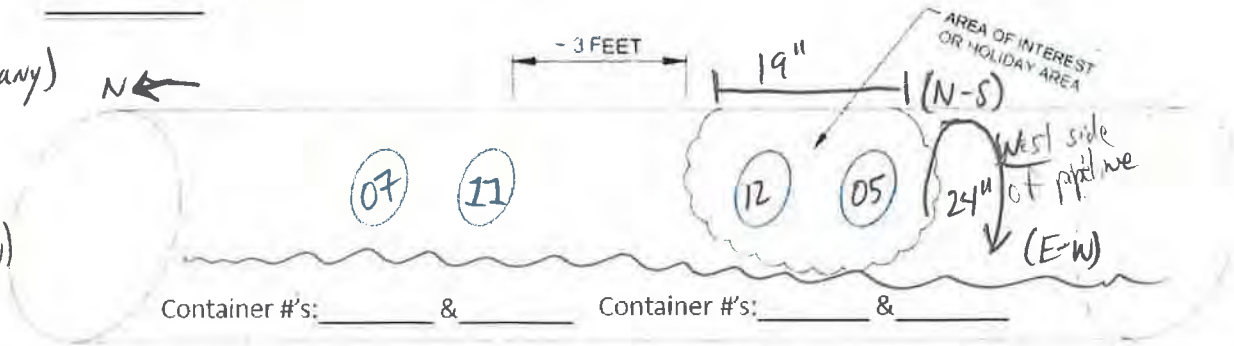


Container #'s: _____ & _____

Container #'s: _____ & _____

No holiday - samples disposed of per MDNR permit

Biota measurements (if any)
1)
2) N/A - AOI site
3)
Clean pipe measures (if any)
1)
2)
3)



Notes (also indicate if additional notes are on reverse side of form): Winds hit 25 knots on crane after sampling. Dislodged coating (presumably outer coating) brought up by diver. Sample ID 170905-EAOI6DC. APB/SRB van will send to GEI for biota measures + to hold. Discussed this with Dave Stafford.

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AOI site

11 Areas of Interest, 3 "Additional Sites" (non-Biota Sites) Checklist			
Date: 9/5/17	Time: 1415	Location ID: E-AOI6	Depth (ft) @ pipeline: [redacted]
Crew initials: RH, DK			

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at Area of Interest		☒	1315 hrs
Slow pan of pipeline		☒	
	Focus on AOI/Additional Site	☒	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☐	
Identify relative level of mussel colonization		☒	
	Use chart to identify mussel density within inspection area	☒	
	Video/snapshot of comparison to mussel density reference card	☒	Sparse w/in AOI, heavy outside
	Use chart to identify mussel density 3 feet upcurrent of Holiday (where other paired sample is to be taken) if identified	☒	Heavy
	Video/snapshot of comparison to mussel density reference card	☒	1318
Biota sampling @ AOI/Additional Site		☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☐	No holiday –
	Collect one sample from AOI/Additional Site	☐	
	Hold second sample container in front of camera, collect sample ~6" from first sample, receive confirmation from topside	☐	Samples disposed of
	Repeat paired sampling 3 feet upcurrent of AOI/Additional Site, verify collection of 4 total samples	☐	
	Clean off/inspection of sampling areas and AOI	☐	per MDNR permit
	If holiday is found, keep samples for analysis If no anamolies found, samples disposed of as per, DNR permit	☐	
Topside sample handling			
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

Proactive sample collection – will only keep for analysis if holiday is found.

- See FDS for "dislodged coating" (presumably outer) sample brought up by diver.

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Line 5 field data sheet

Date: 9 / 6 /2017 **Time:** 1008 Samples disposed of per MDNR **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☒ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** (100-150') ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key Site ID: E-AOI 8 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

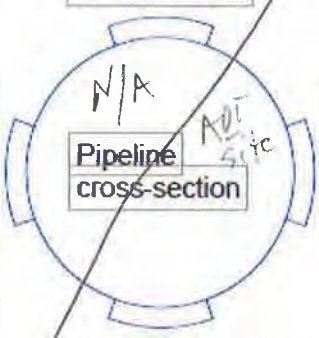
Example Sample ID: ***EPZBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPZDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Sampling ~ 0923 hrs on video.

Biota layers: Multiple
Mussels: Sparse w/in AOI
Depth (ft): 81'
Temp (F): 55°F
Container order: 10, 02 (AOI)
06, 01 (outside AOI) - 3' N of AOI

Container #'s: _____ & _____

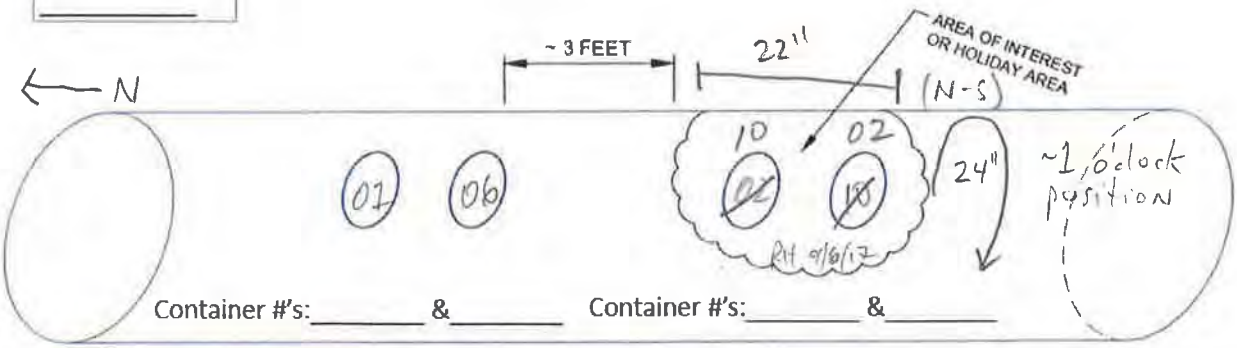
Container #'s: _____ & _____



Container #'s: _____ & _____

No holiday observed

Container #'s: _____ & _____



Container #'s: _____ & _____ Container #'s: _____ & _____

Notes (also indicate if additional notes are on reverse side of form): Lots of sand in area. No holiday observed so samples disposed of per MDNR permit.

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AOI +

RH 9/6/17

Holiday Area Biota Sampling Checklist ~~, only fill out if Holiday Area is found~~

Date: 9/6/17 **Time:** 1000 **Location ID:** F - AOI 8 **Depth (ft) @ pipeline:** [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at ~~potential Holiday Area~~ AOI		☒	
Slow pan of pipeline		☐	
	Focus on Holiday Area	☐	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	0856 hrs
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple - biofilm, periphyton
Identify relative level of mussel colonization		☒	
	Use chart to identify mussel density at ~~Holiday Area~~ AOI	☒	Spoke w/ AOI
	Video/snapshot of comparison to mussel density reference card	☒	0858 - 0859
	Use chart to identify mussel density 3 feet upcurrent of ~~Holiday Area~~ AOI	☒	Heavy outside AOI
	Video/snapshot of comparison to mussel density reference card	☒	0901 hrs
Biota sampling @ ~~Holiday Area~~ AOI		☒	Sampling ~ 0922 - 0927 hrs
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect one sample from ~~Holiday Area~~ AOI	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if Holiday Area is small, receive confirmation from topside	☒	No holiday observed
	Repeat paired sampling 3 feet upcurrent of ~~Holiday Area~~ AOI, verify collection of 4 total samples	☒	- Samples disposed of
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	per MDNR permit
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

- Proactive sample collection - will dispose of samples per MDNR permit if holiday isn't observed.

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AOI

Line 5 field data sheet

Date: 9 / 6 /2017 **Time:** 1120 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, **"AN"** (50-100') ☐ B-North, **"BN"** (100-150') ☐ C-North, **"CN"** (150-200') ☐ "D" (> 200')

☒ A-South, **"AS"** (50-100') ☐ B-South, **"BS"** (100-150') ☐ C-South, **"CS"** (150-200') ☐ Other:

Sample ID Key Site ID: E-AOI9 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN** **ZBN** **ZCN** **ZD** **ZAS** **ZBS** **ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

Example Sample ID: ***EPZBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPZDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

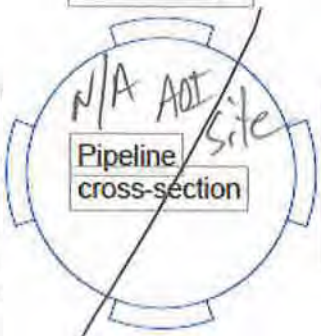
Sampling @ AOI ~ 1045 hrs

Container #'s: _____ & _____

Container #'s: _____ & _____

Container #'s: _____ & _____

Container #'s: _____ & _____



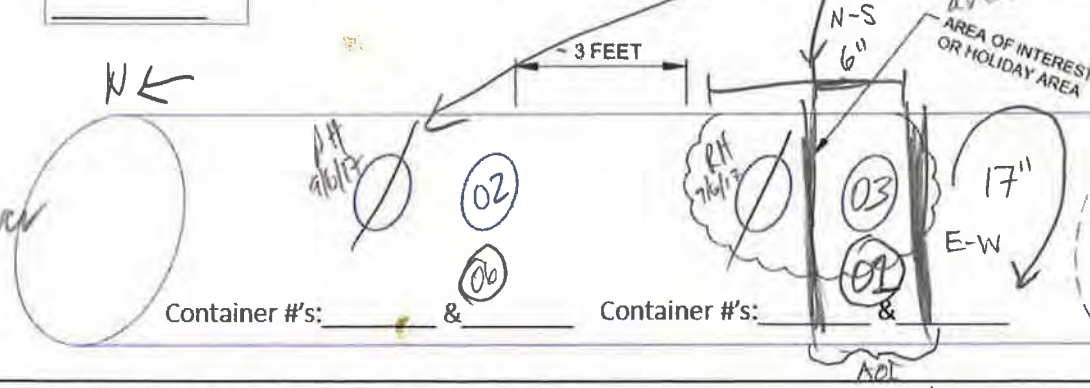
Biota layers: Multiple
Mussels: Moderate, almost heavy
Depth (ft): 82
Temp (F): 55°F
Container order: 01, 03 (AOI)
06, 02 (3' North of AOI)
↳ #4 was used to put (Material found @ end of dive)

No holiday

Paired samples taken vertically to stay w/in AOI & undist. bed area outside AOI

AOI more "vertical" so vertical paired samples instead of horizontal.

Material found by pipeline @ end of inspection placed into sample container #4.



Notes (also indicate if additional notes are on reverse side of form): Pipeline mostly buried, significant amount of sand. "Bands" around pipe. AOI more vertical, wont allow horizontal side by side samples w/in AOI so taking vertical per consensus w/ Gary, Trish, etc. Material in container #4 will be tested for APB/SRB + sent to GEI lab. Sample ID for material of interest: "170906-EAOI9MOI"

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AOI + RH 9/6/17

Holiday Area Biota Sampling Checklist ~~- only fill out if Holiday Area is found~~

Date: 9/6/17	Time: 1120	Location ID: E-AOI9	Depth (ft) @ pipeline: [redacted]
Crew initials: RH, DK			

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at **potential** ~~Holiday Area~~ AOI		☒	
Slow pan of pipeline		☒	Start 1025
	Focus on ~~Holiday Area~~ AOI	☐	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple - biofilm, periphyton
Identify relative level of mussel colonization		☒	
	Use chart to identify mussel density at ~~Holiday Area~~ AOI	☐	1029 hrs Moderate, almost heavy
	Video/snapshot of comparison to mussel density reference card	☒	
	Use chart to identify mussel density 3 feet upcurrent of ~~Holiday Area~~ AOI	☒	Moderate, almost heavy
	Video/snapshot of comparison to mussel density reference card	☒	
Biota sampling @ Holiday Area		☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect one sample from ~~Holiday Area~~ AOI	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if Holiday Area is small, receive confirmation from topside	☒	No holiday observed
	Repeat paired sampling 3 feet upcurrent of ~~Holiday Area~~ AOI, verify collection of 4 total samples	☒	Material found by diver @ end of dive - will be tested for APB/SRB + sent to GEI lab.
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☒	

- Proactive collection of samples @ AOI
- See FDS sheet for notes on sample orientation
- Material of Interest sample 170906-EAOI9MOI

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AOI

Line 5 field data sheet

Date: 9 / 6 /2017 **Time:** 1225 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, "AN" (50-100') ☐ B-North, "BN" (100-150') ☐ C-North, "CN" (150-200') ☐ "D" (> 200')

☒ A-South, "AS" (50-100') ☐ B-South, "BS" (100-150') ☐ C-South, "CS" (150-200') ☐ Other:

Sample ID Key Site ID: E-AOI10 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

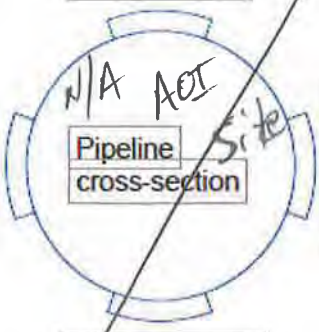
Example Sample ID: ***EPZBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPZDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Good footage of general area ~ 1145-1150 hrs.
Sampling 1200-1205 hrs

Container #'s: _____ & _____

Biota: multiple
Mussels: sparse w/in + outside AOI
Depth (ft): 77
Temp (F):
Container order: 06, 03 (AOI)
04, 12 (outside AOI)

Container #'s: _____ & _____



Container #'s: _____ & _____

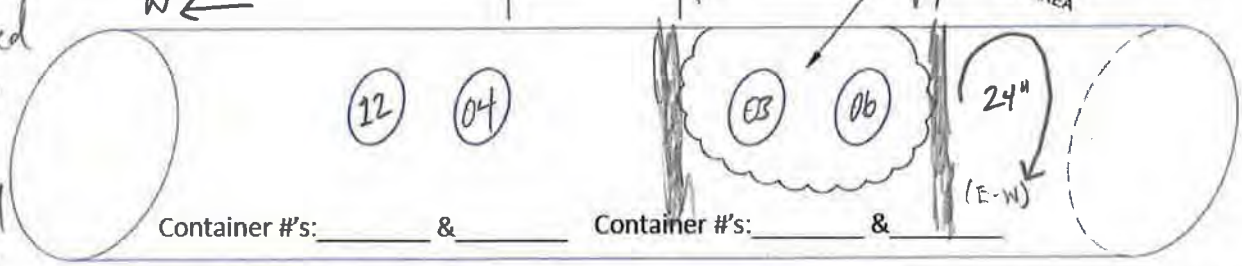
No holiday observed

Container #'s: _____ & _____

Note: symbols for AOI 10 as incorrect on Figure 1 – it's juxtaposed w/ the "Additional Area" (red triangle) just to the North on Fig 1. So E-AOI 10 is actually @ All. site 1 symbol.

Bands that encompass the AOI.

"Banding in general | Area of AOI" some raised off lake bed



Notes (also indicate if additional notes are on reverse side of form): Pipe mostly buried, exposed ~ 11 pm-1 pm. Few "pristine" undisturbed areas but paired samples collected from presumably undisturbed area as no overt indication of maintenance/survey work in area of AOI. Small piece of material pulled up + put into a sampling container. Tested for APB/SRB + sent to GEI lab ID: 170906-EAOI10MOI

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AOI +

RH 9/6/17

AOI

Holiday Area Biota Sampling Checklist - ~~only fill out if Holiday Area is found~~

Date: 9/6/17 **Time:** 1225 **Location ID:** E-AOI10 **Depth (ft) @ pipeline:** [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at potential Holiday Area		☒	
Slow pan of pipeline		☒	1137 hrs
	Focus on Holiday Area	☒	
	Evaluate for Area(s) of interest, holidays, maintenance signs	☒	No holiday observed
	Confirm, and identify if possible, if multiple layers of biota are present	☒	Multiple - biofilm, periphyton
Identify relative level of mussel colonization		☒	
	Use chart to identify mussel density at ~~Holiday Area~~ AOI	☒	Sparse
	Video/snapshot of comparison to mussel density reference card	☒	1140
	Use chart to identify mussel density 3 feet upcurrent ~~of Holiday Area~~ AOI	☒	Sparse - lots of sand
	Video/snapshot of comparison to mussel density reference card	☒	1141 - 1142
Biota sampling @ Holiday Area		☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	No holiday observed material pulled off pipeline + put into sample container.
	Collect one sample from ~~Holiday Area~~ AOI	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if ~~Holiday Area~~ AOI is small, receive confirmation from topside	☒	
	Repeat paired sampling 3 feet upcurrent ~~of Holiday Area~~ AOI, verify collection of 4 total samples	☒	
Topside sample handling		☐	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

- Proactive sampling - samples disposed of per MDNR permit if no holiday found
- 170906 - EAOI10MOI sample run for APB/SRB, sent to GEI for archiving/holding.

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AOI

Line 5 field data sheet

Date: 9 / 6 /2017 **Time:** 1425 hrs Anchors pulled 1500 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, "AN" (50-100') ☐ B-North, "BN" (100-150') ☐ C-North, "CN" (150-200') ☐ "D" (> 200')

☐ A-South, "AS" (50-100') ☒ B-South, "BS" (100-150') ☐ C-South, "CS" (150-200') ☐ Other:

Sample ID Key Site ID: E-AOI5 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPZBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPZDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Figure 1 shows this as being Zone A (50-100') but over 100' so ID will reflect Zone B.

Container #'s: _____ & _____

Biota layers: multiple
Mussels: Sparse after AOI, heavy outside
Depth (ft): 103'
Temp (F): 50°F
Container order: 05, 10 (AOI)
01, 11 (outside AOI)

Container #'s: _____ & _____

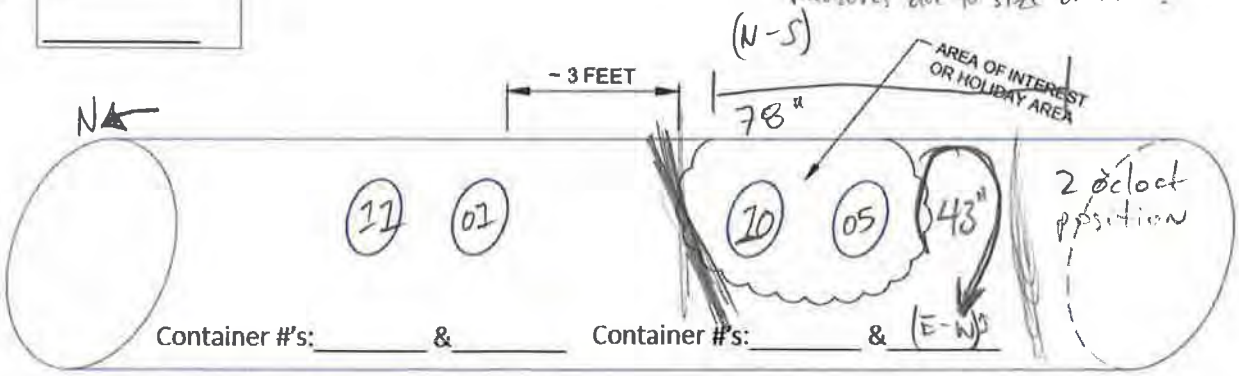
N/A AOI
Pipeline cross-section

Container #'s: _____ & _____

No holiday found

Container #'s: _____ & _____

Long AOI compared to west. Three additional sets of thickness measures due to size of AOI.



Container #'s: _____ & _____ Container #'s: _____ & _____

Notes (also indicate if additional notes are on reverse side of form): Site adjacent to area where anchor was worked on so several disturbed areas. Selected site for AOI was very close (6') to GPS coords and adjacent to an undisturbed area for the other pair of samples. Two thickness measures taken @ areas that diver thought looked different. One was whitish. Thickness readings of 100+ @ both areas.

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AOI +

Holiday Area Biota Sampling Checklist - ~~only fill out if Holiday Area is found~~

Date: 9/6/17 **Time:** Samples dispersed of - anchors pulled 1500 **Location ID:** E-AOIS **Depth (ft) @ pipeline:** bottom [redacted]

Crew Initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☑	
ROV arrival at potential ~~Holiday Area~~ AOI		☑	
Slow pan of pipeline		☑	
	Focus on ~~Holiday Area~~ AOI	☑	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☑	
	Confirm, and identify if possible, if multiple layers of biota are present	☑	Multiple - biofilm, periphyton, mussels @ 6 o'clock
Identify relative level of mussel colonization		☑	
	Use chart to identify mussel density at ~~Holiday Area~~ AOI	☑	Sparse w/in AOI 1350 - 1356 hrs
	Video/snapshot of comparison to mussel density reference card	☑	
	Use chart to identify mussel density 3 feet upcurrent of ~~Holiday Area~~ AOI	☑	Heavy outside AOI 1340 - 1356 hrs
	Video/snapshot of comparison to mussel density reference card	☑	
Biota sampling @ Holiday Area		☑	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☑	
	Collect one sample from ~~Holiday Area~~ AOI	☑	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if ~~Holiday Area~~ AOI is small, receive confirmation from topside	☑	No holiday found
	Repeat paired sampling 3 feet upcurrent of ~~Holiday Area~~ AOI, verify collection of 4 total samples	☑	
Topside sample handling		☑	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

- Proactive sample collection - will dispose of per MDNR permit if holiday is not found.
- Figure 1 shows E-AOIS symbol as being in Zone A. However, bottom is 103' so using Zone B in ID scheme for samples.

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AOI (No samples - No holiday)

Line 5 field data sheet

Date: 9 / 6 /2017 **Time:** 1645 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, "AN" (50-100') ☐ B-North, "BN" (100-150') ☐ C-North, "CN" (150-200') ☐ "D" (> 200')

☒ A-South, "AS" (50-100') ☐ B-South, "BS" (100-150') ☐ C-South, "CS" (150-200') ☐ Other:

Sample ID Key W - AOI6 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02.....12

Example Sample ID: ***EPZBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPZDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Bivalve layers: Multiple
Mussels: Sparse w/in AOI, heavy outside AOI
RH 9/6/17 Depth (ft): ~~88~~ 90'
Temperature (F):
Container order: 08, 09 (AOI)
06, 12 (outside AOI)

Container #'s: _____ & _____

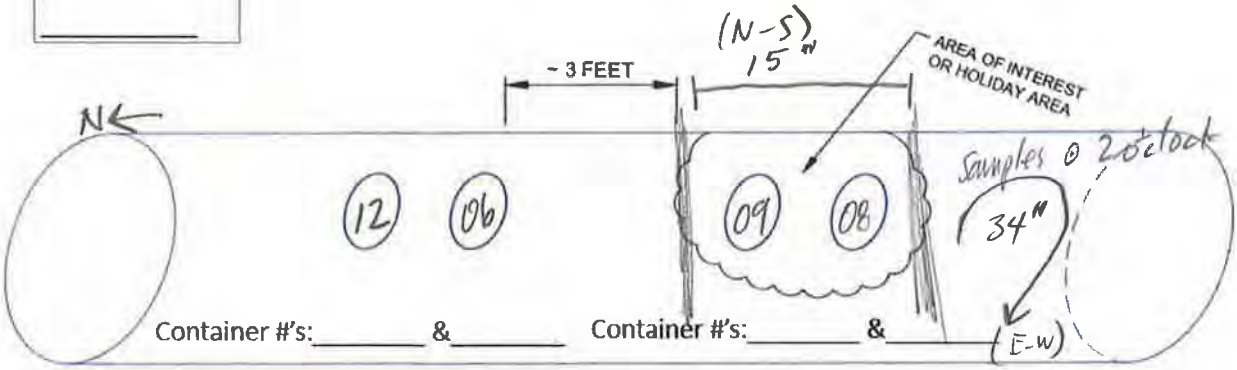
Container #'s: _____ & _____

N/A AOI
Pipeline cross-section

Container #'s: _____ & _____

Container #'s: _____ & _____

No holiday observed
- Dispose of samples per MDNR permit



Notes (also indicate if additional notes are on reverse side of form): Unremarkable AOI - area devoid of mussels etc., surrounded by undisturbed areas w/ heavy mussel growth/colonization. Inspection - outermost "paper" loose in some areas, coating observed underneath though.

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AOI+

AOI

Holiday Area Biota Sampling Checklist ~~- only fill out if Holiday Area is found~~

Date: 9/6/17 Time: 1645 Location ID: W-AOI6 Depth (ft) ~~@ pipeline~~: [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☑	
ROV arrival at ~~potential Holiday Area~~ AOI		☑	
Slow pan of pipeline		☑	
	Focus on ~~Holiday Area~~ AOI	☑	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☑	Multiple - biofilm, periphyton
Identify relative level of mussel colonization		☑	
	Use chart to identify mussel density at ~~Holiday Area~~ AOI	☑	Sparse within AOI
	Video/snapshot of comparison to mussel density reference card	☑	1354 hrs
	Use chart to identify mussel density 3 feet upcurrent of ~~Holiday Area~~ AOI	☑	Heavy outside AOI
	Video/snapshot of comparison to mussel density reference card	☑	1354 hrs
Biota sampling ~~@ Holiday Area~~ AOI		☑	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☑	
	Collect one sample from ~~Holiday Area~~ AOI	☑	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if ~~Holiday Area~~ AOI is small, receive confirmation from topside	☑	No holiday observed
	Repeat paired sampling 3 feet upcurrent of ~~Holiday Area~~ AOI, verify collection of 4 total samples	☑	- Samples to be disposed of per MDNR permit
Topside sample handling		☑	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☐	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

- Proactive collection of paired samples - will be disposed of per MDNR permit if no holiday found.

Biota + AOI

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Line 5 field data sheet

Date: 9 / 7 /2017 **Time:** 1034 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, "AN" (50-100') ☐ B-North, "BN" (100-150') ☐ C-North, "CN" (150-200') ☒ "D" (> 200')

☐ A-South, "AS" (50-100') ☐ B-South, "BS" (100-150') ☐ C-South, "CS" (150-200') ☐ Other:

Sample ID Key W-AOI1,S4,B1 ***Sample IDs (list below)***

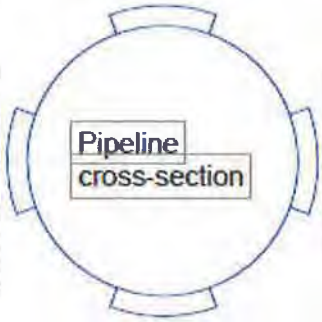
Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPZBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPZDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Biota layers: Multiple - biofilm, mussels
Mussels: Sparse w/in AOI, heavy outside
Depth (ft): 234
Temp (F): 42°F
Container order: 01, 02, 03, 06 (AOI)(outside AOI)
04, 08, 10, 09, 12, 05, 07, 11 (Biota area)

Top
Container #'s: 04 APB/SRB & 08 GEI

West
Container #'s: APB/SRB 10 & GEI 09



East
Container #'s: 07 APB/SRB & 11 GEI

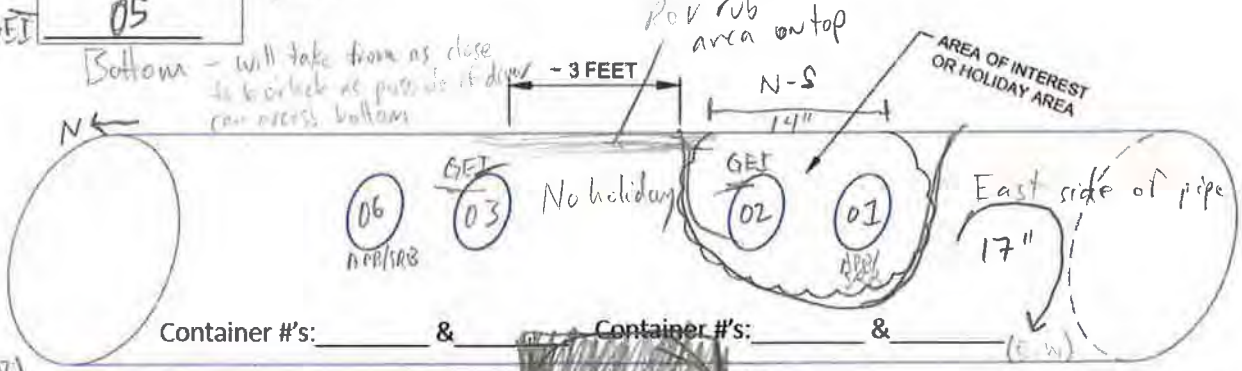
GEI IDs (Biota) APB/SRB Microbial IDs
WPZDT08 E11 B05 W09
WPZDT04 E07 B12 W10

GEI IDs (AOI-related) APB/SRB/Microbial IDs
WPZDE02 WPZDE03
WPZDE01 WPZDE06

Circumference measures
1) Pre-cleaned: 5'9" (69") Cleaned: 5'5" (65")
2) Pre-cleaned: 5'9" (69") Cleaned: 5'5" (65")
3) Pre-cleaned: 5'11" (71") Cleaned: 5'6" (66")

Container #'s: APB/SRB 12 & GEI 05
Samples about RH 9/7/17 ~~7~~ 8 o'clock position

Bottom - will take from as close to 6 o'clock as possible if diver can access bottom



AOI IDs:
APB/SRB WPZDE01 (AOI)
GEI 02
GEI 03 (Outside AOI)
APB/SRB 06

Container #'s: _____ & _____ Container #'s: _____ & _____

Notes (also indicate if additional notes are on reverse side of form): Piece of material resting against pipeline right by the AOI. Unclear what it is. Diver will collect if potentially pipeline related.

170907 - WADI1MOI - MATERIAL DIMENSIONS - 16.75" L x 12" W x 3mm H

Duplicate APB/SRB run with WPZDE07. Two samples for Microbial had <1g mass + likely will not be sufficient for DNA extraction

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7 Areas of Interest at Biota Sites **Sampling** Checklist - ***for use at 7 Biota Sites Coinciding with Area of Interest***

Date: 9/7/17 Time: 1034 Location ID: W-AOI1, S4, B1 Depth (ft) @ ~~pipeline~~: bottom

Crew initials: RH, DK [redacted]

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV **navigates to pipeline**		☒	
ROV arrival at **AOI**, slow **pan of pipeline** with ROV		☒	
	Focus on Area of Interest	☒	
	Evaluate for other Area(s) of **Interest, holidays,** maintenance **signs**	☐	
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☐	
	Confirm, and **identify** if **possible,** if **multiple layers** of biota are **present**	☒	Multiple
Identify relative level of mussel **colonization**			
	Use chart to identify mussel density at Area of Interest	☒	Flyover @ 0856-0858
	Video/snapshot of **comparison** to mussel **density** reference card	☒	Sparse w/in AOI
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☒	Heavy but patchy distribution 0856-0858
	Video/snapshot of **comparison** to mussel **density** reference card	☒	
Biota sampling @ Area of Interest		☒	
	Hold first sample container in front of camera to distinguish sample **ID,** receive confirmation from topside	☒	
	Collect one sample from Area of Interest	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if AOI is small, receive confirmation from **topside**	☒	
	Repeat paired sampling 3 feet upcurrent of Area of Interest, verify collection of 4 total **samples**	☒	
Random-select number **(10-30), ROV navigates** that distance in feet **along pipeline**		☒	~~May not do this~~ 11 Feet
	Proceed into current that distance **(in feet)** and touch **pipeline**	☒	
Slow pan of **pipeline by** ROV **and/or diver**		☒	
	Evaluate for Area(s) of Interest, **holidays,** maintenance signs	☒	
	Confirm, and **identify** if **possible,** if **multiple layers** of biota are **present**	☒	
Identify relative level of mussel **colonization**		☒	
	Use chart to **identify** mussel **density**	☒	Heavy
	Video/snapshot of **comparison** to mussel **density** reference card	☒	
Biota thickness measures via **flexible tape**		☒	
	Measure 1 at site where pipeline was first touched	☒	Measures taken by diver #2, Sampling taken by diver #1 See FDS sheet
	Measure 2 **approx.** 3' north or south from measure 1	☒	
	Measure 3 approx. 3' north or south from measure 2	☒	
Clean pipe measures		☒	
	Remove all attached material then measure circumference at 3 biota thickness measure sites	☒	
Biota sampling		☒	
	Diver walk upcurrent slighlty from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample **ID,** receive confirmation from **topside**	☒	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Confirm collection of 8 samples (or 6 if pipeline is buried)	☒	8 samples
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, **assign** before transfer to ziploc	☒	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☒	
	Place ziplocs into coolers	☒	
	Take representative photos (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and **sample shipment**	☒	

Two Samples for Microbial had minimal (<1g) mass

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Line 5 field data sheet

Date: 9 / 7 /2017 **Time:** 1615 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N:** [redacted]

Pipeline zone and water depth range:

☐ A-North, "AN" (50-100') ☐ B-North, "BN" (100-150') ☐ C-North, "CN" (150-200') ☑ "D" (> 200')

☐ A-South, "AS" (50-100') ☐ B-South, "BS" (100-150') ☐ C-South, "CS" (150-200') ☐ Other:

Sample ID Key RH 9/7/17 ~~E A~~ W - AOI2 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
~~EP~~ (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPZBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPZDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

~~Figure 1 indicates symbol is in Zone D but depth 0 bottom~~ RH 9/7/17

Container #'s: _____ & _____

Container #'s: _____ & _____

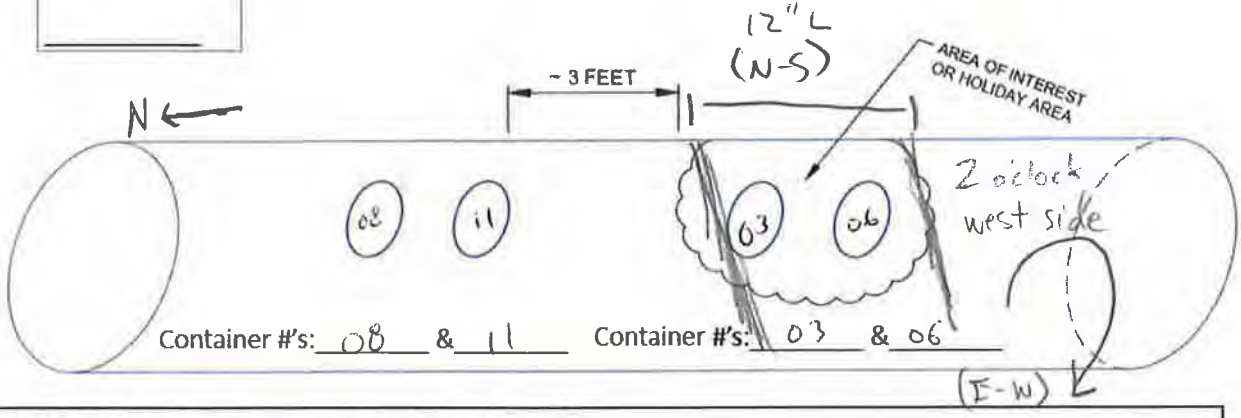
N/A AOI Site

Pipeline cross-section

Container #'s: _____ & _____

Container #'s: _____ & _____

Biota layers: multiple
Mussels: Sparse w/in AOI, heavy outside
Depth (ft): 201'
Temp (F): 45°F
Container order: 06, 03, 11, 08
- AOI MEASURE: 12"L x 60"W
- NO ANOMALIES DETECTED WITHIN AOI
- COLLECTION OF WHITE SUBSTANCE NORTH OF AOI
↳ tested for APB/SRB, will be sent to lab for further testing
ID: 170907 - WAOI2 CD



Container #'s: 08 & 11 Container #'s: 03 & 06

Notes (also indicate if additional notes are on reverse side of form):
Water sample taken from toolbox - Nisken attached to it - ran blank + blank duplicate (APB/SRB) with it - poured water directly over the swabs.

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AOI +

Holiday Area Biota Sampling Checklist - ~~only fill out if Holiday Area is found~~

Date: 9/7/17 **Time:** **Location ID:** **Depth (ft) @ pipeline:**

Crew Initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at potential ~~Holiday Area~~ AOI		☑	
Slow pan of pipeline		☑	1438
	Focus on ~~Holiday Area~~ AOI	☐	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☐	
Identify relative level of mussel colonization		☒	MU High
	Use chart to identify mussel density at ~~Holiday Area~~ AOI	☒	Sparse w/in AOI
	Video/snapshot of comparison to mussel density reference card	☒	1438
	Use chart to identify mussel density 3 feet upcurrent of ~~Holiday Area~~ AOI	☒	Heavy, 1440 hrs
	Video/snapshot of comparison to mussel density reference card	☒	
Biota sampling @ Holiday Area		☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect one sample from ~~Holiday Area~~ AOI	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if ~~Holiday Area~~ AOI is small, receive confirmation from topside	☒	
	Repeat paired sampling 3 feet upcurrent of ~~Holiday Area~~ AOI, verify collection of 4 total samples	☒	No holiday - samples disposed of per MDNR permit
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☐	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☐	
	Place ziplocs into coolers	☐	
	Take representative photos (time-stamped) of sample handling	☐	
	Transport samples to secure, limited access facility for processing and sample shipment	☐	

AOI + biota site

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Line 5 field data sheet

Date: 9 / 8 /2017 **Time:** 1015 **hrs** **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N** [redacted]

Pipeline zone and water depth range:

☐ A-North, "AN" (50-100') ☐ B-North, "BN" (100-150') ☒ C-North, "CN" (150-200') ☐ "D" (> 200')

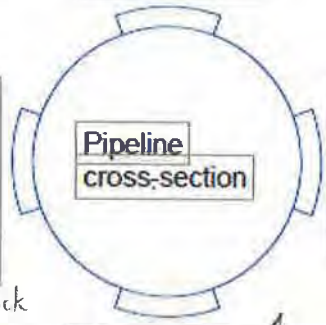
☐ A-South, "AS" (50-100') ☐ B-South, "BS" (100-150') ☐ C-South, "CS" (150-200') ☐ Other:

Sample ID Key Site ID: E-AOI 1, S3, B1 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or **WP** (west pipeline)	**ZAN ZBN ZCN ZD** **ZAS ZBS ZCS**	**T** (top) **E** (east) **B** (bottom) **W** (west)	01, 02……12

Example Sample ID: ***EPZBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPZDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Biota layers: Multiple
Mussels: Moderate within + outside AOI, heavy biota site
Depth(ft): 194'
Temp(F): 42°F
Container order: 03, 14, 08, 05 (AOI, adj. to AOI)
06, 07, 10, 13, 02, 11 (Biota)



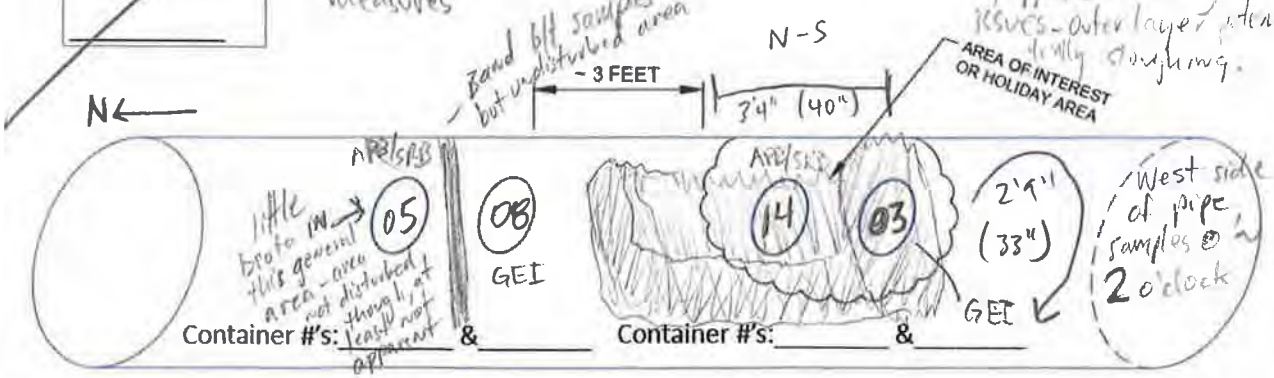
Top
Container #'s: 10 APB/SRB & 13 GEI

West
Container #'s: GEI 06 & APB/SRB 07
more like 10-11 o'clock b/c pipe buried

East
Container #'s: APB/SRB 02 & 11 GEI
more like 1-2 o'clock b/c pipe buried

Container #'s: & ____
N/A - buried
No circumference measures

GEI IDs		Microbial/APB/SRB IDs
EPZCNT13 ↓ E11 W06	(Biota Area)	EPZCNT10 ↓ E02 W07
EPZCNW03 ↓ W08	(AOI Area)	EPZCNW14 ↓ W05



Notes (also indicate if additional notes are on reverse side of form): Also attempting to collect water via mistin attached to toolbox and water chem data via YSI on tool box. Thickness gauges malfunctioned so measures abandoned. Lake water APB/SRB blanks w/ water from 194'. A couple of the randomly-designated samples for APB/SRB had minimal mass such that DNA extraction may not be possible. Three, small patches of whitish material were observed within AOI area. Material wasn't collected given difficulty in collecting it yesterday.

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7 Areas of Interest at Biota Sites Sampling Checklist - *for use at 7 Biota Sites Coinciding with Area of Interest*

Date: 9/8/17 Time: 1015 Location ID: E-AOI1, S3, B1 Depth (ft) @ pipeline: bottom which is [redacted] pipe is

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☒	
	Focus on Area of Interest	☒	0856 + ON...
	Evaluate for other Area(s) of Interest, holidays, maintenance signs	☐	
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	
Identify relative level of mussel colonization			
	Use chart to identify mussel density at Area of Interest	☒	Moderate
	Video/snapshot of comparison to mussel density reference card	☒	
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☒	Moderate
	Video/snapshot of comparison to mussel density reference card	☒	
Biota sampling @ Area of Interest		☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect one sample from Area of Interest	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if AOI is small, receive confirmation from topside	☒	
	Repeat paired sampling 3 feet upcurrent of Area of Interest, verify collection of 4 total samples	☒	
Random-select number (10-30), ROV navigates that distance in feet along pipeline		☒	~~May not do this~~ 21, biota @ ~19' b/c pipe almost completely buried @ 21' - group agreement on this
	Proceed into current that distance (in feet) and touch pipeline	☒	
Slow pan of pipeline by ROV and/or diver		☐	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☐	
Identify relative level of mussel colonization		☒	
	Use chart to identify mussel density	☒	~~Den~~ Heavy
	Video/snapshot of comparison to mussel density reference card	☒	
Biota thickness measures via flexible tape		☐	
	Measure 1 at site where pipeline was first touched	☐	N/A - buried
	Measure 2 approx. 3' north or south from measure 1	☐	
	Measure 3 approx. 3' north or south from measure 2	☐	
Clean pipe measures		☐	
	Remove all attached material then measure circumference at 3 biota thickness measure sites	☐	N/A - buried
Biota sampling		☐	
	Diver walk upcurrent slighlty from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Confirm collection of 8 samples (or 6 if pipeline is buried)	☒	6 samples - pipeline buried on bottom
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☒	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☒	
	Place ziplocs into coolers	☒	
	Take representative photos (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and sample shipment	☒	

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Line 5 field data sheet

Date: 9 / 8 /2017 **Time:** 1545 hrs **Crew initials:** RH, DK

Pipeline: East or West (circle) **Lat N** [redacted]

Pipeline zone and water depth range:

☐ A-North, "AN" (50-100') ☐ B-North, "BN" (100-150') ☐ C-North, "CN" (150-200') ☐ "D" (> 200')

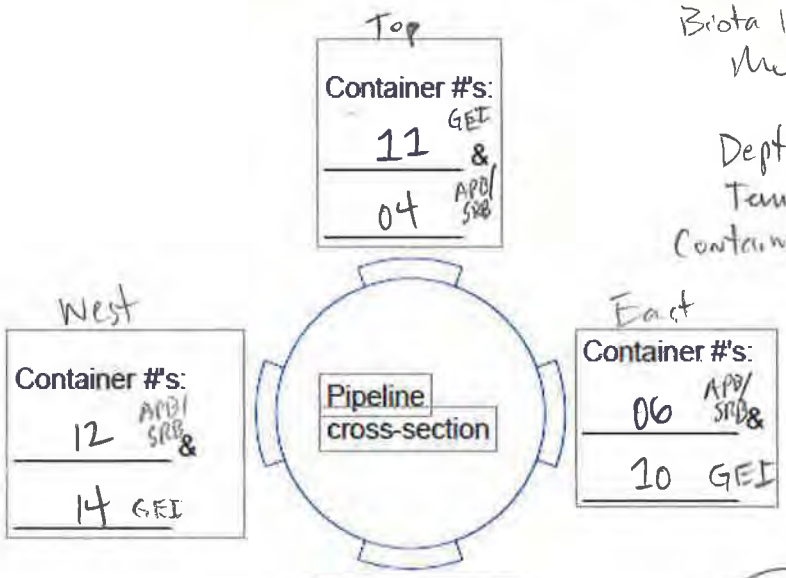
☐ A-South, "AS" (50-100') ☒ B-South, "BS" (100-150') ☐ C-South, "CS" (150-200') ☐ Other:

Sample ID Key W - AOI4, S7, B3 ***Sample IDs (list below)***

Pipeline	Zone	Pipeline position	Sample Container ID
EP (east pipeline) or WP (west pipeline)	ZAN ZBN ZCN ZD ZAS ZBS ok ZCS	T (top) E (east) B (bottom) W (west)	01, 02……12

Example Sample ID: ***EPZBNT01*** – East pipeline, Zone B-north, Top of pipeline, container ID 01
Example Sample ID: ***WPZDB09*** – West pipeline, Zone D, Bottom of pipeline, container ID 09

Biota layers: multiple in AOI + biota area
Mussels: moderate in AOI, heavy 3' to north, heavy @ biota site
Depth (ft): 129' on bottom
Temp (F): 45°F
Container order: 09, 13, 08, 03 (AOI area)
12, 14, 01, 07, 11, 04, 06, 10 (Biota area)



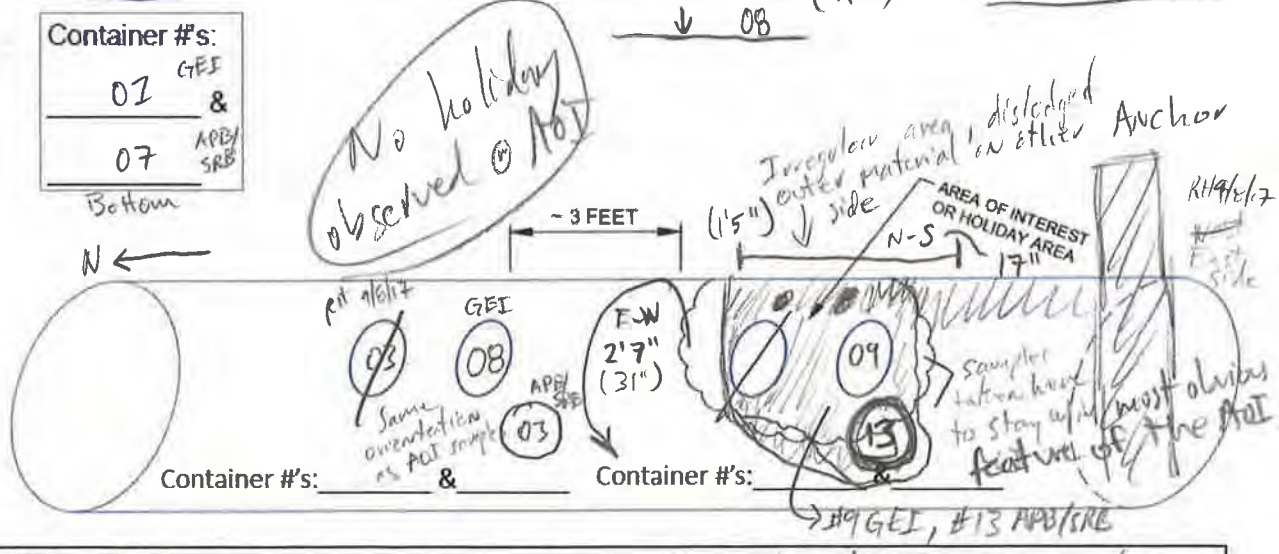
GEI samples		Microbial/APB/SRB samples
WPZBST11	(Biota)	WPZBST04
E10		E06
B01		B07
W14		W12
WPZBSE09	(AOI)	WPZBSE13
08		03

Circumference measures

1) Pre-cleaned: 5'7" (67")
cleaned: 5'5" (65")

2) Pre-cleaned: 5'7.5" (67.5")
cleaned: 5'4" (64")

3) Pre-cleaned: 5'7" (67")
cleaned: 5'4" (64")



Notes (also indicate if additional notes are on reverse side of form): Irregularly shaped AOI. No holidays observed in AOI area. Lake bottom water collected here @ ~129' via niskin bottle on tool crib. Samples from east side of pipe for AOI - confirmed w/ ITP, Enbridge as there was uncertainty b/c "west" was said by diver but corrected in ROV shack.

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7 Areas of Interest at Biota Sites Sampling Checklist - *for use at 7 Biota Sites Coinciding with Area of Interest*

Date: 9/8/17 Time: 1545 Location ID: W-AOI4, S7, B3 Depth (ft) @ pipeline: on bottom [redacted]

Crew initials: RH, DK

Task	Subtask	Complete?	Notes
Deploy ROV into water, ROV navigates to pipeline		☒	
ROV arrival at AOI, slow pan of pipeline with ROV		☒	
	Focus on Area of Interest	☒	
	Evaluate for other Area(s) of Interest, holidays, maintenance signs	☐	1425
	If Holiday is identified, incorporate Holiday Biota sampling protocol	☐	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	1425 Multiple - biofilm, mussels
Identify relative level of mussel colonization			
	Use chart to identify mussel density at Area of Interest	☒	Moderate
	Video/snapshot of comparison to mussel density reference card	☒	
	Use chart to identify mussel density 3 feet upcurrent of Area of Interest	☒	Heavy
	Video/snapshot of comparison to mussel density reference card	☒	
Biota sampling @ Area of Interest		☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect one sample from Area of Interest	☒	
	Hold second sample container in front of camera, collect sample ~6" from first sample or closer if AOI is small, receive confirmation from topside	☒	
	Repeat paired sampling 3 feet upcurrent of Area of Interest, verify collection of 4 total samples	☒	
Random-select number (10-30), ROV navigates that distance in feet along pipeline		☒	~~May not do this~~ 11
	Proceed into current that distance (in feet) and touch pipeline	☐	
Slow pan of pipeline by ROV and/or diver		☒	
	Evaluate for Area(s) of Interest, holidays, maintenance signs	☒	
	Confirm, and identify if possible, if multiple layers of biota are present	☒	multiple
Identify relative level of mussel colonization		☒	
	Use chart to identify mussel density	☒	Heavy
	Video/snapshot of comparison to mussel density reference card	☒	
Biota thickness measures via flexible tape		☒	
	Measure 1 at site where pipeline was first touched	☒	
	Measure 2 approx. 3' north or south from measure 1	☒	See FDS sheet for measurements
	Measure 3 approx. 3' north or south from measure 2	☒	
Clean pipe measures		☒	
	Remove all attached material then measure circumference at 3 biota thickness measure sites	☒	
Biota sampling		☒	
	Diver walk upcurrent slighlty from last measurement site	☒	
	Hold first sample container in front of camera to distinguish sample ID, receive confirmation from topside	☒	
	Collect sample from the top, bottom, or one side of the pipeline (reference N,S,E,W directions)	☒	
	Hold second sample container in front of camera, collect sample as close as possible to first sample, receive confirmation from topside	☒	
	Repeat paired sampling on the other areas of pipeline	☒	
	Confirm collection of 8 samples (or 6 if pipeline is buried)	☒	8 samples colected
Topside sample handling		☒	
	Receive samples from diver, match containers up with position of pipeline they were collected at	☒	
	Randomly select one sample from each pair for GEI lab, designate other set for SRB/APB, assign before transfer to ziploc	☒	
	Transfer biota into individual ziplocs containing ethanol, label ziploc	☒	
	Place ziplocs into coolers	☒	
	Take representative photos (time-stamped) of sample handling	☒	
	Transport samples to secure, limited access facility for processing and sample shipment	☒	

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Line 5 Water &Sediment Field Data Sheet

Date of site visit: 12 / 13 / 2017 **Field Personnel:** [illegible]

Weather Conditions: (circle all that apply)

Clear | Partly Cloudy | Overcast | Precipitation: Rain / Snow / Fog

Wind: Calm | 5-10 kt | 10-15 kt | Above 15 kt | **Direction(s)** N S E W Variable

Other: _____

Location Identification (circle)

Pipeline	Depth Range Zone		Pipe End
EP (east pipeline) or WP (west pipeline)	ZA - 50-100' ZC - 150-200'	ZB - 100-150' ZD - > 200'	N - North S - South

Site Location EAS3 EPZBS

Latitude	Longitude	Waypoint (if applicable)
[redacted]		

Sample ID Key

Site ID	Dash	Type	Sample Specifics	Dash	Sample Number
See Above	-	Water (W)	Surface (S) Mid-column (M) Near Bottom (B)	-	Two-digit sample number
	-	Sediment (S)	Surface Replicate – 1 / 2	-	Two-digit sample number

Water sample example ID: **EPZANWS-01** = First surface water sample from the east pipeline, zone A, on the north end of the pipeline
Sediment sample example ID: **WPZBNS1-06** = Sixth sediment sample collected at the west pipeline, zone B, on the north end of the pipeline

Samples Collected

DATE	Time	Sample ID	Depth (ft)	Time	Sample ID	Depth (ft)
12/13	0845	EPZBS-WS-01	[redacted]			
12/15	0944	EPZBS-WB-05				
	0011	EPZBS-WM-06				
	0947	EPZBS-S1-04				
		EPZBS-S2-05				
		~~EPZBS-S-~~				
		NO DUPLICATE, NOT SUFFICIENT MASS				
			DK 12/15			

Duplicate Samples (if applicable)

Sample ID	Parent Sample ID
EPZBS-	EPZBS-
NO DUPLICATE DK 12/15	

Water Chemistry (if applicable) — SEE YSI DATA

Temp: _____ °C pH: _____ Conductivity: _____ µS/cm

DO: _____ % sat DO: _____ mg/L ORP: _____ mV Turbidity: _____ NTU

OVER

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Additional Notes:

SEDIMENTS PRESENT AT LOCATION WERE MINIMAL - CLAY AND QUAGGA MUSSEL (LIVE AND RELICT SHELL) COMPRISE THE MAJORITY OF BOTH SAMPLES.

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Line 5 Water &Sediment Field Data Sheet

Date of site visit: 12 / 13 / 2017 **Field Personnel:** RH, DK

Weather Conditions: (circle all that apply)

Clear | Partly Cloudy | Overcast | Precipitation: Rain / Snow / Fog

Wind: Calm | 5-10 kt | 10-15 kt | Above 15 kt | **Direction(s):** N S E W Variable

Other: 10°F

Location Identification (circle)

Pipeline	Depth Range Zone	Pipe End
EP (east pipeline) or **WP** (west pipeline)	**ZA** - 50-100' **ZB** - 100-150' **ZC** - 150-200' **ZD** - > 200'	**N** - North **S** - South

Site Location

Latitude	Longitude	Waypoint (if applicable)
[redacted]		

Sample ID Key Site E-10 ~ 83'

Site ID	Dash	Type	Sample Specifics	Dash	Sample Number
See Above	-	Water (**W**)	Surface (**S**) Mid-column (**M**) Near Bottom (**B**)	-	Two-digit sample number
	-	Sediment (**S**)	Surface Replicate – **1** / **2**	-	Two-digit sample number

Water sample example ID: **EPZANWS-01** = First surface water sample from the east pipeline, zone A, on the north end of the pipeline
Sediment sample example ID: **WPZBNS1-06** = Sixth sediment sample collected at the west pipeline, zone B, on the north end of the pipeline

Samples Collected

Time	Sample ID	Depth (ft)	Time	Sample ID	Depth (ft)
1005	EPZAS-WS-02	[redacted]			
1035	EPZAS-WB-03				
1038	EPZAS-S1-01				
1038	EPZAS-S2-02				
1038	EPZAS-S1-03				
1153	EPZAS-WM-04				

Duplicate Samples (if applicable)

Sample ID	Parent Sample ID
EPZAS-S1-03	EPZAS-S1-01

Water Chemistry (if applicable) – See YSI DATA

Temp: _____ °C pH: _____ Conductivity: _____ µS/cm

DO: _____ % sat DO: _____ mg/L ORP: _____ mV Turbidity: _____ NTU

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Additional Notes:

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Appendix I

2017 GEI Line 5 Daily Field Activity Logs

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Daily summary of Line 5 biota sampling activities

9/8/17

- Docks at 0625, safety discussion
- Objectives are to continue biota sampling. Weather: clear, breezy
- Started additional APB/SRB blanks using tap water and distilled water (from unopened gallon). Consistent with yesterday's blanks, water was poured directly over APB/SRB swabs.
- **Biota + designated AOI site sampling (ITP/Enbridge site ID E-AOI1,B1,S3).** AOI [redacted], AOI Long [redacted] Biota site Lat [redacted] Biota site Long [redacted]
- 10 total samples collected: one pair from AOI, one pair from undisturbed area adjacent to AOI, and three pairs from biota site area. No holiday observed but AOI samples still retained for analysis as this AOI was at a designated biota sampling site.
- Rubber tip of coating thickness gauge fell off during dive and backup gauge didn't function so a second dive had to be conducted to finish thickness measures.
- Three, small patches of whitish material were observed in the vicinity of the AOI during inspection. The material was not collected.
- Processed samples on barge during diver decompression.
- Generated additional APB/SRB blanks per conversation with MP, KK, SK, RH. Each type of blank was generated in duplicate and are as follows:
    - Nitrile glove blank – Distilled water (from same gallon used for blanks a few hours ago) was poured directly over gloved hand and collected into palm area. APB/SRB swabs were immersed in the water collected in the palm area.
    - Atmospheric blank – APB/SRB swabs were waved around for a 10 second interval inside the pop-up ice shanty that all APB/SRB tests have been prepared in.
    - Lake bottom water blank – The Niskin water sampler was attached to the tool crib (as with previous lake bottom water blanks) and water was collected from lake bottom at ~129', nearby W-AOI4,S7,B3. Once back at the surface, water was drained from the sampler onto APB/SRB swabs.
    - Lake surface water blank – a pre-cleaned, wide-mouth, 32 oz. poly bottle was taped to a piece of steel. The bottle was rinsed several times at the surface of the lake, then immersed to a depth of approximately 2', after which it was brought to the barge and cut off from the steel rod. APB/SRB swabs were immersed directly into the bottle for approximately 10 seconds.
- Another APB/SRB blank will be generated tomorrow morning so that check times will be consistent with other blanks. The blank will be taken by rinsing Distilled water inside a pre-cleaned, unused, sample container that was part of the original batch of sampling containers produced by Ballard at the start of the biota field effort. APB/SRB swabs will be immersed in the water held inside the sample container for approximately 10 seconds. This blank will also be collected in duplicate.
- **Biota + designated AOI site sampling (ITP/Enbridge site ID W-AOI4,S7,B3**). – Note: in several instances, the ID for a given site has been displayed inconsistently on the screen. Site IDs in this document are recorded directly from the ID that is displayed on the screen, hence any

inconsistencies may be herein as well. AOI Lat [redacted] AOI Long [redacted] Biota site Lat [redacted] Biota site Long [redacted]

- 12 samples were collected in total and circumference measurements were taken. Paired AOI samples plus four pairs of samples from the biota area.
- Observation – additional CP readings are currently being taken at E-AOI5. This AOI was cleaned for inspection on 9/6/17 and accumulation of biota has already taken place. Video taken by Ballard and snapshots were taken via ROV and biota is clearly visible on the cleaned off areas. The biota appears to primarily be biofilm, sediment, and particulate matter – no mussels were observed.
- Pulling anchors at E-AOI5 at 1800 hrs.

9/7/17

- Docks at 0630, safety discussion
- Objectives are to continue biota sampling – most of the remaining sites are in deeper water and may require multiple dives to complete.
- Weather: partly cloudy, breezy
- **Biota + designated AOI site sampling (ITP/Enbridge site ID W-AOI1,B1,S4).** AOI Lat [redacted] AOI Long [redacted]. Biota site Lat [redacted] Biota site Long [redacted]
- Paired samples collected from AOI, four sets of paired samples collected from biota area for a total of 12 samples.
- Samples processed on barge during diver decompression.
- Duplicate APB/SRB sample run with sample WPZDE07.
- Two of the samples designated for DNA extraction by Microbial Insights will likely have insufficient mass.
- Second diver had to obtain circumference measures due to bottom time limitations. Measurements taken approximately 1220.
- Additional APB/SRB blanks run –water was poured directly onto test kit swab as compared to previous equipment blanks in which water was poured onto equipment then the wetted equipment was swabbed. Additional blanks will also be started tomorrow.
- **AOI sampling site (west leg, ITP/Enbridge AOI site ID W-AOI2).** AOI Lat [redacted] AOI Long [redacted]
- Paired samples proactively collected per workplan modifications. No holiday was observed so samples will be disposed of per MDNR permit.
- "Whitish" material was observed near the AOI. Diver obtained some and deposited it into ziploc bag. Sample ID was 170907-WAOI2CD and was run for APB/SRB and will be sent to GEI lab for holding/further analysis.
- Pulling anchors at second site at 1715 hrs, back to fieldhouse at 1915 hrs.
- Finished sample processing, sample shipment prep, chain of custody paperwork, scanning and backing up of field notes, photos, etc. at fieldhouse.

9/6/17

- Docks at 0620, safety discussion
- Breezy in morning, chance we could get blown out but will try to sample
- Objective was to sample AOI sites
- **AOI sampling site (east leg, ITP/Enbridge AOI site ID E-AOI8).** AOI Lat [redacted] AOI Long [redacted]
- Paired samples proactively collected, disposed of per MDNR permit as holiday was not observed.
- **AOI sampling site (east leg, ITP/Enbridge AOI site ID E-AOI9).** AOI Lat [redacted] AOI Long [redacted]
- Paired samples proactively collected, disposed of per MDNR permit as holiday was not observed. Diver brought up some material collected the lake bed (not from pipeline). Material was referred to as Material of Interest – APB/SRB tests were run and material will be sent to GEI until determination made on what to do with the sample. Sample ID was 170906-EAOI9MOI.
- **AOI sampling site (east leg, ITP/Enbridge AOI site ID E-AOI10).** AOI Lat [redacted], AOI Long [redacted]
- Paired samples proactively collected, disposed of per MDNR permit as holiday was not observed. Small amount of material pulled up by diver during inspection. Looked to be thicker than Material of Interest collected on 8/19/17 so was tested for APB/SRB and will be sent to GEI lab until determination is made on what to do with the sample. Sample ID was 170906-EAOI10MOI.
- **AOI sampling site (east leg, ITP/Enbridge AOI site ID E-AOI5).** AOI Lat [redacted] AOI Long [redacted]
- Paired samples proactively collected, disposed of per MDNR permit as holiday was not observed.
- Diver pointed out two small areas that looked different that rest of AOI – one was "whitish" – thickness readings taken on at both areas with both resulting in readings of 100+.
- Pulling anchors at 1500 hrs. Possibly moving to an AOI site on west leg.
- **AOI sampling, site (west leg, ITP/Enbridge AOI site ID W-AOI6).** AOI Lat [redacted] AOI Long [redacted]
- Paired samples proactively collected, disposed of per MDNR permit as holiday was not observed.
- Pulling anchors ~1645.

9/5/17

- At docks 0750 – delayed start due to barge transit from Cheboygan
- Safety discussion 0800
- **AOI + Biota site sampling (east leg, AOI site 7 – ITP/Enbridge ID: E-AOI7,S8,B3).** AOI Lat [redacted] AOI Long [redacted] Paired samples collected there and kept for analysis. Biota site Lat [redacted] Biota site Long [redacted] Eight samples collected at biota site and biota measurements (circumference) also taken as pipeline was in span here. Note that during sample processing, sample container #12 was lost when it slipped out of RH's hands during attempted transfer to mesh bag. This sample was from the AOI site and was designated for SRB/APB and DNA extraction by Microbial Insights. It is highly unlikely there would have been enough mass for DNA extraction as the AOI was essentially devoid of biota. APB/SRB tests were run on the paired sample that was taken 6" away so there should be no overall loss of data.

- YSI multi-parameter probe deployed (attached to tool crib holding sample containers) at this site. Results for a suite of parameters (e.g., DO, temp, pH, etc.) were collected for use in evaluating water chemistry at depth. Did not have enough time to get probe set up for second site but depth was generally the same so data from the first site of the day should be applicable to the second site.
- Slid barge to adjacent AOI site
- **AOI site (east leg, AOI site 6 – ITP/Enbridge ID: E-AOI6**). AOI Lat [redacted] AOI Long [redacted] Paired samples proactively collected per workplan modifications. No holiday was observed so samples to be disposed of per MDNR permit requirements.
- Note that a sample presumed to be outer coating was brought up by the diver from this site. It was very similar in appearance to the "dislodged coating" collected previously so was labeled as such. Sample ID was 170905-EAOI6DC. APB/SRB tests were run and the sample will be shipped to GEI's ecological lab for evaluation of attached biota.
- Had to cease operations after this site as winds climbed over 30 knots, precluding use of the crane.
- Discussed with Matt P. the generation of an APB/SRB summary.
- Back at fieldhouse ~1650 hrs, finished processing samples and other end of day tasks (CoC prep, sample shipment prep, backup of photos, field data sheets, field notebook pages, etc.)

9/4/17

- Mobilization to Straits and gear prep for tomorrow's presumed sampling

8/30/17

- Docks @ 0630, safety discussion.
- Objective per Chris to finish inspection of "abandoned cable". Visibility was hampered towards end of last dive yesterday so needed to verify that cable work had been completed. Then biota sampling.
- Discussed with Chris the desire to obtain more of the apparent calcium material that had been transferred to ATS for evaluation.
- Emails re: sample tracking sheet modifications; phone discussions with SK re: biota tasks remaining and estimated number of dive and weather days left.
- Pulled anchors at cable site ~1200
- **AOI site (east leg, AOI site 3 – ITP/Enbridge ID: E-AOI3)**. AOI Lat 4[redacted] AOI Long [redacted] Paired samples proactively collected per workplan modifications. No holiday was observed so samples disposed of per MDNR permit requirements.
- Slid barge over to adjacent AOI site.
- **AOI site (east leg, AOI site 4 – ITP/Enbridge ID: E-AOI4)**. AOI Lat [redacted] AOI Long [redacted] Paired samples proactively collected per workplan modifications. No holiday was observed so samples disposed of per MDNR permit requirements.
- Checked APB/SRB tests.
- Pulling anchors at E-AOI4 at 1700 hrs.
- Weather turned in the afternoon – winds picked up, patchy precipitation in area. Unclear whether or not tomorrow will be a work day.

- Subsequently found out barge moving to Cheboygan tonight due to incoming weather so no biota sampling Thursday.
- Also briefed on potential for biota sampling to not resume on 9/5 as originally thought. Unclear as to when it might resume.

8/29/17

- Docks @ 0630, safety discussion.
- Objective per Chris is to continue ROV investigation of "abandoned cable" with hopes of getting to biota sampling after inspection. Unclear as to extent of remaining "abandoned cable" inspection.
- Weather: humid and calm in a.m., potential for rain today/tomorrow.
- Two dives for cable inspection (~0930-1445 hrs), pulled anchors ~1600 hrs.
- 1700 hrs pre-dive ROV inspection of AOI + biota site.
- **Biota + designated AOI site sampling (west leg, Zone A south – ITP/Enbridge ID: W-AOI7,S8,B4):** AOI lat [redacted] AOI long [redacted] Biota site Lat [redacted] Biota site Long [redacted]
- 10 samples total; paired samples from AOI and undisturbed area plus 6 samples from biota site. Bottom of pipe not accessible (significant amounts of sand, bottom buried, sides partially buried).
- Mussels were sparse throughout general area and all samples contained relatively little biota.
- Discussed uncertainty as to how much further time may be needed for investigation of the cable. Per Chris, a dive will be done at the cable location tomorrow morning and biota sampling will be resumed after that. So unclear how many biota sites may be able to be sampled Wednesday.
- Discussions re: presumed calcium sample from last week. Per discussion, sample has been shipped to Ann Arbor Technical Services (Ann Arbor, MI) and will arrive Thursday.
- Water sample collected at lake bed on Saturday, 8/26 returned positive for APB. No presence of SRB's thus far but sample still has to run another couple of days.

8/28/17

- Docks @ 0630, safety discussion.
- Investigating "abandoned cable" via ROV. Determined that no biota sampling would be conducted during the day so GEI biologists (DK and SK) and GK (ITP) were transported back to Straits Docks.
- Arrived @ Straits Docks ~1430 hours
- Paperwork and emails

8/27/17

- Weather day
- Checked APB/SRB tests on barge 2x, paperwork, emails re: upcoming sampling, issue with cable that was discovered at end of day Saturday. GEI has not been officially briefed on what the cable was/is.

8/26/17

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- Docks @ 0630, left dock ~0650. Weather sunny, calm in a.m. Slight breeze in p.m., highs in upper 60's.
- Small craft advisory for Sunday and extending into Monday morning, may preclude working Sunday.
- Quotes received for water chemistry monitoring probe yesterday, late afternoon. Have not received authorization to place rental order for probe as of yet.
- SK joined GEI crew today and will stay on through Monday, 8/28.
- **Biota + designated AOI site sampling (east leg, Zone D – ITP/Enbridge ID: E-AOI-2,S-4,B-2):** AOI Lat [redacted] AOI Long [redacted] Biota site Lat [redacted] Biota site Long [redacted]
- 10 total samples; paired samples from AOI and undisturbed area plus 6 samples from biota site. Bottom of pipe was not accessible.
- Note: unclear whether dashes and commas are being utilized consistently in Enbridge and/or ITP site identification nomenclature. GEI logging Enbridge/ITP site ID's on field data sheets as shown on dive log. May need to reconcile/make consistent ID's after conclusion.
- Samples processed on barge during anchors up and moving to next site
- During transit discussed collection of water sample at pipeline depth to start to address discussion had with MP yesterday. Sampler rigged up on sampler box and would be triggered by diver at bottom. Water sample would be utilized as a "Lake bed water blank" for APB/SRB to evaluate APB/SRB presence in comparison to tap water and lake surface water blanks. Discussed with Trish and Brad (Enbridge) and Gary. Believe Gary's notes might be referring to the blanks as "control" samples.
- **Biota + designated AOI site sampling (west leg, Zone C south – ITP/Enbridge ID: W-AOI3-S6-B2):** AOI Lat [redacted] AOI Long [redacted] Biota site Lat [redacted] Biota site Long [redacted] 10 total samples; paired samples from AOI and undisturbed area plus 6 samples from biota site. Bottom of pipe was not accessible.
- Prior to sampling there was a discussion relative to the rate at which biota circumference measurements were being taken. Currently, circumference measures are being taken at only approximately 50% of the locations that were targeted for measurements. This is primarily due to the bottom of the pipeline being buried, close to buried, or "trenched" at randomly selected sampling locations. Possible outcome could be that force/drag/stress calculations may have greater degree of uncertainty if biota circumference measures are generated at a lower than anticipated rate. Per Trish, communication with Enbridge was to proceed as in the workplan – in other words, do not change approach in order to increase circumference measurement counts.
- Diver out of water approximately 1525 hours, pulling anchors ~1535 hours. Samples processed on barge during diver decompression and anchor pulling.
- Final sample processing, CoC forms, documentation backup, etc. at fieldhouse. Next sample shipment will be on Monday due to no shipping capabilities Sunday.

8/25/17

- 0600 - Prepared sample shipments and transferred them to MET for UPS/FedEx drop-off.
- Docks at 0630, safety discussion 0635

- **Biota sampling (west leg, Additional Site 1 – [W-AS1]):** Lat [redacted] Long [redacted] This was site we attempted sampling yesterday morning but could not due to swift currents.
- ROV inspection revealed multiple apparent calcium growths/deposits similar in appearance to what was observed yesterday at E-AS2.
- Paired samples collected, one pair directly over two of the apparent calcium deposits, the other pair in an undisturbed area approximately 3 feet to the north.
- As observed before, mussels were sparse in the vicinity of the additional site features (the apparent calcium deposits), but were heavy in undisturbed areas in close proximity to the additional site.
- Samples processed on deck; vast majority of mussels observed in samples were live. Biofilm/periphyton sample collected on top of apparent calcium deposit that is to be sent to Microbial Insights contained very little mass/volume. It is unclear if they will have enough material to extract DNA.
- Depth at sample area was 196' so multiple dives (3) had to be made to finish taking CP/coating thickness measures at the multiple apparent calcium deposit areas. Diver #3 still in water at 1530 hours. Per conversation with Trish, appears that bare pipe was observed under at least some of the calcified areas that were more closely inspected during dives 2 and 3.
- APB/SRB test checks, positive results observed for tap water and lake water blanks started Tuesday. Email sent to team related to this.
- Subsequent discussion with MP: will conduct APB/SRB blank test using distilled water, also discussed potential to identify relevant water chemistry data for Straits or if water chemistry data could be generated in conjunction with biota sampling at some of the sites yet to be sampled.
- Quotes for rental of water chemistry multi-probes were requested from vendors as were quotes for water chemistry.
- Collection of water samples and/or water chemistry measurements via ROV were discussed with Chris Bauer.
- Tentative plan for tomorrow is to take advantage of the calm weather and attempt to sample one of the deep (200+ feet) biota + Area of Interest sites. This would likely take an entire day given decompression stops, decompression chamber logistics, and multiple tasks required at such sites (biota sampling, potential biota thickness measures, potential CP and coating thickness measures, etc.).

8/24/17

- Docks at 0630, safety discussion 0640
- Deep dive was planned but once anchored it was discovered that current was too swift for ROV operation and likely safe diving so moved to east leg, zone A south.
- Anchored at East leg, zone A south, Additional Site #2. General area disturbed via previous anchor work so little biota in general area. Paired samples collected but subsequently determined (during dive) that the incorrect location was being sampled. Samples were disposed of per MDNR permit.
- **Biota sampling (east leg, Additional Site 2 – [E-AS2**]): Lat [redacted] Long [redacted] Ballard re-evaluated previous video footage and determined that target additional site was within 50 ft of GPS coordinates. Paired samples taken at presumed feature at Additional Site #2. Area was closely

inspected following sampling and an apparent "calcium deposit" was discovered approximately 3 feet from where paired samples were taken. Bare pipe (a holiday) was presumed to be under the calcium as Gary felt the calcium would accumulate on bare pipe that has cathodic protection. Thus, after discussion with Dave Stafford, Gary (ITP), Trish, etc. the decision was made to keep (and analyze) the samples collected as they were collected very close to the presumed holiday and the biota observed in the vicinity of the calcium deposit and sample collection area was consistent.

  - Attempts made to sample the calcium deposit. A few fragments were collected and tested for APB/SRB. They'll also be sent to GEI lab for holding until decision is made on what to do with them. Thought was that if more is wanted then Ballard can collect it when coating repairs are made at that site.

- Key issue that arose again is that it is very difficult to confirm/verify the exact location of the specific feature(s) at an Area of Interest (or in this case an Additional Site) as biofilm/periphyton/particulate matter is covering the pipe. Thus, confirmation sometimes cannot be made until the area has been closely inspected and cleaned off.
- **Biota sampling (east leg, zone A south, Area of Interest 11 [E-AOI11])**: Lat [redacted] Long [redacted] Paired samples proactively collected. Holiday not found/observed so samples to be disposed of per MDNR permit.
- Dislodged coating sample collected by diver and, consistent with previous dislodged coating sample, was evaluated for APB/SRBs and sent to GEI ecological lab for biota evaluation though there was very little biota attached. The coating will be saved at GEI until determination can be made on what to do with it. Dislodged coating sample ID is 170824-EAOI11DC (date-east leg, area of interest 11, dislodged coating).

8/23/17

- Weather day due to sustained high winds
- APB/SRB test checks
- Paperwork, gear prep

8/22/17

- Weather day today due to storms and high winds
- Weather day has also been called for tomorrow, 8/23 due to sustained high winds (30+ knots). This makes the 4th weather day.
- Checked APB/SRB tests on barge, also started "control" APB/SRB tests using tap water and lake water to investigate as to whether or not test kit process could be impacting APB/SRB results
- Prepared and shipped samples to GEI lab and Microbial Insights
- Received confirmation that GPS coordinates will be used to navigate ROV to Areas of Interest and Additional Sites
- Resupply of gear; emails and phone conversations

8/21/17

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- Arrived at docks 0625; safety discussion 0640, including discussion of inclement weather.
- Objectives today are additional biota site (6-8 samples around pipe; biota thickness measures if pipe is in span) sampling and potentially sampling at an Area of Interest in afternoon if time allows.
- Weather: humid, a.m. temps in 60's, overcast, chance of precipitation.
- Discussion with Trish (Enbridge) re: inspection of Areas of Interest and Additional Sites following sample collection. GEI understanding as per discussions/actions on Tuesday, August 21st, was that Areas of Interest and Additional Sites would be cleaned by the diver following sample collection to comply with workplan text (Section 3.5.1) that "Special attention will be given to any areas where Biota have been disturbed and Areas of Interest. Those areas will be closely inspected by the diver(s) allowing for additional video footage to be collected of those areas for further review." Trish to discuss with her colleagues.
- Discussion: we may not know the exact position of the Area of Interest on the pipeline. Data from paired biota sampling at the pipeline will be used to evaluate any potential differences in biota accumulation within Areas of Interest versus outside Areas of Interest. If a Holiday is found prior to sampling then paired samples should be collected from the holiday area as per protocol. If a holiday is not found prior to sampling then Area of Interest biota samples should be collected from a position on the pipeline in which biota is present to enable comparison of biota biomass at Areas of Interest versus proximal non-Areas of Interest.
- **Biota site:** West leg, Zone C north. 8 samples + circumference measurements.
- **Biota site:** West leg, Zone B north. Pipeline "trenched" so bottom could not be sampled. Attempts were made to get circumference measures but tape measure couldn't be wrapped around without disturbing side of pipeline so circumference measure attempts were abandoned. Full agreement on this from ITP, Enbridge, etc.
- **AOI site:** West leg, Zone A south. ITP ID for this site: W-AOI5. No holiday found so samples disposed of per MDNR permit.
- **"Dislodged coating"** was sampled during the AOI inspection. The appearance was somewhat consistent with the material of interest we have been seeing but was much thicker. ITP, Enbridge, etc. concurred that it should be treated as dislodged coating. As such, APB/SRB tests were performed. The sample ID assigned was 170821-WAOI5DC.
    - **Note:** clarification is sought on where today's dislodged coating sample plus the sample of material of interest collected early last week should be sent to. Discussed this with Trish and she is following up with Enbridge. The dislodged coating sample had biota attached to some pieces and could be sent to GEI lab first then held for Enbridge, if desired. The material of interest sample had no biota attached. Samples will be refrigerated in the interim.
- Pulled anchors at ~1630 hours; back to dock 1800 hrs. Processing samples, etc. at fieldhouse.
- **Note:** per discussion with Gary; Chris Bauer (Ballard) is expecting that Zone D biota sites that coincide with an Area of Interest will take an entire day to complete. He is currently projecting 10-12 more work days, which would push end date of effort into September.

8/20/17

- Arrived at docks, 0625; safety discussion 0640.

- **Biota site:** East leg, zone D – deep dive (non-AOI site).
- Bottom of pipe partially buried/not accessible so 6 total samples. Mussel density heavy, multiple layers of biota but little/no periphyton and/or macrophytes due to depth of pipeline (sampled at 229 feet).
- APB/SRB samples checked (been doing this daily since start) and photographed. O.B. (ITP) and Gary (ITP) observed checking of APB/SRB test tubes. O.B. also observed processing of samples from this biota site.
- Moved into vicinity of next biota site ~1300 hrs.
- **Biota site:** West leg, zone D – deep dive (non-AOI site).
- Bottom of pipe partially buried/not accessible so 6 total samples. Mussel density heavy, multiple layers of biota present. Sampled depth was 245'.
- ROV arrived at random number-generated site and it was in what appeared to be a disturbed area. A grout bag was very close and the top of the pipe had significantly fewer mussels. A discussion was had with Gary, Luke, Trish, Chris, and RH. Agreement that what was observed at intended sampling location was consistent with the description of a disturbed area in the pipeline. Hence, the ROV maneuvered until a presumably undisturbed area was located (was approximately 11' from original intended sampling site) which served as the sampling location.
- It should be noted that disturbances to the pipeline, particularly those that are not recent, may be difficult to conclusively determine from appearance alone given that zebra and quagga mussels naturally exhibit "patchy" distribution. Therefore, mussel distribution alone should not be the lone factor in determining if an area is "disturbed". Multiple sources of information such as survey data from Ballard, observation of grout bags, recent anchors, etc. should be used in conjunction.
- Note that water temperature data from the backup ROV (video feed from primary ROV is still down) is not consistent with thermometer mounted on dive bell. Temperature on the ROV has been higher (5-10 degrees F higher).
- Obtained Site ID scheme from Gary and will create a spreadsheet with the ITP's Site ID's to facilitate efficient cross-referencing with GEI sample IDs.
- Pulling anchors at second biota site at 1630 hrs
- Chain of custody forms, sample shipment forms, bagging ice, photo, etc. backup at fieldhouse

8/19/17

- Arrived at docks 0625; safety discussion 0640.
- Discussion with Chris, Luke, Trish, and Gary that biota only sites (6-8 samples around the pipeline) with no Areas of Interest would be pursued today given ongoing discussion about Figures 2 and 3.
- **Biota site:** East leg, zone A north was first site. Pipeline buried so 6 samples total. Mussel colonization heavy.
- Note that material of interest similar to what was observed previously (believe on Wednesday, 8/16/17) was found at this site during post-sampling inspection by diver. Diver bagged some of it and it will be held until determination is made on what to do with it. The material is very thin and brittle, with little/no biota attached. Some of it was also found in biota samples. Discussion was held with Gary, Luke, etc. and determined that this material doesn't represent "dislodged coating" (see

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Section 3.5.3.3 of workplan) due to how thin and flaky it is. The material of interest collected by the diver did not have any mussels or periphyton on it, precluding APB/SRB testing of biota in accordance with section 4.3 of the workplan. Also note that APB/SRB testing is being conducted on the biota samples collected from the pipeline, some of which contain the material of interest.

- **Biota site:** East leg, zone B north. Pipeline buried so 6 samples total. Mussel colonization moderate but close to sparse. Consensus was reached on moderate though. Significant sand deposition on east side of pipeline and some on top. West side of pipeline at randomly-selected location had very little attached material.
- Discussed sand deposition with Gary, Trish, Luke, etc. and consensus was that protocol will be carried out as per workplan. As such, some of the samples will contain considerable amounts of sand.
- **Biota site:** West leg, zone A north. Pipeline not buried so 8 samples taken. 6 o'clock position not safely/efficiently accessible so bottom samples collected ~7 o'clock- 8 o'clock range (this was agreed upon by Gary, Luke, etc.).
- Video feed down on primary ROV so backup ROV being used for this dive. GPS coordinates at site taken from diver who had a GPS transponder affixed to tank.
- Minimal mass/volume on some samples. Will still send all samples per protocol. Labs have been notified that some samples will contain little sample mass/volume.
- Wet weight masses of samples for GEI lab will be taken at fieldhouse since balance cannot be used on barge due to vibration.
- Field data sheets, etc. scanned at fieldhouse and backed up, photos transferred and backed up
- Gear resupply for Sunday sampling; additional equipment (nitrile gloves, etc.) ordered
- Samples will be prepared for shipment on Monday morning given no shipments available on Sunday.

8/18/17

- Weather day, no sampling.
- Discussed via email and phone the issue of Figures 2 and 3 and how the icons for AOIs and Additional Sites are approximate and in some cases slightly off from actual GPS coordinates for respective sites.
- Prepped gear for 8/19/17 sampling.

8/17/17

- Weather day, no sampling. Also note that Ballard has called off efforts on 8/18 due to continued poor weather.
- Samples collected 8/16 were packed into coolers, CoC forms filled out, collers transported to Rudyard for overnight shipment via UPS to GEI ecological lab and Microbial Insights.
- Pick up of additional sampling equipment at MET.
- Straighten up gear, print out additional field forms.
- Communication with Microbial Insights re: sample receipt, minimal mass of some samples.
- APB/SRB checks on barge in a.m. and p.m.

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8/16/17

- Arrived at docks at 0625; safety discussion ~0645; weather heading in, likely tomorrow
- Dave requested review of a document containing changes to workplan prior to submittal to USEPA. RH reviewed (so did Gary and Trish). RH noted that the 10-30 feet random number generation step at the 7 AOIs that coincide with a designated biota sampling area was not in the changes but had been discussed previously. Two paragraphs were added to the document describing rationale for change. All were in agreement that the change was for safety considerations (i.e., less area a diver has to cover while on bottom which is critical, especially at deep sites).
- APB/SRB samples from yesterday were checked. The first sets of samples are changing colors, indicating the presence of APB and SRB. This was discussed with Gary and Trish. A photograph of the test tubes was emailed to BioSan for verification. Confirmation from BioSan that APB/SRBs are present in tubes shown in photograph.
- **Biota site:** 8 biota samples collected at biota sampling site located on east leg, zone C, south. No holiday was found.
- Samples process on barge. APB/SRB test tubes in incubator, GEI eco lab samples bagged and on ice and will be massed later once ethanol is added, periphyton/biofilm parsed out from APB/SRB samples and bagged for Microbial Insights. Once again, most biofilm/periphyton came from near mussel attachment points. Care being taken to minimize extent to which tissue of mussels is included in samples sent to Microbial Insights. Some samples have low mass (1 g or less).
- 1300 hrs, pulling anchor and will head to next site, which as of now will be the biota site in the East leg, zone A, south. This site is also designated as an AOI site. Thus, the following biota tasks will take place: AOI sampling, biota sampling (6-8 samples around pipe), biota thickness and clean pipe measurements.
- Pre-dive ROV inspection: Chris' survey notes did not indicate an AOI "south of 34A" (see Table 1 in workplan). A small area devoid of biota growth on top of pipe was found but no survey notes to match that area. Chris' survey notes did show potential AOI about 70' away from 34A. But that site would have been in span 35, not 34. Significant discussions with Dave S., Gary, Trish, Chris about this. Moving sampling site to 35 would constitute a change to the workplan. Call with Joe S. to discuss. Joe recommended sampling "south of 34A" as described in workplan. Gary noted he will have to document the observation of potential "fork marks" in vicinity of 35 and believes they need to be added to the scope.
- During this time, wind was building and gusting over 25 (not sure if knots or mph), precluding use of crane, which is used to lower box containing biota samplers to lake bed.
- Hydrophone installation was completed at current anchor position (east leg, zone A, south) as was further CP gun testing. One biota site was sampled today given hydrophone, CP testing, and delays due to discussions above and winds.
- Sample shipment prep this evening with transport to UPS tomorrow.
- Thursday has already been called off due to high winds.

8/15/17

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- Arrived at docks 0630; safety discussion 0700
- Objectives: resample location we left off at on 8/14; install one hydrophone; sample a second biota site – which site is still TBD
- Weather: fair in a.m. with slightly more breeze than yesterday in a.m. Expected high temp 75 F.
- Confirmed with Chris Bauer that ROV pre-dive footage is being captured. Pre-dive ROV footage is what we are using to confirm mussel density, biota layers, and slow pan of pipeline in general area of inspection/sampling.
- **AOI site sampled**, confirmed holiday so paired samples were kept. AOI samples contained little/no mussels, periphyton, biofilm, etc. Unclear if there will be enough mass for DNA extraction. Email was sent to Microbial noting minimal sample mass in some samples and a request was made to notify us as soon as possible if minimal mass will preclude DNA extraction.
- **Biota site sampled,** 8 samples total. East leg, zone B, south.
- Back to dock at 1840.
- Prepped coolers and arranged shipment for tomorrow for overnight delivery to GEI and Microbial Insights. They'll each receive 6 samples.
- Worked up samples. Wet weight masses for GEI lab, removed periphyton/biofilm from APB/SRB samples for Microbial. Majority of periphyton/biofilm came from near attachment points of mussels; little was "free" (i.e., not attached to mussels) in the sample.
- End day at 2215 hrs.

8/14/17

- Arrived at boat docks at 0645 per request. Barge arrival after 0900.
- While waiting for barge we were informed that in the afternoon we would attempt to collect actual samples as opposed to a full day of test dives.
- Key discussion topic was proactive collection of biota samples at AOI's and "Additional sites". Consensus was reached by Gary (ITP), Enbridge (Trish, Ryan, Dan, Jim), and GEI that assuming a holiday might be present and collecting biota samples first is best approach to ensure samples are collected in an "undisturbed" condition as opposed to collecting samples after area has been disturbed via coating thickness and CP measures. Following sample collection, if a holiday is not found, the samples collected would be disposed of according to permit conditions (i.e., euthanized via alcohol and landfilled). This was discussed fully and Gary was in full agreement.
- **Test dive was near E-71.** GPS coordinates were not available via the ROV or diver so a measurement was made from known spot (34' from an anchor). No holiday was found. Would one have been found the samples would have been collected per discussion with Enbridge and Gary.
- First actual sampling dive was started ~1630 hrs at location between E-77 and E-72.
    - This location has a very long AOI from previous maintenance/cleaning activities.
    - One pair of samples from north end of AOI, one from area ~3' upcurrent of AOI samples.
    - Barge had engine problems during the dive so dive was aborted and samples were left in the crate on the bottom.

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    - Per discussion with Enbridge and Gary, a new set of samples will be collected at this location tomorrow and the samples collected on 8/14 will not be used given we will not be able to retrieve them until 8/15.
- Unclear if video is being taken during pre-dive ROV fly-over. Need to confirm this is the case as the pre-dive ROV fly-over is when mussel colonization rates are confirmed and biota layers (multiple or single) are confirmed.
- Weather: calm, sunny to partly cloudy, temps ranged from 55-75 F.
- Note that Ballard keeps a detailed dive log for every dive. This could be requested in event that detailed activities need to be verified.

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Enbridge Line 5 Daily Activity Summary

12/15/17

- 0515 preparing gear, boarded barge at 0600
- Safety discussion 0635
- Conducted daily APB/SRB kit observations – no additional trips observed
- EAS-3 was first site (East leg, zone B south) – Coords: N[redacted] W[redacted]
    - Completed water column and sediment sampling, as well as water chemistry measurements at EAS-3.
    - ABP/SRB kits run on all samples
- Moved to E-10 (East leg, zone A south) – N[redacted] W[redacted]
    - Sampling completed 12/13/17, no samples collected
- 1200 - Diving issues halted operations for the day
- Headed back to port ~1300 hrs
- 1430 Arrived at docks
- Off-loaded all gear
- Back to lodging ~1440 hrs
- Packed gear, prepped for demobilization, backed up field files
- 1500 - Departed lodging
- Incubator kept running via power inverter in vehicle
- Water and sediment samples shipped overnight to Microbial Insights
- Replaced vehicle power outlet fuse and inverter blown by incubator
- 2200 – demobilization complete

12/14/17

- 0515 preparing gear, boarded barge at 0600
- Safety discussion 0630
- Generated equipment blanks, in duplicate, for each equipment type used (sediment sampler, niskin sampler, VanDorn) with both distilled and sterile water.
- Sterile water (only) blank APB/SPB kits were run in duplicate in addition to equipment blanks.
- EAS-3 was first site (East leg, zone B south) – Coords: N[redacted] W[redacted]
    - Current deemed too strong for diving; anchors were pulled and barge moved to site near E-10 to complete coating repair.
- E-10 (East leg, zone A south) – N[redacted] W[redacted]
    - Sampling completed 12/13/17, no samples collected
- Held at E-10 until noon, in attempt to wait out heavy currents; however, currents persisted and winds increased.
- No diving activities were carried out.
- Headed back to port ~1200 hrs
- As per Jeff Newlin, currently running Ballard Marine operations, barge crew will show up tomorrow at regular time, but he expects no attempts will be made to depart dock due to weather.
- Off-loaded most of gear, including incubator with APB/SRB test kits, from barge so it wouldn't freeze
- Back to lodging ~1400 hrs

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- Unloaded gear, prepped for tomorrow, backed up field files

12/13/17

- 0500 preparing rest of gear, at barge 0600
- Safety discussion 0630
- Continued decontamination of equipment (sediment samplers, Niskin water sampler, etc.)
- Generated equipment blanks, in duplicate, for each equipment type used (sediment sampler, niskin sampler, VanDorn).
- "Sterile" lab water also purchased from BioSan and utilized for blanks:
    - Poured sterile water into decontaminated equipment then took equipment rinse blank
    - Sterile water only blank via dipping swabs directly into sterile water containers
- EAS-3 was first site (East leg, zone B south) – Coords: N[redacted] W[redacted]
    - Surface water sample collected – ID EPZBS-WS-01 (east pipeline, zone b south, water surface, water sample #1)
    - Current too strong for diving so pulled anchors and went to other site near E-10
- E-10 (East leg, zone A south) – N[redacted] W[redacted]
    - Surface water sample collected – ID EPZAS-WS-02
    - Mid-depth water sample collected via VanDorn – ID EPZAS-WM-04
    - Bottom water sample collected via Niskin - ID EPZAS-WB-03
    - Paired sediment samples collected using biota sampler held horizontally and slid across bottom at depth of approximately 2". IDs were – EPZAS-S1-01; EPZAS-S2-02; EPZAS-S1-03 (duplicate of EPZAS-S1-01).
    - Water was decanted from sediment tube before homogenization with a pre-cleaned spatula for a minimum of 30 seconds.
- Water samples transferred to lab-supplied bottles; sediment into lab-supplied glass jars. Will be sent to Microbial Insights tomorrow.
- APB/SRB tests run on all samples collected; blanks run in duplicate
- Samples at E-10 processed by ~1300 hrs, then continued decontamination of equipment.
- Two divers have already been in water continuing repairs, third diver in water ~1410 hrs.
- Headed back to port ~1600 hrs
- Off-loaded most of gear, including incubator with APB/SRB test kits, from barge so it wouldn't freeze
- Back to lodging ~1720 hrs
- Unloaded gear, decontaminated VanDorn sampler, got gear ready for tomorrow, backed up field files

12/12/17

- Received verbal authorization to begin mobilization and equipment acquisition for water and sediment sampling
- Multiple calls to BioSan and for YSI multi-probe to secure APB/SRB test kits and YSI
- Located and mobilized all other equipment necessary
- Produced field data forms, generated sample ID scheme, conference call with Chris Bauer, coordinated with Jeff (Ballard), etc.

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- Arranged for Ann Arbor GEI staff to pick up BioSan APB/SRB test kits at Warren facility and transport them to Flint for transfer to RH
- DK picked up YSI multiprobe
- RH and DK in Mackinaw City ~2000 hrs
- Unloaded equipment, decontaminated equipment that was in hand (sediment sampling equipment was on the barge). Decontamination procedure was consistent with what was done in summer with the addition of ethanol rinse. Procedure was: liquinox wash, distilled water rinse, ethanol rinse, distilled water rinse.
- Prepared YSI multi-probe and rest of gear for tomorrow's effort.

12/11/17

- 1615 received call regarding potential Line 5 sediment and water sampling consistent with proposals submitted in late summer/early fall 2017.
- Internal discussions re: staffing, equipment requirements, health and safety, etc.
- Time critical issues: whether or not BioSan has APB/SRB test kits on hand, availability of YSI multi-probe

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Appendix J

2017 GEI Chain-of-Custody Forms

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GEI Consultants, Inc./Ecological Division
4601 DTC BLVD., SUITE L100
DENVER, CO 80237
(303) 662-0100

CHAIN-OF-CUSTODY RECORD

	Sample ID	Sample Type	Sample Date/Time	Alcohol volume (ml)	Remarks / Special Instructions
				~~70~~ OK 8/15	
1	EPZASW05	Biota	8/15/17-1000	OK 8/15 ~~80~~ 30	Line 5 biota collected 8/15/17
2	EPZASW12		8/15/17-1000	80	
3	EPZBST05		8/15/17-1620	100	
4	EPZBSE08			100	
5	EPZBSB04			100	
6	EPZBSW02			100	
	Set 1				

Relinquished [redacted]	Date/Time: 8/16/17 0605	[redacted]	Date/Time: 8-16-17 6:00AM
Signature: [redacted]		[redacted]	

For drop-off @ UPS in Rudyard, WI

Michelle [signature] Michelle Chartier 8/17/2017 @ 923

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GEI Consultants of Michigan, P.C.
230 N.Washington Sq., Suite 201, Lansing, MI 48933
Main: (517) 803-4600 Set 2

GENERAL CHAIN-OF-CUSTODY

	Sample Description	Sample Date	Sample Time	Analyses Requested	70% ETHANOL VOLUME (ML) Remarks/Special Instructions
7	EPZCS T08	8.16.17	1015	LINE 5 BIOTA	100ML ; 76.0g ww
8	EPZCS E03	↓	↓	↓	150ML ; 78.0g ww
9	EPZCS B10	↓	↓	↓	50ML ; 7.0g ww*
10	EPZCS W05	↓	↓	↓	100ML ; 51.7g ww
					*SAMPLE CONTAINS MATERIAL OF INTEREST

CLIENT INFORMATION

Company:	
Address:	
GEI Contact:	Ryan Holem
	rholem@geiconsultants.com; 517-881-4558

Relinquished	[redacted]	**Date/Time:** 8.17.17 / 1000
Signature:	[redacted]	
Received By	[redacted]	**Date/Time:** 905 / 8.20.17
Signature:	[redacted]	
Received By	[redacted]	**Date/Time:**
Signature:		

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GEI Consultants of Michigan, P.C.
230 N.Washington Sq., Suite 201, Lansing, MI 48933
Main: (517) 803-4600

Set 3

GENERAL CHAIN-OF-CUSTODY

	Sample Description	Sample Date	Sample Time	Analyses Requested	VOL 70% ETOH (mL); WET WEIGHT (g) Remarks/Special Instructions
11	EPZANW08	8·19·17	0830	LINE 5 BIOTA SAMPLES	80mL; 22.3g
12	EPZANE03	↓	↓	↓	100mL; 30.4g
13	EPZANT02		↓		100mL; 24.6g
14	~~EPZBNW~~ EPZBNW12		1155		100mL; 6.2g
15	EPZBNE04		↓		150mL; 151.2g
16	EPZBNT01		↓		75mL; 7.7g
17	WPZANT01		1530		75mL; 1.9g
18	WPZANE02		↓		75mL; 9.2g
19	WPZANB09		↓		125mL; 37.4g
20	WPZANW08	↓	↓		75mL; 7.2g
21	EPZDT02	8·20·17	1155		100mL; 40.9g
22	EPZDE01	↓	↓		150mL; 78.9g
23	EPZDW08		↓		100mL; 61.4g
24	WPZDT10		1520		50mL; 1.7g
25	WPZDE12		↓		150mL; 47.0g
26	WPZDW03	↓	↓	↓	~~50.7mL; 150~~ 150mL; 50.7g
					OK 8/20

CLIENT INFORMATION

Company:	
Address:	
GEI Contact: Ryan Holem	
rholem@geiconsultants.com; 517-881-4558	

Relinquis[redacted]	Date/Time: 8/21/17 0600
Signature	
Received	Date/Time: 8/21/17 0600
Signature	
Received	Date/Time: 8/22/17 1015
Signature	

Samples not on ice
Different mesh used

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GEI Consultants of Michigan, P.C.
230 N.Washington Sq., Suite 201, Lansing, MI 48933
Main: (517) 803-4600 Set 4

GENERAL CHAIN-OF-CUSTODY

	Sample Description	Sample Date	Sample Time	Analyses Requested	Remarks/Special Instructions (MASS (WET WEIGHT; g) ; VOL 70% ETOH (mL))
27	WPZCNT04	8.21.17	1055	LINE 5 BIOTA SAMPLES	30.8g ; 50mL
33	WPZCNE11				38.6g ; 50mL
28	WPZCNB09				45.4g ; 50mL
29	WPZCNW06				68.0g ; 100mL
30	WPZBNT01		1255		71.6g ; 100mL
31	WPZBNE11				64.2g ; 150mL
32	WPZBNW04				87.7g ; 150mL

CLIENT INFORMATION

Company:

Address:

GEI Contact: Ryan Holem

rholem@geiconsultants.com; 517-881-4558

Relinquis[redacted]	Date/Time: 8/22/17 / 1500
Signature[redacted]	
Received[redacted]	Date/Time: 8/23/17 4:06pm
Signature[redacted]	
Received[redacted]	Date/Time:
Signature:	

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GEI Consultants of Michigan, P.C.
230 N.Washington Sq., Suite 201, Lansing, MI 48933
Main: (517) 803-4600 Set 5

GENERAL CHAIN-OF-CUSTODY

	Sample Description	Sample Date	Sample Time	Analyses Requested	MASS (WET WEIGHT; g); VOL 70% ETOH; Remarks/Special Instructions (mL)
36	EPZASW01	08.24.17	1510	LINE 5 BIOTA SAMPLES	90.2g;
37	EPZASW02	↓	↓	↓	1.8g; 50mL
34	EPZASW07CD	↓	↓	PLEASE HOLD FOR POTENTIAL FUTURE ANALYSIS*	N/A; 50mL
35	170824-EAD11DC	↓	1710	↓	↓

CLIENT INFORMATION

Company:

Address:

GEI Contact: Ryan Holem

rholem@geiconsultants.com; 517-881-4558

Relinquis[redacted]		Date/Time: 08.25.17 / 0600
Signatur[redacted]		
Received[redacted]		Date/Time: 8-25-17
Signatur[redacted]		
Received[redacted]		Date/Time: 8/28/17 1430
Signatur[redacted]		

*Hold any + all material of interest, dislodged coating, etc. Hold w sample ID, date, etc. on bag for efficient location of info.

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GEI Consultants of Michigan, P.C.
230 N.Washington Sq., Suite 201, Lansing, MI 48933
Main: (517) 803-4600

Set 6

GENERAL CHAIN-OF-CUSTODY

	Sample Description	Sample Date	Sample Time	Analyses Requested	MASS(g; WET WEIGHT); VOL(mL) ETOH (70%) Remarks/Special Instructions
38	WPZDT11	8.25.17	1115	LINE 5 BIOTA SAMPLES	12.6g; 50mL
39	WPZDT02	↓	↓	↓	64.7g; 100mL
40	EPZDE09	8.26.17	1030		53.6g; ~~75mL~~ DK 8/28 100mL
41	EPZDT02				15.2g; ~~75mL~~ DK 8/28 50mL
42	EPZDW10				34.7g; ~~50mL~~ DK 8/28 75mL
43	EPZDW06				15.0g; 50mL
44	EPZDW01		↓		1.5g; 50mL
48	WPZCST07		1435		39.7g; 75mL
45	WPZCSE09				61.8g; 100mL
46	WPZCSW11				22.3g; 75mL
49	WPZCSW03				55.3g; 90mL
47	WPZCSW08	↓	↓	↓	1.5g; 50mL
55	EPZANM01	8.19.17	0945	HOLD FOR ENBRIDGE	2.3g; N/A
56	170821-WA01SDC	8.21.17	1600	↓	60.1g; 150mL
				DK 8/28	

CLIENT INFORMATION

Company:

Address:

GEI Contact: Ryan Holem

rholem@geiconsultants.com; 517-881-4558

Relinquisl	[redacted]	Date/Time: 8.28.17 / 0600
Signature		
Received		Date/Time: 8/28/17/0600
Signature		
Received		Date/Time: 8/29/17 1000
Signature		

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GEI Consultants of Michigan, P.C.
230 N.Washington Sq., Suite 201, Lansing, MI 48933
Main: (517) 803-4600

Set 7

GENERAL CHAIN-OF-CUSTODY

	Sample Description	Sample Date	Sample Time	Analyses Requested	MASS (WET WEIGHT: g) ; VOL (mL) EtOH (70%) Remarks/Special Instructions
50	WPZAST04	8.29.17	1804	LINE 5 BIOTA	1.6g ; 50mL
51	WPZASE07	↓	↓	↓	5.8g ; 50mL
52	WPZASW11	↓	↓	↓	3.9g ; 50mL
53	WPZAST06	↓	↓	↓	1.7g ; 50mL
54	WPZAST09	↓	↓	↓	6.6g ; 50mL

CLIENT INFORMATION

Company:

Address:

GEI Contact: Ryan Holem

rholem@geiconsultants.com; 517-881-4558

Relinquish[redacted]	Date/Time: 8-30-17 / 0600
Signature:	
Received E	Date/Time: 8-30-17 / 0600
Signature:	
Received E	Date/Time: 8/31/17 / 1000
Signature:	

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GEI Consultants of Michigan, P.C.
230 N.Washington Sq., Suite 201, Lansing, MI 48933
Main: (517) 803-4600

Set 8

GENERAL CHAIN-OF-CUSTODY

	Sample Description	Sample Date	Sample Time	Analyses Requested	MASS (g; WET WEIGHT); VOL (mL) ETOH (70%) Remarks/Special Instructions
58	EPZASTO9	9.5.17	1225	LINE 5 BIOTA SAMPLES	8.5g ; 50mL
59	EPZASEO8	↓	↓		136.0g ; 200mL
60	EPZASWO4				88.4g ; 100mL
61	EPZASBO1				60.5g ; 50mL
62	EPZASWO2				71.5g ; 100mL
63	EPZASWIO		↓		2.1g ; 50mL
57	170905-EAOIGDC	↓	1400	COATING SAMPLE - HOLD FOR ENBRIDGE	N/A ; STORE @ 4°C

9/6

CLIENT INFORMATION

Company:

Address:

GEI Contact: Ryan Holem

rholem@geiconsultants.com; 517-881-4558

Relinquish	[redacted]	Date/Time: 9.6.17 / 0600
Signature		
Received		Date/Time: 9-6-17/0600
Signature		
Received		Date/Time: 9/7/17/ 1157
Signature		

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230 N.Washington Sq., Suite 201, Lansing, MI 48933
Main: (517) 803-4600

GENERAL CHAIN-OF-CUSTODY

Set 9

	Sample Description	Sample Date	Sample Time	Analyses Requested	Mass (g; wet weight); Vol (mL) EtOH (70%) Remarks/Special Instructions
64	170906-EA0I9M0I	9.6.17	1120	HOLD-NON-BIOTA	N/A
65	170906-EA0I10M0I	↓	1215	HOLD-NON-BIOTA	N/A
66	WPZD508	9.7.17	1034	LINE 5 BIOTA SAMPLES	4.8g ; 50mL
67	WPZDE11				9.23g ; 150mL
68	WPZDW09				80.0g ; 150mL
69	WPZDB05				15.7g ; 50mL
70	WPZDE02				2.8g ; 50mL
71	WPZDE03				73.6g ; 100mL
72	170907-WA0I1M0I		↓	↓ ; HOLD NON BIOTA	N/A ; 150mL
73	170907-WA0I2 ~~M0I~~ CD on 9/7	↓	1615	NO BIOTA ; HOLD FOR ENBRIDGE	N/A

CLIENT INFORMATION

Company:

Address:

GEI Contact: Ryan Holem

rholem@geiconsultants.com; 517-881-4558

Relinqui[redacted]		Date/Time: 9/8/17 0600
Signatur[redacted]		
Received[redacted]		Date/Time: 9/8/17 0600
Signatur[redacted]		
Received[redacted]		Date/Time: 9/11/17 1452
Signatur[redacted]		

Should have been delivered Sat, not delivered till Mon afternoon.
All ice was melted. Samples leaked

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GEI Consultants of Michigan, P.C.
230 N.Washington Sq., Suite 201, Lansing, MI 48933
Main: (517) 803-4600

Set 10

GENERAL CHAIN-OF-CUSTODY

	Sample Description	Sample Date	Sample Time	Analyses Requested	MASS (g; WETWEIGHT); VOL (mL) ETOH 70% Remarks/Special Instructions
74	EPZCNT13	9.8.17	1015	LINE 5 BIOTA SAMPLES	92.0 g ; 100 mL
75	EPZCNE11	↓	↓	↓	35.7 g ; 100 mL
76	EPZCNW06	↓	↓	↓	68.7 g ; 100 mL
77	EPZCNW08	↓	↓	↓	14.5 g ; 75 mL
78	EPZCNW07	↓	↓	↓	86.1 g ; 100 mL
79	WPZBSE11	↓	1545	↓	55.7 g ; 100 mL
80	WPZBSE10	↓	↓	↓	69.1 g ; 100 mL
81	WPZBSW14	↓	↓	↓	91.5 g ; 150 mL
82	WPZBSB01	↓	↓	↓	47.8 g ; 100 mL
83	WPZBSE08	↓	↓	↓	86.7 g ; 150 mL
84	WPZBSE09	↓	↓	↓	22.5 g ; 50 mL

9.11

CLIENT INFORMATION

Company:

Address:

GEI Contact: Ryan Holem

rholem@geiconsultants.com; 517-881-4558

Relinquish	[redacted]	Date/Time: 9.11.17 / 1030
Signature:		
Received B		Date/Time:
Signature:		
Received B		Date/Time: 9/12/17 1503
Signature:		

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REPORT TO: Ryan Holem- GEI Consultants
Name: 230 N. Washington Square, Suite 201
Company: Lansing, MI 48933
Address:

email: rholem@geiconsultants.com
Phone: 517-881-4558
Fax:

Project Manager: Stu Kogge
Project Name:
Project No.: 1411170

INVOICE TO: (For Invoices paid by a third party it is imperative that all information be provided)
Name: Same as "Report To"
Company:
Address:

email:
Phone:
Fax:

Purchase Order No.
Subcontract No.
MI Quote No. Q2017523.0001

microbialinsights
10515 Research Dr
Knoxville, TN 37932
865-573-8188
www.microbe.com

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: ☐ Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (30%)
EDD type: ☐ Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information					Analyses					CENSUS: Please select the target organism/gene																								
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	PLFA	DGGE+3ID	DGGE+5ID	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes bvc, tce, vcr)	DHBt (Dehalobacter)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Dentrifiers-nirS and nirK)	AOB ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA Toluene/Xylene-Anaerobic)	add. qPCR:	add. qPCR:	RNA Expression Option)*	Other: DNA extraction & preservation	Other:	Other:	Wet wt. Mass (g)
0660H1	EPZASW11	8/15/17	1000																												x			4.0g
2	EPZASW02	8/15/17	1000																															<1g*
3	EPZBST11		1620																															1.2g
4	EPZBSE07																																	1.7g
5	EPZBSB06																																	0.6g
6	EPZBSW12																																	2.7g

Relinquished by: Ryan Holem GEI Date 8/16/17 0605hrs [redacted] Date 8-16-17 [redacted] 1020

[redacted]

It is [redacted] relative information is provided.
Failure to provide sufficient and/or correct information regarding reporting, invoicing & analyses requested information may result i[redacted]

For drop-off @ UPS @ Rudyard, MI

[redacted]imal sample mass - retained [redacted]63 um mesh to enable [redacted]er access to sample which appeared to be mostly sand.

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REPORT TO:
Name: Ryan Holem- GEI Consultants
Company: 230 N. Washington Square, Suite 201
Address: Lansing, MI 48933
email: rholem@geiconsultants.com
Phone: 517-881-4558
Fax:

INVOICE TO: (For Invoices paid by a third party it is imperative that all information be provided)
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microbialinsights
10515 Research Dr
Knoxville, TN 37932
865-573-8188
www.microbe.com

Project Manager: Stu Kogge
Project Name:
Project No.: 1411170

Purchase Order No.
Subcontract No.
MI Quote No. Q2017523.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: ☐ Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (30%)
EDD type: ☐ Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information					Analyses					CENSUS: Please select the target organism/gene																								
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	PLFA	DGGE+3ID	DGGE+5ID	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tce, vcr)	DHBt (Dehalobacter)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Denitrifiers-nirS and nirK)	AOB (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add. qPCR:	add. qPCR:	RNA (Expression Option)*	Other: DNA extraction & preservation	Other:	Other:
0660H 7	EPZCST07	8.16.17	1015																												X			0.29
8	EPZCSE01	↓	↓																												↓			1.1g
9	EPZCSB02																																	0.5g
10	EPZCSW04	↓	↓																												↓			0.7g

WET WEIGHT MASS

[redacted] 8.17.16 1000 Receive[redacted]ate 8/18/17 11:13

It is vital that chain of custody [redacted] information is provided.
Failure to provide sufficient and/or correct information regarding reporting, invoicing & analyses requested [redacted] information may result in delays for which MI will not be liable.

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REPORT TO:
Name: Ryan Holem- GEI Consultants
Company: 230 N. Washington Square, Suite 201
Address: Lansing, MI 48933
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865-573-8188
www.microbe.com

Project Manager: Stu Kogge
Project Name:
Project No.: 1411170

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MI Quote No. Q2017523.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

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EDD type: ☐ Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

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Sample Information					Analyses					CENSUS: Please select the target organism/gene																						
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	PLFA	DGGE+3ID	DGGE+5ID	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tca, vcr)	DHBt (Dehalobacter)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Dentrifiers-nirS and nirK)	AOB (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add. qPCR:	add. qPCR:	RNA (Expression Option)*	Other: DNA extraction & preservation	Other:	Other:
0660411	EPZANW07	8.19.17	0830																												X		
12	EPZANE09	↓	↓																												↓		
13	EPZANT10		↓																														
14	EPZBNW05		11.55																														
15	EPZBNE02		↓																														
16	EPZBNT06		↓																														
17	WPZANT12		1530																														
18	WPZANB05		↓																														
19	WPZANE11		↓																														
20	WPZANW04	↓	↓																												↓		

Relinquished by [redacted] Date 8/21/17 - 0600

[redacted] ation is provided.

Failure to provide sufficient and/or correct information regarding reporting, invoicing & analyses requested information may result in delays for which MI will not be liable.

8/22/17
10:10

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REPORT TO:
Name: Ryan Holem- GEI Consultants
Company: 230 N. Washington Square, Suite 201
Address: Lansing, MI 48933
email: rholem@geiconsultants.com
Phone: 517-881-4558
Fax:

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microbialinsights
10515 Research Dr
Knoxville, TN 37932
865-573-8188
www.microbe.com

Project Manager: Stu Kogge
Project Name:
Project No.: 1411170

Purchase Order No.
Subcontract No.
MI Quote No. Q2017523.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: ☐ Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (30%)
EDD type: ☐ Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

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Sample Information					Analyses					CENSUS: Please select the target organism/gene																						
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	PLFA	DGGE+3ID	DGGE+5ID	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tce, vcr)	DHBt (Dehalobacter)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Denitrifiers-nirS and nirK)	AOB (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add. qPCR:	add. qPCR:	RNA (Expression Option)*	Other: DNA extraction & preservation	Other:	Other:
0600121	EPZDT05	8.20.17	1155																												X		
22	EPZDE09	↓	↓																												↓		
23	EPZDW10	↓	↓																												↓		
24	WPZDT05	↓	1520																												↓		
25	WPZDE06	↓	↓																												↓		
26	WPZDW09	↓	↓																												↓		

[redacted] 8.21.17 0600 [redacted] Date 8/21/17 0600 [redacted]

[redacted]ative information is provided.
Failure to provide sufficient and/or correct information regarding reporting, invoicing & analyses requested information may result in delays for which MI will no[redacted]

8/22/17
10:10

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REPORT TO:
Name: Ryan Holem- GEI Consultants
Company: 230 N. Washington Square, Suite 201
Address: Lansing, MI 48933
email: rholem@geiconsultants.com
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Project Manager: Stu Kogge
Project Name:
Project No.: 1411170

Purchase Order No.
Subcontract No.
MI Quote No. Q2017523.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: ☐ Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (30%)
EDD type: ☐ Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information					Analyses					CENSUS: Please select the target organism/gene																						
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	PLFA	DGGE+3ID	DGGE+5ID	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tce, vcr)	DHBt (Dehalobacter)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Dentrifiers-nirS and nirK)	AOB (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add. qPCR:	add. qPCR:	RNA (Expression Option)*	Other: DNA extraction & preservation	Other:	Other:
0660H27	WPZCNT03	8.21.17	1055																												X		
28	WPZCNE05	↓	↓																												↓		
29	WPZCNB01																																
30	WPZCNW10		↓																														
31	WPZBNT10		1255																														
32	WPZBNE09		↓																														
33	WPZBNW02	↓	↓																														

[redacted] 8.22.17 1700 Recei[redacted] 8/23/17 1030

It is vital that chain of custo[redacted]ion is provided.
Failure to provide sufficient and/or correct information regarding re[redacted]ion may result in delays for which MI will not be liable.

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REPORT TO:
Name: Ryan Holem- GEI Consultants
Company: 230 N. Washington Square, Suite 201
Address: Lansing, MI 48933
email: rholem@geiconsultants.com
Phone: 517-881-4558
Fax:

INVOICE TO: (For Invoices paid by a third party it is imperative that all information be provided)
Name: Same as "Report To"
Company:
Address:
email:
Phone:
Fax:

microbialinsights
10515 Research Dr
Knoxville, TN 37932
865-573-8188
www.microbe.com

Project Manager: Stu Kogge
Project Name:
Project No.: 1411170

Purchase Order No.
Subcontract No.
MI Quote No. Q2017523.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: ☐ Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (30%)
EDD type: ☐ Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

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MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	PLFA	DGGE+3ID	DGGE+5ID	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tce, vcr)	DHBt (Dehalobacter)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Denitrifiers-nirS and nirK)	AOB (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add. qPCR:	add. qPCR:	RNA (Expression Option)*	Other: DNA extraction & preservation	Other:	Other:
0660H 34	EPZASW11	8.24.17	1510																												X		
35	EPZASW04	↓	↓																														

Relinquished by: [redacted] 8.25.17 0600 [redacted] Date 8-26-17 [redacted] 8/26/17 10:26

It is vital that chain of custody is filled out correctly & that all relative information is provided.
[redacted] provide sufficient and/or correct information regarding reporting, invoicing & analyses requested information may result in delays for which MI will not be liable.

RH 8/25/17

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0606OH36	WPZDT06	8.25.17	1115																												X		
37	WPZDT04	↓	↓																														
38	EPZDW11	8.26.17	1030																														
39	EPZDW03																																
40	EPZDW12																																
41	EPZDE08																																
42	EPZDT04		↓																														
43	WPZCST12		1435																														
44	WPZCSW04																																
45	WPZCSE06	↓	↓																												↓		

[redacted] 8.28.16 0600 [redacted] Date 8/28/2017 [redacted] 8/29/17 1020

Failure to provide sufficient and/or c[redacted]tive information is provided. [redacted]ted information may result in delays for which [redacted]

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Project Manager: Stu Kogge
Project Name:
Project No.: 1411170

Purchase Order No.
Subcontract No.
MI Quote No. Q2017523.0001

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☐ More samples to follow
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0d6OH46	WPZCSW01	8.26.17	1435																												X		
47	WPZCSW02	↓	↓																												↓		

OK 8/28

Reli[redacted] 8.28.17 0600 [redacted] Date 8/28/2017 [redacted] 8/29/17 1020

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06601H48	WPZASTOB	8-29-17	1804																												X		
49	WPZASE03																																
50	WPZASW12																																
51	WPZASTO1																																
52	WPZASTO2																																

Relinquished by: [redacted] 8-30-17 0600 [redacted] Date 8/30/17 [redacted] 8/31/17 1015

Failure to provide sufficient [redacted] ative information is provided. [redacted] sted information may result in dela[redacted]

* Minimal mass in many samples - please extract contents/material in mesh bags

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Name: 230 N. Washington Square, Suite 201
Company: Lansing, MI 48933
Address:

email: rholem@geiconsultants.com
Phone: 517-881-4558
Fax:

Project Manager: Stu Kogge
Project Name:
Project No.: 1411170

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Subcontract No.
MI Quote No. Q2017523.0001

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☐ More samples to follow
☐ No Additional Samples

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Sample Information					Analyses					CENSUS: Please select the target organism/gene																							
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	PLFA	DGGE+3ID	DGGE+5ID	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tce, vcr)	DHBt (Dehalobacter)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Dentrifiers-nirS and nirK)	AOB (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add. qPCR:	add. qPCR:	RNA (Expression Option)*	Other: DNA extraction & preservation	Other:	Other:
0660H53	EPZAST03	9.5.17	1225																												X		
54	EPZASE05	↓	↓																												↓		
55	EPZASW06																																
56	EPZASB07																																
57	EPZASW11																																

KC 9/6

[redacted] 17 00 Received by: [redacted] Date 9-6-17 0600 [redacted] 9-7-17 10:30am

It is vital that chain of custody [redacted] mation is provided.
[redacted] sufficient and/or correct information regarding reporting, invoicing & analyses requested information may result in delay [redacted]

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865-573-8188
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Project Manager: Stu Kogge
Project Name:
Project No.: 1411170

Purchase Order No.
Subcontract No.
MI Quote No. Q2017523.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: ☐ Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (30%)
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Sample Information					Analyses					CENSUS: Please select the target organism/gene																						
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	PLFA	DGGE+3ID	DGGE+5ID	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tce, vcr)	DHBt (Dehalobacter)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Dentrifiers-nirS and nirK)	AOB (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add qPCR:	add qPCR:	RNA (Expression Option)*	Other: DNA extraction & preservation	Other:	Other:
0660H58	WPZDT04	9-7-17	1034																												X		
59	WPZDE07	↓	↓																												↓		
60	WPZDW10																																
61	WPZDB12																																
62	WPZDE01																																
63	WPZDE06	↓	↓																												↓		

[redacted] 9-8-17 0600 [redacted] y: Date 9-8-12 0600 [redacted] 1:16

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Project Manager: STUART KOLGE
Project Name:
Project No.: 141170

Purchase Order No.
Subcontract No.
MI Quote No. Q2017523:0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: ☐ Standard (default) ☐ Microbial Insights Level III raw data (15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive (15%) ☐ Historical Interpretive (35%)

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Sample Information						Analyses				CENSUS: Please select the target organism/gene																				
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tce, vcr)	DHBt (Dehalobacter)	DHG (Dehalogenimonas)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Dentrifiers-nirS and nirK)	AMO (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add. qPCR:	RNA (Expression Option)*	Other: DNA EXTRACTION/PRESERVATION	Other:	Other:
0660H 64	EPZCNT10	9.8.17	1015																												X		
65	EPZCNE02																																
66	EPZCNW07																																
67	EPZCNW05																																
68	EPZCNW14																																
69	WPZBST04		1545																														
70	WPZBSE06																																
71	WPZBSW12																																
72	WPZBSB07																																
73	WPZBSE03																																

Relinqu[redacted] Date 9.11.17 1030 Received [redacted] 9/12/17 10:15

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* additional cost and sample preservation are associated with RNA samples.

**Saturday delivery: See sampling protocol for alternate shipping address.

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Project Manager: STUART KOLGE
Project Name:
Project No.: 141170

Purchase Order No.
Subcontract No.
MI Quote No. Q2017523.0001

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: ☐ Standard (default) ☐ Microbial Insights Level III raw data(15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive(15%) ☐ Historical Interpretive (35%)

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0660H74	WPZB5E13	9.8.17	1545																												X		

DH 9/8

Relin[redacted] Date 9.11.17 | 1030 Received by [redacted] Date 9/12/17 10:15

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Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information						Analyses				CENSUS: Please select the target organism/gene																						
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tce, vcr)	DHBt (Dehalobacter)	DHG (Dehalogenimonas)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Denitrifiers-nirS and nirK)	AMO (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add. qPCR:	RNA (Expression Option)*	Other: DNA EXTRACTION / PRESERVATION	Other:	Other:
0650L 1	EPZBS-WS-01	12-13-17	0845		1																										X		
2	EPZAS-WS-02		1005																														
3	EPZAS-WB-03		1035																														
4	EPZAS-S1-01		1038																														
5	EPZAS-S2-02																																
6	EPZAS-S1-03																																
7	EPZAS-WM-04		1153																														

12.13.17

Relinquished by [redacted] Date 12/14/17 1414 hrs Rec[redacted] 12/15/17 1055

It is vital that chain of custody is [redacted]ation is provided.
Failure to provide sufficient and/or correct information regarding repor[redacted]ation may result in delays for which MI will not be liable.

PLEASE EXTRACT + HOLD

* additional cost and sample preservation are associated with RNA samples.

**Saturday delivery: See sampling protocol for alternate shipping address.

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REPORT TO:

Name: RYAN HOLEM
Company: GEI CONSULTANTS
Address: 230 N WASHINGTON SQ
SUITE 201
LANSING MI 48933
email: RHOLEM@GEICONSULTANTS.COM
Phone: 517-881-4558
Fax:

INVOICE TO: (For Invoices paid by a third party it is imperative that all information be provided)

Name: SAME AS "REPORT TO"
Company:
Address:
email:
Phone:
Fax:

microbialinsights

10515 Research Dr
Knoxville, TN 37932
865-573-8188

www.microbe.com

Project Manager: STU KOLGE
Project Name:
Project No.: ~~147110~~ 141170
OK 12.15

Purchase Order No.
Subcontract No.
MI Quote No.

Please Check One:
☐ More samples to follow
☐ No Additional Samples

Report Type: ☐ Standard (default) ☐ Microbial Insights Level III raw data (15% surcharge) ☐ Microbial Insights Level IV (25% surcharge) ☐ Comprehensive Interpretive (15%) ☐ Historical Interpretive (35%)

EDD type: ☐ Microbial Insights Standard (default) ☐ All other available EDDs (5% surcharge) Specify EDD Type:

Please contact us with any questions about the analyses or filling out the COC at (865) 573-8188 (9:00 am to 5:00 pm EST, M-F). After hours email: customerservice@microbe.com

Sample Information						Analyses				CENSUS: Please select the target organism/gene																						
MI ID (Laboratory Use Only)	Sample Name	Date Sampled	Time Sampled	Matrix	Total Number of Containers	PLFA	NGS	QuantArray Chlor	QuantArray Petro	DHC (Dehalococcoides)	DHC Functional genes (bvc, tce, vcr)	DHBt (Dehalobacter)	DHG (Dehalogenimonas)	DSM (Desulfuromonas)	DSB (Desulfitobacterium)	EBAC (Total)	SRB (Sulfate Reducing Bacteria-APS)	MGN (Methanogens)	MOB (Methanotrophs)	SMMO	DNF (Denitrifiers-nirS and nirK)	AMO (ammonia oxidizing bacteria)	PM1 (MTBE aerobic)	RMO (Toluene Monooxygenase)	RDEG (Toluene Monooxygenase)	PHE (Phenol Hydroxylase)	NAH (Napthalene-aerobic)	BSSA (Toluene/Xylene-Anaerobic)	add. qPCR:	RNA (Expression Option)*	Other: DNA EXTRACTION + PRESERVATION	Other:	Other:
0650L 8	EPZBS-WB-05	12.15.17	0944	WATER	1																											
9	EPZBS-WM-06	↓	1011	↓	↓																											
10	EPZBS-S1-04	↓	0947	SEDIMENT	↓																											
11	EPZBS-S2-05	↓	↓	↓	↓																											

Relinquished by [redacted] Date 12.15.17 1600 Received [redacted] 12/16/17 11:10

It is vital that chain of custody is filled out correctly & that all relative information is provided.
Failure to provide sufficient and/or correct information regarding reporting, invoicing & analyses requested information may result in delays for which MI will not be liable.

* additional cost and sample preservation are associated with RNA samples.

**Saturday delivery: See sampling protocol for alternate shipping address.

ANN ARBOR TECHNICAL SERVICES, INC.
290 South Wagner Road
Ann Arbor, Michigan 48103
Tel. 734/995-0995 Fax. 734/995-3731
Michigan Laboratory ID: 9604
Wisconsin Laboratory ID: 998321720

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CHAIN OF CUSTODY RECORD

PROJECT ID / NUMBER

LABORATORY INFORMATION: GEI Consultants, Inc.

SAMPLE CUSTODIAN (Print & Signature): Natalie Love/Ryan Holem (rholem@geiconsultants.com; 517-803-2838)

SHIPPING INFORMATION: SHIPPER (Check one) / TRACKING NUMBER(S) (If applicable)

Date	Fed Ex	UPS	DHL	Courier	Tracking Number
8/29/17		✓			

RELINQUISHED BY (Print & Signature)	DATE / TIME	RECEIVED BY (Print & Signature)	DATE / TIME	RELINQUISHED BY (Print & Signature)	DATE / TIME	RECEIVED BY (Print & Signature)	DATE / TIME

COMMENTS (Preservation, etc.): Originally preserved in Ethanol; preservative removed with some potentially remaining in the matrix

ANALYSIS

LINE NO.	BAR CODE	DATE	TIME	COMP.	GRAB	SAMPLE IDENTIFICATION	NO. OF CONTAINERS	PRIORITY NUMBER	Identification											MATRIX Indicate Soil/Water/Air Sediment/Sludge Extract
1.		08/29/2017	14:00		X	EPZASW07CB	1		X											Unknown Solid
2.																				
3.																				
4.																				
5.																				
6.																				
7.																				
8.																				
9.																				
10.																				
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20.																				

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Appendix K

2017 Phycotech Laboratory Analyses

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Project Name	Sample ID	GEI Log #	Taxa ID	Taxon Group	Phylum	Division	Class	Subclass	Order	Family	Genus	Species	Variety	Form
Enbridge	EPZBSB04	EN817-5	127895	Zooplankton	Arthropoda	NA	Maxillipoda	Copepoda	Harpacticoida	NA	NA	NA	NA	NA
Enbridge	EPZBSB04	EN817-5	1013	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthidium	minutissima	NA	NA
Enbridge	EPZBSB04	EN817-5	1071	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	spNA 1	NA	NA
Enbridge	EPZBSB04	EN817-5	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	EPZBSB04	EN817-5	1332	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Tabellariales	Tabellariaceae	Tabellaria	flocculosa	NA	NA
Enbridge	EPZBSB04	EN817-5	2683	Algae	NA	Chlorophyta	Chlorophyceae	NA	Chlorococcales	Chlorococcaceae	NA	NA	NA	NA
Enbridge	EPZBSB04	EN817-5	1000559	Algae	NA	Cyanophyta	Cyanophyceae	NA	Oscillatoriales	Oscillatoriaceae	Heteroleibleinia	NA	NA	NA
Enbridge	EPZBSB04	EN817-5	1000564	Algae	NA	Cyanophyta	Cyanophyceae	NA	Oscillatoriales	Oscillatoriaceae	Leptolyngbya	subtilissima	NA	NA
Enbridge	EPZCST08	EN817-7	9004	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthes	minutissima	gracillima	NA
Enbridge	EPZCST08	EN817-7	1013	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthidium	minutissima	NA	NA
Enbridge	EPZCST08	EN817-7	1341	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	ovalis	NA	NA
Enbridge	EPZCST08	EN817-7	9856	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	atomus	NA	NA
Enbridge	EPZCST08	EN817-7	1071	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	spNA 1	NA	NA
Enbridge	EPZCST08	EN817-7	1095	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	silesiaca	NA	NA
Enbridge	EPZCST08	EN817-7	1109	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Diatoma	tenuis	NA	NA
Enbridge	EPZCST08	EN817-7	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	EPZCST08	EN817-7	9045	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	construens	NA	venter
Enbridge	EPZCST08	EN817-7	9102	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	tripunctata	NA	NA
Enbridge	EPZCST08	EN817-7	9106	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	viridula	rostellata	NA
Enbridge	EPZCST08	EN817-7	1220	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	NA	NA	NA
Enbridge	EPZCST08	EN817-7	1240	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Pinnulariaceae	Pinnularia	NA	NA	NA
Enbridge	EPZCST08	EN817-7	1477	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	filiformis	NA	NA
Enbridge	EPZCST08	EN817-7	1332	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Tabellariales	Tabellariaceae	Tabellaria	flocculosa	NA	NA
Enbridge	EPZCST08	EN817-7	2389	Algae	NA	Chlorophyta	Chlorophyceae	NA	Chlorococcales	Hydrodictyaceae	Pediastrum	boryanum	longicorne	NA
Enbridge	EPZCST08	EN817-7	2554	Algae	NA	Chlorophyta	Chlorophyceae	NA	Chlorococcales	Chlorococcaceae	Tetraedron	minimum	NA	NA
Enbridge	EPZCST08	EN817-7	1653	Algae	NA	Chrysophyta	Chrysophyceae	NA	NA	NA	NA	NA	NA	NA
Enbridge	EPZCST08	EN817-7	1000559	Algae	NA	Cyanophyta	Cyanophyceae	NA	Oscillatoriales	Oscillatoriaceae	Heteroleibleinia	NA	NA	NA
Enbridge	EPZCST08	EN817-7	7240	Detritus/Particulates	NA	Miscellaneous	NA	NA	NA	NA	NA	NA	NA	NA
Enbridge	EPZANW08	EN817-11	127895	Zooplankton	Arthropoda	NA	Maxillipoda	Copepoda	Harpacticoida	NA	NA	NA	NA	NA
Enbridge	EPZANW08	EN817-11	1013	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthidium	minutissima	NA	NA
Enbridge	EPZANW08	EN817-11	9212	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	placentula	lineata	NA
Enbridge	EPZANW08	EN817-11	1099	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	cistula	NA	NA
Enbridge	EPZANW08	EN817-11	1095	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	silesiaca	NA	NA
Enbridge	EPZANW08	EN817-11	1103	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Diatoma	ehrenbergii	NA	NA
Enbridge	EPZANW08	EN817-11	109135	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Paraliales	Paraliaceae	Ellerbeckia	arenaria	NA	NA
Enbridge	EPZANW08	EN817-11	1354	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Rhopalodiales	Rhopalodiaceae	Epithemia	turgida	NA	NA
Enbridge	EPZANW08	EN817-11	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	EPZANW08	EN817-11	109674	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Melosirales	Melosiraceae	Melosira	undulata	NA	NA
Enbridge	EPZANW08	EN817-11	1315	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	NA	NA
Enbridge	EPZANW08	EN817-11	1332	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Tabellariales	Tabellariaceae	Tabellaria	flocculosa	NA	NA
Enbridge	EPZANW08	EN817-11	111263	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Tabellariales	Tabellariaceae	Tabellaria	quadriseptata	NA	NA
Enbridge	EPZANW08	EN817-11	2350	Algae	NA	Chlorophyta	Chlorophyceae	NA	Oedogoniales	Oedogoniaceae	Oedogonium	NA	NA	NA
Enbridge	EPZBNT01	EN817-16	1013	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthidium	minutissima	NA	NA

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Project Name	Sample ID	GEI Log #	Morph	Coloniality	Coloniality State	Structure	Physiological State	Taxonomic Authority
Enbridge	EPZBSB04	EN817-5	All Stages	Animal	Free	Whole Animal	Live	Downing and Rigler 1984 - only estimate found
Enbridge	EPZBSB04	EN817-5	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	EPZBSB04	EN817-5	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) de Brebisson
Enbridge	EPZBSB04	EN817-5	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	EPZBSB04	EN817-5	NA	Complex-Filament	Free	Vegetative	Live	(Roth) KtzNA
Enbridge	EPZBSB04	EN817-5	2-9NA9 um spherical	Cell-Nonmotile	Free	Vegetative	Live	N/A
Enbridge	EPZBSB04	EN817-5	NA	Filament	Attached	Vegetative	Live	(Geitler) Hoffmann 1985
Enbridge	EPZBSB04	EN817-5	NA	Filament	Attached	Vegetative	Live	(Kutzing ex Hansgirg) Komarek in Anagnostidis 2001
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Vegetative	Live	(Meister) Lange-Bertalot
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) Kutzing
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Vegetative	Live	HustNA
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) de Brebisson
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Vegetative	Live	Bleisch
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Vegetative	Live	Agardh
Enbridge	EPZCST08	EN817-7	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	EPZCST08	EN817-7	NA	Lateral-Filament	Attached	Vegetative	Live	(Ehrenberg) Hustedt
Enbridge	EPZCST08	EN817-7	NA	Cell-Motile	Free	Vegetative	Live	(ONA FNA MlINA) Bory
Enbridge	EPZCST08	EN817-7	NA	Cell-Motile	Free	Vegetative	Live	(KtzNA) Cleve
Enbridge	EPZCST08	EN817-7	NA	Cell-Motile	Free	Vegetative	Live	Hassall
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Vegetative	Live	(PantNA) RNA Ross
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Vegetative	Live	Grunow
Enbridge	EPZCST08	EN817-7	NA	Complex-Filament	Free	Vegetative	Live	(Roth) KtzNA
Enbridge	EPZCST08	EN817-7	NA	Colonial-Nonmotile	Attached	Vegetative	Live	Raciborski
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Vegetative	Live	(Braun) Hansgirg
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Cyst	NA	N/A
Enbridge	EPZCST08	EN817-7	NA	Filament	Attached	Vegetative	Live	(Geitler) Hoffmann 1985
Enbridge	EPZCST08	EN817-7	NA	Cell-Nonmotile	Free	Pollen Grain	Dead	N/A
Enbridge	EPZANW08	EN817-11	All Stages	Animal	Free	Whole Animal	Live	Downing and Rigler 1984 - only estimate found
Enbridge	EPZANW08	EN817-11	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	EPZANW08	EN817-11	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) Van Heurck
Enbridge	EPZANW08	EN817-11	NA	Cell-Nonmotile	Free	Vegetative	Live	(Ehrenberg in Hemprich & Ehrenberg) Kirchner in Cohn
Enbridge	EPZANW08	EN817-11	NA	Cell-Nonmotile	Free	Vegetative	Live	Bleisch
Enbridge	EPZANW08	EN817-11	NA	Cell-Nonmotile	Free	Vegetative	Live	KtzNA
Enbridge	EPZANW08	EN817-11	NA	Cell-Nonmotile	Free	Vegetative	Live	(Moore ex Ralfs) RNA MNA Crawford
Enbridge	EPZANW08	EN817-11	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) KtzNA
Enbridge	EPZANW08	EN817-11	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	EPZANW08	EN817-11	NA	Filament	Attached	Vegetative	Live	(EhrenbNA) KtzNA
Enbridge	EPZANW08	EN817-11	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	EPZANW08	EN817-11	NA	Complex-Filament	Free	Vegetative	Live	(Roth) KtzNA
Enbridge	EPZANW08	EN817-11	NA	Complex-Filament	Free	Vegetative	Live	KnudsNA
Enbridge	EPZANW08	EN817-11	NA	Filament	Attached	Vegetative	Live	De Bary
Enbridge	EPZBNT01	EN817-16	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing

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Project Name	Sample ID	GEI Log #	Taxa ID	Taxon Group	Phylum	Division	Class	Subclass	Order	Family	Genus	Species	Variety	Form
Enbridge	EPZBNT01	EN817-16	1021	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Asterionella	formosa	NA	NA
Enbridge	EPZBNT01	EN817-16	1066	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	pediculus	NA	NA
Enbridge	EPZBNT01	EN817-16	9212	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	placentula	lineata	NA
Enbridge	EPZBNT01	EN817-16	1071	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	spNA 1	NA	NA
Enbridge	EPZBNT01	EN817-16	109135	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Paraliales	Paraliaceae	Ellerbeckia	arenaria	NA	NA
Enbridge	EPZBNT01	EN817-16	1140	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Eunotiales	Eunotiaceae	Eunotia	NA	NA	NA
Enbridge	EPZBNT01	EN817-16	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	EPZBNT01	EN817-16	10379	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	mesolepta	NA
Enbridge	EPZBNT01	EN817-16	109674	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Melosirales	Melosiraceae	Melosira	undulata	NA	NA
Enbridge	EPZBNT01	EN817-16	1193	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Melosirales	Melosiraceae	Melosira	varians	NA	NA
Enbridge	EPZBNT01	EN817-16	1315	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	NA	NA
Enbridge	EPZBNT01	EN817-16	1332	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Tabellariales	Tabellariaceae	Tabellaria	flocculosa	NA	NA
Enbridge	EPZBNT01	EN817-16	111263	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Tabellariales	Tabellariaceae	Tabellaria	quadriseptata	NA	NA
Enbridge	EPZBNT01	EN817-16	2641	Algae	NA	Chlorophyta	Chlorophyceae	NA	Tetrasporales	Palmellopsidaceae	Sphaerocystis	schroeteri	NA	NA
Enbridge	WPZANB09	EN817-19	1013	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthidium	minutissima	NA	NA
Enbridge	WPZANB09	EN817-19	1111	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	delicatula	NA	NA
Enbridge	WPZANB09	EN817-19	1095	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	silesiaca	NA	NA
Enbridge	WPZANB09	EN817-19	1109	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Diatoma	tenuis	NA	NA
Enbridge	WPZANB09	EN817-19	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	WPZANB09	EN817-19	10379	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	mesolepta	NA
Enbridge	WPZANB09	EN817-19	9045	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	construens	NA	venter
Enbridge	WPZANB09	EN817-19	109340	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	radians	NA	NA
Enbridge	WPZANB09	EN817-19	9055	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Gomphonemataceae	Gomphonema	pumilum	NA	NA
Enbridge	WPZANB09	EN817-19	1193	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Melosirales	Melosiraceae	Melosira	varians	NA	NA
Enbridge	WPZANB09	EN817-19	9064	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	capitatoradiata	NA	NA
Enbridge	WPZANB09	EN817-19	111189	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	filiformis	exilis	NA
Enbridge	WPZANB09	EN817-19	111208	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ostenfeldii	NA	NA
Enbridge	WPZANB09	EN817-19	1315	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	NA	NA
Enbridge	WPZANB09	EN817-19	4190	Algae	NA	Cyanophyta	Cyanophyceae	NA	Nostocales	Oscillatoriaceae	Phormidium	NA	NA	NA
Enbridge	WPZANB09	EN817-19	4321	Algae	NA	Cyanophyta	Cyanophyceae	NA	Chroococcales	Chroococcaceae	Synechococcus	elongatus	NA	NA
Enbridge	EPZDW08	EN817-23	127895	Zooplankton	Arthropoda	NA	Maxillipoda	Copepoda	Harpacticoida	NA	NA	NA	NA	NA
Enbridge	EPZDW08	EN817-23	9361	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	pseudostelligera	NA	NA
Enbridge	EPZDW08	EN817-23	1071	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	spNA 1	NA	NA
Enbridge	EPZDW08	EN817-23	1111	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	delicatula	NA	NA
Enbridge	EPZDW08	EN817-23	1109	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Diatoma	tenuis	NA	NA
Enbridge	EPZDW08	EN817-23	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	EPZDW08	EN817-23	9397	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	vaucheriae	NA
Enbridge	EPZDW08	EN817-23	109626	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Mastogloiales	Mastogloiaceae	Mastogloia	grevillei	NA	NA
Enbridge	EPZDW08	EN817-23	9064	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	capitatoradiata	NA	NA
Enbridge	EPZDW08	EN817-23	1981	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Opephora	olsenii	NA	NA
Enbridge	EPZDW08	EN817-23	1754	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Rhopalodiales	Rhopalodiaceae	Rhopalodia	gibba	minuta	NA
Enbridge	EPZDW08	EN817-23	1298	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Stephanodiscus	parvus	NA	NA
Enbridge	EPZDW08	EN817-23	1477	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	filiformis	NA	NA

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Project Name	Sample ID	GEI Log #	Morph	Coloniality	Coloniality State	Structure	Physiological State	Taxonomic Authority
Enbridge	EPZBNT01	EN817-16	NA	Colonial-Nonmotile	Attached	Vegetative	Live	HassNA
Enbridge	EPZBNT01	EN817-16	NA	Cell-Nonmotile	Free	Vegetative	Live	EhrenbNA
Enbridge	EPZBNT01	EN817-16	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) Van Heurck
Enbridge	EPZBNT01	EN817-16	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) de Brebisson
Enbridge	EPZBNT01	EN817-16	NA	Cell-Nonmotile	Free	Vegetative	Live	(Moore ex Ralfs) RNA MNA Crawford
Enbridge	EPZBNT01	EN817-16	NA	Cell-Nonmotile	Free	Vegetative	Live	N”rpell-Schempp & Lange-BertNA in Lange-BertNA
Enbridge	EPZBNT01	EN817-16	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	EPZBNT01	EN817-16	NA	Lateral-Filament	Attached	Vegetative	Live	RabenhNA
Enbridge	EPZBNT01	EN817-16	NA	Filament	Attached	Vegetative	Live	(EhrenbNA) KtzNA
Enbridge	EPZBNT01	EN817-16	NA	Filament	Attached	Vegetative	Live	CNA ANA Agardh (for genus)
Enbridge	EPZBNT01	EN817-16	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	EPZBNT01	EN817-16	NA	Complex-Filament	Free	Vegetative	Live	(Roth) KtzNA
Enbridge	EPZBNT01	EN817-16	NA	Complex-Filament	Free	Vegetative	Live	KnudsNA
Enbridge	EPZBNT01	EN817-16	NA	Colonial-Nonmotile	Attached	Vegetative	Live	Chodat
Enbridge	WPZANB09	EN817-19	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	WPZANB09	EN817-19	NA	Cell-Nonmotile	Free	Vegetative	Live	KtzNA
Enbridge	WPZANB09	EN817-19	NA	Cell-Nonmotile	Free	Vegetative	Live	Bleisch
Enbridge	WPZANB09	EN817-19	NA	Cell-Nonmotile	Free	Vegetative	Live	Agardh
Enbridge	WPZANB09	EN817-19	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	WPZANB09	EN817-19	NA	Lateral-Filament	Attached	Vegetative	Live	RabenhNA
Enbridge	WPZANB09	EN817-19	NA	Lateral-Filament	Attached	Vegetative	Live	(Ehrenberg) Hustedt
Enbridge	WPZANB09	EN817-19	NA	Lateral-Filament	Attached	Vegetative	Live	(KtzNA) DNA MNA Williams & Round
Enbridge	WPZANB09	EN817-19	NA	Cell-Nonmotile	Free	Vegetative	Live	(Grunow) Reichardt & Lange-Bertalot
Enbridge	WPZANB09	EN817-19	NA	Filament	Attached	Vegetative	Live	CNA ANA Agardh (for genus)
Enbridge	WPZANB09	EN817-19	NA	Cell-Motile	Free	Vegetative	Live	Germain
Enbridge	WPZANB09	EN817-19	NA	Cell-Nonmotile	Free	Vegetative	Live	ANA Cleve
Enbridge	WPZANB09	EN817-19	NA	Cell-Nonmotile	Free	Vegetative	Live	(Willi KreigNA) ANA Cleve
Enbridge	WPZANB09	EN817-19	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	WPZANB09	EN817-19	NA	Multi-Filament	Attached	Vegetative	Live	Lemmermann
Enbridge	WPZANB09	EN817-19	NA	Cell-Nonmotile	Free	Vegetative	Live	Nageli
Enbridge	EPZDW08	EN817-23	All Stages	Animal	Free	Whole Animal	Live	Downing and Rigler 1984 - only estimate found
Enbridge	EPZDW08	EN817-23	NA	Cell-Nonmotile	Free	Vegetative	Live	(Hustedt) Houk and Klee
Enbridge	EPZDW08	EN817-23	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) de Brebisson
Enbridge	EPZDW08	EN817-23	NA	Cell-Nonmotile	Free	Vegetative	Live	KtzNA
Enbridge	EPZDW08	EN817-23	NA	Cell-Nonmotile	Free	Vegetative	Live	Agardh
Enbridge	EPZDW08	EN817-23	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	EPZDW08	EN817-23	NA	Lateral-Filament	Attached	Vegetative	Live	(Kutzing) Lange-Bertalot
Enbridge	EPZDW08	EN817-23	NA	Cell-Nonmotile	Free	Vegetative	Live	WNA SmNA
Enbridge	EPZDW08	EN817-23	NA	Cell-Motile	Free	Vegetative	Live	Germain
Enbridge	EPZDW08	EN817-23	NA	Lateral-Filament	Attached	Vegetative	Live	Peragallo
Enbridge	EPZDW08	EN817-23	NA	Cell-Nonmotile	Free	Vegetative	Live	Krammer
Enbridge	EPZDW08	EN817-23	NA	Cell-Nonmotile	Free	Vegetative	Live	Stoermer & H†kNA
Enbridge	EPZDW08	EN817-23	NA	Cell-Nonmotile	Free	Vegetative	Live	Grunow

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Project Name	Sample ID	GEI Log #	Taxa ID	Taxon Group	Phylum	Division	Class	Subclass	Order	Family	Genus	Species	Variety	Form
Enbridge	EPZDW08	EN817-23	1315	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	NA	NA
Enbridge	EPZDW08	EN817-23	1653	Algae	NA	Chrysophyta	Chrysophyceae	NA	NA	NA	NA	NA	NA	NA
Enbridge	EPZDW08	EN817-23	4190	Algae	NA	Cyanophyta	Cyanophyceae	NA	Nostocales	Oscillatoriaceae	Phormidium	NA	NA	NA
Enbridge	WPZDW03	EN817-26	10379	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	mesolepta	NA
Enbridge	WPZCNT04	EN817-27	109135	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Paraliales	Paraliaceae	Ellerbeckia	arenaria	NA	NA
Enbridge	WPZCNT04	EN817-27	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	WPZCNT04	EN817-27	9045	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	construens	NA	venter
Enbridge	WPZCNT04	EN817-27	109674	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Melosirales	Melosiraceae	Melosira	undulata	NA	NA
Enbridge	WPZCNT04	EN817-27	1193	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Melosirales	Melosiraceae	Melosira	varians	NA	NA
Enbridge	WPZBNE11	EN817-31	1013	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthidium	minutissima	NA	NA
Enbridge	WPZBNE11	EN817-31	1341	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	ovalis	NA	NA
Enbridge	WPZBNE11	EN817-31	108549	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Pinnulariaceae	Caloneis	silicula	minuta	NA
Enbridge	WPZBNE11	EN817-31	9212	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	placentula	lineata	NA
Enbridge	WPZBNE11	EN817-31	1062	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	placentula	euglypta	NA
Enbridge	WPZBNE11	EN817-31	9361	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	pseudostelligera	NA	NA
Enbridge	WPZBNE11	EN817-31	1099	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	cistula	NA	NA
Enbridge	WPZBNE11	EN817-31	108984	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	helvetica	NA	NA
Enbridge	WPZBNE11	EN817-31	1095	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	silesiaca	NA	NA
Enbridge	WPZBNE11	EN817-31	1096	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	tumida	NA	NA
Enbridge	WPZBNE11	EN817-31	109135	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Paraliales	Paraliaceae	Ellerbeckia	arenaria	NA	NA
Enbridge	WPZBNE11	EN817-31	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	WPZBNE11	EN817-31	10379	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	mesolepta	NA
Enbridge	WPZBNE11	EN817-31	9045	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	construens	NA	venter
Enbridge	WPZBNE11	EN817-31	9038	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	pinnata	pinnata	NA
Enbridge	WPZBNE11	EN817-31	9055	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Gomphonemataceae	Gomphonema	pumilum	NA	NA
Enbridge	WPZBNE11	EN817-31	1722	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Pleurosigmataceae	Gyrosigma	spenceri	NA	NA
Enbridge	WPZBNE11	EN817-31	9072	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	cryptotenella	NA	NA
Enbridge	WPZBNE11	EN817-31	9118	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	linearis	NA	NA
Enbridge	WPZBNE11	EN817-31	1981	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Opephora	olsenii	NA	NA
Enbridge	WPZBNE11	EN817-31	1309	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Surirellales	Surirellaceae	Surirella	minuta	NA	NA
Enbridge	WPZBNE11	EN817-31	9776	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	acus	NA
Enbridge	WPZBNE11	EN817-31	1315	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	NA	NA
Enbridge	WPZBNE11	EN817-31	2350	Algae	NA	Chlorophyta	Chlorophyceae	NA	Oedogoniales	Oedogoniaceae	Oedogonium	NA	NA	NA
Enbridge	WPZBNE11	EN817-31	1653	Algae	NA	Chrysophyta	Chrysophyceae	NA	NA	NA	NA	NA	NA	NA
Enbridge	EPZASW01	EN817-36	1013	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthidium	minutissima	NA	NA
Enbridge	EPZASW01	EN817-36	1346	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	libyca	NA	NA
Enbridge	EPZASW01	EN817-36	1341	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	ovalis	NA	NA
Enbridge	EPZASW01	EN817-36	1066	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	pediculus	NA	NA
Enbridge	EPZASW01	EN817-36	9212	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	placentula	lineata	NA
Enbridge	EPZASW01	EN817-36	9361	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	pseudostelligera	NA	NA
Enbridge	EPZASW01	EN817-36	1090	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	NA	NA	NA
Enbridge	EPZASW01	EN817-36	1099	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	cistula	NA	NA
Enbridge	EPZASW01	EN817-36	1091	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	microcephala	NA	NA

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Project Name	Sample ID	GEI Log #	Morph	Coloniality	Coloniality State	Structure	Physiological State	Taxonomic Authority
Enbridge	EPZDW08	EN817-23	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	EPZDW08	EN817-23	NA	Cell-Nonmotile	Free	Cyst	NA	N/A
Enbridge	EPZDW08	EN817-23	NA	Multi-Filament	Attached	Vegetative	Live	Lemmermann
Enbridge	WPZDW03	EN817-26	NA	Lateral-Filament	Attached	Vegetative	Live	RabenhNA
Enbridge	WPZCNT04	EN817-27	NA	Cell-Nonmotile	Free	Vegetative	Live	(Moore ex Ralfs) RNA MNA Crawford
Enbridge	WPZCNT04	EN817-27	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	WPZCNT04	EN817-27	NA	Lateral-Filament	Attached	Vegetative	Live	(Ehrenberg) Hustedt
Enbridge	WPZCNT04	EN817-27	NA	Filament	Attached	Vegetative	Live	(EhrenbNA) KtzNA
Enbridge	WPZCNT04	EN817-27	NA	Filament	Attached	Vegetative	Live	CNA ANA Agardh (for genus)
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) Kutzing
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	Unknown
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) Van Heurck
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(Ehrenberg) Grunow
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(Hustedt) Houk and Klee
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(Ehrenberg in Hemprich & Ehrenberg) Kirchner in Cohn
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	KtzNA
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	Bleisch
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(Br,bNA) Van Heurck
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(Moore ex Ralfs) RNA MNA Crawford
Enbridge	WPZBNE11	EN817-31	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	WPZBNE11	EN817-31	NA	Lateral-Filament	Attached	Vegetative	Live	RabenhNA
Enbridge	WPZBNE11	EN817-31	NA	Lateral-Filament	Attached	Vegetative	Live	(Ehrenberg) Hustedt
Enbridge	WPZBNE11	EN817-31	NA	Lateral-Filament	Attached	Vegetative	Live	Ehrenberg (Ehrenberg, 1843) DNAMNA Williams & Round, 1987
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(Grunow) Reichardt & Lange-Bertalot
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(WNA Smith) Cleve
Enbridge	WPZBNE11	EN817-31	NA	Cell-Motile	Free	Vegetative	Live	Lange-BertNA
Enbridge	WPZBNE11	EN817-31	NA	Cell-Motile	Free	Vegetative	Live	(CNA Agardh) WNA SmNA
Enbridge	WPZBNE11	EN817-31	NA	Lateral-Filament	Attached	Vegetative	Live	Peragallo
Enbridge	WPZBNE11	EN817-31	NA	Cell-Motile	Free	Vegetative	Live	BrebNA in KutzNA
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	WPZBNE11	EN817-31	NA	Filament	Attached	Vegetative	Live	De Bary
Enbridge	WPZBNE11	EN817-31	NA	Cell-Nonmotile	Free	Cyst	NA	N/A
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	Ehrenberg
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) Kutzing
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	EhrenbNA
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) Van Heurck
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	(Hustedt) Houk and Klee
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	(Schmidt) Cleve
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	(Ehrenberg in Hemprich & Ehrenberg) Kirchner in Cohn
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	Grunow

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Project Name	Sample ID	GEI Log #	Taxa ID	Taxon Group	Phylum	Division	Class	Subclass	Order	Family	Genus	Species	Variety	Form
Enbridge	EPZASW01	EN817-36	1103	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Diatoma	ehrenbergii	NA	NA
Enbridge	EPZASW01	EN817-36	1354	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Rhopalodiales	Rhopalodiaceae	Epithemia	turgida	NA	NA
Enbridge	EPZASW01	EN817-36	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	EPZASW01	EN817-36	10379	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	mesolepta	NA
Enbridge	EPZASW01	EN817-36	9045	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	construens	NA	venter
Enbridge	EPZASW01	EN817-36	9038	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	pinnata	pinnata	NA
Enbridge	EPZASW01	EN817-36	9055	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Gomphonemataceae	Gomphonema	pumilum	NA	NA
Enbridge	EPZASW01	EN817-36	1720	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Pleurosigmataceae	Gyrosigma	NA	NA	NA
Enbridge	EPZASW01	EN817-36	9072	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	cryptotenella	NA	NA
Enbridge	EPZASW01	EN817-36	10356	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	radiosafallax	NA	NA
Enbridge	EPZASW01	EN817-36	9106	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	viridula	rostellata	NA
Enbridge	EPZASW01	EN817-36	9124	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	recta	NA	NA
Enbridge	EPZASW01	EN817-36	1000481	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	radians	NA	NA
Enbridge	EPZASW01	EN817-36	9504	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	tenera	NA	NA
Enbridge	EPZASW01	EN817-36	1315	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	NA	NA
Enbridge	EPZASW01	EN817-36	111238	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	biceps	NA
Enbridge	EPZASW01	EN817-36	1332	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Tabellariales	Tabellariaceae	Tabellaria	flocculosa	NA	NA
Enbridge	EPZASW01	EN817-36	111263	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Tabellariales	Tabellariaceae	Tabellaria	quadriseptata	NA	NA
Enbridge	EPZASW01	EN817-36	7240	Detritus/Particulates	NA	Miscellaneous	NA	NA	NA	NA	NA	NA	NA	NA
Enbridge	EPZDE09	EN817-40	4275	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthes	flexella	NA	NA
Enbridge	EPZDE09	EN817-40	1013	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthidium	minutissima	NA	NA
Enbridge	EPZDE09	EN817-40	1346	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	libyca	NA	NA
Enbridge	EPZDE09	EN817-40	1343	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	pediculus	NA	NA
Enbridge	EPZDE09	EN817-40	1066	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	pediculus	NA	NA
Enbridge	EPZDE09	EN817-40	9212	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	placentula	lineata	NA
Enbridge	EPZDE09	EN817-40	9363	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	ocellata	NA	NA
Enbridge	EPZDE09	EN817-40	9361	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	pseudostelligera	NA	NA
Enbridge	EPZDE09	EN817-40	9368	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	radiosa	NA	NA
Enbridge	EPZDE09	EN817-40	1867	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	lanceolata	NA	NA
Enbridge	EPZDE09	EN817-40	1091	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	microcephala	NA	NA
Enbridge	EPZDE09	EN817-40	109135	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Paraliales	Paraliaceae	Ellerbeckia	arenaria	NA	NA
Enbridge	EPZDE09	EN817-40	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	EPZDE09	EN817-40	9397	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	vaucheriae	NA
Enbridge	EPZDE09	EN817-40	10379	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	mesolepta	NA
Enbridge	EPZDE09	EN817-40	9055	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Gomphonemataceae	Gomphonema	pumilum	NA	NA
Enbridge	EPZDE09	EN817-40	9057	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Gomphonemataceae	Gomphonema	truncatum	NA	NA
Enbridge	EPZDE09	EN817-40	1087	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Lindavia	michiganiana	NA	NA
Enbridge	EPZDE09	EN817-40	1210	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	NA	NA	NA
Enbridge	EPZDE09	EN817-40	9072	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	cryptotenella	NA	NA
Enbridge	EPZDE09	EN817-40	1000650	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	angustata	NA	NA
Enbridge	EPZDE09	EN817-40	9123	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	palea	NA	NA
Enbridge	EPZDE09	EN817-40	9124	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	recta	NA	NA
Enbridge	EPZDE09	EN817-40	1477	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	filiformis	NA	NA

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Project Name	Sample ID	GEI Log #	Morph	Coloniality	Coloniality State	Structure	Physiological State	Taxonomic Authority
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	KtzNA
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) KtzNA
Enbridge	EPZASW01	EN817-36	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	EPZASW01	EN817-36	NA	Lateral-Filament	Attached	Vegetative	Live	RabenhNA
Enbridge	EPZASW01	EN817-36	NA	Lateral-Filament	Attached	Vegetative	Live	(Ehrenberg) Hustedt
Enbridge	EPZASW01	EN817-36	NA	Lateral-Filament	Attached	Vegetative	Live	Ehrenberg (Ehrenberg, 1843) DNAMNA Williams & Round, 1987
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	(Grunow) Reichardt & Lange-Bertalot
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	Hassall
Enbridge	EPZASW01	EN817-36	NA	Cell-Motile	Free	Vegetative	Live	Lange-BertNA
Enbridge	EPZASW01	EN817-36	NA	Cell-Motile	Free	Vegetative	Live	Lange-BertNA
Enbridge	EPZASW01	EN817-36	NA	Cell-Motile	Free	Vegetative	Live	(KtzNA) Cleve
Enbridge	EPZASW01	EN817-36	NA	Cell-Motile	Free	Vegetative	Live	Hantzsch
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutz
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	WNA SmNA
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Vegetative	Live	(KtzNA) KirchnNA
Enbridge	EPZASW01	EN817-36	NA	Complex-Filament	Free	Vegetative	Live	(Roth) KtzNA
Enbridge	EPZASW01	EN817-36	NA	Complex-Filament	Free	Vegetative	Live	KnudsNA
Enbridge	EPZASW01	EN817-36	NA	Cell-Nonmotile	Free	Pollen Grain	Dead	N/A
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	Brun
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	Ehrenberg
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) Grunow
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	EhrenbNA
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) Van Heurck
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	PantNA
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	(Hustedt) Houk and Klee
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	Grunow
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	(CNA Agardh) CNA Agardh
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	Grunow
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	(Moore ex Ralfs) RNA MNA Crawford
Enbridge	EPZDE09	EN817-40	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	EPZDE09	EN817-40	NA	Lateral-Filament	Attached	Vegetative	Live	(Kutzing) Lange-Bertalot
Enbridge	EPZDE09	EN817-40	NA	Lateral-Filament	Attached	Vegetative	Live	RabenhNA
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	(Grunow) Reichardt & Lange-Bertalot
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	EhrenbNA
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	Skvortzov
Enbridge	EPZDE09	EN817-40	NA	Cell-Motile	Free	Vegetative	Live	Bory NA
Enbridge	EPZDE09	EN817-40	NA	Cell-Motile	Free	Vegetative	Live	Lange-BertNA
Enbridge	EPZDE09	EN817-40	NA	Cell-Motile	Free	Vegetative	Live	(Smith) Grunow
Enbridge	EPZDE09	EN817-40	NA	Cell-Motile	Free	Vegetative	Live	(KtzNA) WNA SmNA
Enbridge	EPZDE09	EN817-40	NA	Cell-Motile	Free	Vegetative	Live	Hantzsch
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	Grunow

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Project Name	Sample ID	GEI Log #	Taxa ID	Taxon Group	Phylum	Division	Class	Subclass	Order	Family	Genus	Species	Variety	Form
Enbridge	EPZDE09	EN817-40	1315	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	NA	NA
Enbridge	EPZDE09	EN817-40	1332	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Tabellariales	Tabellariaceae	Tabellaria	flocculosa	NA	NA
Enbridge	WPZCST07	EN817-48	1000303	Zooplankton	Arthropoda	NA	Maxillipoda	Copepoda	NA	NA	NA	NA	NA	NA
Enbridge	WPZCST07	EN817-48	1346	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	libyca	NA	NA
Enbridge	WPZCST07	EN817-48	1343	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	pediculus	NA	NA
Enbridge	WPZCST07	EN817-48	1347	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	veneta	NA	NA
Enbridge	WPZCST07	EN817-48	1021	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Asterionella	formosa	NA	NA
Enbridge	WPZCST07	EN817-48	1000448	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Aulacoseirales	Aulacoseriaceae	Aulacoseira	subarctica	NA	NA
Enbridge	WPZCST07	EN817-48	9351	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillariales	Bacillariaceae	Bacillaria	paradoxa	NA	NA
Enbridge	WPZCST07	EN817-48	1041	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Pinnulariaceae	Caloneis	silicula	NA	NA
Enbridge	WPZCST07	EN817-48	108574	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Rhopalodiales	Surirellales	Campylodiscus	noricus	hibernicus	NA
Enbridge	WPZCST07	EN817-48	9361	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	pseudostelligera	NA	NA
Enbridge	WPZCST07	EN817-48	1071	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	spNA 1	NA	NA
Enbridge	WPZCST07	EN817-48	1869	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	cesatii	NA	NA
Enbridge	WPZCST07	EN817-48	1099	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	cistula	NA	NA
Enbridge	WPZCST07	EN817-48	1111	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	delicatula	NA	NA
Enbridge	WPZCST07	EN817-48	1095	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	silesiaca	NA	NA
Enbridge	WPZCST07	EN817-48	1354	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Rhopalodiales	Rhopalodiaceae	Epithemia	turgida	NA	NA
Enbridge	WPZCST07	EN817-48	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	WPZCST07	EN817-48	10379	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	mesolepta	NA
Enbridge	WPZCST07	EN817-48	9045	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	construens	NA	venter
Enbridge	WPZCST07	EN817-48	1152	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	crotonensis	NA	NA
Enbridge	WPZCST07	EN817-48	1160	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Gomphonemataceae	Gomphonema	NA	NA	NA
Enbridge	WPZCST07	EN817-48	1087	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Lindavia	michiganiana	NA	NA
Enbridge	WPZCST07	EN817-48	1210	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	NA	NA	NA
Enbridge	WPZCST07	EN817-48	9072	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	cryptotenella	NA	NA
Enbridge	WPZCST07	EN817-48	9102	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	tripunctata	NA	NA
Enbridge	WPZCST07	EN817-48	9106	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	viridula	rostellata	NA
Enbridge	WPZCST07	EN817-48	1220	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	NA	NA	NA
Enbridge	WPZCST07	EN817-48	9118	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	linearis	NA	NA
Enbridge	WPZCST07	EN817-48	9439	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	sigma	NA	NA
Enbridge	WPZCST07	EN817-48	1240	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Pinnulariaceae	Pinnularia	NA	NA	NA
Enbridge	WPZCST07	EN817-48	9318	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Surirellales	Surirellaceae	Surirella	visurgis	NA	NA
Enbridge	WPZCST07	EN817-48	1477	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	filiformis	NA	NA
Enbridge	WPZCST07	EN817-48	1315	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	NA	NA
Enbridge	WPZCST07	EN817-48	9776	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	acus	NA
Enbridge	WPZCST07	EN817-48	2350	Algae	NA	Chlorophyta	Chlorophyceae	NA	Oedogoniales	Oedogoniaceae	Oedogonium	NA	NA	NA
Enbridge	WPZCST07	EN817-48	2389	Algae	NA	Chlorophyta	Chlorophyceae	NA	Chlorococcales	Hydrodictyaceae	Pediastrum	boryanum	longicorne	NA
Enbridge	WPZCST07	EN817-48	1653	Algae	NA	Chrysophyta	Chrysophyceae	NA	NA	NA	NA	NA	NA	NA
Enbridge	WPZCST07	EN817-48	7240	Detritus/Particulates	NA	Miscellaneous	NA	NA	NA	NA	NA	NA	NA	NA
Enbridge	WPZAST04	EN817-50	1013	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Achnanthaceae	Achnanthidium	minutissima	NA	NA
Enbridge	WPZAST04	EN817-50	1066	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	pediculus	NA	NA
Enbridge	WPZAST04	EN817-50	9212	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	placentula	lineata	NA

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Project Name	Sample ID	GEI Log #	Morph	Coloniality	Coloniality State	Structure	Physiological State	Taxonomic Authority
Enbridge	EPZDE09	EN817-40	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	EPZDE09	EN817-40	NA	Complex-Filament	Free	Vegetative	Live	(Roth) KtzNA
Enbridge	WPZCST07	EN817-48	NA	Animal	Free	nauplius	Live	Esterley 1911
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	Ehrenberg
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) Grunow
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	WPZCST07	EN817-48	NA	Colonial-Nonmotile	Attached	Vegetative	Live	HassNA
Enbridge	WPZCST07	EN817-48	NA	Filament	Attached	Vegetative	Live	(Muller) Haworth
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	Gmelin
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(Ehrenberg) Cleve
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) Grunow
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(Hustedt) Houk and Klee
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) de Brebisson
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(RabenhNA) Grunow ex ANA WNA FNA Schmidt
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(Ehrenberg in Hemprich & Ehrenberg) Kirchner in Cohn
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	KtzNA
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	Bleisch
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) KtzNA
Enbridge	WPZCST07	EN817-48	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	WPZCST07	EN817-48	NA	Lateral-Filament	Attached	Vegetative	Live	RabenhNA
Enbridge	WPZCST07	EN817-48	NA	Lateral-Filament	Attached	Vegetative	Live	(Ehrenberg) Hustedt
Enbridge	WPZCST07	EN817-48	NA	Lateral-Filament	Attached	Vegetative	Live	Kitton
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	CNA Agardh
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	Skvortzov
Enbridge	WPZCST07	EN817-48	NA	Cell-Motile	Free	Vegetative	Live	Bory NA
Enbridge	WPZCST07	EN817-48	NA	Cell-Motile	Free	Vegetative	Live	Lange-BertNA
Enbridge	WPZCST07	EN817-48	NA	Cell-Motile	Free	Vegetative	Live	(ONA FNA MllNA) Bory
Enbridge	WPZCST07	EN817-48	NA	Cell-Motile	Free	Vegetative	Live	(KtzNA) Cleve
Enbridge	WPZCST07	EN817-48	NA	Cell-Motile	Free	Vegetative	Live	Hassall
Enbridge	WPZCST07	EN817-48	NA	Cell-Motile	Free	Vegetative	Live	(CNA Agardh) WNA SmNA
Enbridge	WPZCST07	EN817-48	NA	Cell-Motile	Free	Vegetative	Live	(KtzNA) WNA SmNA
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(PantNA) RNA Ross
Enbridge	WPZCST07	EN817-48	NA	Cell-Motile	Free	Vegetative	Live	Hustedt
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	Grunow
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	WPZCST07	EN817-48	NA	Filament	Attached	Vegetative	Live	De Bary
Enbridge	WPZCST07	EN817-48	NA	Colonial-Nonmotile	Attached	Vegetative	Live	Raciborski
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Cyst	NA	N/A
Enbridge	WPZCST07	EN817-48	NA	Cell-Nonmotile	Free	Pollen Grain	Dead	N/A
Enbridge	WPZAST04	EN817-50	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	WPZAST04	EN817-50	NA	Cell-Nonmotile	Free	Vegetative	Live	EhrenbNA
Enbridge	WPZAST04	EN817-50	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) Van Heurck

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Project Name	Sample ID	GEI Log #	Taxa ID	Taxon Group	Phylum	Division	Class	Subclass	Order	Family	Genus	Species	Variety	Form
Enbridge	WPZAST04	EN817-50	1099	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	cistula	NA	NA
Enbridge	WPZAST04	EN817-50	1095	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	silesiaca	NA	NA
Enbridge	WPZAST04	EN817-50	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	WPZAST04	EN817-50	10379	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	mesolepta	NA
Enbridge	WPZAST04	EN817-50	9406	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	virescens	NA	NA
Enbridge	WPZAST04	EN817-50	9055	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Gomphonemataceae	Gomphonema	pumilum	NA	NA
Enbridge	WPZAST04	EN817-50	1210	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	NA	NA	NA
Enbridge	WPZAST04	EN817-50	9072	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	cryptotenella	NA	NA
Enbridge	WPZAST04	EN817-50	1000650	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	angustata	NA	NA
Enbridge	WPZAST04	EN817-50	1751	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Rhopalodiales	Rhopalodiaceae	Rhopalodia	gibba	NA	NA
Enbridge	WPZAST04	EN817-50	1314	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	delicatissima	NA	NA
Enbridge	WPZAST04	EN817-50	9776	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	acus	NA
Enbridge	WPZDE11	EN817-67	1869	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	cesatii	NA	NA
Enbridge	WPZDE11	EN817-67	1099	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	cistula	NA	NA
Enbridge	WPZDE11	EN817-67	9397	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	vaucheriae	NA
Enbridge	WPZDE11	EN817-67	9038	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	pinnata	pinnata	NA
Enbridge	WPZDE11	EN817-67	1220	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	NA	NA	NA
Enbridge	WPZDE11	EN817-67	9776	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	ulna	acus	NA
Enbridge	WPZDE11	EN817-67	1653	Algae	NA	Chrysophyta	Chrysophyceae	NA	NA	NA	NA	NA	NA	NA
Enbridge	WPZDE11	EN817-67	6044	Algae	NA	Pyrrhophyta	Dinophyceae	NA	Peridinales	Peridinaceae	Peridinium	umbonatum	NA	NA
Enbridge	EPZCNW03	EN817-78	1347	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	veneta	NA	NA
Enbridge	EPZCNW03	EN817-78	1066	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Achnanthales	Cocconiedaceae	Cocconeis	pediculus	NA	NA
Enbridge	EPZCNW03	EN817-78	1071	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	spNA 1	NA	NA
Enbridge	EPZCNW03	EN817-78	1095	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	silesiaca	NA	NA
Enbridge	EPZCNW03	EN817-78	1098	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Encyonema	caespitosum	NA	NA
Enbridge	EPZCNW03	EN817-78	1354	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Rhopalodiales	Rhopalodiaceae	Epithemia	turgida	NA	NA
Enbridge	EPZCNW03	EN817-78	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	EPZCNW03	EN817-78	9397	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	vaucheriae	NA
Enbridge	EPZCNW03	EN817-78	10379	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	capucina	mesolepta	NA
Enbridge	EPZCNW03	EN817-78	9038	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	pinnata	pinnata	NA
Enbridge	EPZCNW03	EN817-78	1214	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	cryptocephala	NA	NA
Enbridge	EPZCNW03	EN817-78	1000065	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	cryptotenelloides	NA	NA
Enbridge	EPZCNW03	EN817-78	9106	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	viridula	rostellata	NA
Enbridge	EPZCNW03	EN817-78	1220	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	NA	NA	NA
Enbridge	EPZCNW03	EN817-78	1000650	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	angustata	NA	NA
Enbridge	EPZCNW03	EN817-78	1222	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	gracilis	NA	NA
Enbridge	EPZCNW03	EN817-78	9123	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Bacillarales	Bacillariaceae	Nitzschia	palea	NA	NA
Enbridge	EPZCNW03	EN817-78	1751	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Rhopalodiales	Rhopalodiaceae	Rhopalodia	gibba	NA	NA
Enbridge	EPZCNW03	EN817-78	1314	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Synedra	delicatissima	NA	NA
Enbridge	EPZCNW03	EN817-78	1332	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Tabellariales	Tabellariaceae	Tabellaria	flocculosa	NA	NA
Enbridge	EPZCNW03	EN817-78	1653	Algae	NA	Chrysophyta	Chrysophyceae	NA	NA	NA	NA	NA	NA	NA
Enbridge	EPZCNW03	EN817-78	7240	Detritus/Particulates	NA	Miscellaneous	NA	NA	NA	NA	NA	NA	NA	NA
Enbridge	WPZBSE10	EN817-80	1346	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	libyca	NA	NA

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Project Name	Sample ID	GEI Log #	Morph	Coloniality	Coloniality State	Structure	Physiological State	Taxonomic Authority
Enbridge	WPZAST04	EN817-50	NA	Cell-Nonmotile	Free	Vegetative	Live	(Ehrenberg in Hemprich & Ehrenberg) Kirchner in Cohn
Enbridge	WPZAST04	EN817-50	NA	Cell-Nonmotile	Free	Vegetative	Live	Bleisch
Enbridge	WPZAST04	EN817-50	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	WPZAST04	EN817-50	NA	Lateral-Filament	Attached	Vegetative	Live	RabenhNA
Enbridge	WPZAST04	EN817-50	NA	Lateral-Filament	Attached	Vegetative	Live	Ralfs
Enbridge	WPZAST04	EN817-50	NA	Cell-Nonmotile	Free	Vegetative	Live	(Grunow) Reichardt & Lange-Bertalot
Enbridge	WPZAST04	EN817-50	NA	Cell-Motile	Free	Vegetative	Live	Bory NA
Enbridge	WPZAST04	EN817-50	NA	Cell-Motile	Free	Vegetative	Live	Lange-BertNA
Enbridge	WPZAST04	EN817-50	NA	Cell-Motile	Free	Vegetative	Live	(Smith) Grunow
Enbridge	WPZAST04	EN817-50	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) ONA MllNA
Enbridge	WPZAST04	EN817-50	NA	Cell-Nonmotile	Free	Vegetative	Live	WNA Smith
Enbridge	WPZAST04	EN817-50	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	WPZDE11	EN817-67	NA	Cell-Nonmotile	Free	Vegetative	Live	(RabenhNA) Grunow ex ANA WNA FNA Schmidt
Enbridge	WPZDE11	EN817-67	NA	Cell-Nonmotile	Free	Vegetative	Live	(Ehrenberg in Hemprich & Ehrenberg) Kirchner in Cohn
Enbridge	WPZDE11	EN817-67	NA	Lateral-Filament	Attached	Vegetative	Live	(Kutzing) Lange-Bertalot
Enbridge	WPZDE11	EN817-67	NA	Lateral-Filament	Attached	Vegetative	Live	Ehrenberg (Ehrenberg, 1843) DNAMNA Williams & Round, 1987
Enbridge	WPZDE11	EN817-67	NA	Cell-Motile	Free	Vegetative	Live	Hassall
Enbridge	WPZDE11	EN817-67	NA	Cell-Nonmotile	Free	Vegetative	Live	(Nitzsch) EhrenbNA
Enbridge	WPZDE11	EN817-67	NA	Cell-Nonmotile	Free	Cyst	NA	N/A
Enbridge	WPZDE11	EN817-67	NA	Cell-Motile	Free	Vegetative	Live	Stein
Enbridge	EPZCNW03	EN817-78	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	EPZCNW03	EN817-78	NA	Cell-Nonmotile	Free	Vegetative	Live	EhrenbNA
Enbridge	EPZCNW03	EN817-78	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) de Brebisson
Enbridge	EPZCNW03	EN817-78	NA	Cell-Nonmotile	Free	Vegetative	Live	Bleisch
Enbridge	EPZCNW03	EN817-78	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) Brun
Enbridge	EPZCNW03	EN817-78	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) KtzNA
Enbridge	EPZCNW03	EN817-78	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	EPZCNW03	EN817-78	NA	Lateral-Filament	Attached	Vegetative	Live	(Kutzing) Lange-Bertalot
Enbridge	EPZCNW03	EN817-78	NA	Lateral-Filament	Attached	Vegetative	Live	RabenhNA
Enbridge	EPZCNW03	EN817-78	NA	Lateral-Filament	Attached	Vegetative	Live	Ehrenberg (Ehrenberg, 1843) DNAMNA Williams & Round, 1987
Enbridge	EPZCNW03	EN817-78	NA	Cell-Motile	Free	Vegetative	Live	KtzNA
Enbridge	EPZCNW03	EN817-78	NA	Cell-Motile	Free	Vegetative	Live	NA
Enbridge	EPZCNW03	EN817-78	NA	Cell-Motile	Free	Vegetative	Live	(KtzNA) Cleve
Enbridge	EPZCNW03	EN817-78	NA	Cell-Motile	Free	Vegetative	Live	Hassall
Enbridge	EPZCNW03	EN817-78	NA	Cell-Motile	Free	Vegetative	Live	(Smith) Grunow
Enbridge	EPZCNW03	EN817-78	NA	Cell-Motile	Free	Vegetative	Live	Hantzsch
Enbridge	EPZCNW03	EN817-78	NA	Cell-Motile	Free	Vegetative	Live	(KtzNA) WNA SmNA
Enbridge	EPZCNW03	EN817-78	NA	Cell-Nonmotile	Free	Vegetative	Live	(EhrenbNA) ONA MllNA
Enbridge	EPZCNW03	EN817-78	NA	Cell-Nonmotile	Free	Vegetative	Live	WNA Smith
Enbridge	EPZCNW03	EN817-78	NA	Complex-Filament	Free	Vegetative	Live	(Roth) KtzNA
Enbridge	EPZCNW03	EN817-78	NA	Cell-Nonmotile	Free	Cyst	NA	N/A
Enbridge	EPZCNW03	EN817-78	NA	Cell-Nonmotile	Free	Pollen Grain	Dead	N/A
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	Ehrenberg

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Project Name	Sample ID	GEI Log #	Taxa ID	Taxon Group	Phylum	Division	Class	Subclass	Order	Family	Genus	Species	Variety	Form
Enbridge	WPZBSE10	EN817-80	1343	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	pediculus	NA	NA
Enbridge	WPZBSE10	EN817-80	1347	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Thalassiophysales	Catenulaceae	Amphora	veneta	NA	NA
Enbridge	WPZBSE10	EN817-80	9363	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	ocellata	NA	NA
Enbridge	WPZBSE10	EN817-80	9361	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	pseudostelligera	NA	NA
Enbridge	WPZBSE10	EN817-80	1071	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Thalassiosirales	Stephanodiscaceae	Cyclotella	spNA 1	NA	NA
Enbridge	WPZBSE10	EN817-80	1862	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Cymbellaceae	Cymbella	affinis	NA	NA
Enbridge	WPZBSE10	EN817-80	109135	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Paraliales	Paraliaceae	Ellerbeckia	arenaria	NA	NA
Enbridge	WPZBSE10	EN817-80	1140	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Eunotiales	Eunotiaceae	Eunotia	NA	NA	NA
Enbridge	WPZBSE10	EN817-80	1157	Algae	NA	Bacillariophyta	Fragilariophyceae	NA	Fragilariales	Fragilariaceae	Fragilaria	brevistriata	NA	NA
Enbridge	WPZBSE10	EN817-80	1160	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Cymbellales	Gomphonemataceae	Gomphonema	NA	NA	NA
Enbridge	WPZBSE10	EN817-80	1722	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Pleurosigmataceae	Gyrosigma	spenceri	NA	NA
Enbridge	WPZBSE10	EN817-80	109674	Algae	NA	Bacillariophyta	Coscinodiscophyceae	NA	Melosirales	Melosiraceae	Melosira	undulata	NA	NA
Enbridge	WPZBSE10	EN817-80	9102	Algae	NA	Bacillariophyta	Bacillariophyceae	NA	Naviculales	Naviculaceae	Navicula	tripunctata	NA	NA
Enbridge	WPZBSE10	EN817-80	2350	Algae	NA	Chlorophyta	Chlorophyceae	NA	Oedogoniales	Oedogoniaceae	Oedogonium	NA	NA	NA

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Project Name	Sample ID	GEI Log #	Morph	Coloniality	Coloniality State	Structure	Physiological State	Taxonomic Authority
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) Grunow
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	Kutzing
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	PantNA
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	(Hustedt) Houk and Klee
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	(Kutzing) de Brebisson
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	KtzNA
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	(Moore ex Ralfs) RNA MNA Crawford
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	N”rpell-Schempp & Lange-BertNA in Lange-BertNA
Enbridge	WPZBSE10	EN817-80	NA	Lateral-Filament	Attached	Vegetative	Live	Grunow in Van Heurck
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	CNA Agardh
Enbridge	WPZBSE10	EN817-80	NA	Cell-Nonmotile	Free	Vegetative	Live	(WNA Smith) Cleve
Enbridge	WPZBSE10	EN817-80	NA	Filament	Attached	Vegetative	Live	(EhrenbNA) KtzNA
Enbridge	WPZBSE10	EN817-80	NA	Cell-Motile	Free	Vegetative	Live	(ONA FNA MllNA) Bory
Enbridge	WPZBSE10	EN817-80	NA	Filament	Attached	Vegetative	Live	De Bary

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Appendix L

2017 GEI Lab Statistical Analyses Tables for Biota Samples

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Appendix - Table 1. 2017 Biota Sample Dry Weight (g) Descriptive Statistics by Pipeline

Pipeline	Biomass Dry Weight			Total Dry Weight		
	n	Mean	Std. Deviation	*n*	Mean	Std. Deviation
East	24	16.6	11.9	24	24.0	24.0
West	22	14.2	10.1	23	13.9	10.5
Total	46	15.4	11.00	47	18.5	19.0

Square roots of weights were used as dependent variable to improve normality of data in preparation for a General Linear Model Analysis of Covariance.

Bottom position samples excluded

Appendix - Table 2. 2017 Biota Sample Dry weight tests of between-subjects effects results from General Linear Model Two-Way Analysis of Variance

Source	Biomass Dry Weight					Total Dry Weight				
	Type III Sum of Squares	df	Mean Square	F	Sig.	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9.7	5	1.9	0.6	0.7	37.4	5	7.5	2.1	0.1
Intercept	562.4	1	562.4	185.8	0.0	678.8	1	678.8	193.5	0.0
Pipeline (East/West)	2.2	1	2.2	0.7	0.4	13.5	1	13.5	3.8	0.1
Pipeline Position	7.2	2	3.6	1.2	0.3	20.7	2	10.3	2.9	0.1
Pipeline & Pipeline Position	0.4	2	0.2	0.1	0.9	3.8	2	1.9	0.5	0.6
Error	121.1	40	3.0			143.9	41	3.5		
Total	709.4	46				871.5	47			
Corrected Total	130.7	45				181.3	46			

[1] R Squared = .058 (Adjusted R Squared = .014)

[2] R Squared = .125 (Adjusted R Squared = .086)

Square roots of weights were used as dependent variable to improve normality

Bottom position samples excluded

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Appendix - Table 3. 2017 Biota, Area of Interest and Additional Site Sample Dry Weight Descriptive Statistics

Pipeline	Pipeline End	Biomass Dry Weight			Total Dry Weight		
		n	Mean (g)	Std. Deviation	*n*	Mean (g)	Std. Deviation
East	North	12	9.9	7.7	12	22.1	32.6
	South	15	21.1	12.0	15	21.6	11.9
	Total	27	16.1	11.6	27	21.8	22.9
West	North	15	13.6	10.2	15	14.0	10.7
	South	11	13.9	8.9	12	12.9	9.1
	Total	26	13.7	9.4	27	13.6	9.9
Total	North	27	11.9	9.2	27	17.6	23.0
	South	26	18.0	11.2	27	17.8	11.4
	Total	53	14.9	10.6	54	17.7	18.0

Square roots of weights were used as dependent variable to improve normality of data in preparation for a General Linear Model Two-Way Analysis of Variance

Appendix - Table 4. 2017 Biota, Area of Interest and Additional Site Sample Dry Weight (g) Tests of Between-subjects Effects Results from General Linear Model Analysis of Covariance

Source	Biomass Dry Weight					Total Dry Weight				
	Type III Sum of Squares	df	Mean Square	F	Sig.	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16.5 [1]	3	5.5	2.1	0.1	12.8 [2]	3	4.3	1.2	0.3
Intercept	621.9	1	621.9	242.2	0.0	748.6	1	748.6	210.3	0
Pipeline (East/West)	0.7	1	0.7	0.3	0.6	10.8	1	10.8	3.0	0.1
Pipeline End (North/South)	8.4	1	8.4	3.3	0.1	0.4	1	0.4	0.1	0.7
Pipeline & Pipeline End	6.4	1	6.4	2.5	0.1	1.0	1	1	0.3	0.6
Error	125.8	49	2.6	--	--	178.0	50	3.6	--	--
Total	791.1	53	--	--	--	955	54	--	--	--
Corrected Total	142.4	52	--	--	--	190.8	53	--	--	--

[1] R Squared = .096 (Adjusted R Squared = .055)

[2] R Squared = .068 (Adjusted R Squared = .025)

Square roots of weights were used as dependent variable to improve normality

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Appendix - Table 5. 2017 Areas of Interest, Additional Sites and Paired Adjacent Sample Dry Weight (g) Descriptive Statistics

	Biomass Dry Weight					Total Dry Weight				
	n	Mean	Std. Deviation	Min.	Max.	*n*	Mean	Std. Deviation	Min.	Max.
Value	20	9.7	11.0	0.0	27.5	20	11.0	12.0	0.0	33.6
Area of Interest/ Additional Site and Adjacent Sites	20	1.5	0.5	1.0	2.0	20	1.5	0.5	1.0	2.0

Appendix - Table 6. 2017 Areas of Interest, Additional Sites and Paired Adjacent Sample Dry Weight (g) Ranks Test as part of Mann Whitney Test

Sample Type	Biomass Dry Weight			Total Dry Weight		
	n	Mean Rank	Sum of Ranks	*n*	Mean Rank	Sum of Ranks
Area of Interest/ Additional Site	10	7.0	69.5	10	7.6	75.5
Adjacent Site	10	14	140.5	10	13.4	134.5
Total	20	--	--	20	--	--

Appendix - Table 7. 2017 Areas of Interest, Additional Sites and Paired Adjacent Sample Dry Weight (g) Test Statistics2 as part of Mann Whitney Test

Test Statistics[2]	Biomass Dry Weight	Total Dry Weight
Mann-Whitney U	14.5	20.5
Wilcoxon W	69.5	75.5
Z	-2.7	-2.2
Asymp. Sig. (2-tailed)	.007*	.026*
Exact Sig. [2*(1-tailed Sig.)]	.005 [1]	.023 [1]

[1] Not corrected for ties

[2] Grouping Variable: Holiday or Adjacent

* denotes statistical significance

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Appendix M

2017 Water Chemistry Measurements

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Water Chemisty Measurements from East Leg Biota Sampling Location ES8 and Area of Interest EAOI7

Depth (ft)	Temperature (°C)	Specific Conductance (µS/cm)	pH	ORP (mV)	Turbidity (FNU)	DO (% sat)	DO (mg/L)
6	17.03	243.9	8.8	30.3	-0.01	98.3	9.49
14	17.32	244.8	8.1	59.1	0.06	98.2	9.42
33	16.74	242.7	8.4	33.0	-0.03	97.7	9.49
55	15.51	237.7	8.3	45.9	0.08	96.4	9.61
73	13.91	233.6	8.3	50.1	0.08	94.0	9.69
76	12.99	227.6	8.1	59.9	0.21	94.4	9.94

Water chemistry readings collected September 5, 2017

Measurements collected at 1 minute intervals and averaged based on a 1 ft change in depth

Water Chemisty Measurements From East Leg Area of Interest EAOI8

Depth (ft)	Temperature (°C)	Specific Conductance (µS/cm)	pH	ORP (mV)	Turbidity (FNU)	DO (% sat)	DO (mg/L)
0	17.77	259.2	9.1	70.0	0.13	102.3	9.73
4	17.81	260.0	9.1	68.3	0.04	101.2	9.62
7	17.85	261.2	8.3	73.0	-0.11	97.8	9.28
11	17.83	260.8	8.8	66.8	-0.02	100.2	9.51
14	17.83	260.8	8.8	63.4	0.04	99.3	9.43
15	17.79	260.6	8.8	64.7	0.13	99.5	9.45
17	17.84	261.0	8.4	64.3	-0.09	97.9	9.30
18	17.84	260.9	8.5	62.1	-0.11	97.9	9.29
19	17.83	260.9	8.5	62.8	-0.08	98.1	9.31
22	17.84	261.0	8.2	73.4	-0.06	97.7	9.27
24	17.82	260.6	8.5	60.8	-0.13	97.7	9.28
26	17.83	260.7	8.2	73.5	0.02	97.7	9.28
28	17.78	260.5	8.2	73.8	-0.03	97.6	9.28
31	17.83	260.6	8.5	60.8	-0.14	97.7	9.28
33	17.78	260.6	8.2	74.3	-0.04	97.7	9.28
38	17.77	260.2	8.1	74.8	-0.03	98.0	9.31
39	17.83	260.7	8.5	60.7	-0.14	97.6	9.27
45	17.53	256.7	8.1	75.6	0.03	98.4	9.41
50	17.81	260.6	8.5	60.6	-0.14	97.5	9.26
54	16.98	234.9	8.1	76.7	0.08	99.2	9.60
58	17.77	260.3	8.5	60.6	-0.04	97.4	9.26
65	13.85	218.6	8.2	77.1	0.44	99.2	10.60
66	17.68	260.0	8.48	60.6	-0.10	97.2	9.25
69	16.71	259.8	8.49	60.6	-0.11	95.7	9.30
76	15.89	247.6	8.50	60.9	-0.10	95.2	9.41
77	15.42	248.2	8.50	61.0	-0.11	94.2	9.39
78	12.42	226.6	8.24	74.7	0.22	93.3	9.96

Water chemistry readings collected September 6, 2017

Measurements collected at 10 second intervals and averaged based on a 1 ft change in depth

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Water Chemisty Measurements from East Leg Biota Sampling Location ES3 and Area of Interest EAOI1

Depth (ft)	Temperature (°C)	Specific Conductance (µS/cm)	pH	ORP (mV)	Turbidity (FNU)	DO (% sat)	DO (mg/L)
1	16.6	161.4	8.5	84.6	41.69	99.3	9.68
6	17.0	253.4	8.4	80.4	0.03	98.8	9.54
18	16.8	250.4	8.1	101.9	0.08	98.3	9.55
19	17.0	253.4	8.6	60.1	-0.02	98.7	9.54
27	16.5	248.7	8.0	102.4	0.01	98.2	9.59
28	17.0	253.1	8.6	61.1	-0.02	98.4	9.51
36	16.3	247.2	8.0	103.0	0.03	98.5	9.67
42	16.4	248.3	8.3	83.1	0.06	98.4	9.62
49	15.7	242.5	7.9	106.0	0.08	99.3	9.85
52	16.5	250.0	8.6	63.2	-0.01	97.2	9.47
53	15.8	243.1	8.6	65.2	0.04	96.8	9.59
54	15.8	242.9	8.5	66.3	0.06	96.9	9.61
58	15.6	239.1	7.9	107.1	0.15	101.0	10.05
59	15.8	243.1	8.5	66.8	0.04	96.9	9.60
64	15.8	243.0	8.5	67.3	0.22	96.8	9.59
67	15.7	242.9	8.5	67.6	0.14	96.7	9.59
70	15.2	218.4	7.9	107.4	0.18	100.3	10.09
73	15.7	242.8	8.5	67.7	0.06	96.7	9.59
79	15.6	242.9	8.5	67.8	0.10	96.3	9.57
80	12.9	239.1	8.5	68.1	0.07	95.3	10.05
84	12.9	227.8	8.5	69.2	0.05	95.8	10.11
85	12.3	217.9	8.2	88.7	0.21	96.8	10.36
87	11.3	236.2	8.5	70.2	0.05	93.1	10.18
94	10.9	225.6	8.5	70.7	0.02	93.9	10.38
98	9.5	212.4	8.0	107.8	0.33	96.4	11.00
108	10.7	218.5	8.5	71.4	0.05	94.6	10.48
112	9.5	212.3	8.0	108.0	0.38	96.5	11.02
119	10.3	218.0	8.5	72.2	0.04	94.5	10.56
128	9.4	211.8	7.9	108.3	0.39	96.5	11.05
133	10.0	215.6	8.5	72.7	0.21	94.6	10.66
141	9.2	211.1	7.9	108.7	0.52	96.5	11.09
144	9.8	214.5	8.5	73.1	0.22	94.9	10.75
153	9.7	213.7	8.5	73.4	0.07	95.2	10.81
155	9.3	210.8	8.4	77.6	0.20	95.6	10.95
156	9.3	210.8	8.2	83.6	0.23	95.7	10.97
162	9.1	209.9	8.2	88.5	0.27	95.3	11.00
166	8.8	209.6	7.9	109.2	0.38	95.9	11.12
169	9.0	209.7	8.2	88.8	0.38	95.4	11.01
177	9.0	209.8	8.2	89.0	0.21	95.5	11.03
180	8.8	209.5	7.9	109.3	0.4	95.8	11.12
188	9.0	209.6	8.2	89.0	0.24	95.4	11.03
188	8.8	209.4	7.9	109.3	0.31	95.7	11.11
192	8.9	209.5	8.2	89.0	0.25	95.4	11.04
193	8.9	209.7	8.0	101.2	0.62	95.6	11.07

Water chemistry readings collected September 8, 2017

Measurements collected at 10 second intervals and averaged based on a 1 ft change in depth

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Water Chemisty Measurements from West Leg Area of Interest WAOI1

Depth (ft)	Temperature (°C)	Specific Conductance (µS/cm)	pH	ORP (mV)	Turbidity (FNU)	DO (% sat)	DO (mg/L)
0	17.46	255.0	9.1	15.0	-0.01	100.9	9.65
1	17.48	255.1	9.0	15.4	-0.01	100.0	9.56
8	17.34	252.8	7.9	82.0	0.09	99.5	9.55
11	17.50	255.3	8.8	16.7	-0.01	99.0	9.46
23	17.48	255.1	8.8	19.4	0.03	98.3	9.40
26	17.21	251.3	7.9	83.7	0.11	101.6	9.77
38	17.46	254.9	8.8	22.2	0.07	97.8	9.36
48	17.06	248.7	7.9	85.4	0.17	103.4	9.98
50	17.44	254.7	8.7	24.2	0.09	97.5	9.34
53	17.36	253.2	8.7	25.1	0.02	97.2	9.32
54	17.22	250.2	8.6	26.3	0.05	97.3	9.35
55	17.19	249.8	8.6	28.4	0.02	97.3	9.36
56	17.12	249.1	8.5	36.6	-0.01	97.2	9.36
57	17.10	249.0	8.5	51.8	-0.07	96.9	9.34
63	16.96	248.0	8.4	58.2	-0.12	96.8	9.35
65	15.99	251.6	8.5	58.0	-0.12	96.4	9.54
69	15.29	243.9	8.5	58.0	-0.09	94.8	9.49
76	12.14	201.7	7.9	86.3	0.21	99.0	10.72
78	14.92	234.5	8.5	58.2	-0.05	95.4	9.62
88	14.68	233.6	8.5	58.5	-0.02	95.5	9.69
101	13.14	235.0	8.5	58.8	-0.03	94.5	9.93
110	9.36	200.8	7.9	85.9	0.21	97.1	11.13
112	12.53	229.5	8.48	59.3	0.00	94.1	10.00
125	11.61	225.9	8.48	59.8	0.03	93.2	10.11
137	10.86	219.8	8.48	60.3	0.05	93.2	10.29
145	7.72	204.7	7.96	84.7	0.18	95.6	11.41
147	9.95	217.5	8.48	60.9	0.06	92.7	10.46
155	9.40	214.6	8.48	61.6	0.07	93.2	10.65
167	9.06	213.3	8.46	62.2	0.07	93.7	10.80
176	8.93	212.1	8.45	62.7	0.07	94.2	10.89
185	8.68	210.7	8.44	62.9	0.05	94.1	10.95
188	7.59	204.5	7.98	83.7	0.14	95.2	11.39
193	8.35	209.4	8.44	63.1	0.07	93.9	11.01
198	8.06	207.5	8.42	63.6	0.08	94.0	11.11
210	7.74	205.5	8.20	73.8	0.08	94.8	11.28
218	7.72	205.4	8.38	64.8	0.07	94.6	11.27
220	7.56	204.5	7.98	83.5	0.50	95.1	11.38
229	7.69	205.0	8.36	65.5	0.14	95.1	11.35
230	7.56	204.5	7.98	83.5	0.73	95.1	11.38
234	7.59	204.5	8.06	79.4	0.22	95.1	11.37

Water chemistry readings collected September 7, 2017

Measurements collected at 10 second intervals and averaged based on a 1 ft change in depth

Water Chemisty Measurements from West Leg Area of Interest WAOI6

Depth (ft)	Temperature (°C)	Specific Conductance (µS/cm)	pH	ORP (mV)	Turbidity (FNU)	DO (% sat)	DO (mg/L)
0	17.75	257.1	9.0	68.3	0.04	100.4	9.56
4	17.76	261.6	8.9	66.6	-0.06	100.5	9.55
7	17.78	262.6	8.2	84.5	-0.04	97.6	9.27
10	17.76	261.6	8.7	64.9	-0.06	100.6	9.56
15	17.79	262.6	8.2	84.7	-0.04	97.5	9.27
17	17.75	261.4	8.6	62.6	-0.07	100.2	9.52
24	17.76	261.6	8.2	85.2	-0.05	97.4	9.26
25	17.70	261.1	8.6	61.4	0.02	99.7	9.49
32	17.72	261.3	8.2	85.9	-0.04	97.4	9.27
35	17.70	260.8	8.6	61.1	0.01	99.3	9.46
38	17.70	260.4	8.1	86.7	-0.02	97.4	9.28
45	17.64	259.6	8.1	87.8	0.00	97.5	9.30
49	17.71	260.9	8.5	61.1	-0.01	99.1	9.43
50	17.46	259.3	8.5	61.5	-0.08	98.2	9.39
52	17.54	256.5	8.0	89.2	0.03	97.7	9.33
57	17.39	254.3	8.0	90.5	0.08	98.0	9.39
59	17.39	257.3	8.5	62.0	-0.01	98.2	9.41
62	17.31	244.5	8.0	91.7	0.20	98.7	9.48
68	16.93	204.5	8.0	92.6	0.13	99.3	9.67
74	17.39	257.1	8.5	62.2	-0.04	97.9	9.38
76	11.05	217.8	8.0	92.6	0.20	94.6	10.43
84	10.69	217.6	8.0	92.2	0.32	93.8	10.41
88	10.9	218.8	8.131082	84.2	1.35	93.9	10.38131

Water chemistry readings collected September 6, 2017

Measurements collected at 10 second intervals and averaged based on a 1 ft change in depth

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Water Chemisty Measurements from East Leg Area Water and Sediment Collection Location EAS-3

Depth (ft)	Temperature (°C)	Specific Conductance (µS/cm)	pH	ORP (mV)	Turbidity (FNU)	DO (% sat)	DO (mg/L)
0	0.6	63.4	6.82	6.8	22.24	93.0	13.42
1	1.7	57.2	7.81	88.4	0.18	90.1	12.55
3	2.6	263.3	9.07	67.5	-0.29	99.1	13.49
6	1.7	257.8	8.08	79.8	0.05	90.0	12.56
17	2.7	244.5	9.41	50.4	0.11	98.3	13.33
18	1.6	258.6	8.07	80.0	0.11	89.7	12.55
26	1.5	258.5	8.06	80.4	0.16	89.6	12.54
33	2.1	249.5	8.72	64.1	0.13	93.3	12.84
41	1.5	258.8	8.05	80.6	0.10	89.3	12.51
45	2.7	238.2	9.33	47.3	0.09	95.7	12.98
47	1.5	258.6	8.05	80.5	0.05	89.1	12.46
52	1.7	257.1	8.05	80.2	0.05	89.3	12.42
58	1.9	256.3	8.06	79.6	0.08	89.6	12.43
61	1.7	257.1	8.10	77.7	0.08	89.3	12.45
62	2.8	235.5	9.25	46.7	0.09	95.0	12.84
66	1.6	257.5	8.13	75.8	0.08	88.5	12.35
71	1.9	253.8	8.14	75.0	0.07	88.2	12.19
76	2.5	246.6	8.15	74.5	0.08	89.0	12.13
78	2.8	236.0	9.18	45.8	0.10	94.0	12.70
80	2.7	242.7	8.15	74.5	0.12	89.6	12.15
85	2.7	242.1	8.15	74.5	0.09	89.6	12.14
90	2.7	242.2	8.14	74.5	0.12	89.5	12.12
91	2.9	235.5	9.12	44.7	0.11	93.7	12.65
95	2.8	240.4	8.14	74.4	0.15	89.50	12.09
97	2.9	238.4	8.15	74.2	0.16	89.60	12.08
100	3.1	231.8	9.07	43.7	0.13	93.6	12.56
102	3.0	237.7	8.15	74.2	0.23	89.7	12.07
106	3.1	233.6	8.59	58.9	0.19	91.4	12.27
108	3.0	237.0	8.15	74.1	0.14	89.6	12.05
110	3.2	230.6	8.89	43.9	0.16	91.9	12.29
111	3.2	230.2	8.95	44.3	0.15	92.5	12.38
112	3.1	236.3	8.15	73.9	0.17	89.6	12.04
114	3.2	233.0	8.49	59.0	0.13	90.6	12.14
117	3.1	234.8	8.23	69.1	0.12	89.7	12.04
118	3.1	234.3	8.43	56.1	0.10	90.1	12.09

Water chemistry readings collected December 15, 2017

Measurements collected at 10 second intervals and averaged based on a 1 ft change in depth

Water Chemisty Measurements from East Leg Area Water and Sediment Collection Location E-10

Depth (ft)	Temperature (°C)	Specific Conductance (µS/cm)	pH	ORP (mV)	Turbidity (FNU)	DO (% sat)	DO (mg/L)
0	0.96	13.9	6.4	167.5	10.10	99.2	14.18
2	3.70	230.2	8.0	154.7	1.58	93.6	12.36
6	3.15	88.4	9.1	231.2	4.66	116.1	15.59
10	3.70	230.2	8.0	154.7	1.33	93.6	12.35
17	3.70	230.0	8.0	155.1	1.71	93.5	12.34
18	3.27	104.8	9.1	228.8	1.44	113.7	15.20
23	3.77	229.1	8.0	155.5	1.92	93.6	12.34
29	3.78	229.0	8.0	155.7	2.72	93.7	12.35
34	3.74	229.1	8.0	155.3	2.19	93.6	12.34
34	3.34	163.1	9.1	226.3	1.10	110.4	14.72
40	3.76	227.8	8.0	154.2	2.29	93.6	12.34
42	3.76	224.5	8.0	153.4	3.05	93.7	12.35
47	3.75	224.7	8.0	153.1	2.23	93.6	12.35
48	3.76	224.9	8.0	153.4	2.12	93.6	12.34
49	3.41	188.7	9.1	221.6	1.00	107.5	14.30
52	3.74	225.3	8.0	153.7	2.03	93.6	12.35
57	3.74	225.4	8.0	153.9	3.37	93.6	12.35
60	3.74	225.5	8.0	154.1	3.06	93.6	12.34
62	3.48	198.9	9.1	216.9	1.14	105.2	13.97
65	3.75	225.7	8.0	154.3	2.31	93.6	12.35
69	3.59	224.3	8.1	161.7	1.94	93.8	12.42
70	3.57	220.6	8.2	167.8	1.95	94.2	12.48

Water chemistry readings collected December 13, 2017

Measurements collected at 10 second intervals and averaged based on a 1 ft change in depth

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Appendix N

2017 Microbial Insights Biota, Water, and Sediment Census qPCR DNA Analysis Results and Lab Report

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Identifier: 066OH **Report Date:** 01/26/2018

Client Project #: 1411170 **Client Project Name:**

Purchase Order #:

Analysis Requested: CENSUS

Reviewed By:

[redacted]

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CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:		**EPZASW11**	**EPZASW02**	**EPZBST11**	**EPZBSE07**	**EPZBSB06**
Sample Date:		08/15/2017	08/15/2017	08/15/2017	08/15/2017	08/15/2017
Units:		cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:		JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**6.74E+06**	**1.42E+08**	**1.04E+06**	**1.01E+06**	**6.82E+04**
Sulfate Reducing Bacteria	APS-1	**2.17E+05**	**3.79E+06**	**6.93E+03 (J)**	**3.16E+04**	**2.04E+03 (J)**
Sulfate Reducing Bacteria	APS-2	**6.06E+06**	**1.36E+08**	**9.57E+05**	**8.54E+05**	**5.93E+04**
Sulfate Reducing Bacteria	APS-3	**4.60E+05**	**2.47E+06**	**8.01E+04**	**1.26E+05**	**6.82E+03 (J)**
Sulfate Reducing Bacteria	APS-4	<1.52E+04	<6.94E+04	<1.85E+04	<1.52E+04	<2.38E+04
Sulfate Reducing Bacteria	APS-5	<1.52E+04	<6.94E+04	<1.85E+04	<1.52E+04	<2.38E+04
Sulfate Reducing Bacteria	APS-6	<1.52E+04	<6.94E+04	<1.85E+04	<1.52E+04	<2.38E+04
Sulfate Reducing Bacteria	APS-7	<1.52E+04	<6.94E+04	<1.85E+04	<1.52E+04	<2.38E+04
Acetogens	AGN	<1.52E+04	**1.41E+04 (J)**	**1.43E+03 (J)**	**1.27E+03 (J)**	<2.38E+04
Acetogens	AGN-1	<1.52E+04	<6.94E+04	<1.85E+04	**1.27E+03 (J)**	<2.38E+04
Acetogens	AGN-2	<1.52E+04	<6.94E+04	**1.43E+03 (J)**	<1.52E+04	<2.38E+04
Acetogens	AGN-3	<1.52E+04	<6.94E+04	<1.85E+04	<1.52E+04	<2.38E+04
Acetogens	AGN-7	<1.52E+04	**1.41E+04 (J)**	<1.85E+04	<1.52E+04	<2.38E+04
Acetogens	AGN-8	<1.52E+04	<6.94E+04	<1.85E+04	<1.52E+04	<2.38E+04

Legend and Report Qualifiers:
J = Estimated gene copies below PQL but above LQL
< = Result not detected

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MICROBIAL INSIGHTS, INC.

10515 Research Dr., Knoxville, TN 37932
Tel. (865) 573-8188 Fax. (865) 573-8133

CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:	**EPZBSW12**	**EPZCST07**	**EPZCSE01**	**EPZCSB02**	**EPZCSW04**
Sample Date:	08/15/2017	08/16/2017	08/16/2017	08/16/2017	08/16/2017
Units:	cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:	JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**8.98E+05**	**6.57E+06**	**2.62E+06**	**2.30E+04**	**5.75E+05**
Sulfate Reducing Bacteria	APS-1	**1.14E+04 (J)**	**6.74E+04**	**5.38E+04**	**7.99E+03 (J)**	**1.49E+04 (J)**
Sulfate Reducing Bacteria	APS-2	**7.12E+05**	**5.13E+06**	**2.10E+06**	**1.50E+04 (J)**	**5.60E+05**
Sulfate Reducing Bacteria	APS-3	**1.75E+05**	**1.37E+06**	**4.71E+05**	<2.08E+04	<1.72E+04
Sulfate Reducing Bacteria	APS-4	<1.56E+04	<2.17E+04	<2.17E+04	<2.08E+04	<1.72E+04
Sulfate Reducing Bacteria	APS-5	<1.56E+04	<2.17E+04	<2.17E+04	<2.08E+04	<1.72E+04
Sulfate Reducing Bacteria	APS-6	<1.56E+04	<2.17E+04	<2.17E+04	<2.08E+04	<1.72E+04
Sulfate Reducing Bacteria	APS-7	<1.56E+04	<2.17E+04	<2.17E+04	<2.08E+04	<1.72E+04
Acetogens	AGN	**1.07E+03 (J)**	**4.24E+03 (J)**	**2.28E+04**	<2.08E+04	<1.72E+04
Acetogens	AGN-1	<1.56E+04	<2.17E+04	<2.17E+04	<2.08E+04	<1.72E+04
Acetogens	AGN-2	**1.07E+03 (J)**	**4.24E+03 (J)**	**2.28E+04**	<2.08E+04	<1.72E+04
Acetogens	AGN-3	<1.56E+04	<2.17E+04	<2.17E+04	<2.08E+04	<1.72E+04
Acetogens	AGN-7	<1.56E+04	<2.17E+04	<2.17E+04	<2.08E+04	<1.72E+04
Acetogens	AGN-8	<1.56E+04	<2.17E+04	<2.17E+04	<2.08E+04	<1.72E+04

Legend and Report Qualifiers:
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CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:		**EPZANW07**	**EPZANE09**	**EPZANT10**	**EPZBNE02**	**EPZBNT06**
Sample Date:		08/19/2017	08/19/2017	08/19/2017	08/19/2017	08/19/2017
Units:		cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:		JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**1.18E+06**	**9.77E+05**	**2.06E+06**	**8.22E+06**	**2.50E+06**
Sulfate Reducing Bacteria	APS-1	**6.98E+04**	**2.47E+05**	**9.60E+04**	**5.89E+05**	**9.96E+04**
Sulfate Reducing Bacteria	APS-2	**9.34E+05**	**5.03E+05**	**1.61E+06**	**5.72E+06**	**2.14E+06**
Sulfate Reducing Bacteria	APS-3	**1.77E+05**	**2.27E+05**	**3.59E+05**	**1.91E+06**	**2.59E+05**
Sulfate Reducing Bacteria	APS-4	<2.08E+04	<1.25E+04	<1.72E+04	<1.14E+04	<2.63E+04
Sulfate Reducing Bacteria	APS-5	<2.08E+04	<1.25E+04	<1.72E+04	<1.14E+04	<2.63E+04
Sulfate Reducing Bacteria	APS-6	<2.08E+04	<1.25E+04	<1.72E+04	<1.14E+04	<2.63E+04
Sulfate Reducing Bacteria	APS-7	<2.08E+04	<1.25E+04	<1.72E+04	<1.14E+04	<2.63E+04
Acetogens	AGN	**9.14E+03 (J)**	**4.24E+02 (J)**	<1.72E+04	<1.14E+04	<2.63E+04
Acetogens	AGN-1	**9.14E+03 (J)**	<1.25E+04	<1.72E+04	<1.14E+04	<2.63E+04
Acetogens	AGN-2	<2.08E+04	**4.24E+02 (J)**	<1.72E+04	<1.14E+04	<2.63E+04
Acetogens	AGN-3	<2.08E+04	<1.25E+04	<1.72E+04	<1.14E+04	<2.63E+04
Acetogens	AGN-7	<2.08E+04	<1.25E+04	<1.72E+04	<1.14E+04	<2.63E+04
Acetogens	AGN-8	<2.08E+04	<1.25E+04	<1.72E+04	<1.14E+04	<2.63E+04

Legend and Report Qualifiers:
J = Estimated gene copies below PQL but above LQL
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10515 Research Dr., Knoxville, TN 37932
Tel. (865) 573-8188 Fax. (865) 573-8133

CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:	**WPZANT12**	**WPZANB05**	**WPZANE11**	**WPZANW04**	**EPZDT05**
Sample Date:	08/19/2017	08/19/2017	08/19/2017	08/19/2017	08/20/2017
Units:	cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:	JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**1.23E+06**	**1.97E+06**	**2.01E+07**	**1.22E+05**	**2.10E+06**
Sulfate Reducing Bacteria	APS-1	**7.34E+04**	**1.06E+05**	**1.02E+06**	**3.37E+04**	**3.97E+04**
Sulfate Reducing Bacteria	APS-2	**1.03E+06**	**1.50E+06**	**1.47E+07**	**7.27E+04**	**1.70E+06**
Sulfate Reducing Bacteria	APS-3	**1.23E+05**	**3.61E+05**	**4.41E+06**	**1.55E+04 (J)**	**3.63E+05**
Sulfate Reducing Bacteria	APS-4	<2.27E+04	<2.27E+04	<6.25E+04	<2.00E+04	<1.72E+04
Sulfate Reducing Bacteria	APS-5	<2.27E+04	<2.27E+04	<6.25E+04	<2.00E+04	<1.72E+04
Sulfate Reducing Bacteria	APS-6	<2.27E+04	<2.27E+04	<6.25E+04	<2.00E+04	<1.72E+04
Sulfate Reducing Bacteria	APS-7	<2.27E+04	<2.27E+04	<6.25E+04	<2.00E+04	<1.72E+04
Acetogens	AGN	**5.65E+03 (J)**	<2.27E+04	**1.33E+04 (J)**	**1.33E+03 (J)**	<1.72E+04
Acetogens	AGN-1	<2.27E+04	<2.27E+04	**4.16E+03 (J)**	<2.00E+04	<1.72E+04
Acetogens	AGN-2	<2.27E+04	<2.27E+04	**9.17E+03 (J)**	**1.33E+03 (J)**	<1.72E+04
Acetogens	AGN-3	<2.27E+04	<2.27E+04	<6.25E+04	<2.00E+04	<1.72E+04
Acetogens	AGN-7	**5.65E+03 (J)**	<2.27E+04	<6.25E+04	<2.00E+04	<1.72E+04
Acetogens	AGN-8	<2.27E+04	<2.27E+04	<6.25E+04	<2.00E+04	<1.72E+04

Legend and Report Qualifiers:
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CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:		**EPZDE09**	**EPZDW10**	**WPZDT05**	**WPZDE06**	**WPZDW09**
Sample Date:		08/20/2017	08/20/2017	08/20/2017	08/20/2017	08/20/2017
Units:		cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:		JS	JS	JS	JS	JS
Functional Genes						
Sulfate Reducing Bacteria	APS	**6.30E+03 (J)**	<1.61E+04	**8.37E+06**	**3.69E+06**	**7.18E+04**
Sulfate Reducing Bacteria	APS-1	**7.89E+02 (J)**	<1.61E+04	**2.52E+05**	**1.27E+05**	**4.60E+03 (J)**
Sulfate Reducing Bacteria	APS-2	**5.51E+03 (J)**	<1.61E+04	**6.37E+06**	**2.73E+06**	**6.72E+04**
Sulfate Reducing Bacteria	APS-3	<1.67E+04	<1.61E+04	**1.75E+06**	**8.36E+05**	<1.61E+04
Sulfate Reducing Bacteria	APS-4	<1.67E+04	<1.61E+04	<5.00E+04	<1.72E+04	<1.61E+04
Sulfate Reducing Bacteria	APS-5	<1.67E+04	<1.61E+04	<5.00E+04	<1.72E+04	<1.61E+04
Sulfate Reducing Bacteria	APS-6	<1.67E+04	<1.61E+04	<5.00E+04	<1.72E+04	<1.61E+04
Sulfate Reducing Bacteria	APS-7	<1.67E+04	<1.61E+04	<5.00E+04	<1.72E+04	<1.61E+04
Acetogens	AGN	**2.90E+03 (J)**	<1.61E+04	**5.95E+03 (J)**	<1.72E+04	<1.61E+04
Acetogens	AGN-1	**8.90E+02 (J)**	<1.61E+04	<5.00E+04	<1.72E+04	<1.61E+04
Acetogens	AGN-2	**2.01E+03 (J)**	<1.61E+04	**5.95E+03 (J)**	<1.72E+04	<1.61E+04
Acetogens	AGN-3	<1.67E+04	<1.61E+04	<5.00E+04	<1.72E+04	<1.61E+04
Acetogens	AGN-7	<1.67E+04	<1.61E+04	<5.00E+04	<1.72E+04	<1.61E+04
Acetogens	AGN-8	<1.67E+04	<1.61E+04	<5.00E+04	<1.72E+04	<1.61E+04

Legend and Report Qualifiers:
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< = Result not detected

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CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:	**WPZCNT03**	**WPZCNE05**	**WPZCNB01**	**WPZCNW10**	**WPZBNT10**
Sample Date:	08/21/2017	08/21/2017	08/21/2017	08/21/2017	08/21/2017
Units:	cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:	JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**2.98E+06**	**4.85E+06**	**3.12E+06**	**5.03E+06**	**1.73E+05**
Sulfate Reducing Bacteria	APS-1	**8.85E+04**	**1.22E+05**	**2.80E+05**	**2.57E+05**	**8.81E+03 (J)**
Sulfate Reducing Bacteria	APS-2	**2.22E+06**	**3.50E+06**	**2.05E+06**	**3.72E+06**	**1.49E+05**
Sulfate Reducing Bacteria	APS-3	**6.75E+05**	**1.23E+06**	**7.89E+05**	**1.05E+06**	**1.54E+04 (J)**
Sulfate Reducing Bacteria	APS-4	<1.43E+04	<1.92E+04	<1.72E+04	<1.67E+04	<2.27E+04
Sulfate Reducing Bacteria	APS-5	<1.43E+04	<1.92E+04	<1.72E+04	<1.67E+04	<2.27E+04
Sulfate Reducing Bacteria	APS-6	<1.43E+04	<1.92E+04	<1.72E+04	<1.67E+04	<2.27E+04
Sulfate Reducing Bacteria	APS-7	<1.43E+04	<1.92E+04	<1.72E+04	<1.67E+04	<2.27E+04
Acetogens	AGN	**1.79E+03 (J)**	<1.92E+04	<1.72E+04	<1.67E+04	<2.27E+04
Acetogens	AGN-1	<1.43E+04	<1.92E+04	<1.72E+04	<1.67E+04	<2.27E+04
Acetogens	AGN-2	**1.79E+03 (J)**	<1.92E+04	<1.72E+04	<1.67E+04	<2.27E+04
Acetogens	AGN-3	<1.43E+04	<1.92E+04	<1.72E+04	<1.67E+04	<2.27E+04
Acetogens	AGN-7	<1.43E+04	<1.92E+04	<1.72E+04	<1.67E+04	<2.27E+04
Acetogens	AGN-8	<1.43E+04	<1.92E+04	<1.72E+04	<1.67E+04	<2.27E+04

Legend and Report Qualifiers:
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CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:		**WPZBNE09**	**WPZBNW02**	**EPZASW11**	**EPZASW04**	**WPZDT06**
Sample Date:		08/21/2017	08/21/2017	08/24/2017	08/24/2017	08/25/2017
Units:		cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:		JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**1.76E+05**	**1.80E+04**	**1.48E+06**	**1.17E+07**	**5.43E+06**
Sulfate Reducing Bacteria	APS-1	**1.67E+04 (J)**	**1.11E+03 (J)**	**5.64E+04 (J)**	**3.63E+05**	**1.61E+05**
Sulfate Reducing Bacteria	APS-2	**1.46E+05**	**1.69E+04**	**1.42E+06**	**1.03E+07**	**4.29E+06**
Sulfate Reducing Bacteria	APS-3	**1.29E+04 (J)**	<1.67E+04	<1.52E+05	**1.08E+06**	**9.75E+05**
Sulfate Reducing Bacteria	APS-4	<1.85E+04	<1.67E+04	<1.52E+05	<1.67E+04	<2.00E+04
Sulfate Reducing Bacteria	APS-5	<1.85E+04	<1.67E+04	<1.52E+05	<1.67E+04	<2.00E+04
Sulfate Reducing Bacteria	APS-6	<1.85E+04	<1.67E+04	<1.52E+05	<1.67E+04	<2.00E+04
Sulfate Reducing Bacteria	APS-7	<1.85E+04	<1.67E+04	<1.52E+05	<1.67E+04	<2.00E+04
Acetogens	AGN	**4.55E+02 (J)**	<1.67E+04	**2.62E+04 (J)**	**1.96E+04**	<2.00E+04
Acetogens	AGN-1	<1.85E+04	<1.67E+04	<1.52E+05	<1.67E+04	<2.00E+04
Acetogens	AGN-2	<1.85E+04	<1.67E+04	**2.22E+04 (J)**	**1.87E+04**	<2.00E+04
Acetogens	AGN-3	<1.85E+04	<1.67E+04	<1.52E+05	<1.67E+04	<2.00E+04
Acetogens	AGN-7	**4.55E+02 (J)**	<1.67E+04	**4.03E+03 (J)**	**8.77E+02 (J)**	<2.00E+04
Acetogens	AGN-8	<1.85E+04	<1.67E+04	<1.52E+05	<1.67E+04	<2.00E+04

Legend and Report Qualifiers:
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Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:	**WPZDT04**	**EPZDW11**	**EPZDW12**	**EPZDE08**	**EPZDT04**
Sample Date:	08/25/2017	08/26/2017	08/26/2017	08/26/2017	08/26/2017
Units:	cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:	JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**2.12E+05**	**2.45E+06**	**5.25E+05**	**1.13E+06**	**2.58E+06**
Sulfate Reducing Bacteria	APS-1	**6.86E+03 (J)**	**8.86E+04**	**9.18E+03 (J)**	**1.45E+03 (J)**	**1.10E+05**
Sulfate Reducing Bacteria	APS-2	**1.68E+05**	**1.55E+06**	**3.85E+05**	**8.24E+05**	**1.91E+06**
Sulfate Reducing Bacteria	APS-3	**3.67E+04**	**8.07E+05**	**1.31E+05**	**3.01E+05**	**5.63E+05**
Sulfate Reducing Bacteria	APS-4	<3.21E+04	<2.27E+04	<1.79E+04	<1.85E+04	<1.85E+04
Sulfate Reducing Bacteria	APS-5	<3.21E+04	<2.27E+04	<1.79E+04	<1.85E+04	<1.85E+04
Sulfate Reducing Bacteria	APS-6	<3.21E+04	<2.27E+04	<1.79E+04	<1.85E+04	<1.85E+04
Sulfate Reducing Bacteria	APS-7	<3.21E+04	<2.27E+04	<1.79E+04	<1.85E+04	<1.85E+04
Acetogens	AGN	<3.21E+04	<2.27E+04	<1.79E+04	**1.28E+04 (J)**	<1.85E+04
Acetogens	AGN-1	<3.21E+04	<2.27E+04	<1.79E+04	<1.85E+04	<1.85E+04
Acetogens	AGN-2	<3.21E+04	<2.27E+04	<1.79E+04	**1.28E+04 (J)**	<1.85E+04
Acetogens	AGN-3	<3.21E+04	<2.27E+04	<1.79E+04	<1.85E+04	<1.85E+04
Acetogens	AGN-7	<3.21E+04	<2.27E+04	<1.79E+04	<1.85E+04	<1.85E+04
Acetogens	AGN-8	<3.21E+04	<2.27E+04	<1.79E+04	<1.85E+04	<1.85E+04

Legend and Report Qualifiers:
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< = Result not detected

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CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:	**WPZCST12**	**WPZCSW04**	**WPZCSE06**	**WPZCSW01**	**WPZCSW02**
Sample Date:	08/26/2017	08/26/2017	08/26/2017	08/26/2017	08/26/2017
Units:	cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:	JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**1.09E+04 (J)**	**2.96E+06**	**1.27E+06**	**2.32E+06**	**1.62E+05**
Sulfate Reducing Bacteria	APS-1	**9.84E+02 (J)**	**7.79E+04**	**1.74E+04**	**5.06E+04**	<8.93E+04
Sulfate Reducing Bacteria	APS-2	**9.94E+03 (J)**	**2.15E+06**	**1.02E+06**	**1.73E+06**	**1.29E+05**
Sulfate Reducing Bacteria	APS-3	<1.79E+04	**7.34E+05**	**2.33E+05**	**5.36E+05**	**3.34E+04 (J)**
Sulfate Reducing Bacteria	APS-4	<1.79E+04	<2.17E+04	<1.47E+04	<1.39E+04	<8.93E+04
Sulfate Reducing Bacteria	APS-5	<1.79E+04	<2.17E+04	<1.47E+04	<1.39E+04	<8.93E+04
Sulfate Reducing Bacteria	APS-6	<1.79E+04	<2.17E+04	<1.47E+04	<1.39E+04	<8.93E+04
Sulfate Reducing Bacteria	APS-7	<1.79E+04	<2.17E+04	<1.47E+04	<1.39E+04	<8.93E+04
Acetogens	AGN	<1.79E+04	<2.17E+04	<1.47E+04	<1.39E+04	<8.93E+04
Acetogens	AGN-1	<1.79E+04	<2.17E+04	<1.47E+04	<1.39E+04	<8.93E+04
Acetogens	AGN-2	<1.79E+04	<2.17E+04	<1.47E+04	<1.39E+04	<8.93E+04
Acetogens	AGN-3	<1.79E+04	<2.17E+04	<1.47E+04	<1.39E+04	<8.93E+04
Acetogens	AGN-7	<1.79E+04	<2.17E+04	<1.47E+04	<1.39E+04	<8.93E+04
Acetogens	AGN-8	<1.79E+04	<2.17E+04	<1.47E+04	<1.39E+04	<8.93E+04

Legend and Report Qualifiers:
J = Estimated gene copies below PQL but above LQL
< = Result not detected

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MICROBIAL INSIGHTS, INC.

10515 Research Dr., Knoxville, TN 37932
Tel. (865) 573-8188 Fax. (865) 573-8133

CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:	**WPZAST08**	**WPZASE03**	**WPZASW12**	**WPZAST01**	**WPZAST02**
Sample Date:	08/29/2017	08/29/2017	08/29/2017	08/29/2017	08/29/2017
Units:	cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:	JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**8.20E+05**	**4.55E+07**	**1.15E+05**	**7.93E+05**	**1.08E+07**
Sulfate Reducing Bacteria	APS-1	**3.21E+04**	**2.40E+06**	**5.16E+03 (J)**	**2.34E+04 (J)**	**4.04E+05**
Sulfate Reducing Bacteria	APS-2	**6.80E+05**	**3.45E+07**	**4.09E+04**	**6.63E+05**	**9.53E+06**
Sulfate Reducing Bacteria	APS-3	**1.08E+05**	**8.58E+06**	**6.92E+04**	**1.07E+05**	**9.16E+05**
Sulfate Reducing Bacteria	APS-4	<1.85E+04	<9.80E+03	<2.17E+04	<3.65E+04	<3.33E+04
Sulfate Reducing Bacteria	APS-5	<1.85E+04	<9.80E+03	<2.17E+04	<3.65E+04	<3.33E+04
Sulfate Reducing Bacteria	APS-6	<1.85E+04	<9.80E+03	<2.17E+04	<3.65E+04	<3.33E+04
Sulfate Reducing Bacteria	APS-7	<1.85E+04	<9.80E+03	<2.17E+04	<3.65E+04	<3.33E+04
Acetogens	AGN	**1.15E+03 (J)**	<9.80E+03	<2.17E+04	<3.65E+04	<3.33E+04
Acetogens	AGN-1	<1.85E+04	<9.80E+03	<2.17E+04	<3.65E+04	<3.33E+04
Acetogens	AGN-2	**1.15E+03 (J)**	<9.80E+03	<2.17E+04	<3.65E+04	<3.33E+04
Acetogens	AGN-3	<1.85E+04	<9.80E+03	<2.17E+04	<3.65E+04	<3.33E+04
Acetogens	AGN-7	<1.85E+04	<9.80E+03	<2.17E+04	<3.65E+04	<3.33E+04
Acetogens	AGN-8	<1.85E+04	<9.80E+03	<2.17E+04	<3.65E+04	<3.33E+04

Legend and Report Qualifiers:
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Tel. (865) 573-8188 Fax. (865) 573-8133

CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:		**EPZAST03**	**EPZASE05**	**EPZASW06**	**EPZASB07**	**EPZASW11**
Sample Date:		09/05/2017	09/05/2017	09/05/2017	09/05/2017	09/05/2017
Units:		cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:		JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**1.07E+06**	**3.89E+05**	**6.19E+05**	**3.72E+05**	**9.88E+05**
Sulfate Reducing Bacteria	APS-1	**2.39E+04**	**1.10E+04 (J)**	<1.32E+04	**7.38E+03 (J)**	**1.25E+04**
Sulfate Reducing Bacteria	APS-2	**9.07E+05**	**2.76E+05**	**5.35E+05**	**3.32E+05**	**7.47E+05**
Sulfate Reducing Bacteria	APS-3	**1.40E+05**	**1.02E+05**	**8.39E+04**	**3.23E+04**	**2.29E+05**
Sulfate Reducing Bacteria	APS-4	<1.04E+04	<1.52E+04	<1.32E+04	<1.28E+04	<1.09E+04
Sulfate Reducing Bacteria	APS-5	<1.04E+04	<1.52E+04	<1.32E+04	<1.28E+04	<1.09E+04
Sulfate Reducing Bacteria	APS-6	<1.04E+04	<1.52E+04	<1.32E+04	<1.28E+04	<1.09E+04
Sulfate Reducing Bacteria	APS-7	<1.04E+04	<1.52E+04	<1.32E+04	<1.28E+04	<1.09E+04
Acetogens	AGN	<1.04E+04	<1.52E+04	<1.32E+04	**1.51E+03 (J)**	**1.20E+04**
Acetogens	AGN-1	<1.04E+04	<1.52E+04	<1.32E+04	<1.28E+04	<1.09E+04
Acetogens	AGN-2	<1.04E+04	<1.52E+04	<1.32E+04	**1.51E+03 (J)**	**1.20E+04**
Acetogens	AGN-3	<1.04E+04	<1.52E+04	<1.32E+04	<1.28E+04	<1.09E+04
Acetogens	AGN-7	<1.04E+04	<1.52E+04	<1.32E+04	<1.28E+04	<1.09E+04
Acetogens	AGN-8	<1.04E+04	<1.52E+04	<1.32E+04	<1.28E+04	<1.09E+04

Legend and Report Qualifiers:
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MICROBIAL INSIGHTS, INC.

10515 Research Dr., Knoxville, TN 37932
Tel. (865) 573-8188 Fax. (865) 573-8133

CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:	**WPZDE07**	**WPZDW10**	**WPZDB12**	**WPZDE01**	**WPZDE06**
Sample Date:	09/07/2017	09/07/2017	09/07/2017	09/07/2017	09/07/2017
Units:	cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:	JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**7.78E+05**	**1.03E+06**	**6.16E+05**	**1.02E+06**	**4.69E+06**
Sulfate Reducing Bacteria	APS-1	**5.69E+04**	**1.06E+04 (J)**	<1.85E+04	**1.71E+04 (J)**	**7.74E+04**
Sulfate Reducing Bacteria	APS-2	**4.78E+05**	**6.25E+05**	**3.50E+05**	**6.91E+05**	**3.30E+06**
Sulfate Reducing Bacteria	APS-3	**2.43E+05**	**3.93E+05**	**2.66E+05**	**3.11E+05**	**1.31E+06**
Sulfate Reducing Bacteria	APS-4	<1.85E+04	<1.52E+04	<1.85E+04	<2.78E+04	<1.25E+04
Sulfate Reducing Bacteria	APS-5	<1.85E+04	<1.52E+04	<1.85E+04	<2.78E+04	<1.25E+04
Sulfate Reducing Bacteria	APS-6	<1.85E+04	<1.52E+04	<1.85E+04	<2.78E+04	<1.25E+04
Sulfate Reducing Bacteria	APS-7	<1.85E+04	<1.52E+04	<1.85E+04	<2.78E+04	<1.25E+04
Acetogens	AGN	**9.23E+03 (J)**	<1.52E+04	**3.44E+03 (J)**	**2.24E+04 (J)**	<1.25E+04
Acetogens	AGN-1	**9.23E+03 (J)**	<1.52E+04	**2.26E+03 (J)**	<2.78E+04	<1.25E+04
Acetogens	AGN-2	<1.85E+04	<1.52E+04	**1.18E+03 (J)**	**2.24E+04 (J)**	<1.25E+04
Acetogens	AGN-3	<1.85E+04	<1.52E+04	<1.85E+04	<2.78E+04	<1.25E+04
Acetogens	AGN-7	<1.85E+04	<1.52E+04	<1.85E+04	<2.78E+04	<1.25E+04
Acetogens	AGN-8	<1.85E+04	<1.52E+04	<1.85E+04	<2.78E+04	<1.25E+04

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MICROBIAL INSIGHTS, INC.

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CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:	**EPZCNT10**	**EPZCNE02**	**EPZCNW07**	**EPZCNW05**	**EPZCNW14**
Sample Date:	09/08/2017	09/08/2017	09/08/2017	09/08/2017	09/08/2017
Units:	cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:	JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**1.11E+06**	**1.49E+06**	**5.47E+04**	**1.24E+06**	**2.93E+05**
Sulfate Reducing Bacteria	APS-1	**3.71E+04**	**2.92E+04 (J)**	**3.92E+03 (J)**	**8.74E+04**	**1.35E+04 (J)**
Sulfate Reducing Bacteria	APS-2	**8.39E+05**	**1.27E+06**	**4.37E+04**	**8.18E+05**	**2.11E+05**
Sulfate Reducing Bacteria	APS-3	**2.35E+05**	**1.95E+05**	**7.11E+03 (J)**	**3.39E+05**	**6.84E+04**
Sulfate Reducing Bacteria	APS-4	<1.39E+04	<4.55E+04	<1.61E+04	<2.50E+04	<1.52E+04
Sulfate Reducing Bacteria	APS-5	<1.39E+04	<4.55E+04	<1.61E+04	<2.50E+04	<1.52E+04
Sulfate Reducing Bacteria	APS-6	<1.39E+04	<4.55E+04	<1.61E+04	<2.50E+04	<1.52E+04
Sulfate Reducing Bacteria	APS-7	<1.39E+04	<4.55E+04	<1.61E+04	<2.50E+04	<1.52E+04
Acetogens	AGN	<1.39E+04	<4.55E+04	<1.61E+04	<2.50E+04	**4.55E+02 (J)**
Acetogens	AGN-1	<1.39E+04	<4.55E+04	<1.61E+04	<2.50E+04	<1.52E+04
Acetogens	AGN-2	<1.39E+04	<4.55E+04	<1.61E+04	<2.50E+04	<1.52E+04
Acetogens	AGN-3	<1.39E+04	<4.55E+04	<1.61E+04	<2.50E+04	<1.52E+04
Acetogens	AGN-7	<1.39E+04	<4.55E+04	<1.61E+04	<2.50E+04	**4.55E+02 (J)**
Acetogens	AGN-8	<1.39E+04	<4.55E+04	<1.61E+04	<2.50E+04	<1.52E+04

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Tel. (865) 573-8188 Fax. (865) 573-8133

CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **066OH**
Date Received: 08/17/2017

Sample Information

Client Sample ID:	**WPZBST04**	**WPZBSE06**	**WPZBSW12**	**WPZBSB07**	**WPZBSE03**
Sample Date:	09/08/2017	09/08/2017	09/08/2017	09/08/2017	09/08/2017
Units:	cells/g	cells/g	cells/g	cells/g	cells/g
Analyst/Reviewer:	JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**3.32E+06**	**4.33E+04 (J)**	**6.57E+05**	**1.33E+05**	**1.95E+05**
Sulfate Reducing Bacteria	APS-1	**6.19E+04**	<5.00E+04	**2.00E+04**	<1.56E+04	<1.39E+04
Sulfate Reducing Bacteria	APS-2	**2.36E+06**	**2.53E+04 (J)**	**4.09E+05**	**8.01E+04**	**1.37E+05**
Sulfate Reducing Bacteria	APS-3	**8.95E+05**	**1.80E+04 (J)**	**2.28E+05**	**5.30E+04**	**5.78E+04**
Sulfate Reducing Bacteria	APS-4	<1.92E+04	<5.00E+04	<1.22E+04	<1.56E+04	<1.39E+04
Sulfate Reducing Bacteria	APS-5	<1.92E+04	<5.00E+04	<1.22E+04	<1.56E+04	<1.39E+04
Sulfate Reducing Bacteria	APS-6	<1.92E+04	<5.00E+04	<1.22E+04	<1.56E+04	<1.39E+04
Sulfate Reducing Bacteria	APS-7	<1.92E+04	<5.00E+04	<1.22E+04	<1.56E+04	<1.39E+04
Acetogens	AGN	**6.77E+02 (J)**	<5.00E+04	**8.20E+02 (J)**	**2.29E+03 (J)**	**7.68E+03 (J)**
Acetogens	AGN-1	<1.92E+04	<5.00E+04	<1.22E+04	<1.56E+04	<1.39E+04
Acetogens	AGN-2	**6.77E+02 (J)**	<5.00E+04	**8.20E+02 (J)**	**2.29E+03 (J)**	<1.39E+04
Acetogens	AGN-3	<1.92E+04	<5.00E+04	<1.22E+04	<1.56E+04	**7.68E+03 (J)**
Acetogens	AGN-7	<1.92E+04	<5.00E+04	<1.22E+04	<1.56E+04	<1.39E+04
Acetogens	AGN-8	<1.92E+04	<5.00E+04	<1.22E+04	<1.56E+04	<1.39E+04

Legend and Report Qualifiers:
J = Estimated gene copies below PQL but above LQL
< = Result not detected

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Quality Assurance/Quality Control Data

Samples Received **8/17/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
APS	08/17/2017	01/18/2018	0 °C	103%	non-detect	non-detect
APS-1	08/17/2017	01/18/2018	0 °C	119%	non-detect	non-detect
APS-2	08/17/2017	01/18/2018	0 °C	120%	non-detect	non-detect
APS-3	08/17/2017	01/18/2018	0 °C	100%	non-detect	non-detect
APS-4	08/17/2017	01/18/2018	0 °C	93%	non-detect	non-detect
APS-5	08/17/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-6	08/17/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-7	08/17/2017	01/18/2018	0 °C	96%	non-detect	non-detect
AGN	08/17/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-1	08/17/2017	01/18/2018	0 °C	102%	non-detect	non-detect
AGN-2	08/17/2017	01/18/2018	0 °C	105%	non-detect	non-detect
AGN-3	08/17/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-7	08/17/2017	01/18/2018	0 °C	109%	non-detect	non-detect
AGN-8	08/17/2017	01/18/2018	0 °C	95%	non-detect	non-detect

Samples Received **8/18/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
AGN	08/18/2017	09/28/2017	0 °C	100%	non-detect	non-detect
APS	08/18/2017	09/28/2017	0 °C	92%	non-detect	non-detect
AGN-1	08/18/2017	09/28/2017	0 °C	100%	non-detect	non-detect
AGN-2	08/18/2017	09/28/2017	0 °C	100%	non-detect	non-detect
AGN-3	08/18/2017	09/28/2017	0 °C	100%	non-detect	non-detect
AGN-7	08/18/2017	09/28/2017	0 °C	100%	non-detect	non-detect
AGN-8	08/18/2017	09/28/2017	0 °C	100%	non-detect	non-detect
APS-1	08/18/2017	09/28/2017	0 °C	107%	non-detect	non-detect
APS-2	08/18/2017	09/28/2017	0 °C	99%	non-detect	non-detect
APS-3	08/18/2017	09/28/2017	0 °C	92%	non-detect	non-detect
APS-4	08/18/2017	09/28/2017	0 °C	83%	non-detect	non-detect
APS-5	08/18/2017	09/28/2017	0 °C	85%	non-detect	non-detect
APS-6	08/18/2017	09/28/2017	0 °C	91%	non-detect	non-detect
APS-7	08/18/2017	09/28/2017	0 °C	84%	non-detect	non-detect
APS	08/18/2017	01/18/2018	0 °C	103%	non-detect	non-detect
APS-1	08/18/2017	01/18/2018	0 °C	119%	non-detect	non-detect
APS-2	08/18/2017	01/18/2018	0 °C	120%	non-detect	non-detect
APS-3	08/18/2017	01/18/2018	0 °C	100%	non-detect	non-detect
APS-4	08/18/2017	01/18/2018	0 °C	93%	non-detect	non-detect
APS-5	08/18/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-6	08/18/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-7	08/18/2017	01/18/2018	0 °C	96%	non-detect	non-detect
AGN	08/18/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-1	08/18/2017	01/18/2018	0 °C	102%	non-detect	non-detect
AGN-2	08/18/2017	01/18/2018	0 °C	105%	non-detect	non-detect
AGN-3	08/18/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-7	08/18/2017	01/18/2018	0 °C	109%	non-detect	non-detect
AGN-8	08/18/2017	01/18/2018	0 °C	95%	non-detect	non-detect

Samples Received **8/22/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
AGN	08/22/2017	09/28/2017	0 °C	100%	non-detect	non-detect
APS	08/22/2017	09/28/2017	0 °C	92%	non-detect	non-detect
AGN-1	08/22/2017	09/28/2017	0 °C	100%	non-detect	non-detect
AGN-2	08/22/2017	09/28/2017	0 °C	100%	non-detect	non-detect
AGN-3	08/22/2017	09/28/2017	0 °C	100%	non-detect	non-detect
AGN-7	08/22/2017	09/28/2017	0 °C	100%	non-detect	non-detect
AGN-8	08/22/2017	09/28/2017	0 °C	100%	non-detect	non-detect
APS-1	08/22/2017	09/28/2017	0 °C	107%	non-detect	non-detect
APS-2	08/22/2017	09/28/2017	0 °C	99%	non-detect	non-detect
APS-3	08/22/2017	09/28/2017	0 °C	92%	non-detect	non-detect
APS-4	08/22/2017	09/28/2017	0 °C	83%	non-detect	non-detect
APS-5	08/22/2017	09/28/2017	0 °C	85%	non-detect	non-detect
APS-6	08/22/2017	09/28/2017	0 °C	91%	non-detect	non-detect
APS-7	08/22/2017	09/28/2017	0 °C	84%	non-detect	non-detect
APS	08/22/2017	01/18/2018	0 °C	103%	non-detect	non-detect
APS-1	08/22/2017	01/18/2018	0 °C	119%	non-detect	non-detect
APS-2	08/22/2017	01/18/2018	0 °C	120%	non-detect	non-detect
APS-3	08/22/2017	01/18/2018	0 °C	100%	non-detect	non-detect
APS-4	08/22/2017	01/18/2018	0 °C	93%	non-detect	non-detect
APS-5	08/22/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-6	08/22/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-7	08/22/2017	01/18/2018	0 °C	96%	non-detect	non-detect
AGN	08/22/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-1	08/22/2017	01/18/2018	0 °C	102%	non-detect	non-detect
AGN-2	08/22/2017	01/18/2018	0 °C	105%	non-detect	non-detect
AGN-3	08/22/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-7	08/22/2017	01/18/2018	0 °C	109%	non-detect	non-detect
AGN-8	08/22/2017	01/18/2018	0 °C	95%	non-detect	non-detect

Samples Received **8/23/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
APS	08/23/2017	01/18/2018	0 °C	103%	non-detect	non-detect
APS-1	08/23/2017	01/18/2018	0 °C	119%	non-detect	non-detect
APS-2	08/23/2017	01/18/2018	0 °C	120%	non-detect	non-detect
APS-3	08/23/2017	01/18/2018	0 °C	100%	non-detect	non-detect
APS-4	08/23/2017	01/18/2018	0 °C	93%	non-detect	non-detect
APS-5	08/23/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-6	08/23/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-7	08/23/2017	01/18/2018	0 °C	96%	non-detect	non-detect
AGN	08/23/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-1	08/23/2017	01/18/2018	0 °C	102%	non-detect	non-detect
AGN-2	08/23/2017	01/18/2018	0 °C	105%	non-detect	non-detect
AGN-3	08/23/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-7	08/23/2017	01/18/2018	0 °C	109%	non-detect	non-detect
AGN-8	08/23/2017	01/18/2018	0 °C	95%	non-detect	non-detect

Samples Received **8/26/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
APS	08/26/2017	01/18/2018	0 °C	103%	non-detect	non-detect
APS-1	08/26/2017	01/18/2018	0 °C	119%	non-detect	non-detect
APS-2	08/26/2017	01/18/2018	0 °C	120%	non-detect	non-detect
APS-3	08/26/2017	01/18/2018	0 °C	100%	non-detect	non-detect
APS-4	08/26/2017	01/18/2018	0 °C	93%	non-detect	non-detect
APS-5	08/26/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-6	08/26/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-7	08/26/2017	01/18/2018	0 °C	96%	non-detect	non-detect
AGN	08/26/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-1	08/26/2017	01/18/2018	0 °C	102%	non-detect	non-detect
AGN-2	08/26/2017	01/18/2018	0 °C	105%	non-detect	non-detect
AGN-3	08/26/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-7	08/26/2017	01/18/2018	0 °C	109%	non-detect	non-detect
AGN-8	08/26/2017	01/18/2018	0 °C	95%	non-detect	non-detect

Samples Received **8/29/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
APS	08/29/2017	01/18/2018	0 °C	103%	non-detect	non-detect
APS-1	08/29/2017	01/18/2018	0 °C	119%	non-detect	non-detect
APS-2	08/29/2017	01/18/2018	0 °C	120%	non-detect	non-detect
APS-3	08/29/2017	01/18/2018	0 °C	100%	non-detect	non-detect
APS-4	08/29/2017	01/18/2018	0 °C	93%	non-detect	non-detect
APS-5	08/29/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-6	08/29/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-7	08/29/2017	01/18/2018	0 °C	96%	non-detect	non-detect
AGN	08/29/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-1	08/29/2017	01/18/2018	0 °C	102%	non-detect	non-detect
AGN-2	08/29/2017	01/18/2018	0 °C	105%	non-detect	non-detect
AGN-3	08/29/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-7	08/29/2017	01/18/2018	0 °C	109%	non-detect	non-detect
AGN-8	08/29/2017	01/18/2018	0 °C	95%	non-detect	non-detect

Samples Received **8/31/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
APS	08/31/2017	01/18/2018	0 °C	103%	non-detect	non-detect
APS-1	08/31/2017	01/18/2018	0 °C	119%	non-detect	non-detect
APS-2	08/31/2017	01/18/2018	0 °C	120%	non-detect	non-detect
APS-3	08/31/2017	01/18/2018	0 °C	100%	non-detect	non-detect
APS-4	08/31/2017	01/18/2018	0 °C	93%	non-detect	non-detect
APS-5	08/31/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-6	08/31/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-7	08/31/2017	01/18/2018	0 °C	96%	non-detect	non-detect
AGN	08/31/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-1	08/31/2017	01/18/2018	0 °C	102%	non-detect	non-detect
AGN-2	08/31/2017	01/18/2018	0 °C	105%	non-detect	non-detect
AGN-3	08/31/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-7	08/31/2017	01/18/2018	0 °C	109%	non-detect	non-detect
AGN-8	08/31/2017	01/18/2018	0 °C	95%	non-detect	non-detect

Samples Received **9/7/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
APS	09/07/2017	01/18/2018	0 °C	103%	non-detect	non-detect
APS-1	09/07/2017	01/18/2018	0 °C	119%	non-detect	non-detect
APS-2	09/07/2017	01/18/2018	0 °C	120%	non-detect	non-detect
APS-3	09/07/2017	01/18/2018	0 °C	100%	non-detect	non-detect
APS-4	09/07/2017	01/18/2018	0 °C	93%	non-detect	non-detect
APS-5	09/07/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-6	09/07/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-7	09/07/2017	01/18/2018	0 °C	96%	non-detect	non-detect
AGN	09/07/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-1	09/07/2017	01/18/2018	0 °C	102%	non-detect	non-detect
AGN-2	09/07/2017	01/18/2018	0 °C	105%	non-detect	non-detect
AGN-3	09/07/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-7	09/07/2017	01/18/2018	0 °C	109%	non-detect	non-detect
AGN-8	09/07/2017	01/18/2018	0 °C	95%	non-detect	non-detect

Samples Received **9/9/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
APS	09/09/2017	01/18/2018	0 °C	103%	non-detect	non-detect
APS-1	09/09/2017	01/18/2018	0 °C	119%	non-detect	non-detect
APS-2	09/09/2017	01/18/2018	0 °C	120%	non-detect	non-detect
APS-3	09/09/2017	01/18/2018	0 °C	100%	non-detect	non-detect
APS-4	09/09/2017	01/18/2018	0 °C	93%	non-detect	non-detect
APS-5	09/09/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-6	09/09/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-7	09/09/2017	01/18/2018	0 °C	96%	non-detect	non-detect
AGN	09/09/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-1	09/09/2017	01/18/2018	0 °C	102%	non-detect	non-detect
AGN-2	09/09/2017	01/18/2018	0 °C	105%	non-detect	non-detect
AGN-3	09/09/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-7	09/09/2017	01/18/2018	0 °C	109%	non-detect	non-detect
AGN-8	09/09/2017	01/18/2018	0 °C	95%	non-detect	non-detect

Samples Received **9/12/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
APS	09/12/2017	01/18/2018	4 °C	103%	non-detect	non-detect
APS-1	09/12/2017	01/18/2018	4 °C	119%	non-detect	non-detect
APS-2	09/12/2017	01/18/2018	4 °C	120%	non-detect	non-detect
APS-3	09/12/2017	01/18/2018	4 °C	100%	non-detect	non-detect
APS-4	09/12/2017	01/18/2018	4 °C	93%	non-detect	non-detect
APS-5	09/12/2017	01/18/2018	4 °C	95%	non-detect	non-detect
APS-6	09/12/2017	01/18/2018	4 °C	95%	non-detect	non-detect
APS-7	09/12/2017	01/18/2018	4 °C	96%	non-detect	non-detect
AGN	09/12/2017	01/18/2018	4 °C	103%	non-detect	non-detect
AGN-1	09/12/2017	01/18/2018	4 °C	102%	non-detect	non-detect
AGN-2	09/12/2017	01/18/2018	4 °C	105%	non-detect	non-detect
AGN-3	09/12/2017	01/18/2018	4 °C	103%	non-detect	non-detect
AGN-7	09/12/2017	01/18/2018	4 °C	109%	non-detect	non-detect
AGN-8	09/12/2017	01/18/2018	4 °C	95%	non-detect	non-detect

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Phone: (865) 573-8188
Fax: (865) 573-8133

Identifier: 066OH **Date Rec:** 08/17/2017 **Report Date:** 01/26/2018

Client Project #: 1411170 **Client Project Name:**

Purchase Order #:

Comments: APS = Sum of all detected APS genera, AGN = Sum of all detected AGN genera. Upon request, MI surveyed results from previously analyzed samples contained in an internal database to determine upper and lower quartile concentrations for the targets and media included below. Quartiles are provided for comparison purposes only. Quartiles exclude samples in which the target gene concentration was below the laboratory detection limit.

Target	Matrix	Lower Quartile	Upper Quartile	Units
APS	Liquid	<1E+04	>5E+05	cells/mL
	Solid	<7E+04	>5E+07	cells/g
AGN	Liquid	<2E+03	>1E+05	cells/mL
	Solid	<2E+04	>1E+06	cells/g

Notes:
Liquid includes samples from a wide variety of environments including but not limited to groundwaters, surface waters, and industrial waters
Solid includes includes samples from a wide variety of environments including but not limited to soils, sediments, sludges, and industrial deposits

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Phone: (865) 573-8188
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Client:

GEI Consultants, Inc
230 N. Washington Square
Suite 201
Lansing, MI 48933

Phone:

Fax:

Identifier: 065OL **Report Date:** 01/26/2018

Client Project #: 1411170 **Client Project Name:**

Purchase Order #:

Analysis Requested: CENSUS

Reviewed By:

[redacted]

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10515 Research Dr., Knoxville, TN 37932
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CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **065OL**
Date Received: 12/15/2017

Sample Information

Client Sample ID:	**EPZBS-WS-01**	**EPZAS-WS-02**	**EPZAS-WB-03**	**EPZAS-S1-01**	**EPZAS-S2-02**
Sample Date:	12/13/2017	12/13/2017	12/13/2017	12/13/2017	12/13/2017
Units:	cells/mL	cells/mL	cells/mL	cells/g	cells/g
Analyst/Reviewer:	JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**1.13E+02**	**7.58E+01**	**2.56E+01**	**1.02E+08**	**1.41E+08**
Sulfate Reducing Bacteria	APS-1	**1.01E+01**	**6.30E+00**	**3.20E+00 (J)**	**1.32E+07**	**1.37E+07**
Sulfate Reducing Bacteria	APS-2	**8.92E+01**	**6.54E+01**	**2.24E+01**	**8.04E+07**	**1.03E+08**
Sulfate Reducing Bacteria	APS-3	**1.34E+01**	**4.10E+00 (J)**	<5.30E+00	**8.34E+06**	**2.44E+07**
Sulfate Reducing Bacteria	APS-4	<5.00E+00	<4.90E+00	<5.30E+00	<1.00E+04	<1.00E+04
Sulfate Reducing Bacteria	APS-5	<5.00E+00	<4.90E+00	<5.30E+00	<1.00E+04	<1.00E+04
Sulfate Reducing Bacteria	APS-6	<5.00E+00	<4.90E+00	<5.30E+00	<1.00E+04	<1.00E+04
Sulfate Reducing Bacteria	APS-7	<5.00E+00	<4.90E+00	<5.30E+00	<1.00E+04	<1.00E+04
Acetogens	AGN	**2.00E+00 (J)**	**7.30E+00**	**4.05E+01**	<1.00E+04	**1.17E+04**
Acetogens	AGN-1	<5.00E+00	**2.60E+00 (J)**	**1.12E+01**	<1.00E+04	**4.09E+03 (J)**
Acetogens	AGN-2	**2.00E+00 (J)**	**1.00E+00 (J)**	**1.31E+01**	<1.00E+04	**7.29E+03 (J)**
Acetogens	AGN-3	<5.00E+00	**3.70E+00 (J)**	**1.62E+01**	<1.00E+04	<1.00E+04
Acetogens	AGN-7	<5.00E+00	<4.90E+00	<5.30E+00	<1.00E+04	**2.78E+02 (J)**
Acetogens	AGN-8	<5.00E+00	<4.90E+00	<5.30E+00	<1.00E+04	<1.00E+04

Legend and Report Qualifiers:
J = Estimated gene copies below PQL but above LQL
< = Result not detected

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Tel. (865) 573-8188 Fax. (865) 573-8133

CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **065OL**
Date Received: 12/15/2017

Sample Information

Client Sample ID:		**EPZAS-S1-03**	**EPZAS-WM-04**	**EPZBS-WB-05**	**EPZBS-WM-06**	**EPZBS-S1-04**
Sample Date:		12/13/2017	12/13/2017	12/15/2017	12/15/2017	12/15/2017
Units:		cells/g	cells/mL	cells/mL	cells/mL	cells/g
Analyst/Reviewer:		JS	JS	JS	JS	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**1.57E+08**	**7.11E+01**	**3.06E+01**	**1.13E+02**	**2.60E+06**
Sulfate Reducing Bacteria	APS-1	**1.47E+07**	**9.30E+00**	**2.70E+00 (J)**	**7.70E+00**	**4.03E+05**
Sulfate Reducing Bacteria	APS-2	**1.13E+08**	**5.83E+01**	**2.47E+01**	**9.71E+01**	**1.68E+06**
Sulfate Reducing Bacteria	APS-3	**2.96E+07**	**3.50E+00 (J)**	**3.20E+00 (J)**	**8.60E+00**	**5.14E+05**
Sulfate Reducing Bacteria	APS-4	<1.00E+04	<4.70E+00	<4.90E+00	<6.80E+00	<1.00E+04
Sulfate Reducing Bacteria	APS-5	<1.00E+04	<4.70E+00	<4.90E+00	<6.80E+00	<1.00E+04
Sulfate Reducing Bacteria	APS-6	<1.00E+04	<4.70E+00	<4.90E+00	<6.80E+00	<1.00E+04
Sulfate Reducing Bacteria	APS-7	<1.00E+04	<4.70E+00	<4.90E+00	<6.80E+00	<1.00E+04
Acetogens	AGN	**2.31E+04**	**7.36E+01**	**6.00E-01 (J)**	**6.00E-01 (J)**	<1.00E+04
Acetogens	AGN-1	**7.72E+03 (J)**	**2.05E+01**	<4.90E+00	<6.80E+00	<1.00E+04
Acetogens	AGN-2	**1.51E+04**	**3.08E+01**	**6.00E-01 (J)**	**6.00E-01 (J)**	<1.00E+04
Acetogens	AGN-3	<1.00E+04	**2.23E+01**	<4.90E+00	<6.80E+00	<1.00E+04
Acetogens	AGN-7	**2.43E+02 (J)**	<4.70E+00	<4.90E+00	<6.80E+00	<1.00E+04
Acetogens	AGN-8	<1.00E+04	<4.70E+00	<4.90E+00	<6.80E+00	<1.00E+04

Legend and Report Qualifiers:
J = Estimated gene copies below PQL but above LQL
< = Result not detected

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CENSUS

Client: **GEI Consultants, Inc**
Project:

MI Project Number: **065OL**
Date Received: 12/15/2017

Sample Information

Client Sample ID:	**EPZBS-S2-05**
Sample Date:	12/15/2017
Units:	cells/g
Analyst/Reviewer:	JS

Functional Genes

Sulfate Reducing Bacteria	APS	**7.85E+04**
Sulfate Reducing Bacteria	APS-1	**9.64E+02 (J)**
Sulfate Reducing Bacteria	APS-2	**7.20E+04**
Sulfate Reducing Bacteria	APS-3	**5.53E+03 (J)**
Sulfate Reducing Bacteria	APS-4	<1.00E+04
Sulfate Reducing Bacteria	APS-5	<1.00E+04
Sulfate Reducing Bacteria	APS-6	<1.00E+04
Sulfate Reducing Bacteria	APS-7	<1.00E+04
Acetogens	AGN	<1.00E+04
Acetogens	AGN-1	<1.00E+04
Acetogens	AGN-2	<1.00E+04
Acetogens	AGN-3	<1.00E+04
Acetogens	AGN-7	<1.00E+04
Acetogens	AGN-8	<1.00E+04

Legend and Report Qualifiers:
J = Estimated gene copies below PQL but above LQL
< = Result not detected

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Quality Assurance/Quality Control Data

Samples Received **12/15/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
APS	12/15/2017	01/18/2018	3 °C	103%	non-detect	non-detect
APS-1	12/15/2017	01/18/2018	3 °C	119%	non-detect	non-detect
APS-2	12/15/2017	01/18/2018	3 °C	120%	non-detect	non-detect
APS-3	12/15/2017	01/18/2018	3 °C	100%	non-detect	non-detect
APS-4	12/15/2017	01/18/2018	3 °C	93%	non-detect	non-detect
APS-5	12/15/2017	01/18/2018	3 °C	95%	non-detect	non-detect
APS-6	12/15/2017	01/18/2018	3 °C	95%	non-detect	non-detect
APS-7	12/15/2017	01/18/2018	3 °C	96%	non-detect	non-detect
AGN	12/15/2017	01/18/2018	3 °C	103%	non-detect	non-detect
AGN-1	12/15/2017	01/18/2018	3 °C	102%	non-detect	non-detect
AGN-2	12/15/2017	01/18/2018	3 °C	105%	non-detect	non-detect
AGN-3	12/15/2017	01/18/2018	3 °C	103%	non-detect	non-detect
AGN-7	12/15/2017	01/18/2018	3 °C	109%	non-detect	non-detect
AGN-8	12/15/2017	01/18/2018	3 °C	95%	non-detect	non-detect

Samples Received **12/16/2017**

Component	Date Prepared	Date Analyzed	Arrival Temperature	Positive Control	Extraction Blank	Negative Control
APS	12/16/2017	01/18/2018	0 °C	103%	non-detect	non-detect
APS-1	12/16/2017	01/18/2018	0 °C	119%	non-detect	non-detect
APS-2	12/16/2017	01/18/2018	0 °C	120%	non-detect	non-detect
APS-3	12/16/2017	01/18/2018	0 °C	100%	non-detect	non-detect
APS-4	12/16/2017	01/18/2018	0 °C	93%	non-detect	non-detect
APS-5	12/16/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-6	12/16/2017	01/18/2018	0 °C	95%	non-detect	non-detect
APS-7	12/16/2017	01/18/2018	0 °C	96%	non-detect	non-detect
AGN	12/16/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-1	12/16/2017	01/18/2018	0 °C	102%	non-detect	non-detect
AGN-2	12/16/2017	01/18/2018	0 °C	105%	non-detect	non-detect
AGN-3	12/16/2017	01/18/2018	0 °C	103%	non-detect	non-detect
AGN-7	12/16/2017	01/18/2018	0 °C	109%	non-detect	non-detect
AGN-8	12/16/2017	01/18/2018	0 °C	95%	non-detect	non-detect

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Identifier: 065OL **Date Rec:** 12/15/2017 **Report Date:** 01/26/2018

Client Project #: 1411170 **Client Project Name:**

Purchase Order #:

Comments: APS = Sum of all detected APS genera, AGN = Sum of all detected AGN genera. Upon request, MI surveyed results from previously analyzed samples contained in an internal database to determine upper and lower quartile concentrations for the targets and media included below. Quartiles are provided for comparison purposes only. Quartiles exclude samples in which the target gene concentration was below the laboratory detection limit.

Target	Matrix	Lower Quartile	Upper Quartile	Units
APS	Liquid	<1E+04	>5E+05	cells/mL
	Solid	<7E+04	>5E+07	cells/g
AGN	Liquid	<2E+03	>1E+05	cells/mL
	Solid	<2E+04	>1E+06	cells/g

Notes:
Liquid includes samples from a wide variety of environments including but not limited to groundwaters, surface waters, and industrial waters
Solid includes includes samples from a wide variety of environments including but not limited to soils, sediments, sludges, and industrial deposits

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Appendix O

ATS Line 5 Pipeline Byssal Thread Investigation Report of Findings

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Line 5 Pipeline Byssal Thread Investigation Report of Findings

Prepared for

WSP USA
200 Michigan Street, Suite 411
Hancock, Michigan 49930

March 27, 2018

Prepared by

Ann Arbor Technical Services, Inc.
290 South Wagner Road
Ann Arbor, Michigan 48103

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1. PROBLEM DEFINITION AND OBJECTIVES

The objectives of this phase of investigation were as follows:

- Determine whether byssal threads from zebra, quagga or other mussels were present on the Line 5 samples.
- If byssal threads are present, determine their morphology and elemental composition in order to be able to differentiate them from other fibrous materials.
- If byssal threads are present, determine whether they attach to both the calcium carbonate (tan) deposits and/or the pipe coating (black) material.
- If byssal threads attach to the pipe coating (black) material, determine if they penetrate or otherwise deteriorate this pipe coating material.

Sample #12

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2. DESCRIPTION OF METHODS

The methods used in this phase of investigation were the same as for the Line 5 deposits, including:

- Optical Photography and Microscopy
- Scanning Electron Microscopy
- Energy Dispersive Spectroscopy and Elemental Mapping

The utility and application of these methods is described in the main body of the Line 5 Deposits Report.

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3. DESCRIPTION OF SAMPLES AND SELECTION FOR ANALYSIS

Examination of all the Line 5 samples revealed that byssal threads were present, to a greater or lesser degree, in each of them.

Sample #13: This sample was selected as representative of the Line 5 samples because it had both tan and black material on opposing sides, as discussed in the deposit report, and because it had visible byssal threads on both these surfaces.

Sample #13

"Pipe Exterior Parent Coating": This sample was selected because it was a documented pipe coating layer removed from a known pipe section, and because it had a large cluster of byssal threads attached at one end.

"Pipe Exterior Parent Coating" Sample

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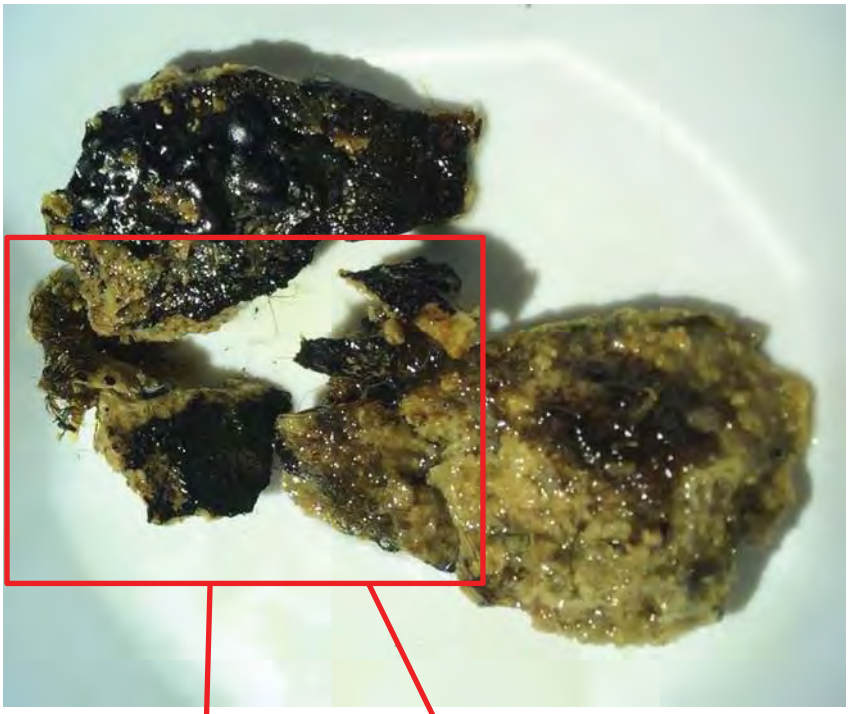
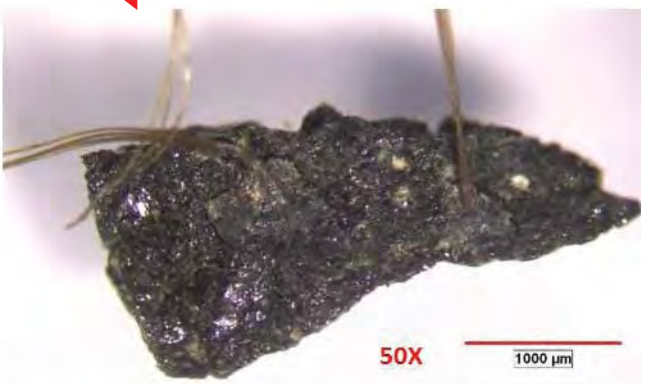
4. FINDINGS

Sample #13

Pieces of this sample containing tan and black surfaces, both with visible byssal threads, were selected for analysis.





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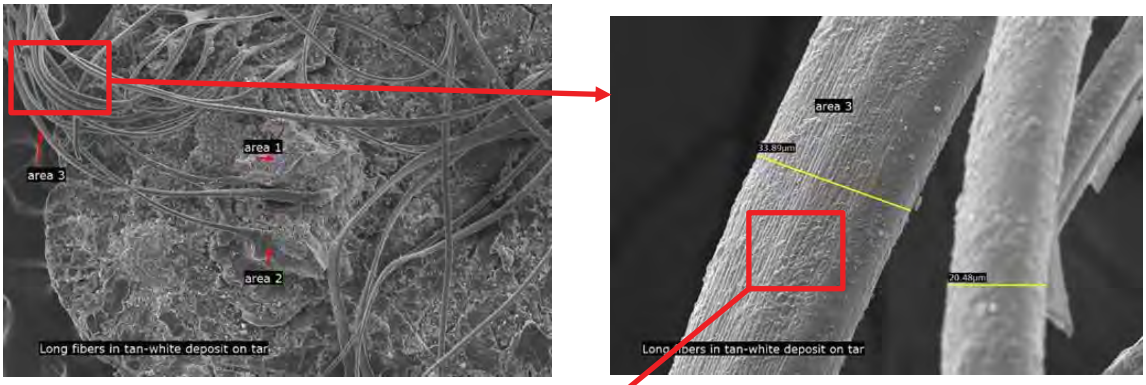
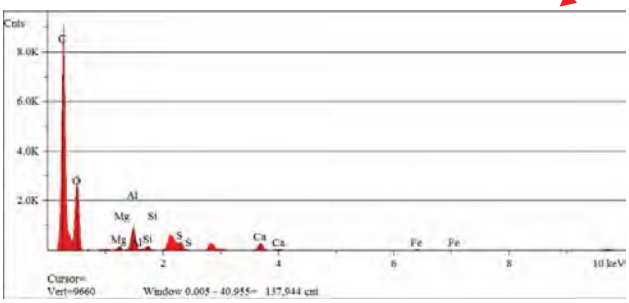
Byssal Threads on Calcium Carbonate (Tan) Deposit

Byssal threads are abundant on the calcium carbonate deposits in Sample #13. The striated thread surfaces, foot morphologies, and elemental composition reflecting protein are consistent and characteristic.

Byssal thread fiber:





Element	Relative Weight %
Carbon (C) + Nitrogen (N)	54.6
Oxygen (O)	39.4
Magnesium (Mg)	0.5
Aluminum (Al)	2.5
Silicon (Si)	0.5
Sulfur (S)	0.9
Calcium (Ca)	1.1
Iron (Fe)	0.5
Total:	100.0

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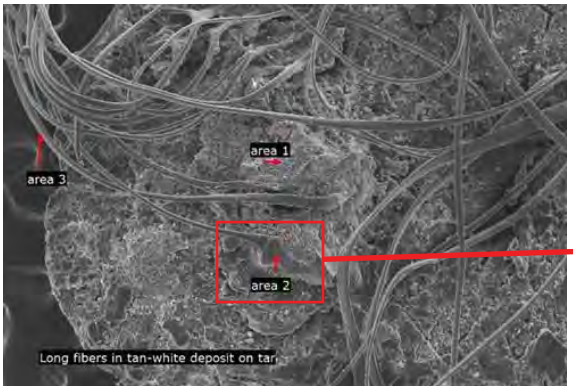
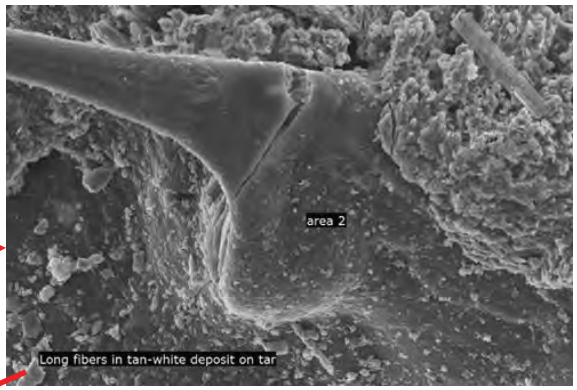
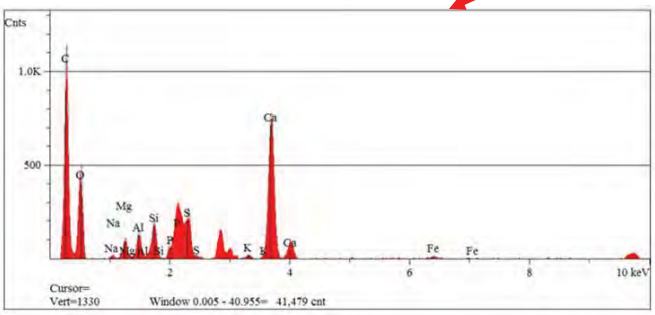
Byssal thread foot:







Element	Relative Weight %
Carbon (C) + Nitrogen (N)	43.3
Oxygen (O)	32.9
Sodium (Na)	0.4
Magnesium (Mg)	1.3
Aluminum (Al)	1.6
Silicon (Si)	2.1
Phosphorus (P)	1.2
Sulfur (S)	3.0
Potassium (K)	0.4
Calcium (Ca)	13.1
Iron (Fe)	0.7
Total:	100.0

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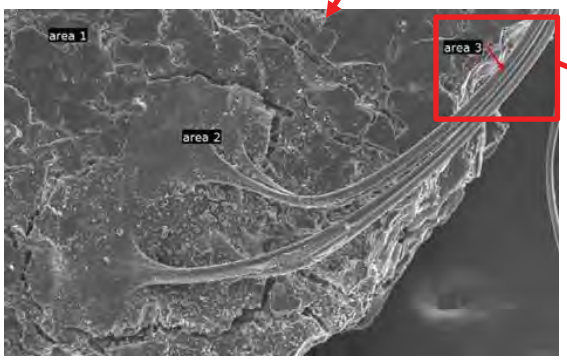
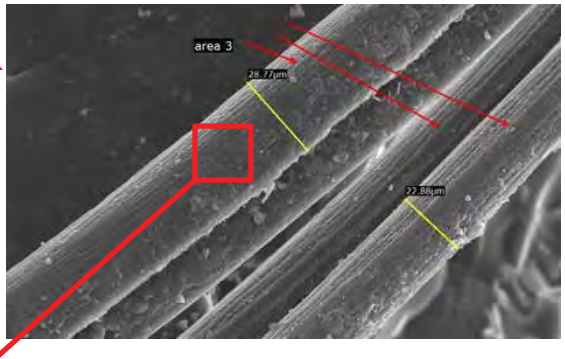
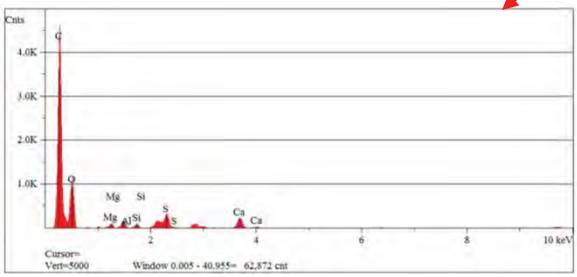
Byssal Threads on Pipe Coating (Black) Material

Byssal threads are also present on the pipe coating material in Sample #13, though they appear less abundant than on the calcium carbonate deposits. The striated thread surfaces, foot morphologies, and elemental composition reflecting protein are the same between the two types of substrate surfaces.

Byssal thread fibers:







Element	Relative Weight %
Carbon (C) + Nitrogen (N)	58.6
Oxygen (O)	35.5
Magnesium (Mg)	0.6
Aluminum (Al)	0.9
Silicon (Si)	0.6
Sulfur (S)	1.8
Calcium (Ca)	2.0
Total:	100.0

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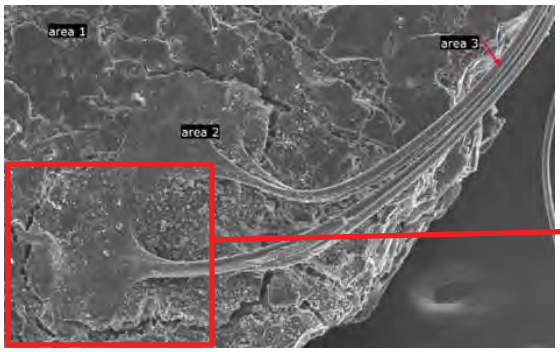
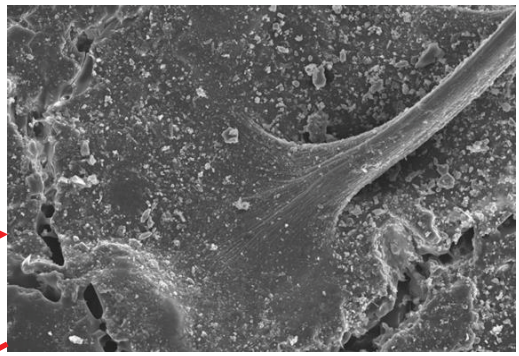
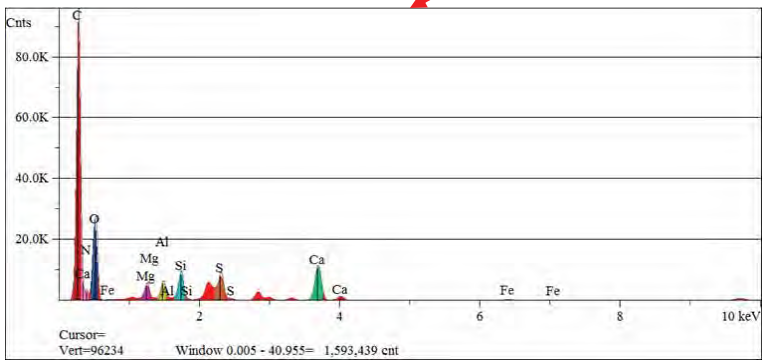
Byssal thread foot:







Element	Relative Weight %
Carbon (C)	47.2
Nitrogen (N)	11.2
Oxygen (O)	32.3
Magnesium (Mg)	1.1
Aluminum (Al)	1.2
Silicon (Si)	1.7
Sulfur (S)	1.7
Calcium (Ca)	3.3
Iron (Fe)	0.3
Total:	100.0

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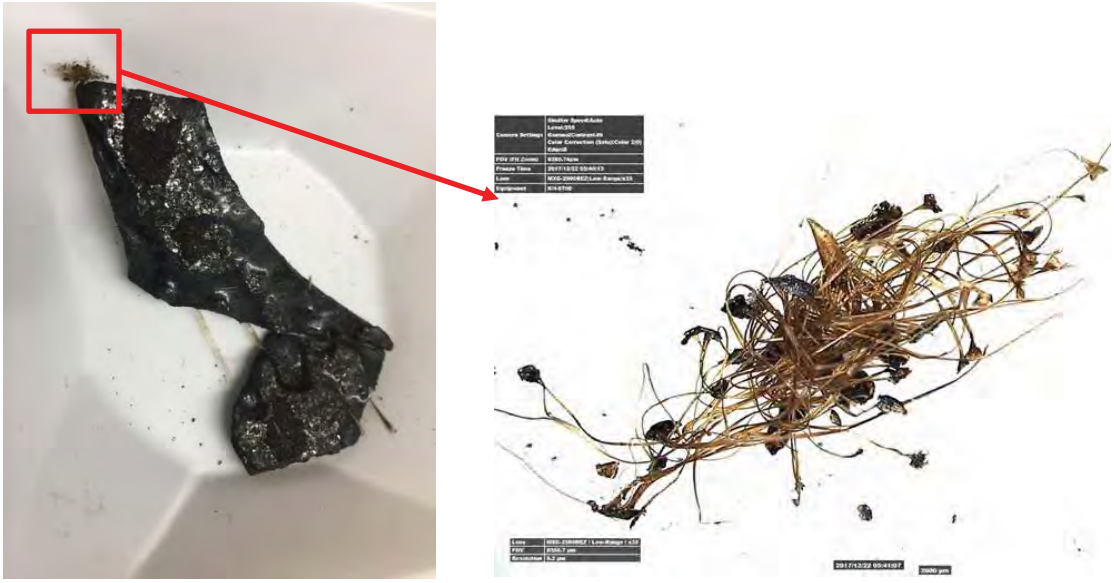
Pipe Exterior Parent Coating

A cluster of detached byssal threads was recovered from one end of this sample and was selected for analysis.



Individual threads from this cluster were disaggregated and mounted on carbon tape for SEM/EDS imaging.

Disaggregated Byssal Threads

Transferred to Carbon Black Tape

The SEM images reveal byssal threads of relatively uniform lengths and diameters, but with a variety of morphologies in the byssal thread foot. EDS spectra and elemental mapping indicate the byssal threads and feet are uniformly composed of carbon, nitrogen and oxygen, with lesser amounts of sulfur and calcium, a composition consistent with their protein makeup.

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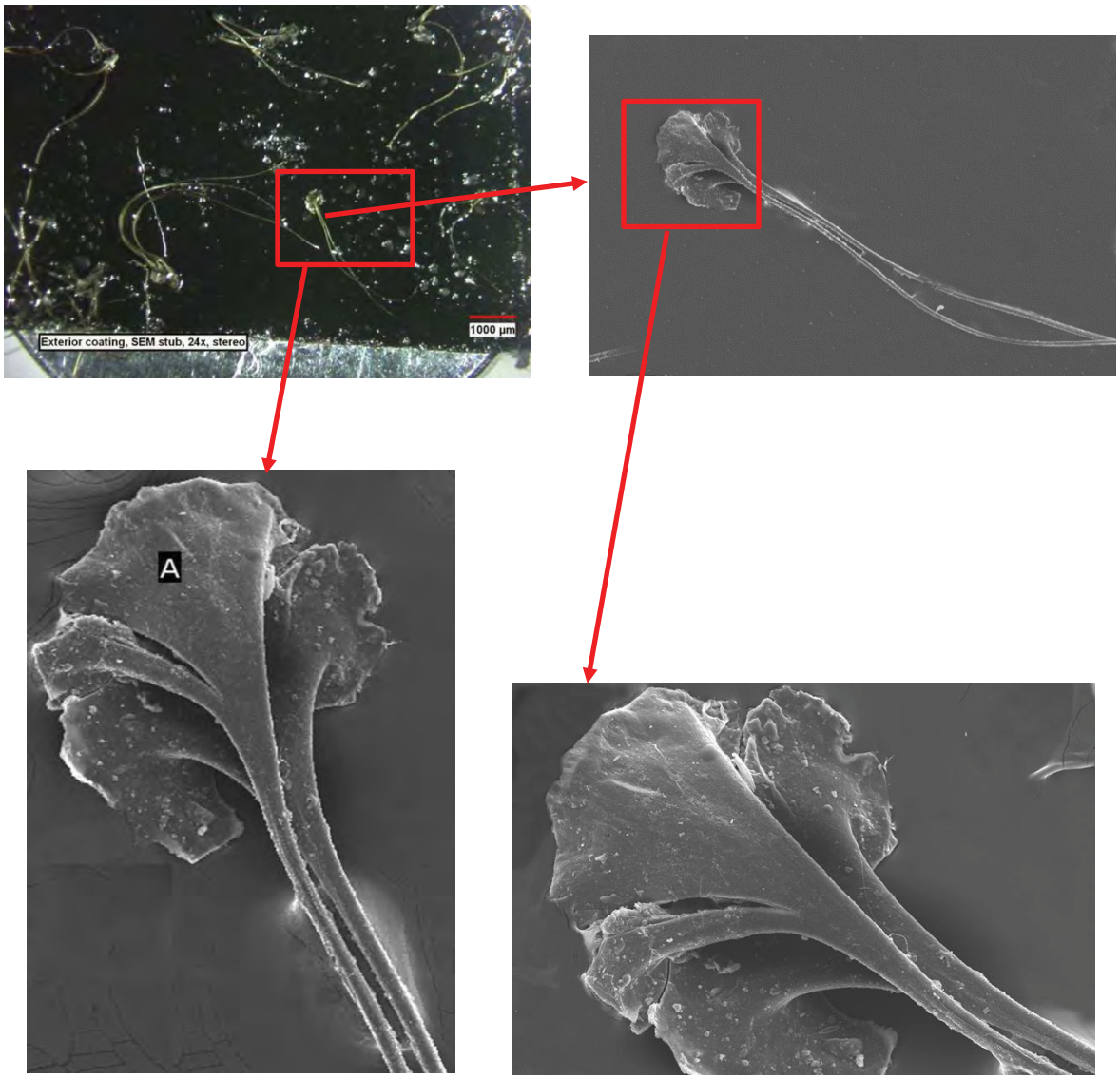
EXAMPLE 1: Byssal thread with simple foot on black carbon tape, top view – morphology and composition



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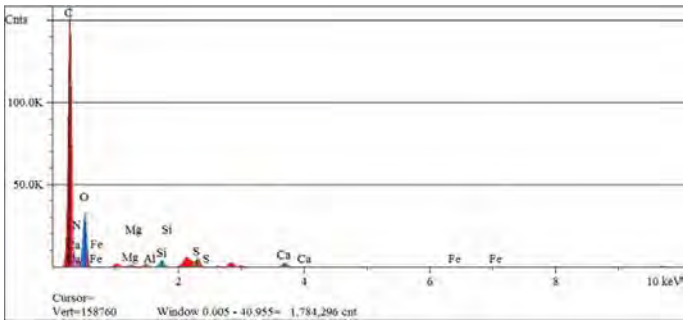
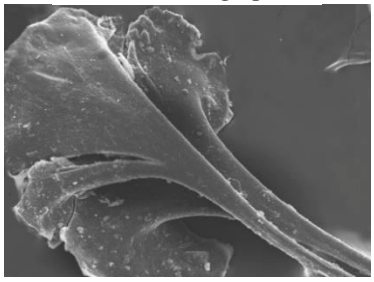
SEM/EDS Spectrum



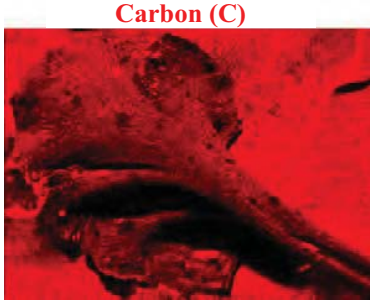
Element	Relative Weight %
Carbon (C)	52.3
Nitrogen (N)	10.9
Oxygen (O)	33.9
Magnesium (Mg)	0.2
Aluminum (Al)	0.4
Silicon (Si)	0.6
Sulfur (S)	0.9
Calcium (Ca)	0.7
Iron (Fe)	0.1
Total:	100.0

EDS Elemental Maps

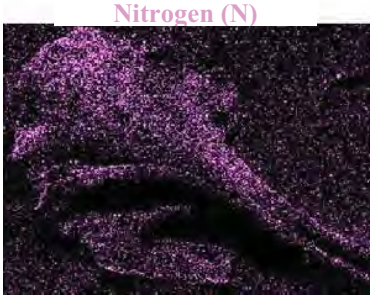
SEM Micrograph



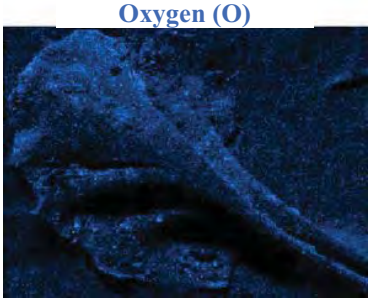
Carbon (C)



Nitrogen (N)

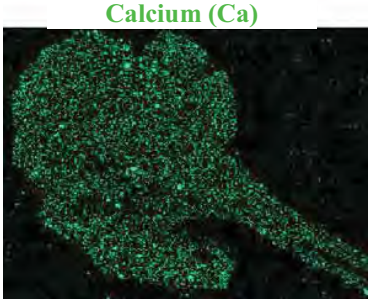


Oxygen (O)



Sulfur (S)

Calcium (Ca)



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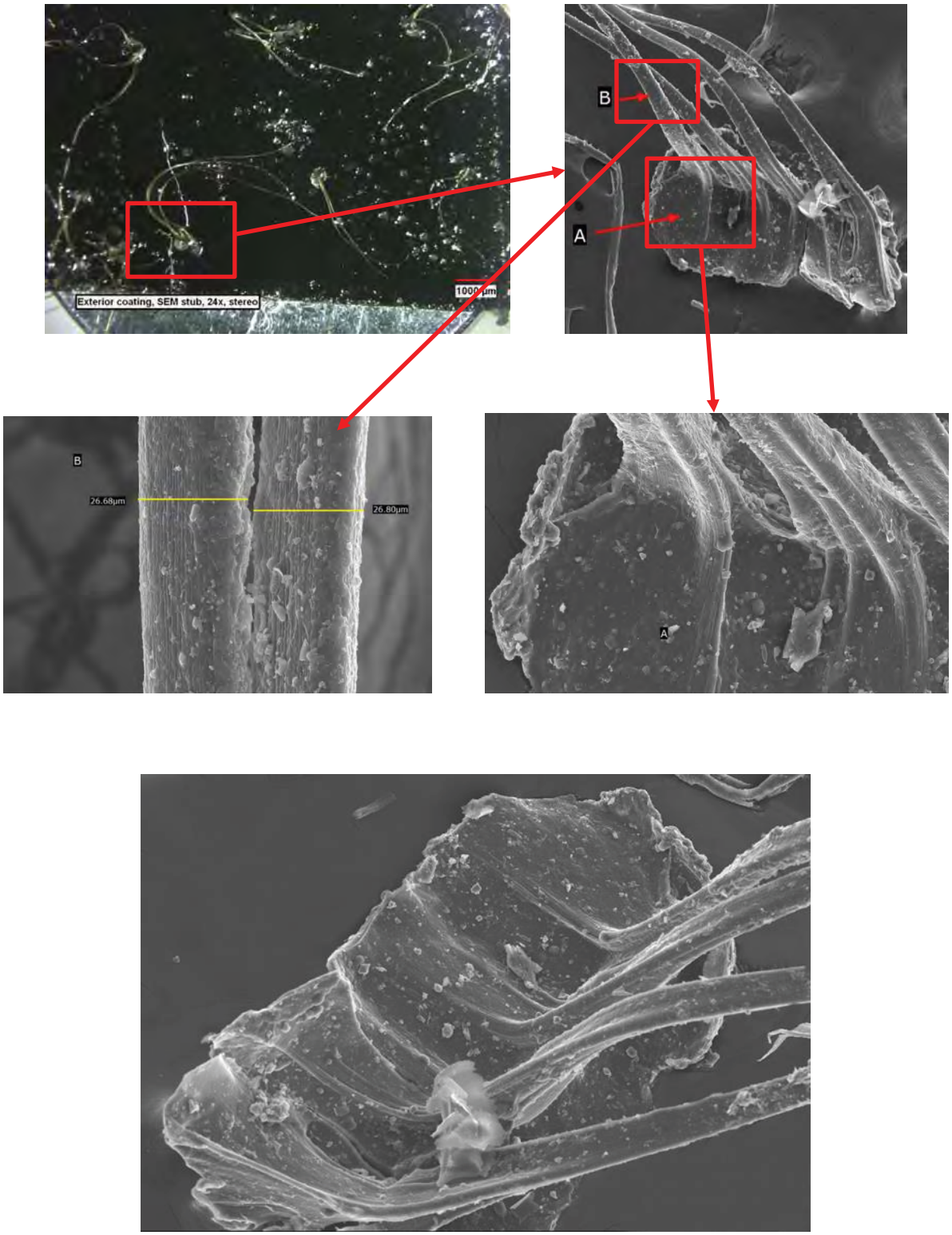
EXAMPLE 2: Byssal thread with compound foot on black carbon tape, top view – morphology and composition



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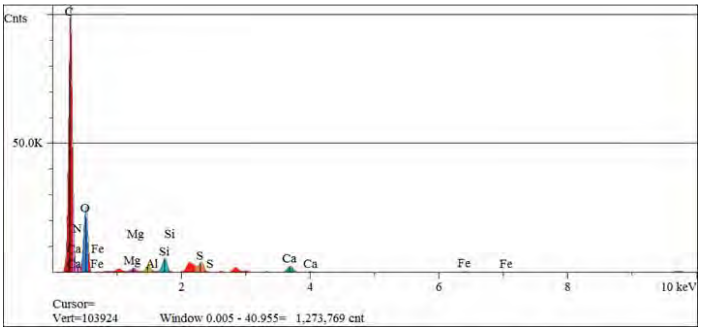
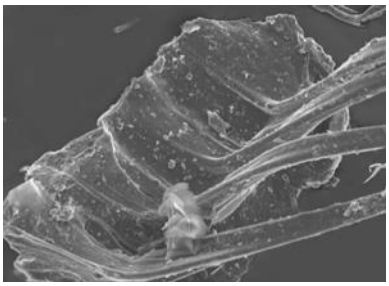
SEM/EDS Spectrum



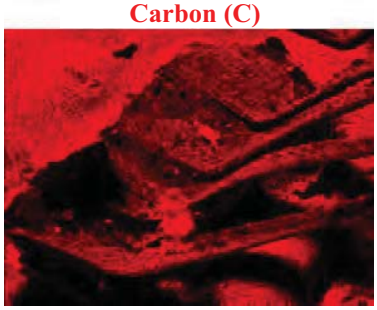
Element	Relative Weight %
Carbon (C)	50.7
Nitrogen (N)	10.6
Oxygen (O)	34.4
Magnesium (Mg)	0.4
Aluminum (Al)	0.6
Silicon (Si)	1.2
Sulfur (S)	0.9
Calcium (Ca)	0.9
Iron (Fe)	0.3
Total:	100.0

EDS Elemental Mapping

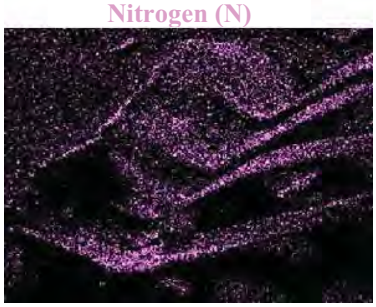
SEM Micrograph



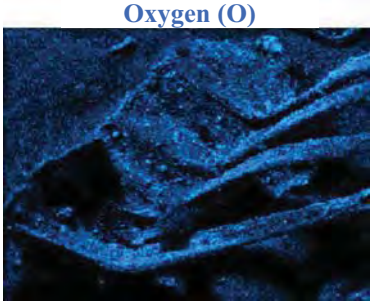
Carbon (C)



Nitrogen (N)

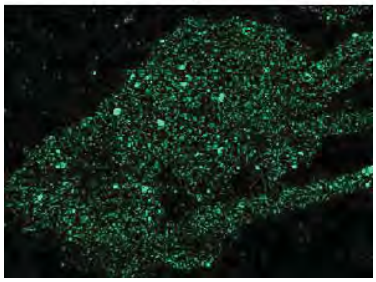


Oxygen (O)



Sulfur (S)

Calcium (Ca)



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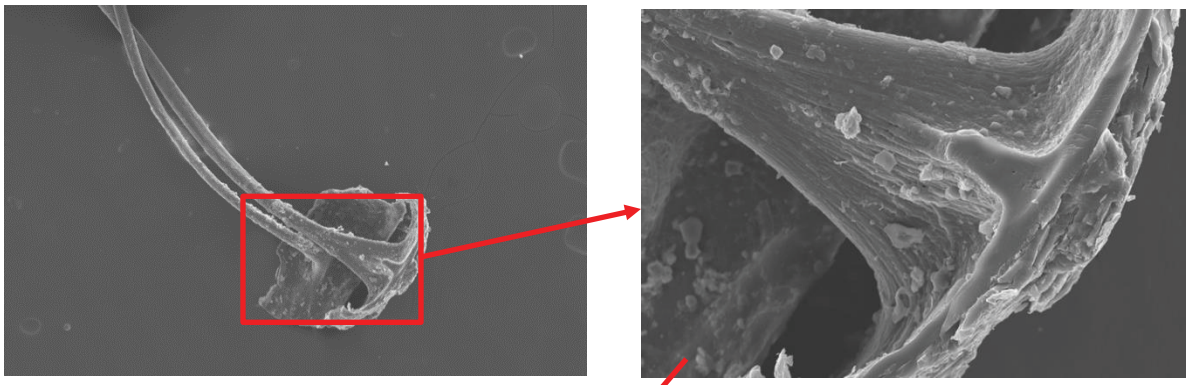
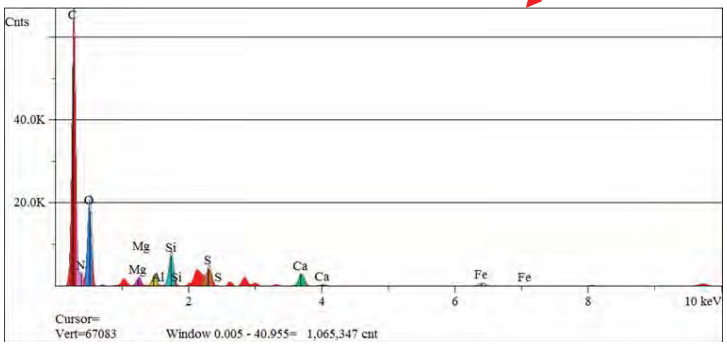
EXAMPLE 3: Byssal thread with simple foot on black carbon tape, side/bottom view – morphology and composition



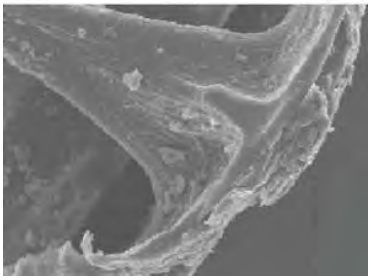
SEM/EDS Spectrum



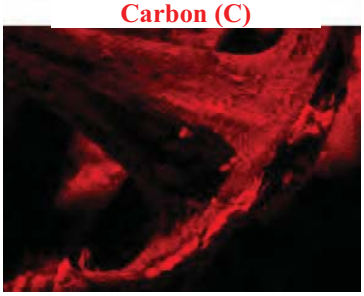
Element	Relative Weight %
Carbon (C)	45.0
Nitrogen (N)	13.5
Oxygen (O)	34.5
Magnesium (Mg)	0.7
Aluminum (Al)	0.8
Silicon (Si)	2.1
Sulfur (S)	1.3
Calcium (Ca)	1.2
Iron (Fe)	0.9
Total:	100.0

EDS Elemental Mapping

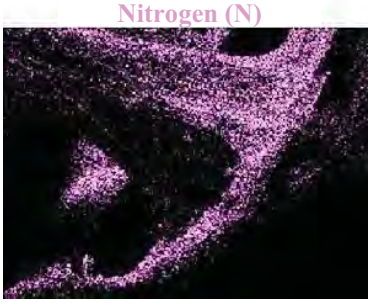
SEM Micrograph



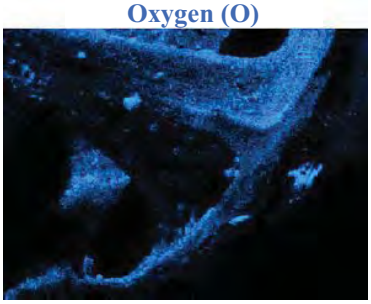
Carbon (C)



Nitrogen (N)

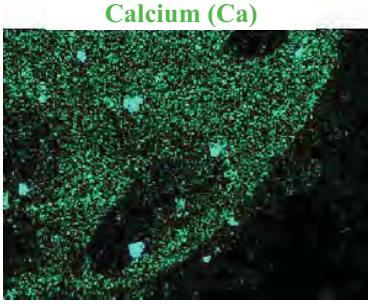


Oxygen (O)



Sulfur (S)

Calcium (Ca)



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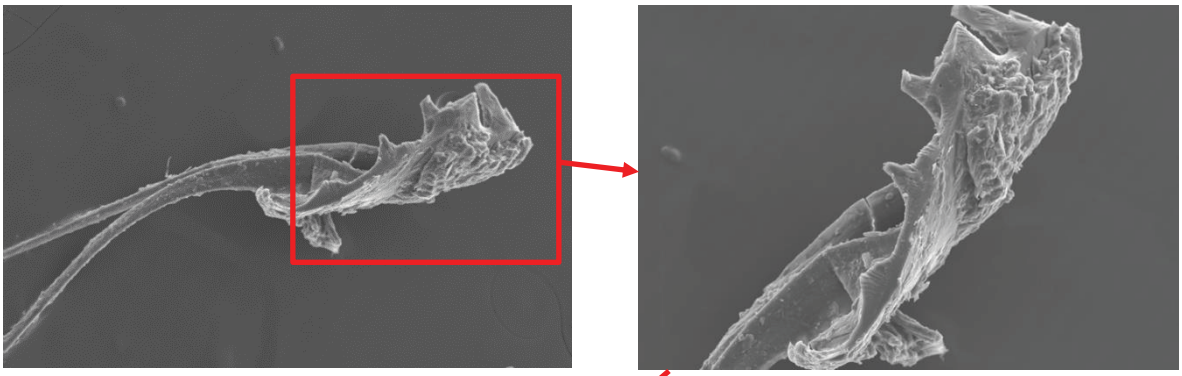
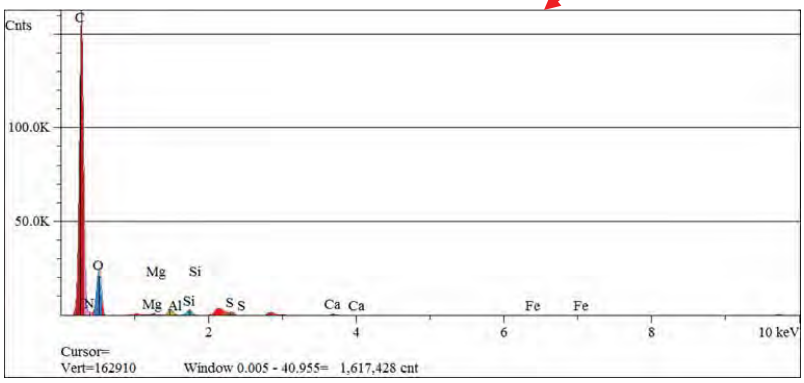
EXAMPLE 4: Byssal thread with simple foot on black carbon tape, side/bottom view – morphology and composition



SEM/EDS Spectrum

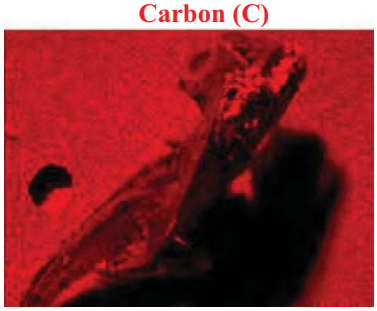


Element	Relative Weight %
Carbon (C)	59.1
Nitrogen (N)	7.2
Oxygen (O)	31.3
Magnesium (Mg)	0.3
Aluminum (Al)	0.6
Silicon (Si)	0.6
Sulfur (S)	0.4
Calcium (Ca)	0.3
Iron (Fe)	0.2
Total:	100.0

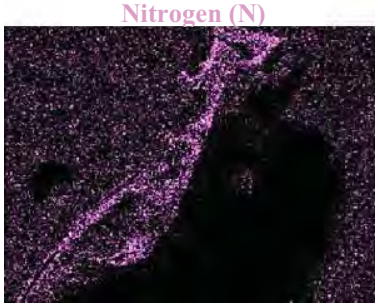
EDS Elemental Mapping

SEM Micrograph

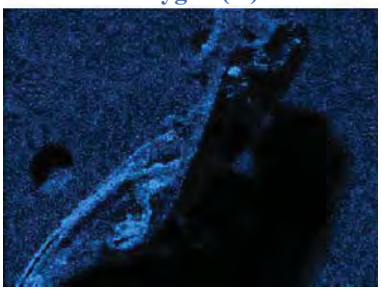
Carbon (C)



Nitrogen (N)

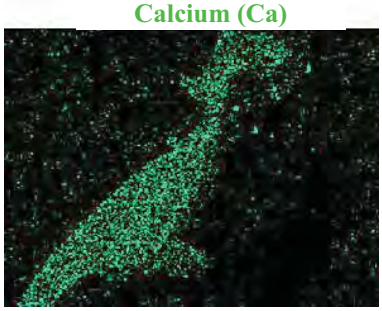


Oxygen (O)



Sulfur (S)

Calcium (Ca)



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5. CONCLUSIONS

The findings from this investigation are as follows:

- Byssal threads are present on virtually all Line 5 samples submitted for evaluation.
- Byssal threads have a unique morphology readily distinguishable under a microscope or SEM, with a striated thread and distinct foot structures.
- Byssal threads are composed principally of carbon, nitrogen and oxygen, with lesser amounts of sulfur and calcium.
- In the samples examined, Byssal threads are attached to both calcium carbonate deposits and the pipe coating material itself; there is substantially greater relative abundance on the calcium carbonate deposit surfaces. Byssal thread attachment has reportedly been inhibited by surface composition, which may account for this difference in relative abundance (O'Neill, C., et. al., 1991; Bureau of Reclamation Tech. Memo. PAP-1074, 2013; Bureau of Reclamation Tech. Memo. MERL-2014-64, 2014; Merten, B.J., et. al., 2015; Skaja, A.D., et. al., 2015).
- When attached to the pipe coating, the byssal threads do not appear to penetrate these surfaces.
- Byssal threads detach from surfaces by two mechanisms, biochemically moderated self- detachment, and externally induced mechanical detachment through breakage of the thread or removal of the foot from the surface to which it is attached, as during scraping, "jetting" or "pigging" (O'Neill, C., et. al., 1991; Bureau of Reclamation Tech. Memo. PAP-1074, 2013; Merten, B.J., et. al., 2015).
- When byssal threads detach biochemically from the pipe coating they do not appear to transfer any of the pipe coating itself, and there is no evidence suggesting the pipe coating has been deteriorated or otherwise compromised by their attachment or detachment. This contrasts to the deterioration of concrete surfaces reported in the literature (Perez, M., et. al., 2003; Yao, G., et. al., 2017).
- Reports in the literature exist indicating when byssal threads are detached by external forces on less durable pipe coatings, transfer of some coating during the process may result. At the present time it is uncertain whether that occurs with more durable pipe coatings such as epoxies or similar durable coating formulations in general, and the Line 5 pipe coating in particular.

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Yao, G., Xu, M., and An, X., (2017). "*Concrete Deterioration Caused by Freshwater Mussel Limnoperna Fortunei Fouling*," International Biodeterioration and Biodegration, 121, pp 55-65.

Appendix G: Coating Repair Reports

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ENBRIDGE

Coating Repair Form for L5 Straits of Mackinac

General Information

Date:	11/12/2017 11/13/2017 12/02/2017	Diver:	11/12 – Joe Reiman, Andrew Alber, ChadCantrell, 11/13 – Brad Jonas 12/02 – Shawn Binsfield
AFE / W.O.#:	20011702	Company Inspector:	[redacted]
Segment:	EAOI-1	Water Depth (ft):	[redacted]
Longitude:	[redacted]	Latitude:	[redacted]

Material Information

BIO- DUR™ 563 SW Epoxy Base – Black	17T-715	Expiration Date:	11/06/2019
BIO – DUR ™ 563SW Curing Agent – White	17T-717	Expiration Date:	11/06/2019
X100 – UW Epoxy Base – Blue	17T-598 17T-596	Expiration Date:	9/25/2019 9/25/2019
BIO-SEAL ™ X-100 Curing Agent – Clear	17t-581	Expiration Date:	9/20/2019

Temperature (°F):	46, 46, 44,48	Wall Thickness Measurements (mil):	816, 818, 814, 814, 812
Location of the Coating Repair:	Top of Pipe	Coating Repair Method:	Full Circumferential Composite Wrap Repair

Quaity Assurance During Application

☑	The steel surface was cleaned using scarpers, hydroblasting cleaning, wet abrasive blasting, or pneumatic power wire wheel brush. (3.1)
☑	Feathering removed the sharp edge at the transition from the parent coating. The parent coating was roughened (abraded) using a cup disk brush to remove the loosely adherent biota, coating and provide a surface for overcoating (3.2)
☑	Immediately prior to coating application, the Diver removed any flash rust and/or accumulated debris (silt, clay, etc.) using a wire brush or other method approved by the Manufacturer (4.1).
☑	The diver applied sufficient BIO-DUR epoxy filler so that the bare steel is completely covered and the repair area is flush with the adjacent parent coating (4.2.2 and 4.2.3).
☑	Full Circumferential Composite Wrap Repair (4.3) or Composite Patch Repair (4.4) applied in accordance with the coating procedure.
☑	Blue Stricture Banding® or alternative protective wraps/encasements allowed by the coating Manufacturer applied over the composite wrap or patch repair.

After Cure of Coating Repair

Date:	12/02/2017	Cure Time (days)	19
Temperature (°F):	41	Hardness Quaity Check (4.5.2)	Pass
Total thickness measurements of the Coating Repair (mil):	250+, 250+, 250+		

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- No external corrosion reported by diver.
- Additional bare metal exposed during surface preparation. No external corrosion reported by diver at these areas.
- After surface preparation, anchor profile was 3.5 mils and 3.2 mils.
- Epoxy filler transferred to diver within 6 minutes after initial mixing.

[redacted]	[redacted]
Contractor Signature	Company Inspector Signature

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ENBRIDGE

Coating Repair Form for L5 Straits of Mackinac

Surface of pipe after surface preparation.

Date:	11/12/2017	Frame (HH:MM:SS)	11:04:55

Surface of the pipe after filler application.

Date:	11/12/2017	Frame (HH:MM:SS)	11:22:52

Surface of the pipe after composite wrap.

Date:	11/13/2017	Frame (HH:MM:SS)	12:31:25

Surface of the pipe after Stricture Banding.

Date:	12/02/2017	Frame (HH:MM:SS)	11:24:09

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Coating Repair Form for L5 Straits of Mackinac

Surface of the pipe after cure and removal of Stricture banding.	[Additional Photograph Caption]

Date:	12/02/2017	Frame (13:20:55)	11:44:31	Date:	DD/MM/YY	Frame (HH:MM:SS)	

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Coating Repair Form for L5 Straits of Mackinac

General Information

Date:	10/01/2017	Diver:	Chad Palmer Mackenzie Thopkins
AFE / W.O.#:	BPI-1264792-17	Company Inspector:	[redacted]
Segment:	EAOI-5	Water Depth (ft):	[redacted]
Longitude:	[redacted]	Latitude:	[redacted]

Material Information

BIO- DUR™ 563 SW Epoxy Base – Black	17T-391	Expiration Date:	07/04/19
BIO – DUR ™ 563SW Curing Agent – White	17T-534	Expiration Date:	09/05/19
X100 – UW Epoxy Base – Blue	17T-580	Expiration Date:	09/20/19
BIO-SEAL ™ X-100 Curing Agent – Clear	17T-581 17T-571	Expiration Date:	09/20/19 09/12/19

Temperature (°F):	54	Wall Thickness Measurements (mil):	766, 762, 762, 766, 754, 764
Location of the Coating Repair:	Top of Pipe	Coating Repair Method:	Full Circumferential Composite Wrap Repair

Quaity Assurance During Application

☑	The steel surface was cleaned using scarpers, hydroblasting cleaning, wet abrasive blasting, or pneumatic power wire wheel brush. (3.1)
☑	Feathering removed the sharp edge at the transition from the parent coating. The parent coating was roughened (abraded) using a cup disk brush to remove the loosely adherent biota, coating and provide a surface for overcoating (3.2).
☑	Immediately prior to coating application, the Diver removed any flash rust and/or accumulated debris (silt, clay, etc.) using a wire brush or other method approved by the Manufacturer (4.1).
☑	The diver applied sufficient BIO-DUR epoxy filler so that the bare steel is completely covered and the repair area is flush with the adjacent parent coating (4.2.2 and 4.2.3).
☑	Full Circumferential Composite Wrap Repair (4.3) or Composite Patch Repair (4.4) applied in accordance with the coating procedure.
☑	Blue Stricture Banding® or alternative protective wraps/encasements allowed by the coating Manufacturer applied over the composite wrap or patch repair.

After Cure of Coating Repair

Date:	10/28/2017	Cure Time (days):	27
Temperature (°F):	54	Hardness Quaity Check (4.5.2)	PASS
Total thickness measurements of the Coating Repair (mil):	250+, 250+, 250+		

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Coating Repair Form for L5 Straits of Mackinac

Comments/Issues/Discussion

- No external corrosion reported by diver.
- Additional bare metal exposed during surface preparation. No external corrosion reported by diver at these areas.
- After surface preparation, two anchor profile were measured at 2.9 and 3.3 mils.
- Epoxy filler transferred to diver within 14 minutes after initial mixing.

[redacted]	[redacted]
Contractor Signature	Company Inspector Signature

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Coating Repair Form for L5 Straits of Mackinac

Surface of pipe after surface preparation.

Date:	10/01/2017	Frame (HH:MM:SS)	15:15:20

Surface of the pipe after filler application.

Date:	10/01/2017	Frame (HH:MM:SS)	16:02:17

Surface of the pipe after composite wrap.

Date:	10/01/2017	Frame (HH:MM:SS)	16:23:10

Surface of the pipe after Stricture Banding.

Date:	10/01/2017	Frame (HH:MM:SS)	16:38:43

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Coating Repair Form for L5 Straits of Mackinac

Surface of the pipe after cure and removal of Stricture banding.	[Additional Photograph Caption]

Date:	10/28/2017	Frame	11:58:43	Date:	DD/MM/YY	Frame (HH:MM:SS)	

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Coating Repair Form for L5 Straits of Mackinac

General Information

Date:	10/01/2017 10/12/2017 10/13/2017 10/14/2017 10/16/2017 10/20/2017 10/21/2017 10/22/2017 10/23/2017 11/01/2017	Diver:	10/01 - Shawn Binsfield 10/12 – Shawn Binsfield, Craig Palmer, Joe Rieman, Jesse Tabor 10/13 – Daylon Hutton, Mike Rosette 10/14 – Andrew Alber, Shawn Binsfield, Craig Palmer, Joe Rieman, Jesse Tabor 10/16 – Mike Rosette, Shawn Binsfield, Craig Palmer 10/20 – McKenzie Tompkins, Joe Rieman, Jesse Tabor 10/21 Mike Rosette, Shawn Binsfield, Craig Palmer,Mckenzie Tompkins 10/22 Joe Reiman, Jessie Tabor, Mike Rosette,Andrew Alber 10/23 Shawn Binsfield, Mackenzie Tompson 11/01 Daylin Hutton, Mackenzie Tompson
AFE / W.O.#:	BPI-1264792-17	Company Inspector:	[redacted]
Segment:	EAOI-7	Water Depth (ft):	[redacted]
Longitude:	[redacted]	Latitude:	[redacted]

Material Information

BIO- DUR™ 563 SW Epoxy Base – Black	17T-582 17T-586	Expiration Date:	09/19/2019 09/20/2019
BIO – DUR ™ 563SW Curing Agent – White	17T-583 17T-587	Expiration Date:	09/19/2019 09/20/2019
X100 – UW Epoxy Base – Blue	17T-580	Expiration Date:	09/20/2019
BIO-SEAL ™ X-100 Curing Agent – Clear	17T-571	Expiration Date:	09/12/19

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Coating Repair Form for L5 Straits of Mackinac

Temperature (°F):	54, 56, 55, 55, 59, 55, 55, 56, 56, 59,56,56, 58,56,58,56,53,56,56,53	Wall Thickness Measurements (mil):	1	824, 824, 822, 812, 802, 828, 812, 822
			1a	790, 792, 794, 784, 788, 788, 792, 792
			1b	810, 806, 790, 776, 804, 794, 776, 776
			1c/d/e	832, 826, 822, 806, 794, 796, 794, 786, 774, 776, 800, 792, 778, 818, 804, 812, 824, 828, 836, 836, 840, 840, 840, 830, 826, 820
			1f	814, 816, 824, 826, 822, 798, 788, 798, 808
			1g	840, 836, 836, 838, 838
			1h	818, 818, 820, 820, 822
			1i	830, 812, 794, 814, 834, 826, 798, 786, 786
			1j	826, 830, 834, 840, 834, 834, 846, 840
			1k	779, 778, 772, 774, 774, 782, 778, 810, 808, 810
			1l	786, 804, 794, 800, 810, 806, 808, 798
			1m	768, 768, 774, 784, 780, 806, 802
			1n	784, 784, 802, 802, 816, 814, 834, 838
			1o	802, 802, 818, 834, 830, 838, 844, 836
Location of the Coating Repair:	Top, Side, and Bottom of Pipe		Coating Repair Method:	Full Circumferential Composite Wrap Repair

Quaity Assurance During Application

☑	The steel surface was cleaned using scarpers, hydroblasting cleaning, wet abrasive blasting, or pneumatic power wire wheel brush. (3.1)
☑	Feathering removed the sharp edge at the transition from the parent coating. The parent coating was roughened (abraded) using a cup disk brush to remove the loosely adherent biota, coating and provide a surface for overcoating (3.2).
☑	Immediately prior to coating application, the Diver removed any flash rust and/or accumulated debris (silt, clay, etc.) using a wire brush or other method approved by the Manufacturer (4.1).
☑	The diver applied sufficient BIO-DUR epoxy filler so that the bare steel is completely covered and the repair area is flush with the adjacent parent coating (4.2.2 and 4.2.3).
☑	Full Circumferential Composite Wrap Repair (4.3) or Composite Patch Repair (4.4) applied in accordance with the coating procedure.
☑	Blue Stricture Banding® or alternative protective wraps/encasements allowed by the coating Manufacturer applied over the composite wrap or patch repair.

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ENBRIDGE	Coating Repair Form for L5 Straits of Mackinac

After Cure of Coating Repair			
Date:	11/01/2017	Cure Time (days)	9
Temperature (°F):	53	Hardness Quaiity Check (4.5.2)	PASS
Total thickness measurements of the Coating Repair (mil):		245, 250+, 250+, 250+, 250+, 250+, 250+, 250+, 250+, 250+,	

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Coating Repair Form for L5 Straits of Mackinac

Comments/Issues/Discussion

- No external corrosion reported by diver.
- Additional bare metal exposed during surface preparation. No external corrosion reported by diver at these areas.
- After surface preparation, anchor profile at 1, 1a, ..., 1o were 4.0, 3.9, 3.0, 3.4, 3.3, 3.7, 3.6, 3.8, 2.7, 3.7, 3.3, 4.0, 4.0, 2.8, 3.4, 4.0, 4.1 mils, respectively.
- Filler was applied within 16 minutes of mixing.

[redacted]	[redacted]
Contractor Signature	Company Inspector Signature

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Coating Repair Form for L5 Straits of Mackinac

Surface of pipe after surface preparation.

Date:	10/21/2017	Frame (HH:MM:SS)	13:38:24

Surface of the pipe after filler application.

Date:	10/21/2017	Frame (HH:MM:SS)	11:33:38

Surface of the pipe after composite wrap.

Date:	11/01/2017	Frame (HH:MM:SS)	10:03:35

Surface of the pipe after Stricture Banding.

Date:	10/23/2017	Frame (HH:MM:SS)	14:04:09

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Coating Repair Form for L5 Straits of Mackinac

Surface of the pipe after cure and removal of Stricture banding.				[Additional Photograph Caption]			
Date:	11/01/2017	Frame (HH:MM:SS)	10:03:35	Date:	DD/MM/YY	Frame (HH:MM:SS)	

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Coating Repair Form for L5 Straits of Mackinac

General Information			
Date:	10/06/2017 10/09/2017 10/10/2017 10/22/2017	Diver:	10/06 – Mike Rosette, Andrew Alber 10/09 – McKenzie Tompkins, Joe Rieman, Mike Rosette, Andrew Alber 10/10 – Joe Rieman, Mike Rosette, Andrew Alber 10/22 – Andrew Alber
AFE / W.O.#:	BPI-1264792-17	Company Inspector:	[redacted]
Segment:	EAS-1	Water Depth (ft):	[redacted]
Longitude:	[redacted]	Latitude:	[redacted]

Material Information			
BIO- DUR™ 563 SW Epoxy Base – Black	17T-391 17T-582 17T-586	Expiration Date:	7/04/2019 9/19/2019 9/20/2019
BIO – DUR ™ 563SW Curing Agent – White	17T-534 17T-583 17T-587	Expiration Date:	9/05/2019 9/19/2019 9/20/2019
X100 – UW Epoxy Base – Blue	17T-580 17T-570 17T-598	Expiration Date:	9/20/2019 9/12/2019 9/25/2019
BIO-SEAL ™ X-100 Curing Agent – Clear	17T-581 17T-571 17T-597	Expiration Date:	9/20/2019 9/12/2019 9/25/2019

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ENBRIDGE	Coating Repair Form for L5 Straits of Mackinac

Temperature (°F):	61, 56, 57, 56, 61	Wall Thickness Measurements (mil):	1	808, 814, 824, 824, 824, 824,822
			1b	UT cannot read on weld.
			1c/d	842, 842, 850, 838, 818, 788, 798, 790, 788, 788, 786, 782, 776, 764, 770, 772, 774, 780, 790, 780, 780, 792, 808, 798, 808, 820, 834
			1e	838, 830, 822, 816
			1f	812, 814, 812, 814, 816
Location of the Coating Repair:	Top, Side, and Bottom of Pipe		Coating Repair Method:	Full Circumferential Composite Wrap Repair

Quaity Assurance During Application	
☑	The steel surface was cleaned using scarpers, hydroblasting cleaning, wet abrasive blasting, or pneumatic power wire wheel brush. (3.1)
☑	Feathering removed the sharp edge at the transition from the parent coating. The parent coating was roughened (abraded) using a cup disk brush to remove the loosely adherent biota, coating and provide a surface for overcoating (3.2).
☑	Immediately prior to coating application, the Diver removed any flash rust and/or accumulated debris (silt, clay, etc.) using a wire brush or other method approved by the Manufacturer (4.1).
☑	The diver applied sufficient BIO-DUR epoxy filler so that the bare steel is completely covered and the repair area is flush with the adjacent parent coating (4.2.2 and 4.2.3).
☑	Full Circumferential Composite Wrap Repair (4.3) or Composite Patch Repair (4.4) applied in accordance with the coating procedure.
☑	Blue Stricture Banding® or alternative protective wraps/encasements allowed by the coating Manufacturer applied over the composite wrap or patch repair.

After Cure of Coating Repair			
Date:	10/22/2017	Cure Time (days):	12
Temperature (°F):	56	Hardness Quaity Check (4.5.2)	Pass
Total thickness measurements of the Coating Repair (mil):		250+, 250+, 250+, 250+, 250+	

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Coating Repair Form for L5 Straits of Mackinac

Comments/Issues/Discussion

- No external corrosion reported by diver.
- Additional bare metal exposed during surface preparation. No external corrosion reported by diver at these areas. After surface preparation, anchor profile was (1) 3.2 mils, (1b) 4.5 mils, (1c/d/e) 2.6, 2.5, 2.6, 2.5, and 3.5 mils, and (1f) 3.5 mils.
- Time from mixing filler to application did not exceed 16 minutes.

[redacted]	[redacted]
Contractor Signature	Company Inspector Signature

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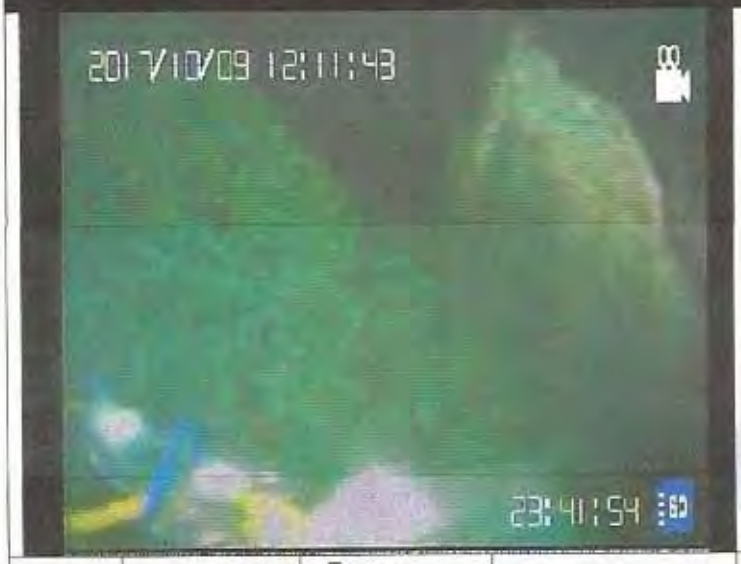
Coating Repair Form for L5 Straits of Mackinac

Surface of pipe after surface preparation.



Date:	9/10/2017	Frame (HH:MM:SS)	12:11:43

Surface of the pipe after filler application.

Date:	9/10/2017	Frame (HH:MM:SS)	12:58:42

Surface of the pipe after composite wrap.

Date:	10/10/2017	Frame (HH:MM:SS)	14:26:08

Surface of the pipe after Stricture Banding.

Date:	10/10/2017	Frame (HH:MM:SS)	14:26:47

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ENBRIDGE	Coating Repair Form for L5 Straits of Mackinac

Surface of the pipe after cure and removal of Stricture banding.	[Additional Photograph Caption]

Date:	10/22/2017	Frame (HH:MM:SS)	15:27:01	Date:	DD/MM/YY	Frame (HH:MM:SS)	

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Coating Repair Form for L5 Straits of Mackinac

General Information

Date:	09/21/2017	Diver:	Mackenzie Thopkins Mike Rosette
AFE / W.O.#:	BPI-1264792-17	Company Inspector:	[redacted]
Segment:	EAS-2	Water Depth (ft):	[redacted]
Longitude:	[redacted]	Latitude:	[redacted]

Material Information

BIO- DUR™ 563 SW Epoxy Base – Black	17T-391	Expiration Date:	07/04/19
BIO – DUR ™ 563SW Curing Agent – White	17T-534	Expiration Date:	09/05/19
X100 – UW Epoxy Base – Blue	17T-535	Expiration Date:	09/05/19
BIO-SEAL ™ X-100 Curing Agent – Clear	17T-537	Expiration Date:	09/05/19

Temperature (°F):	55	Wall Thickness Measurements (mil):	848, 848, 854, 852, 850
Location of the Coating Repair:	Top of Pipe	Coating Repair Method:	Full Circumferential Composite Wrap Repair

Quaity Assurance During Application

☑	The steel surface was cleaned using scarpers, hydroblasting cleaning, wet abrasive blasting, or pneumatic power wire wheel brush. (3.1)
☑	Feathering removed the sharp edge at the transition from the parent coating. The parent coating was roughened (abraded) using a cup disk brush to remove the loosely adherent biota, coating and provide a surface for overcoating (3.2).
☑	Immediately prior to coating application, the Diver removed any flash rust and/or accumulated debris (silt, clay, etc.) using a wire brush or other method approved by the Manufacturer (4.1).
☑	The diver applied sufficient BIO-DUR epoxy filler so that the bare steel is completely covered and the repair area is flush with the adjacent parent coating (4.2.2 and 4.2.3).
☑	Full Circumferential Composite Wrap Repair (4.3) or Composite Patch Repair (4.4) applied in accordance with the coating procedure.
☑	Blue Stricture Banding® or alternative protective wraps/encasements allowed by the coating Manufacturer applied over the composite wrap or patch repair.

After Cure of Coating Repair

Date:	10/6/2017	Cure Time (days): 15	Craig Palmer
Temperature (°F):	62	Hardness Quaiity Check (4.5.2)	Pass
Total thickness measurements of the Coating Repair (mil):	250+, 250+, 250+, 250+		

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Coating Repair Form for L5 Straits of Mackinac

Comments/Issues/Discussion

- No external corrosion reported by diver.
- Additional bare metal exposed during surface preparation. No external corrosion reported by Diver at these areas.
- After surface preparation, anchor profile was 3.4 mils.

[redacted]

Contractor Signature

[redacted]

Company Inspector Signature

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Coating Repair Form for L5 Straits of Mackinac

Surface of pipe after surface preparation.

Date:	09/21/2017	Frame (HH:MM:SS)	15:53:26

Surface of the pipe after filler application.

Date:	09/21/2017	Frame (HH:MM:SS)	16:19:04

Surface of the pipe after composite wrap.

Date:	09/21/2017	Frame (HH:MM:SS)	18:08:24

Surface of the pipe after Stricture Banding.

Date:	09/21/2017	Frame (HH:MM:SS)	18:16:16

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Coating Repair Form for L5 Straits of Mackinac

Surface of the pipe after cure and removal of Stricture banding.	[Additional Photograph Caption]

Date:	10/06/2017	Frame (HH:MM:SS)	16:02:08	Date:	DD/MM/YY	Frame (HH:MM:SS)	

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ENBRIDGE	Coating Repair Form for L5 Straits of Mackinac

General Information

Date:	10/01/2017 10/29/2017 12/15/2017	**Diver:**	10/01 - Joe Rieman 10/29 – Mike Rosette, Andrew Alber 12/15 – Joe Rieman
AFE / W.O.#:	BPI-1264792-17	**Company Inspector:**	[redacted]
Segment:	EAS-3	**Water Depth (ft):**	[redacted]
Longitude:	[redacted]	**Latitude:**	[redacted]

Material Information

BIO- DUR™ 563 SW Epoxy Base – Black	17T-582	**Expiration Date:**	9/19/19
BIO – DUR ™ 563SW Curing Agent – White	17T-583	**Expiration Date:**	9/19/19
X100 – UW Epoxy Base – Blue	17T-580 17T-570	**Expiration Date:**	9/20/19 9/12/19
BIO-SEAL ™ X-100 Curing Agent – Clear	17T-581 17T-571	**Expiration Date:**	9/20/19 9/12/19

Temperature (°F):	55	**Wall Thickness Measurements (mil):**	1	806, 802, 804, 800, 800, 802, 808, 810, 806, 806, 804
			1a	810, 810, 812, 810, 808, 808
Location of the Coating Repair:	Top of Pipe and side of pipe		**Coating Repair Method:**	Full Circumferential Composite Wrap Repair

Quaity Assurance During Application

☑	The steel surface was cleaned using scrapers, hydroblasting cleaning, wet abrasive blasting, or pneumatic power wire wheel brush. (3.1)
☑	Feathering removed the sharp edge at the transition from the parent coating. The parent coating was roughened (abraded) using a cup disk brush to remove the loosely adherent biota, coating and provide a surface for overcoating (3.2).
☑	Immediately prior to coating application, the Diver removed any flash rust and/or accumulated debris (silt, clay, etc.) using a wire brush or other method approved by the Manufacturer (4.1).
☑	The diver applied sufficient BIO-DUR epoxy filler so that the bare steel is completely covered and the repair area is flush with the adjacent parent coating (4.2.2 and 4.2.3).
☑	Full Circumferential Composite Wrap Repair (4.3) or Composite Patch Repair (4.4) applied in accordance with the coating procedure.
☑	Blue Stricture Banding® or alternative protective wraps/encasements allowed by the coating Manufacturer applied over the composite wrap or patch repair.

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ENBRIDGE	Coating Repair Form for L5 Straits of Mackinac

After Cure of Coating Repair			
Date:	112/15/2017	**Cure Time (days)**	54
Temperature (°F):	38	**Hardness Quaiity Check (4.5.2)**	PASS
Total thickness measurements of the Coating Repair (mil):		240, 250+, 250+, 225	

Comments/Issues/Discussion

- No external corrosion reported by diver.
- Additional bare metal exposed during surface preparation. No external corrosion reported by diver at these areas.
- After surface preparation, anchor profile was (1) - 4.3 and 3.7, and (1a) - 3.3 mils.
- Filler was applied within 15 minutes of mixing.

[redacted]	[redacted]
Contractor Signature	**Company Inspector Signature**

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ENBRIDGE	Coating Repair Form for L5 Straits of Mackinac

Surface of pipe after surface preparation.

Date:	10/29/2017	Frame (HH:MM:SS)	10:26:50

Surface of the pipe after filler application.

Date:	10/29/2017	Frame (HH:MM:SS)	10:45:33

Surface of the pipe after composite wrap.

Date:	10/29/2017	Frame (HH:MM:SS)	12:28:32

Surface of the pipe after Stricture Banding.

Date:	10/29/2017	Frame (HH:MM:SS)	12:34:35

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ENBRIDGE	Coating Repair Form for L5 Straits of Mackinac

Surface of the pipe after cure and removal of Stricture banding.	[Additional Photograph Caption]

Date:	12/15/2017	Frame (HH:MM:SS)	09:58:00	Date:	DD/MM/YY	Frame (HH:MM:SS)	

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Coating Repair Form for L5 Straits of Mackinac

General Information

Date:	09/22/2017 09/23/2017 09/24/2017 09/25/2017 09/26/2017 09/30/2017 11/1/2017	Diver:	9/22 - Joe Rieman, Chad Cantrell, George Palmer 9/23 – Shawn Binsfield, Craig Palmer, McKenzine Thompkins, Mike Rosette 9/24 – Troy Basket, Andrew Alber, Joe Rieman 9/25 – Chad Cantrell, Shawn Binsfield, George Palmer, McKenzie Thompkins 9/26 – Mike Rosette, Andrew Alber 9/30 – Craig Palmer, McKenzie Thompkins, Mike Rosette 11/01 – Mackenzie Tompkins
AFE / W.O.#:	BPI-1264792-17	Company Inspector:	[redacted]
Segment:	WAS-1	Water Depth (ft):	[redacted]
Longitude:	[redacted]	Latitude:	[redacted]

Material Information

BIO- DUR™ 563 SW Epoxy Base – Black	17T-391	Expiration Date:	07/04/19
BIO – DUR ™ 563SW Curing Agent – White	17T-534	Expiration Date:	09/05/19
X100 – UW Epoxy Base – Blue	17T-535 17T-570	Expiration Date:	09/05/19 09/05/19
BIO-SEAL ™ X-100 Curing Agent – Clear	17T-537 17T-571	Expiration Date:	09/05/19 09/05/19

Temperature (°F):	42, 40, 42, 40, 46, 41, 40, 41, 40, 44, 49, 49, 41, 45, 49, 50	Wall Thickness Measurements (mil):	1	No bare steel at area
			1b	860, 860, 860, 862, 862
			2	830, 820, 830, 818, 820, 826, 822, 836
			3	820, 834, 832, 822, 824
			4	848, 836, 828, 840, 826
			4b	832, 832, 834, 832, 834
Location of the Coating Repair:	Top to side		Coating Repair Method:	Full Circumferential Composite Wrap Repair

Quaity Assurance During Application

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ENBRIDGE	Coating Repair Form for L5 Straits of Mackinac

☑	The steel surface was cleaned using scarpers, hydroblasting cleaning, wet abrasive blasting, or pneumatic power wire wheel brush. (3.1)
☑	Feathering removed the sharp edge at the transition from the parent coating. The parent coating was roughened (abraded) using a cup disk brush to remove the loosely adherent biota, coating and provide a surface for overcoating (3.2).
☑	Immediately prior to coating application, the Diver removed any flash rust and/or accumulated debris (silt, clay, etc.) using a wire brush or other method approved by the Manufacturer (4.1).
☑	The diver applied sufficient BIO-DUR epoxy filler so that the bare steel is completely covered and the repair area is flush with the adjacent parent coating (4.2.2 and 4.2.3).
☑	Full Circumferential Composite Wrap Repair (4.3) or Composite Patch Repair (4.4) applied in accordance with the coating procedure.
☑	Blue Stricture Banding® or alternative protective wraps/encasements allowed by the coating Manufacturer applied over the composite wrap or patch repair.

After Cure of Coating Repair			
Date:	11/01/2017	**Cure Time (days)**	32
Temperature (°F):	50	**Hardness Quaiity Check (4.5.2)**	PASS
Total thickness measurements of the Coating Repair (mil):		250+, 250+, 250+, 250+, 250+, 250+, 250+, 250+, 250+, 250+	

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Coating Repair Form for L5 Straits of Mackinac

Comments/Issues/Discussion

- No external corrosion reported by diver.
- Additional bare metal exposed during surface preparation. No external corrosion reported by diver at these areas.
- After surface preparation, anchor profile was (1) 4.0, (1b) 2.7, (2) 3.3, (3) 3.9 and 3.0, (4) 3.3, and (4b) 3.3 mils.
- Epoxy filler transferred to diver within 16 minutes after initial mixing.

[redacted]	[redacted]
Contractor Signature	Company Inspector Signature

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ENBRIDGE	Coating Repair Form for L5 Straits of Mackinac

Surface of pipe after surface preparation.

Date:	9/23/2017	Frame (HH:MM:SS)	11:53:43

Surface of the pipe after filler application.

Date:	9/23/2017	Frame (HH:MM:SS)	14:33:06

Surface of the pipe after composite wrap.

Date:	9/23/2017	Frame (HH:MM:SS)	16:56:12

Surface of the pipe after Stricture Banding.

Date:	9/23/2017	Frame (HH:MM:SS)	17:03:06

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ENBRIDGE	Coating Repair Form for L5 Straits of Mackinac

Surface of the pipe after cure and removal of Stricture banding.	[Additional Photograph Caption]

Date:	11/01/2017	Frame (HH:MM:SS)	12:10:31	Date:	DD/MM/YY	Frame (HH:MM:SS)	

Appendix H: Engineering Stress Analysis (Kiefner)

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Enbridge Energy, Limited Partnership

Final Report No. 18-050

Assessment of the Effect of Biota on the Integrity of Free-Spanning Pipelines in the Straits of Mackinac

Benjamin Zand, PhD

March 27, 2018

Kiefner

0023-1707

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Final Report No. 18-050

Final Report

ASSESSMENT OF THE EFFECT OF BIOTA ON THE INTEGRITY OF FREE-SPANNING PIPELINES IN THE STRAITS OF MACKINAC

to

ENBRIDGE ENERGY, LIMITED PARTNERSHIP

on

March 27, 2018

Prepared by

[redacted]

Zand, Benjamin, PhD
Principal Engineer

Approved by

[redacted]

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Vice President, Pipeline

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Columbus, OH 43219

0023-1707

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The analysis and conclusions provided in this report are for the sole use and benefit of the Client. No information or representations contained herein are for the use or benefit of any party other than the party contracting with Kiefner. The scope of use of the information presented herein is limited to the facts as presented and examined, as outlined within the body of this document. No additional representations are made as to matters not specifically addressed within this report. Any additional facts or circumstances in existence but not described or considered within this report may change the analysis, outcomes and representations made in this report.

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Assessment of the Effect of Biota on the Integrity of Free-Spanning Pipelines in the Straits of Mackinac

Benjamin Zand, PhD

INTRODUCTION

Enbridge Energy, Limited Partnership (Enbridge) operates two 20-inch outer diameter (OD) pipelines that cross the Straits of Mackinac approximately 1.3 miles west of the Mackinaw Bridge. The pipelines (also collectively referred to as Line 5) were constructed in 1953 and transport petroleum products from Superior, Wisconsin to Sarnia, Ontario.

The pipelines have a minimum of 15 feet of cover at the shore area and the cover depth tapers from approximately 15 to 0 feet at water depths of 50 to 65 feet, respectively. The remaining segments of the two pipeline crossings are placed at the lakebed along the Straits of Mackinac. Enbridge has periodically conducted subaquatic inspections to monitor the condition of the pipelines. The inspections showed that portions of the pipelines have formed free spans due to lakebed roughness. The inspections also showed the build-up of bio-mass on the pipeline due to growth of aquatic biota. Enbridge contacted Kiefner and Associates, Inc. (Kiefner) to evaluate the structural integrity of the dual Pipelines due to the weight of such biomass or the pressure caused by current or ice movement around such biomass in areas where the pipelines are suspended above the floor of the Straits (spans).

This assessment includes a) acceptable free span lengths; and b) susceptibility to vibration induced by vortex shedding. Potential effects of the bio-mass (biota) on the stress and vortex-induced vibration (VIV) thresholds of the pipelines suspended above the lakebed were accounted for. Effects of added pipe mass, increased hydrodynamic diameter, and increased drag force on pipe longitudinal stress and vibration characteristics were studied. The assessment for VIV was based on the June 2017 Edition of DNVGL-RP-F105 [1], Free Spanning Pipelines. The DNV RP uses SI units, thus all the calculations were performed in SI units. The results are generally reported in US Customary units but whenever appropriate, equivalent SI conversions are provided.

The pipe weight (with varying products, including natural gas liquids and light crude), internal pressure, pipeline diameter and wall thickness, pipe steel grade and pipe coating were also included in the stress analysis and VIV assessments. The assessment used a combination of analytical methods and finite element analysis (FEA) to examine the sensitivity of allowable span length against these factors.

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SUMMARY AND CONCLUSIONS

Codes, Standards, and Regulations

A review of Code of Federal Regulations [2] confirmed that the pipelines possess all the physical attributes of offshore pipelines. Therefore, the stress limits of ASME B31.4 [3], Chapter IX "Offshore Liquid Pipeline Systems" were adopted for the static assessment of the free spans. The allowable stresses are set forth in Table A402.3.5-1 as 80% specified minimum yield strength (SMYS) for the longitudinal stress and 90% SMYS for the equivalent stress.

Engineering Analysis of Spans

FEA of single and multiple continuous spans were carried out to calculate pipe stresses due to differential temperature, internal pressure, and drag and gravitational forces. The analysis showed that in a span shorter than 150 feet with 1.0 inch biota growth (the maximum measured biota thickness), the longitudinal and equivalent stresses will remain within allowable limits. Variations in biota thickness up to 6 inches on multiple continuous spans created by installing screw anchor supports are not expected to affect the stresses by more than 5% SMYS.

Vortex-Induced Vibration (VIV)

The approach undertaken in the study was to determine allowable span lengths to prevent fatigue cycles based on the VIV avoidance criteria in DNVGL-RP-F105. The study resulted in a span length of 87 feet for a single span.

The assessment contains sufficient safety factors to cover normal variations in the biota thickness (including future growth up to 6 inches). Furthermore, the presence of biota is expected to reduce the likelihood and intensity of VIV because it is expected to break the period regime of vortex shedding. However, this effect was not included in the assessment, which is believed to increase the level of conservatism.

Effects of Water Velocity and Span Length

Water velocity, along with the span length, are the two primary factors, which control stresses in the free span from gravity and drag forces, as well as the VIV characteristics of the pipeline. For a given span length, there is a VIV threshold velocity (as delineated under the prevention criteria of DNVGL-RP-F105), below which VIV is unlikely. With increasing water velocity beyond the threshold, VIV could take place.

A realistic water velocity probability density distribution is a key element in establishing allowable span length. The water velocity distribution used in this study was based on the measurements taken

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between September 2002 and October 2004 by Enbridge. An extreme water velocity of 3.44 ft/sec (1.05 m/sec) was determined based on 1% annual probability of exceedance.

Effects of Pipe Internal Pressure and Differential Temperature

Pipe axial stress has a moderate influence on the onset of VIV, through changing the natural frequency of vibration. Compression lowers while tension increases the natural frequency of vibration. The maximum operating pressure of Line 5 at the crossings is 600 psi, or 24.6% SMYS, which indicates the pipelines operates at a relatively low circumferential stress. The component of longitudinal stress due to internal pressure, with the pipeline in the least constrained condition, is at most half of the hoop stress. Pressure induced axial stress under the maximum operating pressure was assessed to have insignificant effect on the acceptable span length concerning VIV (<5%), and therefore the internal pressure was ignored in the VIV assessment. Ignoring the axial tension from internal pressure was conservative. The effect of internal pressure of up to 600 psig; however, was included in the engineering analysis of the spans to calculate longitudinal and effective stresses.

Differential temperature affects the allowable span length by producing longitudinal stress in the pipeline. Longitudinal stress, in turn, affects natural frequency of vibration. The differential temperature was estimated to vary between zero to 30 F (17 C) based on the differences between the pipeline operating temperatures and the water temperatures. The effect of differential temperatures was included in the assessment.

Effects of Multiple Supports

The assessment concluded that when two to four continuous spans of no longer than 75-feet were formed by installation of screw anchor supports, 100-year cumulative fatigue damage was negligible. Bending stress and frequency of vibration of continuous spans do not change significantly with increasing number of spans beyond four. As such, four continuous 75-foot long spans were determined to be conservative representation of the pipeline continuous spans.

Effects of Biota and Pipe Mass

Engineering analysis of the span used the maximum product weight and drag forces calculated from the extreme water velocity with 1.0-inch biota growth (the maximum measured thickness). Biota slightly increased the longitudinal stresses in the pipe. However, the longitudinal stress was found not to be the critical factor for the acceptable span length. VIV avoidance criteria resulted in significantly shorter allowable span lengths as compared to the longitudinal and equivalent stress limits.

Biota was also found to lower the vibration frequency of the pipelines by increasing their mass. However, the effect of a reduction in the frequency was more or less offset by the increase in VIV onset

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velocity. Overall, biota thickness of up to 6 inches did not affect the span length in terms of VIV avoidance. VIV assessments were performed for two product densities as well as empty pipe to study the effect of pipe mass.

BACKGROUND

The two pipelines crossing Straits of Mackinac consist of 20-inch OD, 0.812-inch WT, API 5L Grade A seamless line pipe, constructed in 1953. The SMYS and specified minimum tensile strength (SMTS) of Grade A line pipe is 30 and 48 ksi, respectively, in accordance with the contemporaneous edition of API 5L [4]. The maximum operating pressure (MOP) of each line is 600 psig, corresponding to a hoop stress of 7,389 psi, or 24.6% of SMYS, without accounting for the external pressure associated with the submerged depth of the pipelines. The normal operation is at pressures up to 280 psig, corresponding to a circumferential stress level of 11.5% of SMYS. Pipeline characteristics are listed in Table 1.

The Straits crossing is approximately 5 miles long from Point La Barbe on the north side to McGulpin Point on the south side of the Straits. The pipelines are located in the pipeline corridor indicated in Figure 1. The two lines are approximately 1,000 feet apart and situated approximately 1.3 miles west of the Mackinaw Bridge. The maximum depth of the crossing is approximately 260 feet. The pipelines were hydrostatically tested at a pressure of 1,200 psig, corresponding to a hoop stress of 49% of SMYS (without accounting for external pressure), for a period of 10 hours.

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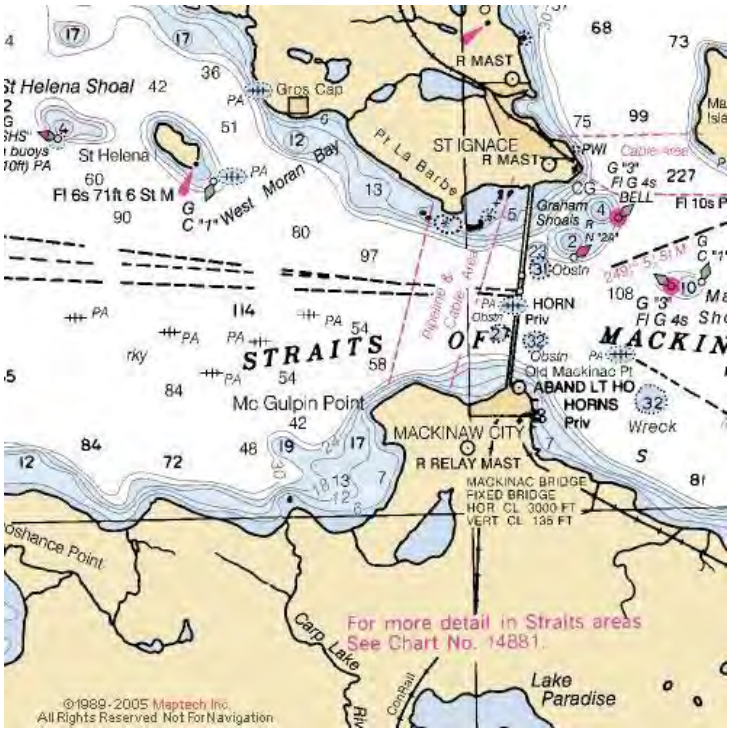

Figure 1. Location of Pipeline Crossing

Table 1. Characteristics of the Pipelines at the Straits of Mackinac Crossing

Parameter	Value / Description	Unit
OD (outer diameter)	20	inch
WT (wall thickness)	0.812	inch
Grade	A	n/a
Specified minimum yield stress (SMYS)	30	ksi
Seam type	seamless	n/a
MOP (maximum operating pressure)	600	psig
MOP	24.6	% SMYS
Normal operating pressure	280	psig
Normal operating pressure	11.5	% SMYS
Year constructed	1953	n/a
Product specific gravity	0.547 or 0.868	n/a
Coating thickness	0.125	inch
Coating specific gravity	1.28	n/a
Buoyant pipe weight	94.6 or 131.5	lb/ft

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The products transported by the pipelines include light crude oil with a specific gravity of 0.868 and natural gas liquids (NGLs) having a specific gravity of 0.547. The pipeline coating consists of coal tar coating with a net thickness of approximately 0.125 inch and having a specific gravity of approximately 1.28. The buoyant weight of the pipelines was calculated as 131.5 lb/ft when filled with crude oil, or 94.6 lb/ft when transporting NGLs.

The pipelines have a minimum of 15 feet of cover at the shore area and the cover depth tapers from approximately 15 to 0 feet at water depths of 50 to 65 feet, respectively. The remaining segments of the two pipeline crossings rest on the lakebed.

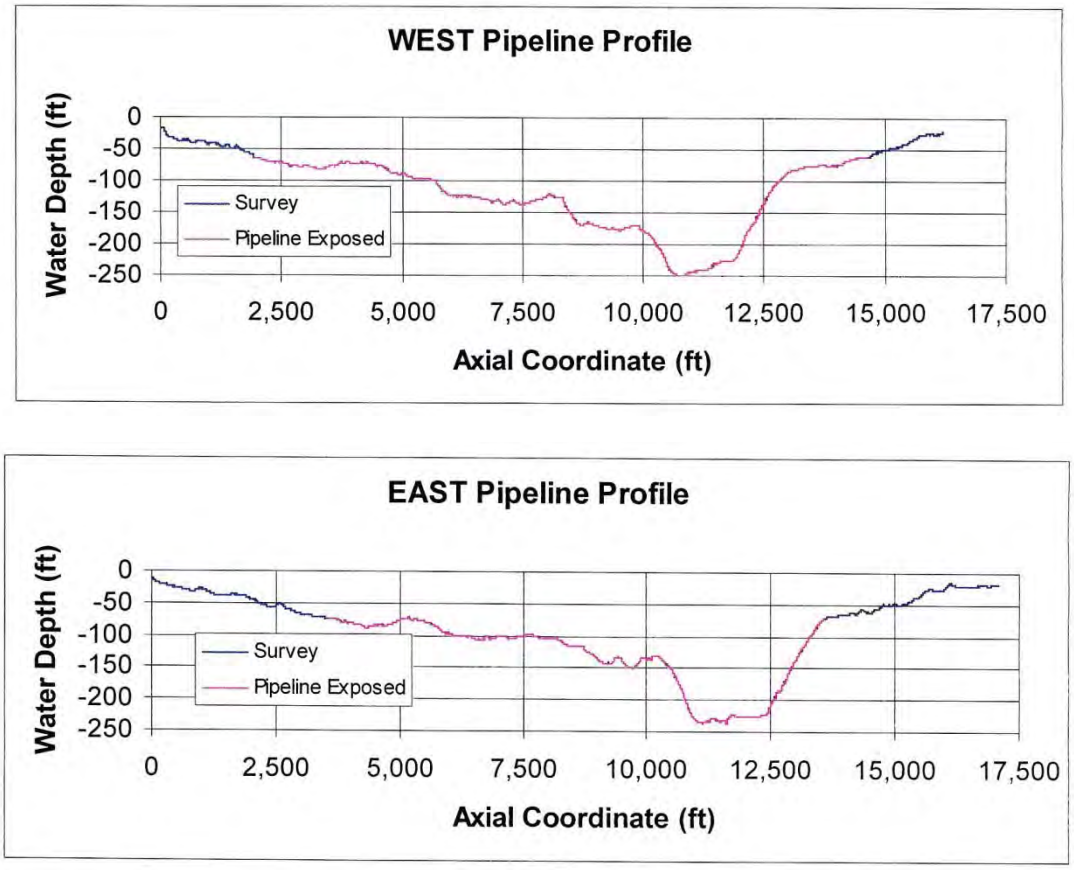

Figure 2. Crossing Bottom Elevation Profiles

APPLICABLE REGULATIONS AND STANDARDS

The relevant portions of the Code of Federal Regulations, Part 195 [2] and ASME B31.4-2016 [3] were reviewed. The pipelines along the Straits crossings fall within the scope of US Federal pipeline safety regulations, Easement with the State of Michigan, and the crossings share the physical attributes of offshore pipelines in terms of construction method, loading, and environmental conditions.

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Thus, Kiefner concluded that an offshore pipeline technical standard would be the most relevant source to determine allowable stress levels. ASME B31.4-2016, Chapter IX was adopted for the static assessment of the free spans. The allowable stresses are set forth in Table A402.3.5-1 as 80% SMYS for the longitudinal stress and 90% SMYS for the equivalent stress.

STRESS ANALYSIS OF FREE SPANS

Water Velocities

The water velocities used in the assessment were measured by Enbridge between September 2002 and August 2004. In addition to the data provided by Enbridge, Kiefner reviewed the velocities reported by the National Oceanic and Atmospheric Administration (NOAA) for the summer and fall of 1990 [5]. It was concluded that the 2002-2004 data set was a better representation of the flow velocities experienced by the pipelines. This conclusion was primarily based on the fact that the NOAA measurements were not taken at the pipeline locations and depths. According to the information provided to Kiefner the velocity measurements were taken near the pipelines and at depths a few feet from the lakebed.

The water velocities used in the assessment were measured at four locations along the crossing in order to obtain representative data regarding the exposed spans identified at that time (2002-2004). Measurements were taken at one-minute intervals between September 26, 2002 and August 9, 2004. The velocities selected for the analysis were taken at about 2.3 feet distance from the lake bottom which is equal to the average distance of the west pipeline centerline to the lakebed along the free spans (the average distance of the east pipeline to the lakebed along the free spans is about 2.1 feet). The velocities were averaged to 15 minute intervals. Figure 3 through Figure 6 show Easting and Northing water velocities recorded by the four monitoring units. The Easting current velocity component is approximately 3 times the Northing current velocity component. The velocities reverse direction every 2 to 3 days, and are predominately oriented in the east-northeast and west-southwest directions.

The water velocities perpendicular to the pipelines were calculated by projecting velocity vectors into the normal direction of the pipelines. Each data set was then fitted with a Weibull distribution using the least-square method. The calculated cumulative density functions for Unit 1 through Unit 4 are shown in Figure 7 through Figure 10, respectively. In each figure the measured data are indicated by green stars, while the fitted curve is shown in a brown continuous line. A comparison between the functions shows that Unit 2 (Figure 8) experienced the highest water velocities within the tail section for a given probability value. Weibull parameters for the velocity probability distribution functions are listed in Table 2 in US customary (ft/sec) and SI (m/sec) units.

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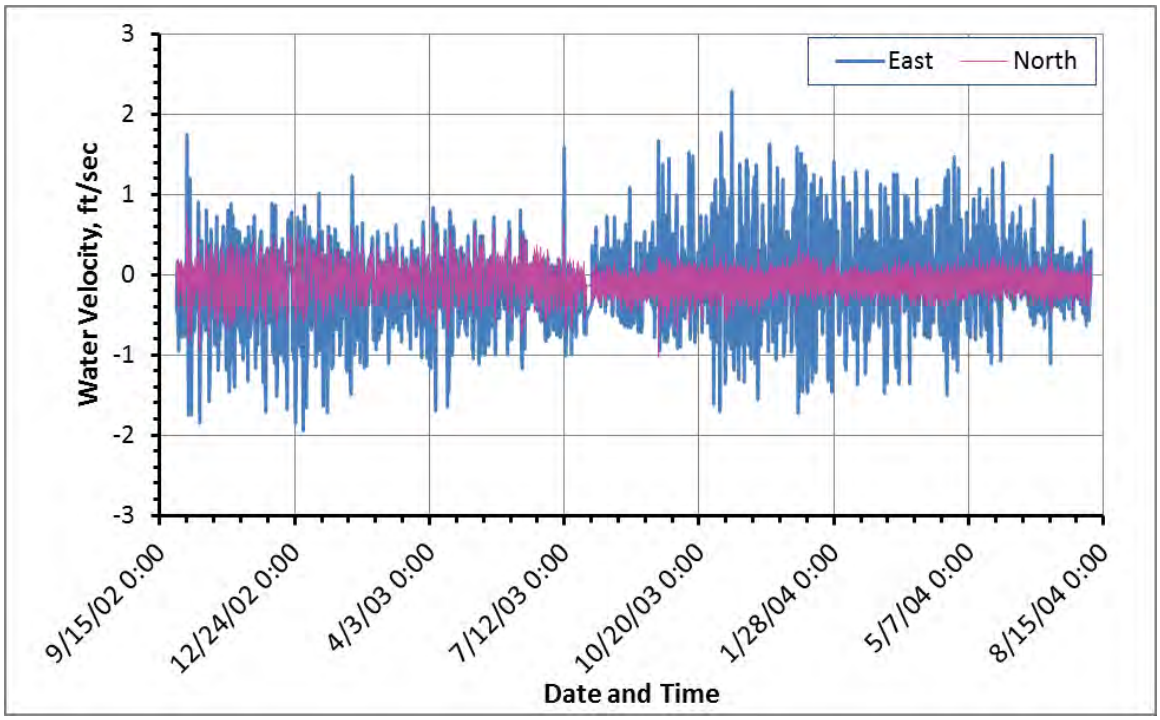

Figure 3. Water Velocity Measurement Unit 1

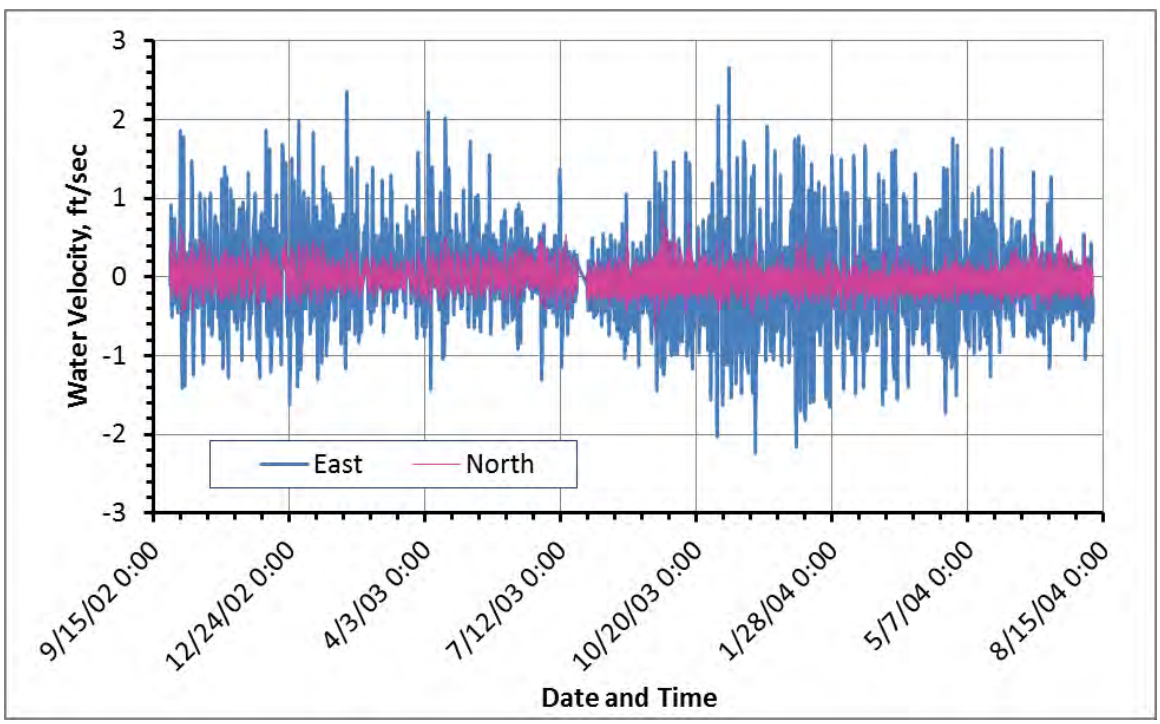

Figure 4. Water Velocity Measurement Unit 2

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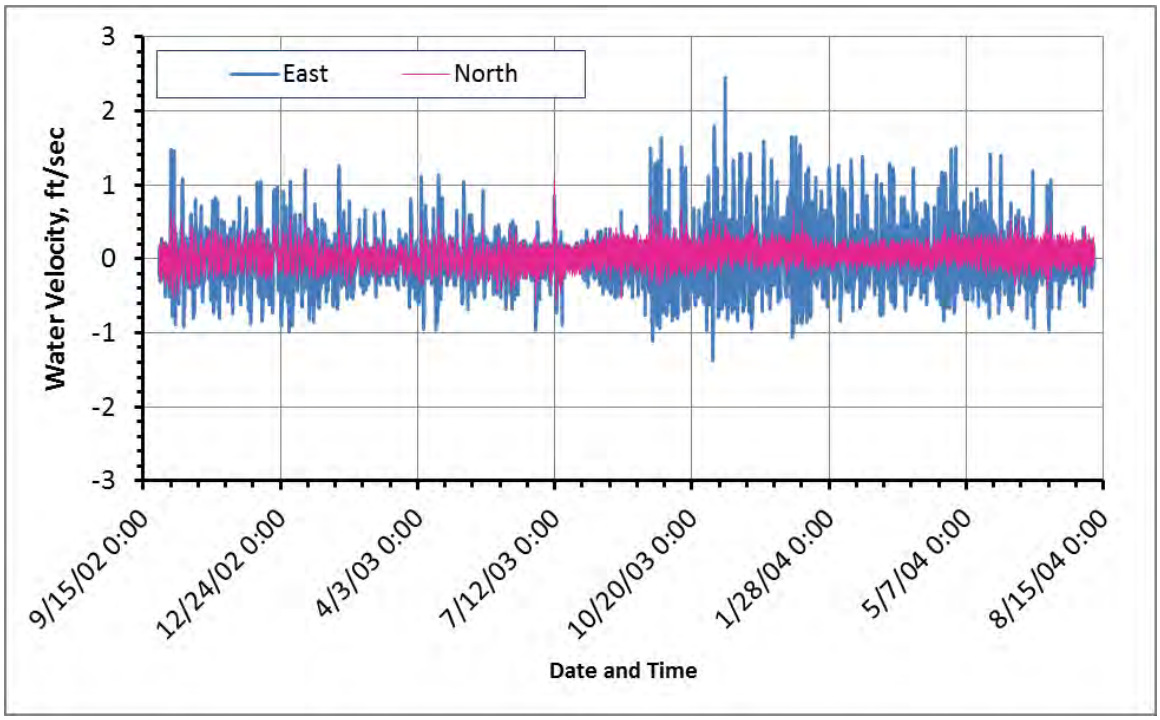

Figure 5. Water Velocity Measurement Unit 3

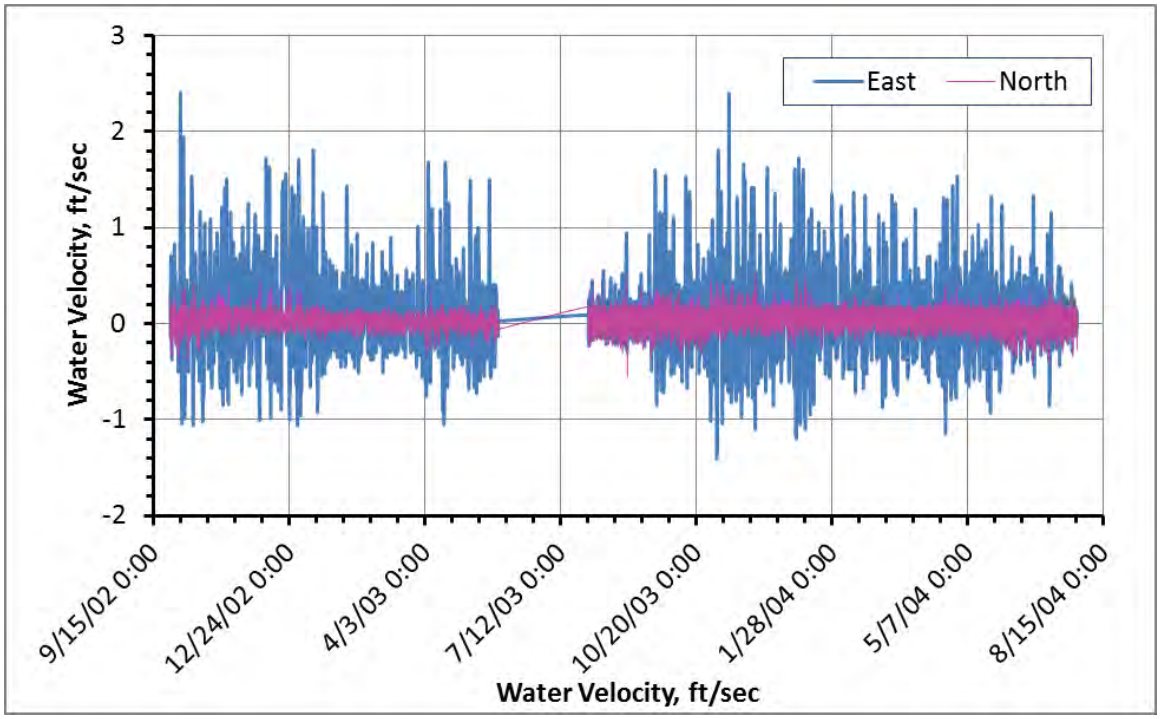

Figure 6. Water Velocity Measurement Unit 4

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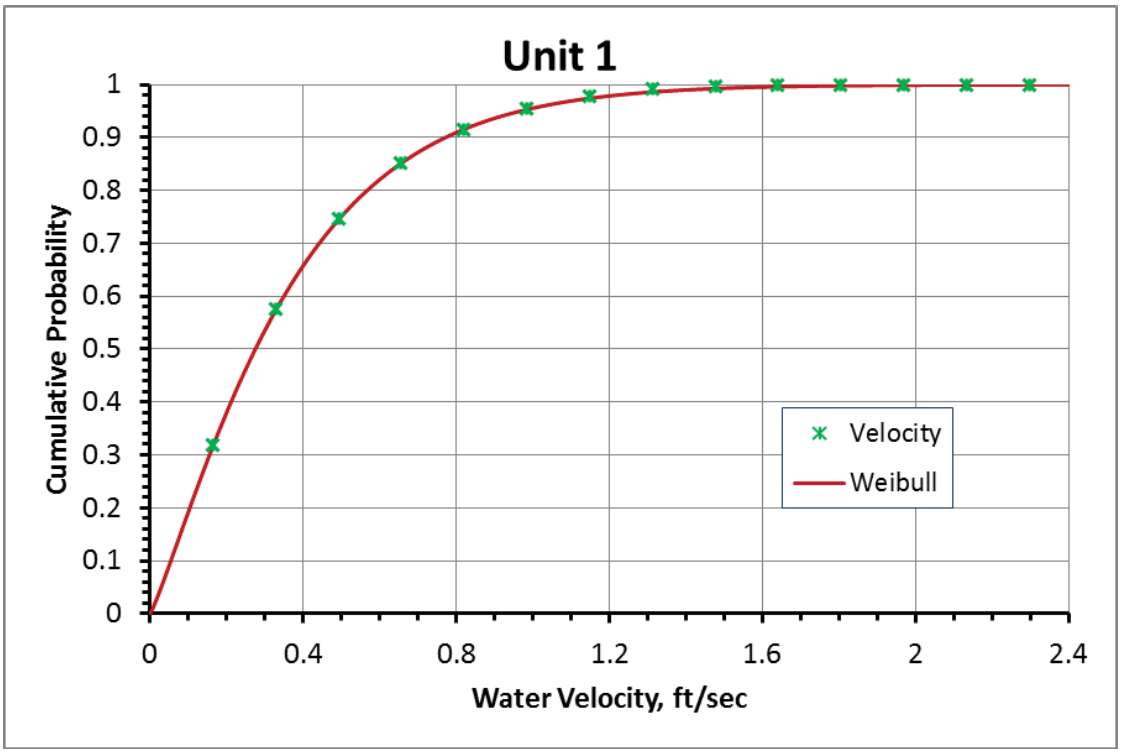

Figure 7. Water Velocity Cumulative Distribution Function for Unit 1

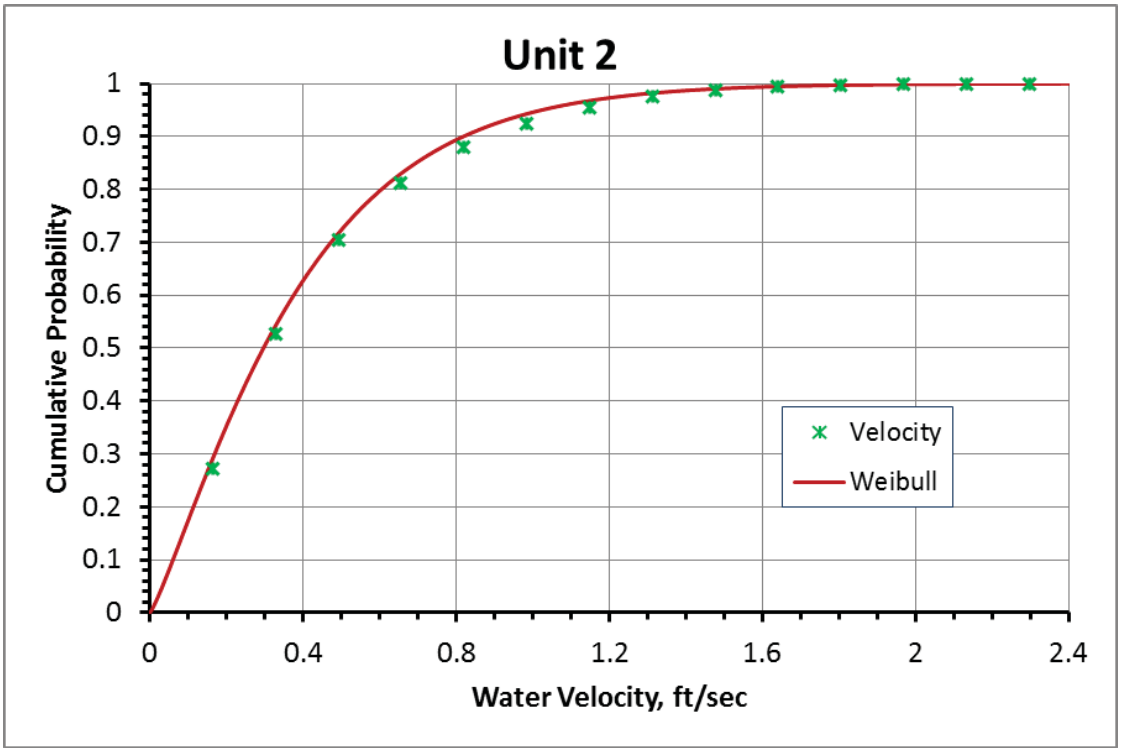

Figure 8. Water Velocity Cumulative Distribution Function for Unit 2

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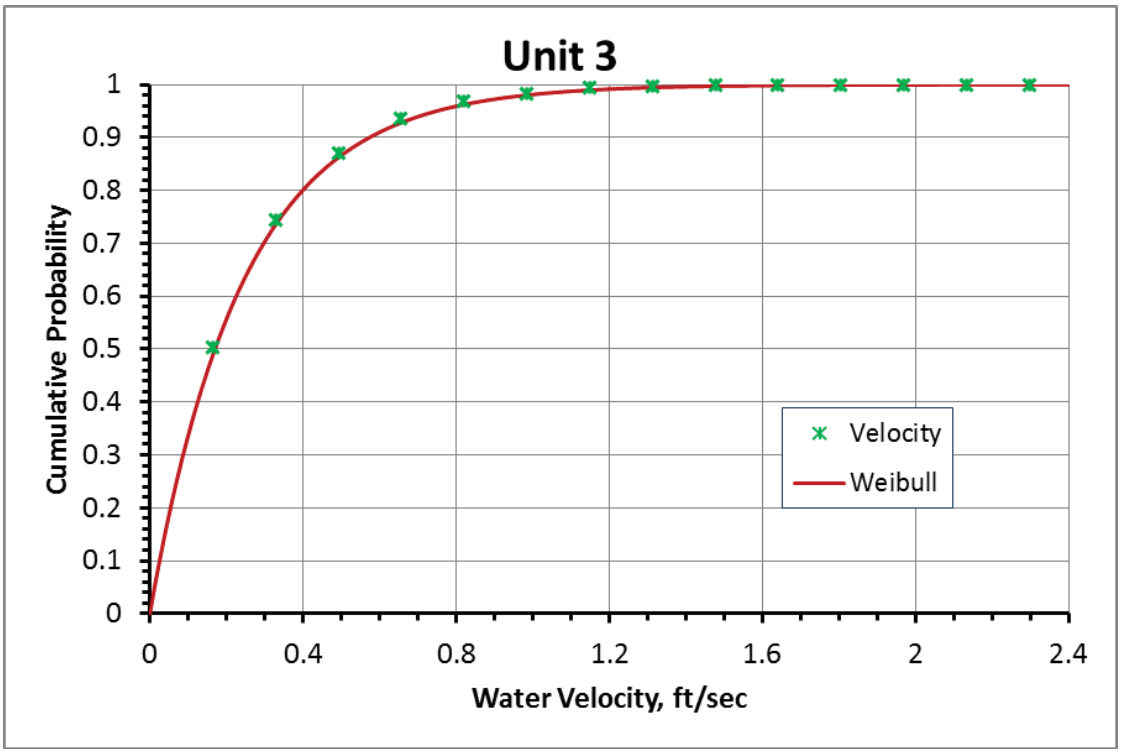

Figure 9. Water Velocity Cumulative Distribution Function for Unit 3

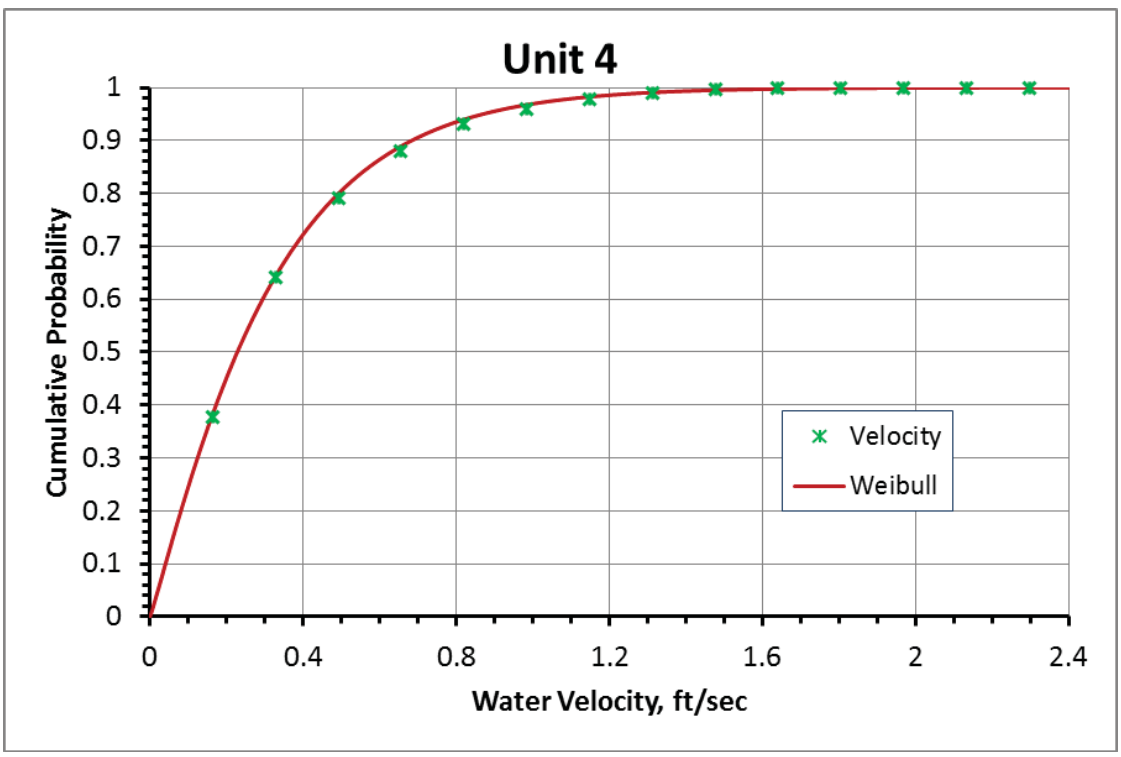

Figure 10. Water Velocity Cumulative Distribution Function for Unit 4

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Table 2. Weibull Parameters

Measurement Location	Shape Parameter (exponent)	Scale Parameter		Calculated Extreme Velocity	
		ft/sec	m/sec	ft/sec	m/sec
Unit 1	1.16512	0.37707	0.11493	3.31	1.01
Unit 2	1.18213	0.40408	0.12316	3.44	1.05
Unit 3	0.98703	0.24613	0.07502	3.22	0.98
Unit 4	1.09396	0.31887	0.09719	3.25	0.99

Using the above parameters, water velocities corresponding to a 3-hour-long 100-year event were calculated for all units. This corresponds to a 3-hour-long event with 1% annual probability (in accordance with Section 2.3 of DNVGL-RP-F105). The calculated water velocities are listed in Table 2 and it can be seen that the greatest velocity is 3.44 ft/sec (1.05 m/sec). This value is denoted as the *extreme water velocity* hereafter. The probability calculations were such that the 3-hour event did not need to be one single continuous event. Several short events adding up to an accumulated 3 hours were included in the probability. This approach accounted for cumulative fatigue effects of water velocities exceeding the extreme water velocity in short durations. Also note that the calculated extreme water velocity is greater than any single measurement in Figure 3 through Figure 6.

Screw Anchor Support Stiffness

Enbridge has installed screw anchor supports to limit the maximum length of the free spans in the Straits. The design of the screw anchor supports is shown schematically in Figure 11. As discussed in the subsequent sections, Kiefner performed static and modal FEA to calculate stresses in free spans and determine natural frequency of vibration and mode shapes for spans with such support systems. Elastic stiffness of the support was one of the factors which was incorporated in the FEA study. The elastic stiffness was calculated in a detailed FEA model of the support.

The screw anchor support was modeled in ANSYS FEA software. Figure 12(a) shows the FEA model geometry in ANSYS Workbench. The structural elements of the support were modeled as thin surfaces meshed with predominantly square-shaped shell elements. The gasket between the pipe and the saddle used solid elements. Figure 12(b) shows the FEA mesh in a portion of the model. Pre-tensioned bolts were included in the model as loaded springs with axial stiffness.

The results of the analysis are listed in Table 3. Each stiffness value was determined by application of a unit force or moment to the model in the respective direction and calculating the corresponding displacement. The torsional and side-bending stiffness values were ignored because these stiffness components were determined to be low.

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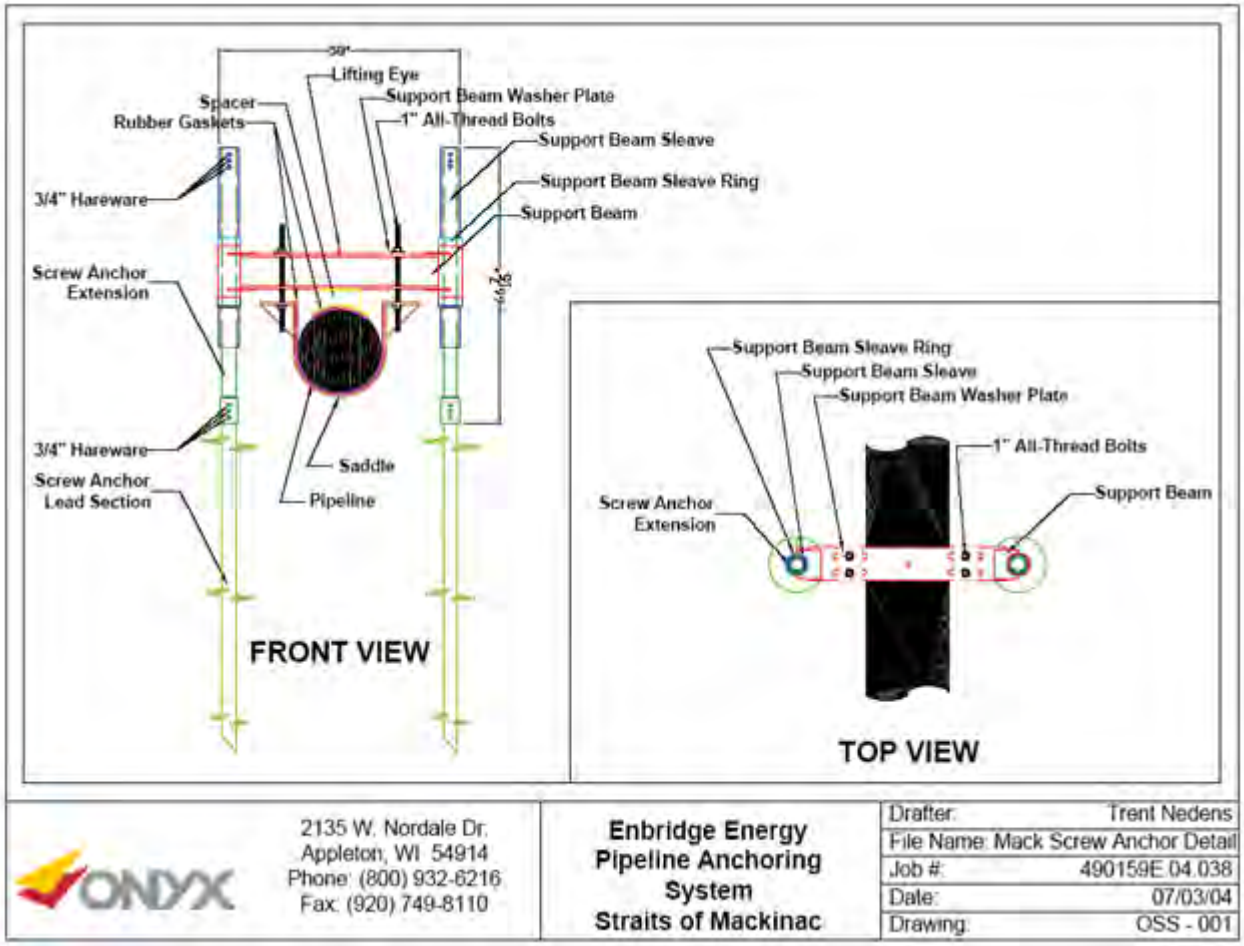

Figure 11. Screw Anchor Support Configuration

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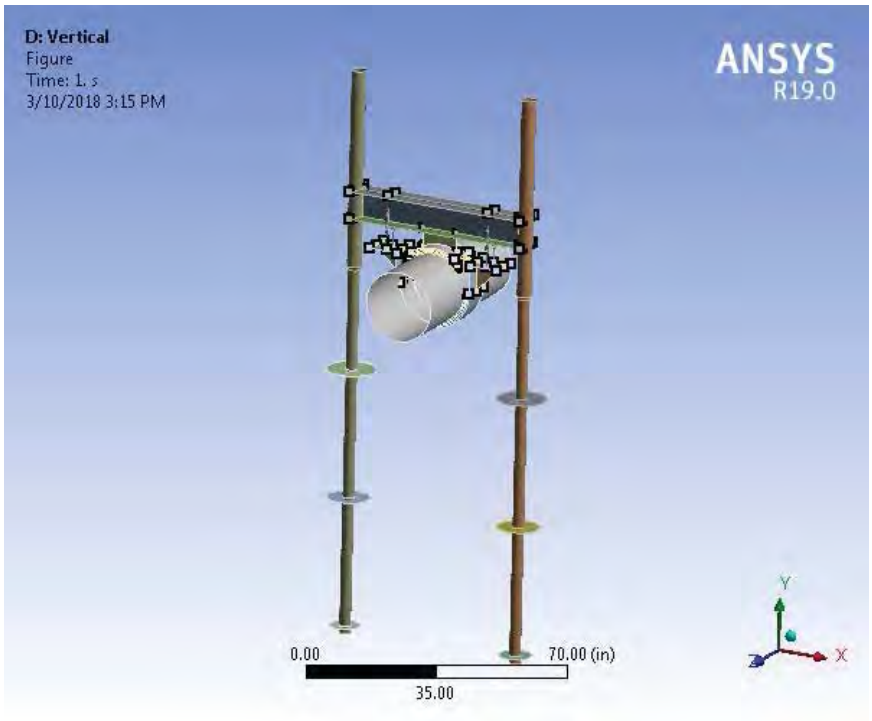
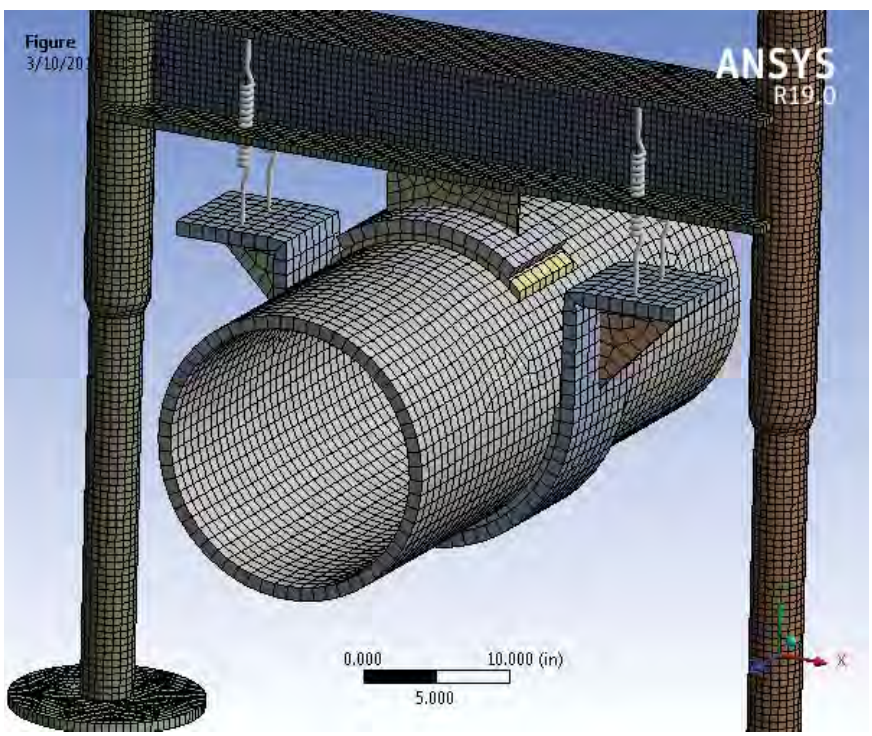


(a)



(b)

Figure 12. Screw Anchor Support FEA model (a) Model Geometry; and (b) FEA Mesh

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Table 3. Elastic Stiffness of Screw Anchor Supports

Stiffness	US Customary	SI
Vertical translation	99357 lb/in	17420 kN/m
Lateral translation	29234 lb/in	4606 kN/m
Longitudinal translation	5610 lb/in	1139 kN/m
Longitudinal rotation	28057 lb.in/rad	317 kN.m/rad

Engineering Analysis of Free Spans

Free span analyses considered pipe, product, coating weight, buoyancy, biota weight, drag force, and support stiffness. FEA was utilized to calculate longitudinal stress due to drag and gravitational forces in free spans. FEA models used solid elements along the span shoulders to account for soil and pipe interaction. Based on the data provided to Kiefner the maximum thickness of biota was measured to be about 1.0 inch. A biota specific gravity of 1.350 was adopted per DNV-RP-C205 [6]. Other FEA input parameters are listed in Table 4.

Water drag force acting on the pipelines was calculated following the method described in DNV-RP-C205, Chapter 6; and DNVGL-RP-F105, Chapter 5. The following equation was used for drag force per unit length of the pipeline in the perpendicular direction:

$$\boldsymbol{f_N = 0.5\rho_w \cdot C_D \cdot D \cdot v|v|} \qquad \textbf{Equation 1}$$

where

C_D is drag coefficient (calculated as 1.05 per DNV method),

D is outer diameter, including the coating and biota,

v is water velocity vector normal to the pipelines, and

ρ_w is the water density in kg/m^3 (1000 kg/m^3).

A pipe surface roughness (k) of 2 inches (50 mm) from Table 5-1 of DNVGL-RP-F105 was used[1]. The analyses were performed for span lengths varying from 75 ft (22.9 m) to 197 ft (60 m) and the maximum

[1] This is greater than the observed biota thickness on the pipelines. However, for the given total pipe diameter of about 22 inches, the drag force coefficient becomes independent of the surface roughness for roughness values greater than about 0.3 inch. Therefore, using a more realistic roughness value will not change the amount of drag force acting on the pipelines.

calculated drag force under the extreme current velocity of 3.44 ft/sec (1.05 m/sec). The increased pipe diameter due to the biota build-up was included in the drag force calculations, resulting in a corresponding increase in the drag force. Sensitivity analyses were conducted with water velocities ranging from zero to about 9.8 ft/sec (0 to 3 m/sec).

Table 4. Analysis Parameters

Parameter	Value / Description	
	US Customary	SI
Elastic modulus	29600 ksi	204.08 GPa
Poisson's ratio	0.3	0.3
Pipe steel coefficient of thermal expansion	6.5×10^{-6} in/in/ F	1.17×10^{-5} mm/mm/ C
Differential temperature (operating minus installation temperatures)	0 to 30 F	0 to 17 C
Maximum biota thickness	1.0 inch	25.4 mm
Biota density	84.28 pcf	1,350 kg/m^3
Soil modulus along shoulders	1740 psi	12 MPa
Free span length	75 to 196 ft	23 to 60 m

Figure 13 shows the results for a 75-foot long span. The horizontal axis is water velocity in ft/sec and the vertical axis is pipe longitudinal stress as a percent of SMYS. The plots show the maximum additive longitudinal stress (Max SL) and minimum additive longitudinal stress (Min SL) for a pipeline with no biota as well as two different biota thicknesses of 1.0 and 6 inches (25.4 and 75 mm) under a differential temperature of 30 F. The pipelines normally operates at temperatures between 40 (winter) and 60 F (summer), while the water temperature vary from about 35 F in winter to about 45 F in summer. This creates differential temperatures of 0 to about 25 F between the pipelines and the water (pipeline operates at temperatures warmer than the water). Since the pipe body temperature would have to be about the same as the water temperature during the installation, a differential temperature of 30 F is deemed to be conservative. A differential temperature of 30 F creates an axial compressive stress of about 19.4% in the pipeline. The limits of the vertical axis represent the allowable stress limit of 0.8 SMYS. The extreme water velocity of 3.44 ft/sec is marked with a red vertical line. The net axial stress is compressive due to the positive differential temperature. The green line in the figure is the bending stress due to the water drag force only (excluding gravitational forces and differential temperatures). It can be seen that for this span length bending stress from the drag force is not significant, even at the extreme water velocity of 3.44 ft/sec. The figure shows that for water velocities below the extreme velocity the highest additive longitudinal stress is less than 33% SMYS.

Thickness of biota affects the results in two ways: first it increases the drag force; and second it increases pipe weight. The solid lines in the figure represent the maximum and minimum longitudinal stresses for a pipe with no biota, while the dashed lines represent the longitudinal stresses for 1.0-inch and 6-inch biota thickness. A comparison between the solid and dashed lines shows that the differences are insignificant relative to the material SMYS. At water velocities equal to or less than 3.44 ft/sec (the extreme water velocity) a biota thickness of 1 inch increases the stresses by less than 1% SMYS compared to a pipe with no biota. A biota thickness of 6 inches increases the stresses by less than 4% SMYS compared to a pipe with no biota. The insensitivity of the longitudinal stress to biota thickness is because the longitudinal stress is dominated by the compression from the differential temperature and bending stress from the pipe and product weight. Since biota thickness was found not to be an influential factor, in the reminder of this section the actual (measured) biota thickness of 1.0 inch was used.

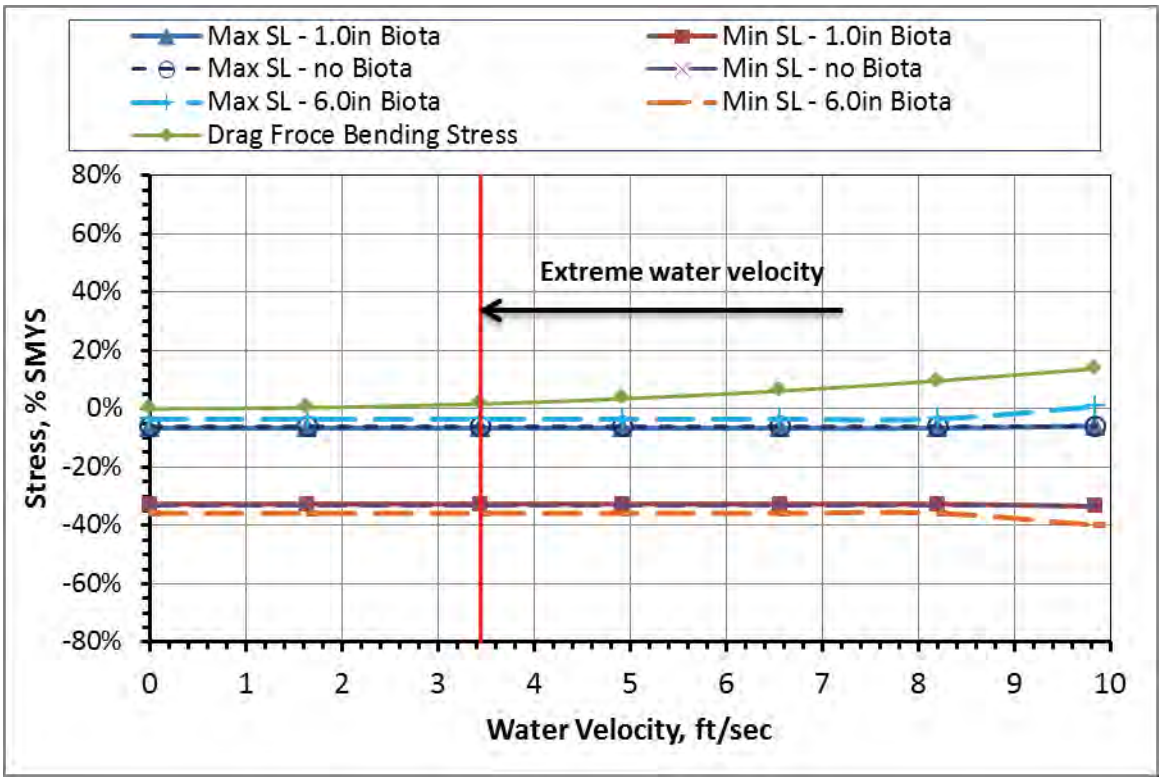

Figure 13. Longitudinal Stress vs Water Velocity for 75-foot Span

Figure 14 shows a comparison between the longitudinal stresses for span lengths of 75, 90, and 140 feet. The data shows that (as expected) the span length plays a significant role in the longitudinal stresses. Although water velocity has a substantial effect on the drag force, it does not appear to influence the longitudinal stresses for water velocities below about 8 ft/sec. The insensitivity of the

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longitudinal stress to water velocity is because of the dominance of the longitudinal compression from differential temperature and the weight of the pipe and product.

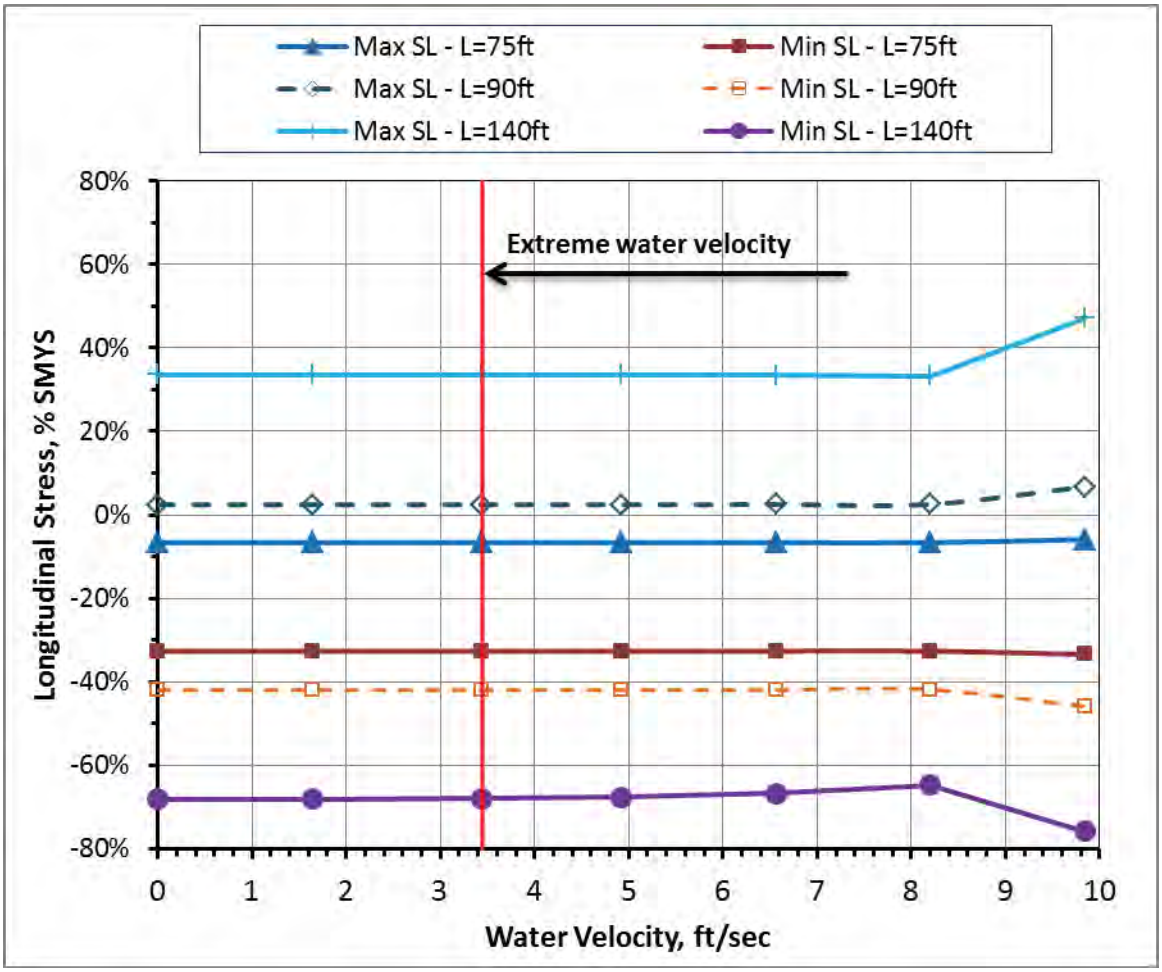

Figure 14. Longitudinal Stress vs Water Velocity for 75- to 140-ft Spans

Figure 15 shows the effect of the number of continuous spans on the longitudinal stress values. Each curve in this figure is the maximum or minimum longitudinal stress versus water velocity. The data is presented for one through four continuous spans, each 75 feet long. Figure 17 shows similar graphs for one to four continuous 140-ft long spans. Figure 17 shows the effect of the number of spans for 75- and 140- foot spans. In Figure 17 and Figure 18 the longitudinal and equivalent stresses are plotted against the number of spans for the extreme water velocity of 3.44 ft/sec. Equivalent stresses in the figure are calculated as:

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$$S_{equ} = \sqrt{S_H{}^2 + S_L{}^2 + S_H \cdot S_L} \qquad \textbf{Equation 2}$$

where

S_L is longitudinal stress, and
S_H is hoop stress from internal pressure of 600 psig.

The limits for the longitudinal and equivalent stresses are also marked on the figure in green dashed and red dashed-dotted lines, respectively. Figure 15 through Figure 17 show that the number of continuous spans is not a very influential factor in the longitudinal and equivalent stress calculations. Furthermore, Figure 15 and Figure 16 show the effect of the number of continuous spans does not vary with water velocity.

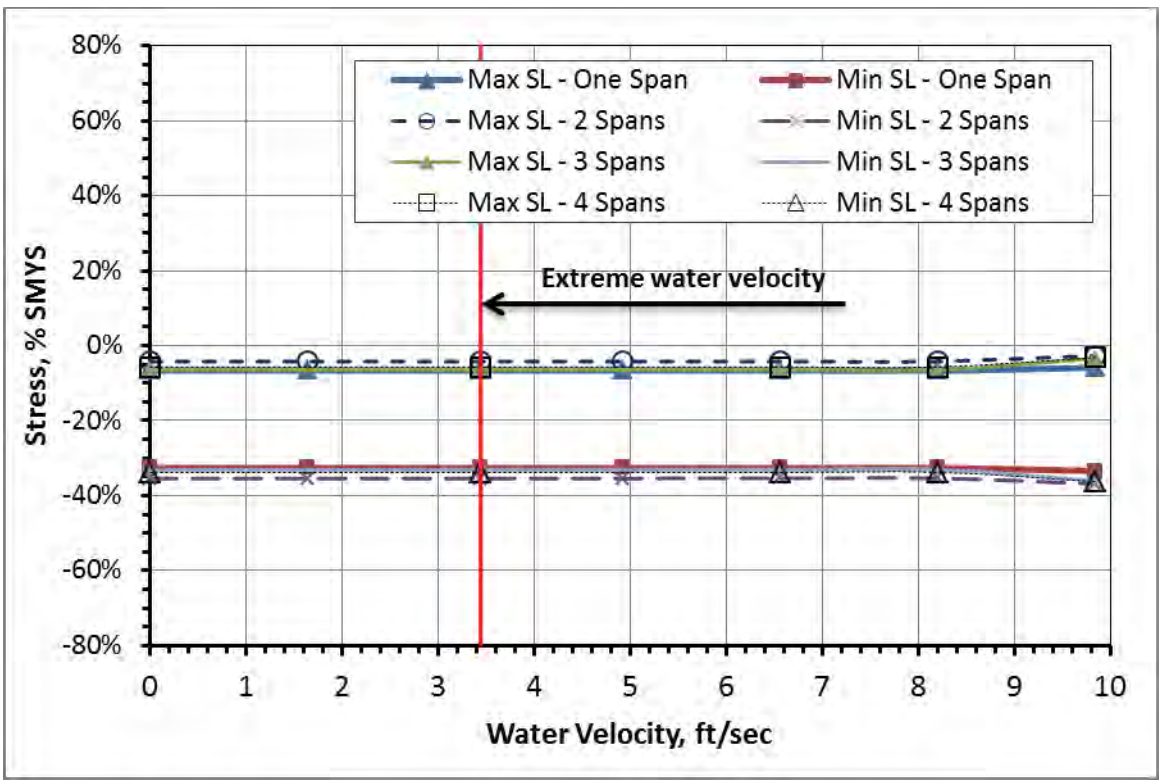

Figure 15. Effect of the Number of Continuous Spans on the Longitudinal Stress in 75-ft Long Spans

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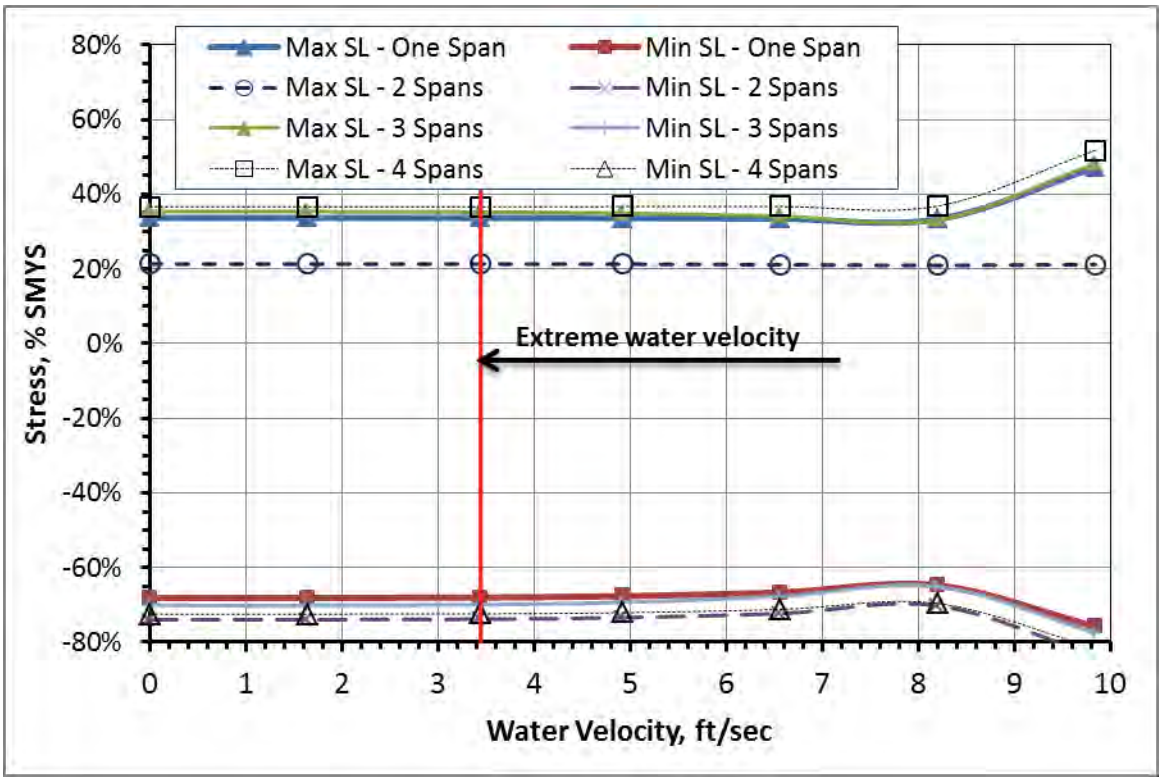

Figure 16. Effect of the Number of Continuous Spans on Longitudinal Stress in 140-ft Long Spans

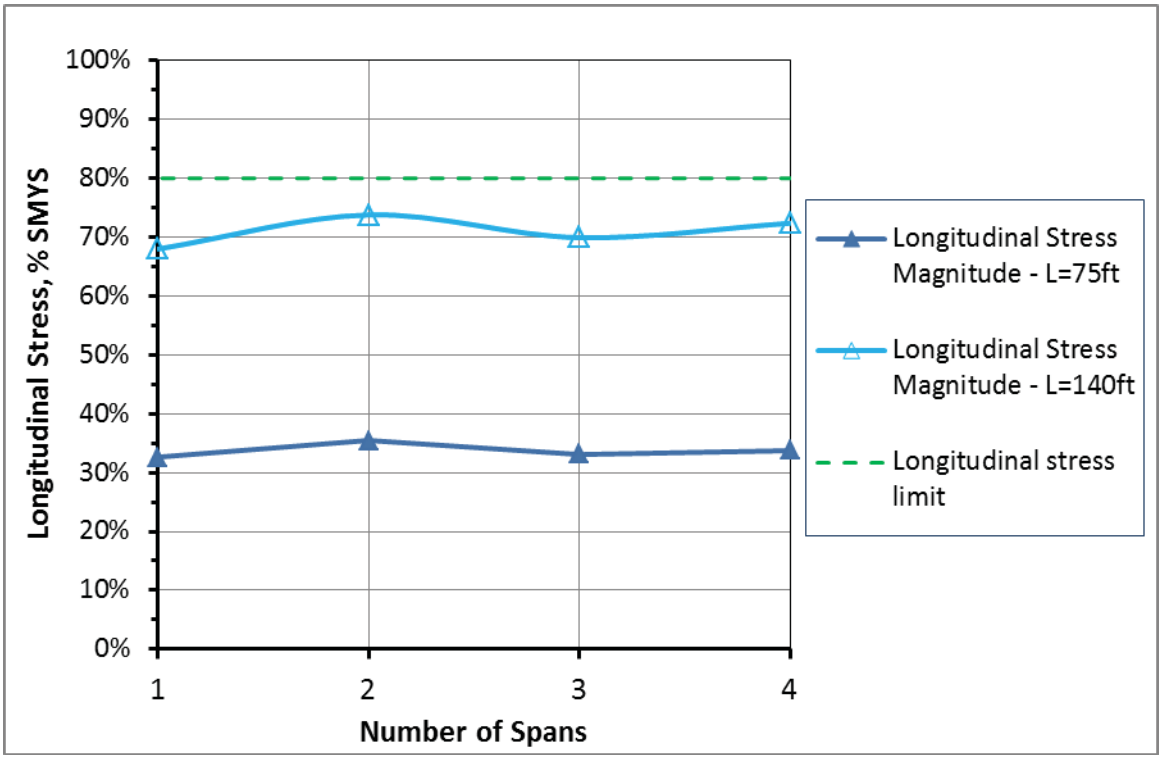

Figure 17. Effect of the Number of Continuous Spans on the Longitudinal Stress

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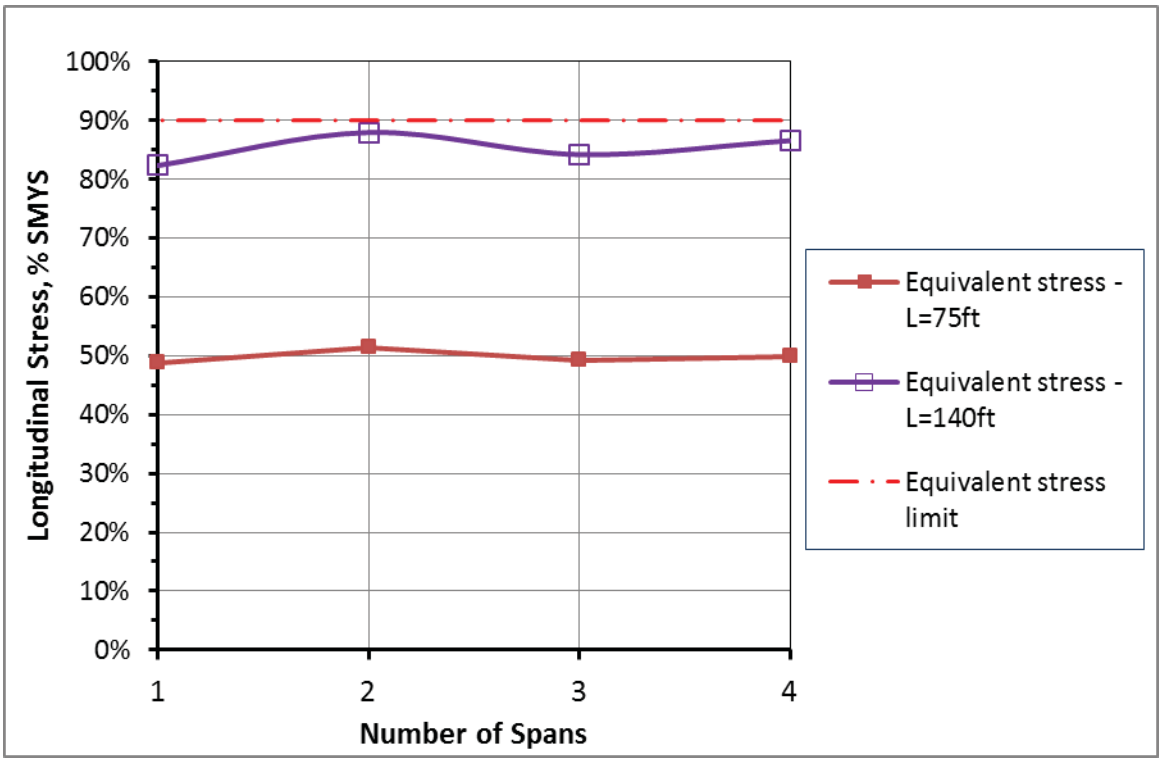

Figure 18. Effect of the Number of Continuous Spans on the Equivalent Stress

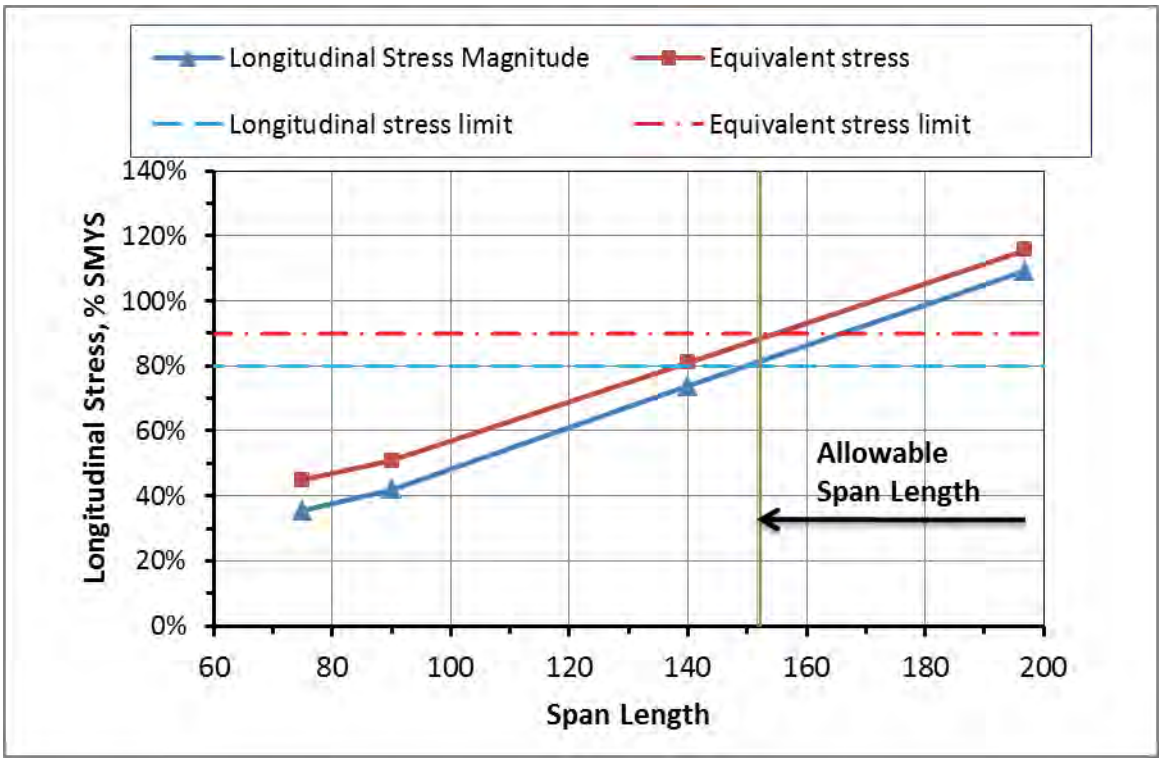

Figure 19. Longitudinal and Equivalent Stresses vs Span Length (two Continuous Spans)

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Figure 19 shows the longitudinal stress magnitude and the equivalent stress versus span length for when there are two continuous spans. The stresses are presented for the extreme water velocity of 3.44 ft/sec. By limiting the allowable equivalent stress to the 0.9 SMYS limit, the allowable span length is determined as about 150 feet. As discussed above (and shown in Figure 17 and Figure 18) the number of continuous spans up to four spans does not affect the calculated length. Furthermore, more than 4 continuous spans does not increase the bending stress (e.g. see [7]). Based on the results presented in Figure 13 through Figure 18 combinations of a water velocity up to 8 ft/sec, a biota buildup of up to 6 inches, and number of continuous spans do not affect the calculated stresses by more than 5% SMYS. The calculations of the span length used a conservative value for differential temperature and extreme water velocity of 3.44 ft/sec.

VIBRATION INDUCED BY VORTEX-SHEDDING

Introduction

The steady flow of fluid around a cylindrical body creates a wake. Under certain conditions, the wake is characterized by discrete vortices which form and then detach from the trailing surface of the body in an organized periodic fashion. As each vortex detaches, momentary hydrodynamic lift and drag forces are produced giving rise to alternating inertial forces acting on the cylinder. The vortices may shed simultaneously from the opposite trailing surfaces, causing pressure differentials in the direction of the flow, or alternate from the opposite tailing surfaces causing pressure differentials in the direction normal to the flow direction[2]. If the frequency of vortex shedding is close to the frequency of a fundamental mode of structural vibration, then the shedding synchronizes with the vibration frequency of the structure. This condition is called vortex shedding lock-in. Upon lock-in a low damped system resonance and large oscillation amplitudes occurs. The non-dimensional shedding frequency is characterized by the Strouhal Number defined as

$$S_t = \frac{f_v \cdot D}{u} \qquad \textbf{Equation 3}$$

where f_v is the vortex shedding frequency, D is the hydrodynamic diameter, and u is the mean water velocity. The Strouhal Number is relatively constant and equal to approximately 0.2 at values of the Reynolds Number below 3.5×10^5. The Reynolds Number is a dimensionless parameter that defines the flow regime, calculated as:

[2] Under certain conditions inline lock-in may accompany alternate vortex shedding.

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$$Re = \frac{\rho \cdot D \cdot u}{\mu} \qquad \textbf{Equation 4}$$

where ρ is the fluid density and μ is the fluid viscosity. In a free spanning pipeline subjected to water velocity the onset of VIV is characterized by the dimensionless reduced velocity [8]:

$$V_R = \frac{u_t}{f_i \cdot D} \qquad \textbf{Equation 5}$$

where u_t is the total water velocity (current plus the wave induced velocities) and f_i is the structural eigen frequency in the i'th fundamental mode. VIV of a free spanning pipeline subjected to a flow current can take place in inline mode, cross flow mode, or a combination of both. Inline mode is when the vibration is in the plane designated by the flow velocity vector and the pipeline, while the cross flow is normal to this plane. VIV in each mode can take place within a limited range of reduced velocities. The lower limit of this range is known as the *onset reduced velocity*. Thus, if the reduced velocity is lower than the onset reduced velocity VIV is completely avoided. Generally, the inline vibration has a lower onset reduced velocity (see Chapter 4 of DNVGL-RP-F105), but it has a lower vibration amplitude in the range of zero to 0.2D. Cross flow VIV occurs at higher reduced velocities (about 3) and it usually has greater amplitudes up to 1.3D.

VIV Analysis of Single Span

In the 'Engineering Analysis of Free Spans' Section it was shown that free spans up to 150 ft long are acceptable under the worst loading combinations resulted from extreme water velocity and operating conditions. The acceptance criteria were based on the maximum allowable longitudinal stresses of ASME B31.4. In this section acceptable span lengths are calculated based on VIV avoidance criteria.

VIV assessment of a single span was carried out following the DNVGL-RP-F105 methodology. Section 2.3 of this recommended practice (RP) sets forth the following '*VIV Avoidance Criteria*' for the inline and cross flow vibrations, respectively:

$$f_{IL,1} > \frac{U_{extreme}\gamma_{f,IL}}{V_{R,onset}^{IL} D} \qquad \textbf{Equation 6}$$

$$f_{CF,1} > \frac{U_{extreme}\gamma_{f,CF}}{2D} \qquad \textbf{Equation 7}$$

where

$f_{IL,1}$, $f_{CF,1}$ are the natural frequencies of the first participating inline and cross flow modes,

D is outer hydrodynamic diameter, including any coating,

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$U_{extreme}$ is the extreme condition water velocity magnitude,

$V_{R,onset}^{IL}$ is the onset reduced velocity for the inline VIV, and

$\gamma_{f,IL}$, $\gamma_{f,CF}$ are natural frequency safety factors.

The avoidance criteria require that span natural frequency in inline and cross flow directions be greater than the values calculated from the right sides of Equation 6 and Equation 7. The onset VIV reduced velocities were calculated according to the inline response model described in Section 4.6 of DNVGL-RP-F105. A stability safety factor of 1.3 and onset reduced velocity safety factors of 1.1 and 1.2 for the inline and cross flow vibrations were incorporated in the calculations. Table 5 lists the DNV safety factors which were used in the calculations.

Table 5. DNVGL-RP-F105 Safety Factors

Safety Factor	Inline Value	Cross flow	DNVGL-RP-F105 Reference
Frequency	1.00	1.15	Table 2-3
Onset reduced velocity	1.1	1.2	Table 2-2
Stability parameter	1.3	1.3	Table 2-2
Stress range	1.3	1.3	Table 2-2

The natural frequency safety factors, $\gamma_{f,IL}$ and $\gamma_{f,CF}$ are provided in Table 2-3 of the DNVGL-RP-F105 as 1.0 and 1.15 for well to very well defined spans in a high classification area. Pipe natural frequency of vibration was calculated using the following equation from Section 6.8.2 of DNVGL-RP-F105:

$$\boldsymbol{f_1 = C_1\sqrt{1+CSF}\sqrt{\frac{EI}{m_e \cdot L_{eff}{}^4}\left(1+\frac{P_{eff}}{P_{cr}}+C_3\left(\frac{\delta}{D}\right)^2\right)}} \qquad \textbf{Equation 8}$$

where

C_1 and C_3 are boundary condition coefficients given as 3.56 and 0.4 respectively for a single span on seabed,

D is the pipe outer diameter,

E is the Young's modulus of pipe material,

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I is the second moment of area for the pipe section,

CSF is coating stiffness enhancement factor,

L_{eff} is effective span length,

m_e is pipe mass per length including the coating, product, and biota mass,

P_{eff} is effective axial load,

P_{cr} is critical buckling load, and

δ is static span deflection.

The soil was assumed to be medium sand because, given the measured water velocities as discussed in the 'Water Velocities' section, fine particles would have been washed away by the relatively intense current in the Strait. The critical buckling load was calculated as:

$$\boldsymbol{P_{cr} = \frac{C_2(1 + CSF)\pi^2 EI}{{L_{eff}}^2}} \qquad \textbf{Equation 9}$$

where C_2 is a boundary coefficient given as 4.0 for a single span on a seabed. The coating stiffness enhancement factor was calculated using the following equation from Section 6.3.7 of DNVGL-RP-F105:

$$\boldsymbol{CSF = 0.33\left(\frac{EI_{coating}}{EI_{pipe}}\right)^{0.75}} \qquad \textbf{Equation 10}$$

Free span lengths were calculated under a variety of conditions based on the avoidance criteria for cross flow and inline VIV. Figure 20 shows allowable span length versus pipe axial stress calculated based on VIV avoidance criteria for three different water velocities when the pipelines carry liquid product with a 0.868 specific gravity. The model included 1.0-inch biota growth. The three water velocities depicted in the figure represent 0.9, 1.0, and 1.1 times the extreme water velocity of 3.44 ft/sec. These velocities are selected to demonstrate the sensitivity of the results to the water velocities. The vertical red lines show a conservative range of operating axial stresses in the pipelines. The minimum axial stress is calculated by assuming zero internal pressure and a differential temperature of 30 F, while the maximum axial stress is calculated by assuming no differential temperature and an internal pressure of 600 psig. These two scenarios are extreme cases and they do not necessarily exist in reality. The actual axial stress in the pipelines is expected to fall between the two red lines and normally within the compressive side because the pipeline operates at temperatures warmer than the water.

The figure shows that tensile stress in the pipeline increases the frequency of vibration. Internal pressure tends to increase the axial tension and thereby the natural frequency of vibration. Zero internal

pressure represents the most conservative loading scenario and therefore this loading condition is utilized in the VIV assessment. Based on the results presented in this figure the allowable span length is about 87 feet at the extreme water velocity for a single span. In other words, when the span length of a single span is 87 ft or shorter VIV will be completely avoided under the extreme water velocity. This span length is shorter than the 150 ft span length calculated in the 'Engineering Analysis of Spans' Section based on longitudinal stress limit. Therefore, for these pipelines the VIV avoidance criteria is more stringent than the longitudinal stress limit of ASME B31.4.

The results show that a higher compressive stress in the pipeline lowers the natural frequency of vibration, leading to a shorter span length. For this reason in the remainder of this report the axial stress is set to the lowest value of −19.4% SMYS based on FEA results under the differential temperature of 30 F. This value was calculated from the FEA models discussed in the 'Engineering Analysis of Spans' Section. The inline onset reduced velocity was lower than the cross flow reduced velocity and therefore was the critical criterion in determining the allowable span length. The inline onset reduced velocity for the pipelines was between 1 and 1.25 (with a safety factor of 1.1 included), while the cross flow onset reduced velocity was about 2.5 (with a safety factor of 1.2 included). Figure 20 also shows that water velocity is a major factor affecting the span length. A 10% increase in the water velocity reduces the acceptable span length from 87 to about 80 feet, while a 10% decrease in the water velocity, increases the span length to about 95 feet.

As seen in Figure 20 the axial stress has a moderate influence on the span lengths. The component of longitudinal stress due to internal pressure, with the pipeline in the least constrained condition, is at most half of the hoop stress. Pressure induced axial stress under the maximum operating pressure of 600 psig was assessed to have insignificant effect on the acceptable span length (<5%), and therefore the internal pressure component of the axial stress was ignored in the VIV assessment.

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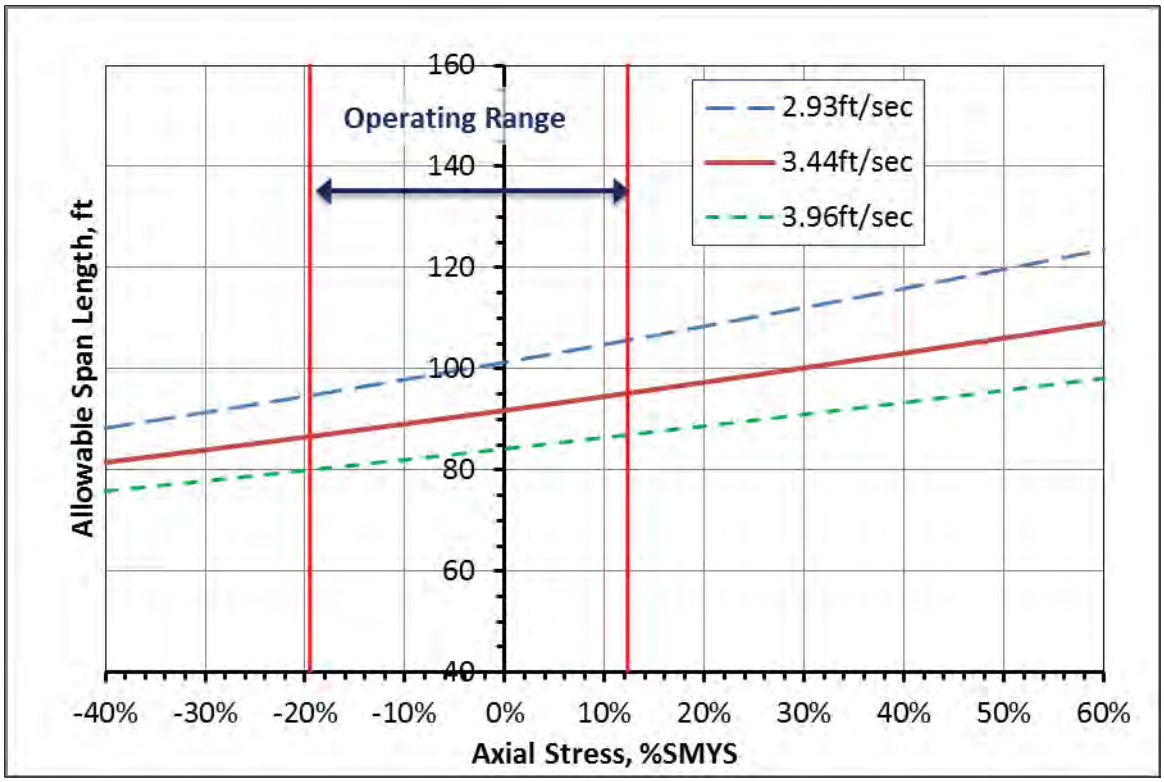

Figure 20. Allowable Span Length vs Axial Stress Based on VIV Avoidance Criteria for Three Water Velocities of $.9U_{extreme}$, $U_{extreme}$, and $1.1U_{extreme}$

Figure 21 shows the calculated span lengths versus water velocity for empty pipe, NGLs, and liquid product. The plotted span lengths are calculated based on the VIV avoidance criteria (Equation 6 and Equation 7) to prevent VIV. The vertical red line is at the extreme water velocity of 3.44 ft/sec. The VIV avoidance span length from this figure is again 87 feet for a single span with NGLs or liquid products and it is not very sensitive to the product unit weight. The empty pipeline was analyzed under a differential temperature of 15 F (versus 30 F for operating pipeline) because an empty pipe achieves thermal equilibrium with the water very quickly.

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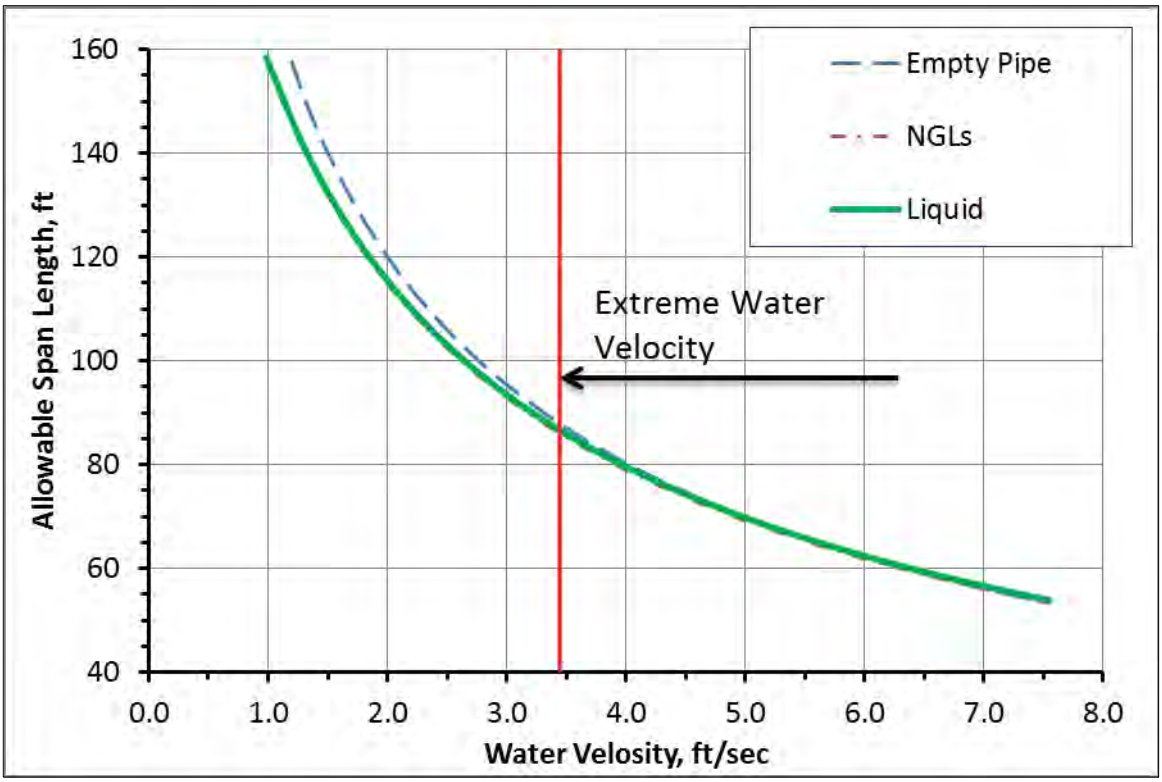

Figure 21. Allowable Span Length vs Water Velocity for Various Product Types

Figure 22 show the effect of biota thickness on the VIV avoidance span length. The biota thickness is seen not to affect the span length significantly. Although, variations of biota thickness change the natural frequency of vibration, for the range of water velocities and biota thicknesses examined in this work the change is offset by a corresponding increase or decrease of the pipe hydrodynamic diameter and VIV onset reduced velocity. In essence the VIV analysis showed that spans with lengths equal to or shorter than 87 feet will not experience VIV when exposed to the extreme water velocity. The analysis used all the design safety factors recommended in DNVGL-RP-F105 (Table 5), and therefore is believed to be conservative.

The maximum measured thickness of biota was 1 inch. Information provided by Enbridge indicates that biota was introduced to the Great Lakes about 20 year ago. Therefore, it is not expected that the biota growth on the pipeline exceeds 6 inches of thickness.

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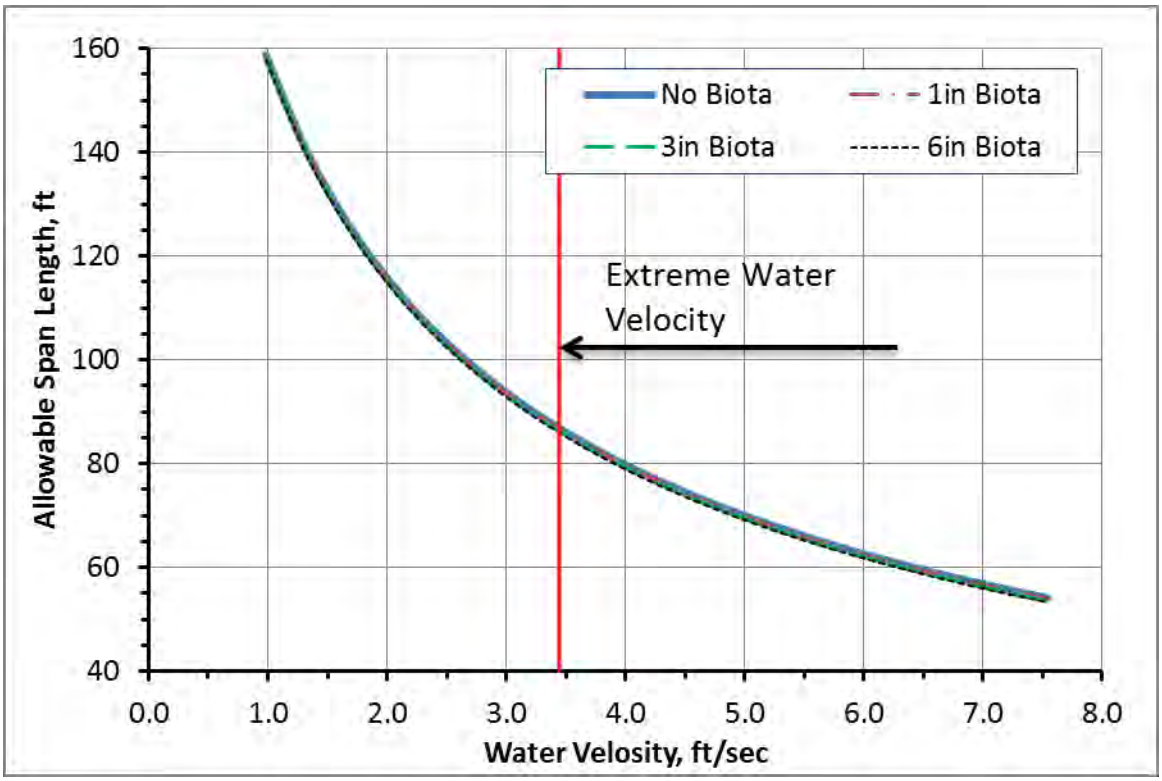

Figure 22. Allowable Span Length vs Water Velocity for Various Biota Buildups

FEA Sensitivity Analysis

FEA Model Calibration and Single Span Sensitivity Analysis

Modal FEA analysis was conducted in ANSYS FEA package. As recommended in DNVGL-RP-F105 the model analysis used the pre-stress option to account for the axial and bending stresses from differential temperature, gravitational, buoyancy and drag forces. Table 6 shows a comparison between the FEA results and the analytical results for a single span with 1.0 inch of Biota and light crude product.

Table 6. Comparison between the FEA and Analytical Results

Parameter	DNVGL-RP-F105	FEA
Mode 1 inline frequency	2.106 Hz	2.113 Hz
Mode 1 cross flow frequency	2.234 Hz	2.240 Hz
Inline maximum unit diameter stress amplitude	85.5 ksi	82 ksi

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Maximum unit diameter stress amplitude (MUDSA) represents cyclic stress amplitude during vibration in a given mode shape which is normalized by pipe diameter. Conversely, cyclic stress can be calculated by multiplying maximum pipe deflection by MUDSA and dividing by pipe diameter. The maximum pipe deflection can be determined following the methods described in sections 4.4 and 4.6 of DNVGL-RP-F105. Section 6.8.3 of DNVGL-RP-F105 contains the following equations for MUDSA:

$$\boldsymbol{A_{IL/CF,1}^{max} = 2C_4(1 + CSF)\frac{D \cdot E \cdot z}{{L_{eff}}^2}}$$ **Equation 11**

$$\boldsymbol{C_4 = 14.1\left(\frac{L}{L_{eff}}\right)^2}$$ shoulder

Equation 12

$$\boldsymbol{C_4 = 8.6}$$ mid-span

where z represents the position of the point of interest with respect to the neutral axis (e.g. $z = 0.5D_s$ for weld toe). All the other parameters are as previously defined. MUDSA was also calculated based on the FEA mode shapes and resultant modal stresses.

FEA simulations were first performed to confirm some of the sensitivity results presented in the previous section. Figure 23 shows a comparison between FEA and analytical results (DNV RPs equations) for the effect of biota thickness on the inline and cross flow fundamental frequencies. The two methods are in a good agreement for a biota range of zero to 6 inches. This shows that the results discussed in the 'VIV Analysis of Single Span' section are consistent with the FEA data.

Figure 24 shows the results of a sensitivity analysis on pipe mass per unit length. The FEA results are normalized by dividing pipe mass and Mode 1 inline frequencies to those of a benchmark case. The benchmark case was selected to be a pipe with liquid product and no biota built up. The mass ratio represents the actual mass of the pipeline with liquid product and coating (the added mass was excluded from the ratio because it is not a physical quantity). The continuous brown line in the graph represents the analytical trend from Equation 8, including the effect of soil support on the shoulders. It can be seen that the FEA results match the analytical trends closely.

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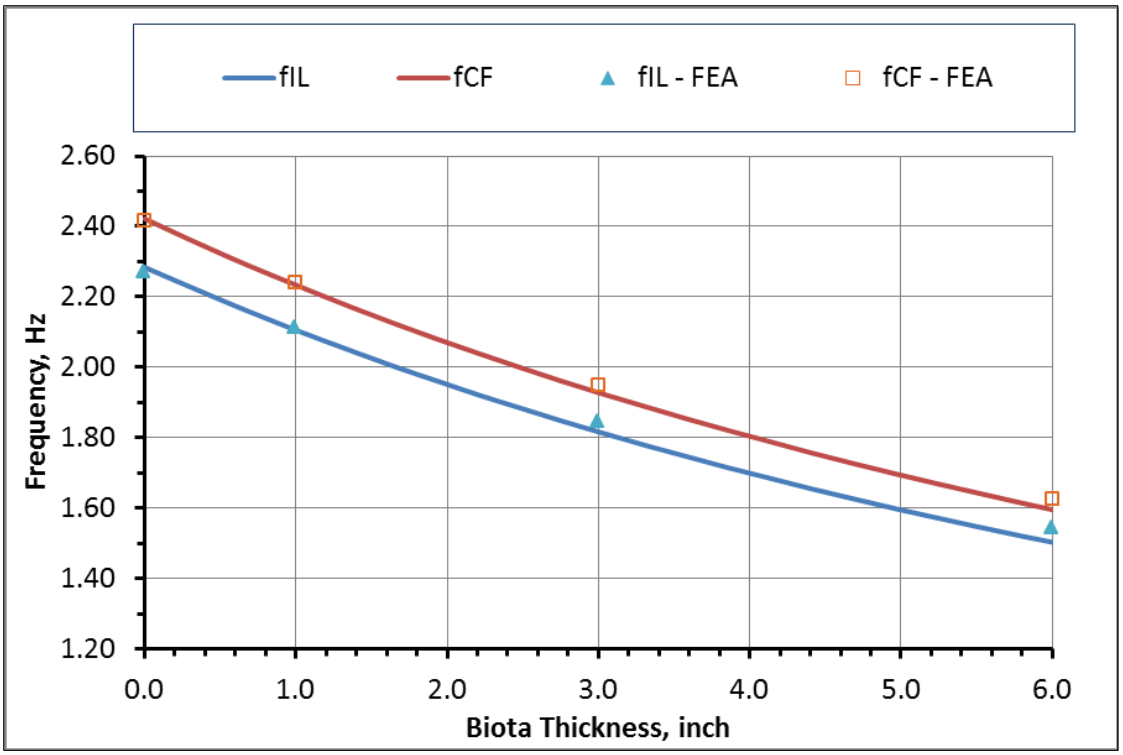

Figure 23. Effect of Biota Thickness on the Span Frequency; FEA vs Analytical Results

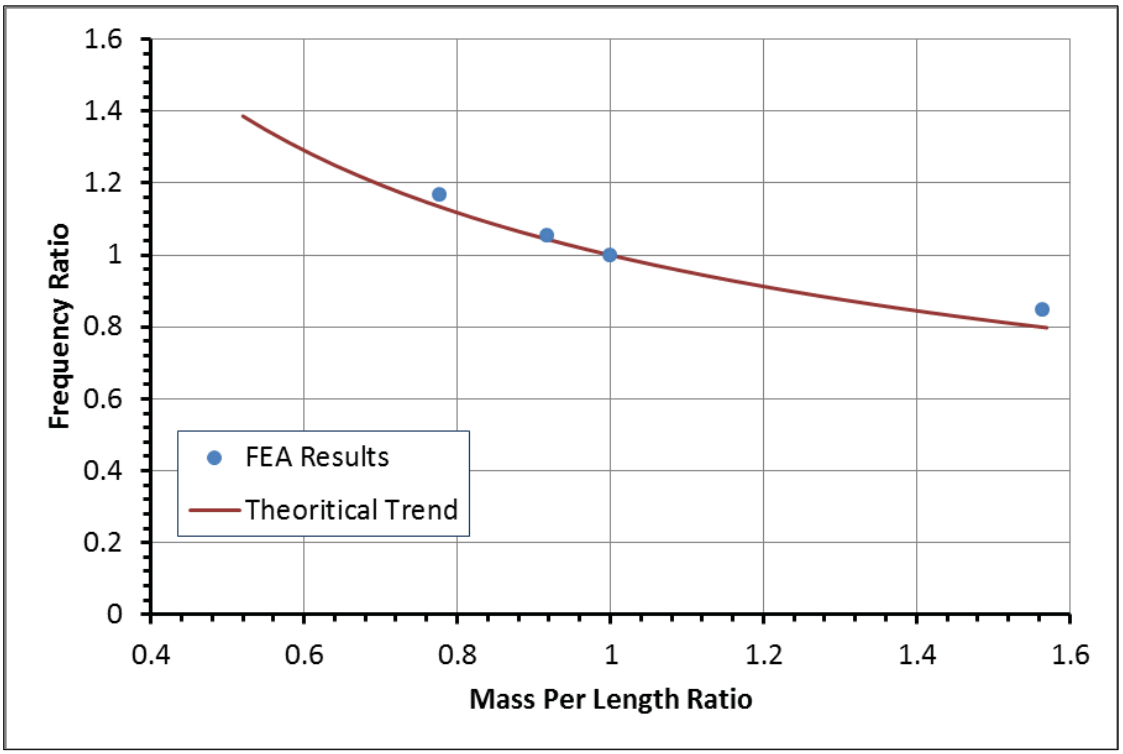

Figure 24. Effect of Pipe Mass on Mode 1 Inline Frequency of Vibration

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Figure 25 shows the axial stress sensitivity analysis results for a single 75-foot long span with 1.0 inch of biota. The horizontal axis is the pipe axial stress as a percent of SMYS. The left vertical axis is Mode 1 frequency, while the right vertical axis is the MUDSA in ksi. The continuous lines in the figure represent analytical results per DNV RPs and the individual symbols are the FEA results. The figure shows good agreement between the analytical and FEA results for a single span.

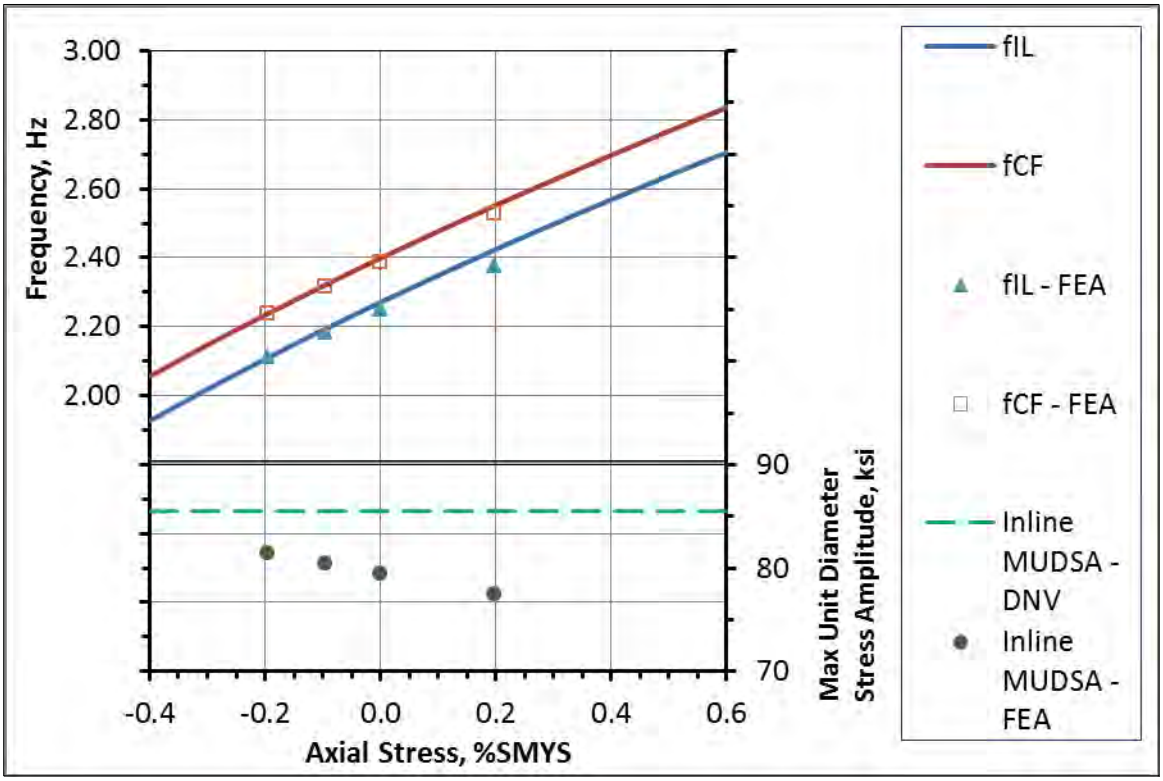

Figure 25. Modal FEA Sensitivity Results for Pipe Axial Stress

Multiple Span Analysis

Multiple continuous spans are known to decrease the natural frequency of vibration [1], [7]. Modal FEA were performed to study the sensitivity of frequency and MUDSA to the number of continuous spans. The mid-span support stiffness values listed in Table 3 were built into the FEA models.

Figure 26 shows the results of modal FEA for 1 through 4 continuous 75-foot spans. The horizontal axis of the graph is the number of continuous spans and the vertical axis is normalized frequency and MUDSA values. Each value is normalized by dividing the value to the corresponding single span value. For example Mode 1 inline frequencies are divided by Mode 1 inline frequency of a single 75-foot long span. Similarly Mode 1 cross flow frequencies are divided by the Mode 1 cross flow frequency of a single 75-foot long span. The graph represents how the number of continuous spans affects these parameters in a relative sense. Frequency decreases with the increasing number of spans, however the

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graphs level off as the number of continuous spans increase. MUDSA shows some dependence with the number of continuous spans, but overall it does not decrease significantly with increasing number of continuous spans. The horizontal red and orange lines represent the avoidance criteria for the inline and cross flow VIV. As shown in the figure, with two or more continuous spans, the pipelines may potentially violate the inline avoidance criterion, while they meet the cross flow avoidance criterion.

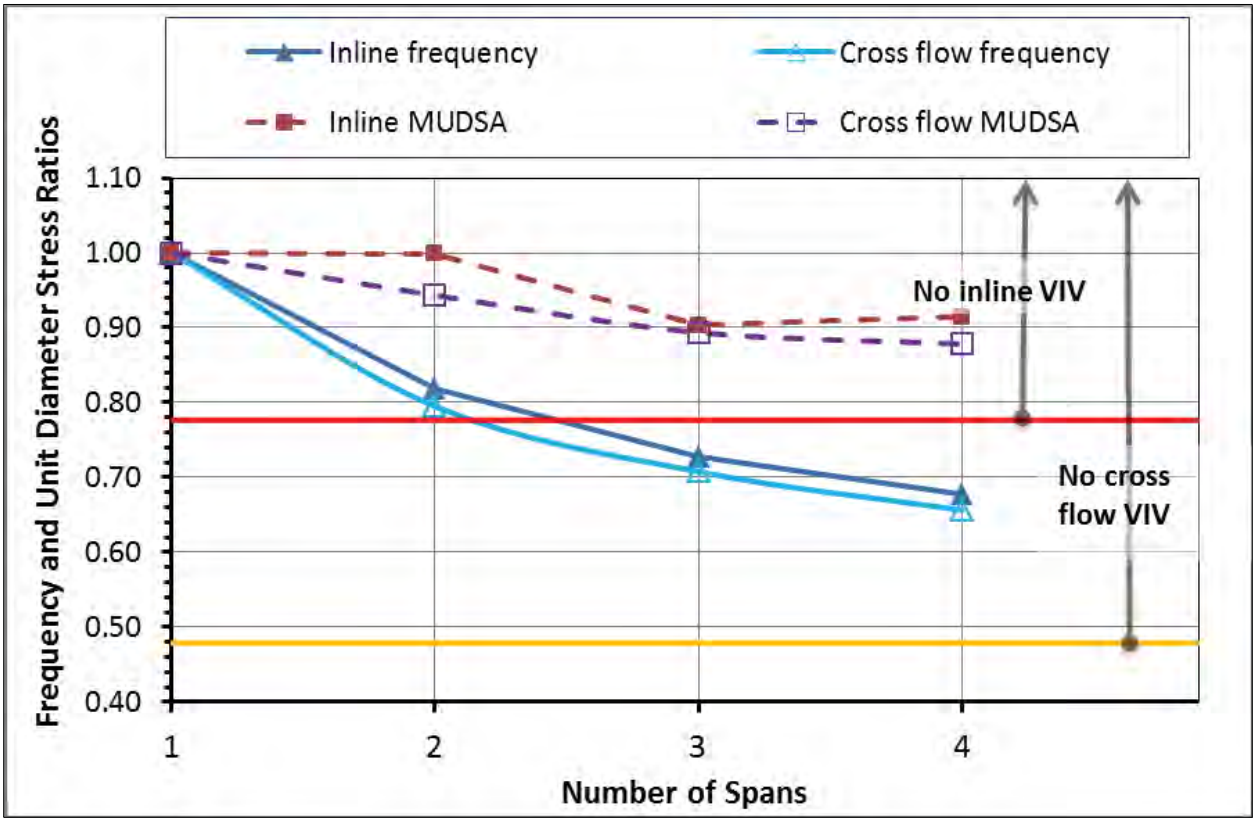

Figure 26. Modal Multi-Span FEA Results

Inline fatigue assessments were conducted to assess 100-year cumulative fatigue damage for 2 or more continuous spans. The fatigue calculations followed DNVGL-RP-F105 guidance. Cyclic stress magnitudes were calculated based on the MUDSA values and intensified using the pertinent DNV safety factors listed in the last row of Table 5. Stress concentration factor and fatigue resistance (S-N curve) parameters were based on DNVGL-RP-C203, Table 2-1, F3 [9]. The assessment showed that 100-year

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cumulative fatigue damage in the pipelines was negligible for one through four continuous spans, each 75 feet long. The highest calculated fatigue index was 0.003 corresponding to four continuous spans[3].

An increase in the number of spans is not expected to change the results significantly because the frequency of vibration becomes insensitive to the number of span beyond four [7]. A review of the span information provided by Enbridge shows that only 4 spans are 70 feet or longer, with the longest span being 72 feet. No portion of the pipeline contains two consecutive spans longer than 70 feet. Therefore, the study results for the four continuous 75-foot spans case is conservative.

DISCUSSION

The approach undertaken in the study was to determine allowable span lengths to prevent fatigue damage accumulation. The study showed that when a single free span or two continuous spans were limited to 75 feet no future fatigue damage to the pipelines would be anticipated. When three or four continuous spans were present, the respective portion of the pipeline did not meet the inline VIV avoidance criterion but fatigue assessment indicated negligible fatigue accumulation.

The presence of biota is expected to reduce the likelihood and intensity of VIV because of the uneven and non-uniform surface texture. In order for VIV lock-in to occur vortices should shed at the same frequency along a significant portion of the pipeline as determined by the mode shape of a participating vibration. Unevenness of the pipe surface is expected to make this much less likely as compared to a smooth pipe, first because it causes turbulence which tends to make the shedding aperiodic, and second because the conditions of the pipe surface vary along the length, making it less likely that vortices shed in harmony along a long portion of the pipelines. However, since the effect of surface roughness is difficult to quantify, it was ignored in the assessment. The effect can be considered as an added safety factor.

According to the technical memorandum published by NOAA in 1988 [10] the maximum ice buildup reported at the pipeline area was approximately 2 feet. The exposed portions of the pipeline are deeper than 65 feet. As such, the ice buildup in the Strait does not exceed 65 feet and the ice is not considered to be a threat to the exposed pipelines in the crossing.

[3] For a given cyclic stress amplitude, the fatigue index increases with the number of cycles. Theoretical fatigue limit is when the index reaches unity.

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The assessment contains a sufficient safety factor to cover normal variations in the biota thickness (including future growth up to 6 inches). Furthermore, normal variation in the product density (for the two product type studied, namely light crude and NGL) is not expected to affect the results.

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