From: Ziegelbauer, Heather/MKE <Heather.Ziegelbauer@jacobs.com>
Sent: Monday, June 24, 2019 3:19 PM
To: Neal, Conor; Carey, Angela J - DNR
Cc: Joseph Janeczek; Ryan Suennen; Jeff Danko; Mitchell, David/BOS; Finney, David/BOS
Subject: Tyco – Final Addendum to 2015 Barrier Wall Groundwater Monitoring Plan Update
Attachments: Final_TycoAddendumToBWGMPU_062419.pdf

Follow Up Flag: Follow up
Flag Status: Flagged

Categories: Green category

Conor and Angie:
On behalf of Tyco, attached for your review is the final Addendum to 2015 Barrier Wall Groundwater Monitoring Plan Update for the Tyco Fire Products LP site, Marinette, WI. The submittal has been prepared to document enhancements to the hydraulic monitoring program and vertical barrier wall visual inspections that have been agreed to during discussions between Tyco, U.S. Environmental Protection Agency, and Wisconsin Department of Natural Resources. Based on a series of meetings in 2018, it was agreed that the monitoring program would be enhanced to provide a final barrier wall effectiveness monitoring approach. The attached addendum has been updated to address the March 25, 2019 comments provided by EPA and WDNR on the February 20, 2019 draft addendum, as discussed and agreed to during the May 13, 2019 meeting.

Hard copies will be forwarded via regular mail. Please let us know if you have any questions.

Thanks,

Heather Ziegelbauer, PE*
Jacobs
Project Manager | Global Environmental Solutions
+ 1.262.644.6167
+ 1.312.933.1017 mobile
heather.ziegelbauer@jacobs.com
www.jacobs.com
135 South 84th Street, Suite 400
Milwaukee, WI 53214
US
www.jacobs.com
**Wisconsin*

JACOBS®

Memorandum

1610 N. 2nd Street, Suite 201
Miwaukee, Wisconsin 53212
United States
T +1.414.272.2426
F +1.414.272.4408
www.jacobs.com

Subject	**Addendum to 2015 Barrier Wall Groundwater Monitoring Plan Update**
Project Name	Tyco Fire Products LP, Marinette, Wisconsin
Attention	Conor Neal/U.S. Environmental Protection Agency Angela Carey/Wisconsin Department of Natural Resources
From	Jacobs Engineering Group Inc.
Date	June 2019
Copies to	Jeffrey Danko/Johnson Controls Inc. Joseph Janeczek/Johnson Controls Inc. Ryan Suennen/Tyco Fire Products LP Stephenson Public Library
Document Control No.	704683CH.264

On behalf of Tyco Fire Products LP (Tyco), Jacobs Engineering Group Inc.(Jacobs) has prepared this final addendum to the *2015 Final Revision 2, Revised Barrier Wall Groundwater Monitoring Plan Update* (BWGMPU) (CH2M HILL, Inc. [CH2M] 2015) for the Tyco site located at One Stanton Street, Marinette, Wisconsin, to document enhancements to the hydraulic monitoring program and vertical barrier wall (VBW) visual inspections that have been agreed to during discussions between Tyco, U.S. Environmental Protection Agency (EPA), and Wisconsin Department of Natural Resources (WDNR). Based on a series of meetings in 2018, it was agreed that the monitoring program would be enhanced to provide a final barrier wall effectiveness monitoring approach. This final addendum has been updated to address the March 25, 2019 comments provided by EPA and WDNR (hereafter referred to as the Agencies) on the February 20, 2019 draft addendum, as discussed and agreed to during the May 13, 2019 meeting. The barrier wall effectiveness monitoring approach will be annually reviewed by Tyco based on evaluation of current and historical information, and conclusions and recommendations will be provided to the Agencies to optimize the program. The conclusions and recommendations for optimization will be based on data interpretation.

1. Background

Based on the Administrative Order on Consent between Tyco and EPA, dated February 26, 2009 (EPA 2009) and updates required in the 2014 *Agreement on Resolution of 2013 Five-Year Review Technical Issues* (EPA 2014), the 2015 BWGMPU included the following monitoring aspects:

- Barrier wall inspections (visual above-water inspection and surveying), groundwater elevation monitoring, and water quality monitoring to demonstrate barrier wall effectiveness
- An outfall investigation and monitoring plan to evaluate whether the outfalls may serve as discharge points for arsenic to the Menominee River
- A pump down program to lower water levels in the former Salt Vault and the former 8th Street Slip and eliminate the potential for outward movement of groundwater from these areas to the Menominee River

- Dye testing to evaluate whether groundwater at the Main Plant is seeping across the VBW into the Menominee River
- Sample collection of post-dredging accumulated soft sediment in the river channel outside the Main Plant Area and the Turning Basin

This addendum includes updates to the Visual Inspection and Surveys (Section 2.1) and Groundwater Elevation Monitoring (Section 2.2) sections of the 2015 BWGMPU (CH2M 2015). Under separate cover, a work plan is being prepared to evaluate potential migration of arsenic to sediments and surface water of the Menominee River. An updated version of Table 1-1 of the 2015 BWGMPU is included in this addendum to update the status of the *Schedule for Barrier Wall Effectiveness Evaluation Activities* to reflect completed, removed, and updated aspects. As described in detail in the 2018 *Five Year Technical Review* (Jacobs 2018), after a series of comments and responses to comments on the proposed dye testing, performance of a pilot dye test, evaluation of dye test alternatives, and additional evaluation of a passive arsenic sampling approach along the wall, Tyco agreed to evaluate the feasibility of using an enhanced hydraulic monitoring and data evaluation approach in lieu of dye testing or other wall testing approaches. This document does not update the outfall monitoring plan, pump down program, or sediment sampling program components of the 2015 BWGMPU.

A June 26, 2018 conference call was conducted to confirm the objective of establishing a final permanent monitoring system to assess changes in river/groundwater interactions over time. The conference call also established necessary information to confirm the approach and implementation for the enhanced monitoring well network. The additional information, including groundwater flow model simulations and a proposed monitoring well spacing of 100 feet from a potential leak (200 foot well spacing), was presented to the Agencies during an August 1, 2018 conference call (Tyco 2018b). In response, the Agencies provided comments in an email on September 4, 2018 (EPA 2018). To respond to the comments, additional groundwater flow model simulations, details on the proposed hydrograph analysis method (the U.S. Geological Survey [USGS] program SeriesSEE [USGS 2016]), and other information were presented to the Agencies during an October 22, 2018 meeting (Tyco 2018a). A draft addendum was submitted on February 20, 2019, and comments were provided by the Agencies on March 25, 2019. At a May 13, 2019 meeting, Tyco presented responses to the April comments, and it was agreed that the presentation would be used to memorialize the responses (emailed to the Agencies on May 24, 2019) and the addendum would be finalized. The agreed upon approach included the following with the enhanced approach to be documented in an addendum to the BWGMPU (this document):

- Performing a below water visual survey to evaluate VBW condition and serve as a baseline for USGS SeriesSEE analyses (updates to BWGMPU Section 2.1)
- Enhanced groundwater elevation monitoring in the Main Plant (updates to BWGMPU Section 2.2), including:
  - Installing five additional shallow monitoring wells so that a monitoring well would be located within 100 feet of a potential VBW leak along the Menominee River
  - Selecting a network of existing and new monitoring wells for continuous monitoring and which of those monitoring wells would be proposed for evaluation using USGS SeriesSEE modeling to assess the VBW for potential leaks
  - Documenting the procedure for evaluation using USGS SeriesSEE tool
- Documenting approaches for managing apparent leaks (updates/clarifications to BWGMPU Sections 2.1.6, 2.2.6, and 2.2.3)

This addendum documents these enhancements as well as provides updates to the following tables and figures in the 2015 BWGMPU:

- Table 1-1, Proposed Schedule for Barrier Wall Effectiveness Evaluation Activities and Reports (includes updates to proposed frequency for VBW monitoring elements)
- Table 2-1, Proposed Wells and Data Collection for Barrier Wall Monitoring

- Table 4-1, Proposed Wells for Groundwater Elevation Monitoring at the Former Salt Vault and 8th Street Slip
- Figure 2-1, Proposed Groundwater Elevation and Total Arsenic Monitoring Wells
- Figure 2-3, Barrier Wall Effectiveness Evaluation Decision Tree (updated to reflect the overall effectiveness evaluation approach)
- New Figure 2-4 created to identify and update the technical evaluation approach for each line of evidence

The other figures (1-1, 1-2, 1-3, 1-4, 2-2, 3-1, 4-1, and 5-1) and Table 5-1 in the BWGMPU have not been updated for this addendum.

2. Barrier Wall Inspection Enhancements (Update to BWGMPU Section 2.1)

This section provides an update to Section 2.1 of the 2015 BWGMPU, specifically the methods used to complete the visual inspection of the Main Plant section of the VBW. A below waterline visual inspection will be conducted in 2019 as a potential component of the barrier wall monitoring program. Per an agreement at the October 22, 2018 meeting, the frequency of the above-waterline inspections will be reduced to annually.

In summer 2019, when weather allows and river conditions are optimal (less turbid), the exposed surfaces of the steel sheet pile bulkhead will be inspected by a diver from the waterline to the mudline with particular attention given to any observed areas of deterioration or damage. A visual and tactile inspection will be performed along 100% of the exposed structural elements of the Main Plant bulkhead. If visual/tactile inspection indicates unexpected corrosion (that is, corrosion resulting in breaches in the wall or that may be affecting wall or seam integrity), additional investigation such as cleaning inspections and ultrasonic thickness measurements will be performed (during the inspection) in the area of observed corrosion. Additionally, the conditions of bolts and other exposed bulkhead elements will be documented. The bulkhead also will be visually inspected above water from the waterline to the top of bulkhead. Photographs will be taken above and below water to document general conditions and observed deficiencies such as areas of corrosion, holes, split seams, or other apparent leakage. If visibility is sufficient, video will be taken of at least two representative sections of the wall that appear to be in good condition. All areas that have observed deficiencies based on the diver inspection will be videoed.

An underwater inspection report will be submitted for the bulkhead as part of a 2019 quarterly report. Results also will be summarized in the annual report in conjunction with the results of the SeriesSEE analysis. The report will include inspection findings, photographs, and recommendations for future inspection frequencies. Videos also will be provided to the Agencies for their review. If the underwater survey proves to be an effective barrier wall evaluation method, Tyco may recommend relying on underwater surveys in place of other barrier wall monitoring elements. If effective, and the wall is in good condition, it is anticipated that the underwater surveys would be conducted approximately every 5 years. After the 2019 underwater survey, the surveys are anticipated to be conducted before each Five-Year Review (for example, before the 2023 Five Year Review). However, the effectiveness of the underwater inspections and frequency will be reassessed after each inspection, and more frequent inspections may be recommended by Tyco for suspect portions of the wall. If a deficiency requiring repair is identified a follow-up survey will be conducted (only in the area of the deficiency) approximately 1 year post-repair.

The frequency of other inspection elements may also be adjusted following 2019, as indicated in Table 1-1. For example, after the spring 2019 barrier wall survey, 4 years of survey data will have been collected since the 2015 baseline. To date, these survey data showed only minor movement (majority is less than one inch, with some locations slightly exceeding one inch) of the VBW, therefore it may be appropriate to reduce the survey frequency. Recommendations for barrier wall inspection approach and frequency will be provided by Tyco in the annual reports and recommendations will be based on the collected data.

3. Enhancements to Groundwater Elevation Monitoring (Update to BWGMPU Section 2.2)

3.1 New Monitoring Well Installation

Five new shallow monitoring wells (MW107S, MW121S, MW122S, MW123S, and MW124S) were installed in June 2019 in the Main Plant to provide a monitoring well network along the VBW near the Menominee River with approximately 200-foot (or better) spacing.[1] Such spacing means that a monitoring well will be within 100 feet of a potential Main Plant VBW leak.[2] New monitoring well installation locations are shown on updated Figure 2-1; well spacing ranges from 160 to 200 feet between wells. Well installation, development, and surveying methods are described in the Monitoring Well Construction, Well Development, and Site Surveying portions of BWGMPU Section 2.2.3 and will be reported in the next annual report. Monitoring wells were installed within approximately 10 to 15 feet of the VBW.

3.2 Updated Hydraulic Monitoring Network

Vented pressure transducers will be installed in the following monitoring wells and river gage to collect continuous hydraulic head data (this list replaces the list in the 2015 BWGMPU and is included in updated Table 2-1;[3] new pressure transducer locations are indicated with bold font):

- Four shallow monitoring wells outside the VBW that are expected to show a hydraulic response to river level fluctuations (MW003S, MW100S, MW104S, and **MW048S** [if accessible and in good condition])[4]
- River stream gage (SG-4) to monitor river level fluctuations
- Two shallow monitoring wells in the Wetlands Area (MW047S and MW109S)
- Eight shallow monitoring wells in the Main Plant located adjacent to the VBW (MW108S, MW117S, MW118S and new wells **MW107S**, **MW121S**, **MW122S**, **MW123S**, and **MW124S**)
- Two shallow monitoring well pairs in the Main Plant area on either side of the VBW and located farther from the river (MW064S/MW102S, and MW106S/MW003S)
- Eight bedrock monitoring wells (MW047D, MW064D, MW106D, **MW107D**, MW108D, MW109D, MW117D, and MW118D)
- Three wells (MW002S, MW115S, and MW119D) in the Salt Vault area and two wells in the 8th Street Slip area (MW120S and MW120D) to monitor the pump down program[5]
- A barometric pressure transducer to monitor barometric pressure changes placed above the water table within one existing well (currently MW103M, but may be moved if conditions limit access or usability of the data)

---

[1] Monitoring well MW118D was abandoned in 2018 and was replaced in June 2019 and named MW118D-R. Additionally, MW118S and MW118M, which were damaged by a snowplow in winter 2018-2019, were repaired at the same time.

[2] As presented during August 1 and October 22, 2018 presentations to the Agencies (Tyco 2018a, 2018b), the existing groundwater flow model was used to evaluate potential hydraulic responses inside the VBW to river level fluctuations when there were simulated breaches of 1.0, 1.6, and 2.8 gallons per minute (gpm). The model results indicated that hydraulic responses would be observable at least 100 feet from the leak.

[3] USEPA approved the proposed locations for additional monitoring wells and agreed to proceeding with their installation in an April 5, 2019 email. Monitoring wells were installed in June 2019.

[4] MW048S is in the eastern portion of the Wetlands Area, adjacent to the Menominee River. Initial reconnaissance over winter indicates this monitoring well should be accessible despite presence of dense vegetation but will need to be confirmed during spring/summer conditions. If access is severely restricted due to site conditions (which may include being underwater due to flooding conditions) or the well condition is suspect, installation of the transducer will not occur.

[5] These wells will be evaluated annually to determine whether transducers at these monitoring well locations are still needed to monitor pump down progress. It is anticipated that once target elevations are achieved and maintained, that continuous monitoring with pressure transducers may not be necessary.

The following wells were previously removed from the pressure transducer network:

- The pressure transducers in MW040S, MW105S, MW105D were previously moved to **MW003S**, **MW106S**, and **MW106D**, respectively, with agency approval.

The monitoring well network will be evaluated as part of the annual reports to determine its effectiveness at evaluating the remedy performance and make recommendations for optimizing the network. For example, once hydraulic data has been collected and analyzed after a year of hydraulic monitoring, it may be evident that only one or two monitoring wells outside the VBW may be required to provide the information necessary to compare to river fluctuations and hydrographs from inside the VBW system. Similarly, hydraulic responses in the bedrock wells have generally been similar and therefore monitoring only one or two bedrock monitoring wells may be necessary. The recommendations will be driven by interpretation of available data.

Pressure transducer installation is described in the Water Level Measurement portion of BWGMPU Section 2.2.3 with the following changes/clarifications:

- Transducer data will be downloaded and manual water levels will be collected three times per year April or May (once ice is off the river and snow has melted), approximately 3 months later (July or August), and approximately 3 months after the second event (October or November). This schedule is appropriate because the hydraulic response analysis (using SeriesSEE) will focus on periods when there is not ice on the river (affecting river level measurements) and snow on the ground (affecting recharge into the aquifer).
- For those locations that will be included as part of the SeriesSEE evaluations (Section 3.3) pressure transducers will be programmed to collect data every 15 minutes in 2019. The data collection frequency may be reduced based on initial SeriesSEE analyses if it is shown that a lower measurement frequency will provide sufficient data for analysis. All other locations equipped with pressure transducers will continue to collect data at 1-hour intervals (per previous EPA approval to change from 30 minutes).
- All pressure transducer clocks will be synchronized at the time of each data download to ensure that data measurements are taken concurrently.

In addition to the continuous hydraulic head measurements at monitoring wells equipped with pressure transducers, synoptic manual hydraulic head measurements will be collected during arsenic groundwater sampling events from a wider set of wells to evaluate sitewide groundwater flow directions. Newly installed monitoring wells, and several additional wells on the interior of the Main Plant (MW009S, MW012S, MW032S, MW044S MW045S, MW067S, and MW068S) have been added to the manual groundwater elevation measurement events. Based on discussions at the May 13, 2019 meeting, rationales for inclusion of wells in the manual groundwater elevation measurement events have been added to Table 2-1.[6] Wells measured as part of the pump down program (Figure 4-1 in the 2015 BWGMPU) are measured at the same time as the sitewide synoptic survey and groundwater elevations will be included in the contour maps. An updated Table 4-1 is provided in the addendum to include rationale for the pump down program monitoring wells.[7] Recommendations for continuing or revising the manual groundwater elevation measurement program and/or production of groundwater elevation contour maps will be made by Tyco in each annual report and will be based on evaluation of the data collected.

Table 2-1 and Figure 2-1 from the 2015 BWGMPU have been updated to reflect the new well locations, manual groundwater elevation monitoring wells, and updated pressure transducer locations.

3.3 Enhanced Evaluation of Hydraulic Head Transducer Data

This section provides an update to BWGMPU Section 2.2.5 (Reports to Agencies), specifically the methods for evaluating continuous hydraulic head data measured with the pressure transducers. As

[6] Arsenic sampling frequencies were updated for wells in the former Salt Vault and 8th Street Slip areas to reflect that the 2015 BWGMPU would be sampled annually in 2016, 2017, and 2018 and thereafter before every Five-Year Review, beginning in 2023.

[7] Wells measured as part of the pump down program interim and drawdown phases will only be measured during those phases.

stated in that section, hydraulic data from the wells indicated on updated Figure 2-1 and Table 2-1 will be evaluated to confirm the groundwater inside the VBW is acting independently of the groundwater outside the VBW, as well as independently of the Menominee River stage. Evidence of independent behavior of groundwater will serve as a line of evidence the VBW is effectively containing site groundwater. Continuous hydraulic head data from monitoring wells installed at the following well sets will be compared visually only, using similar techniques to those described in the 2015 BWGMPU and 2016, 2017, and 2018 annual reports (Tyco 2017, 2018c; Jacobs 2018):

- Wetlands Area (MW047S-MW047D-River)
- Wetlands Area (MW109S-MW109D-River)
- South Main Plant area (MW064S-MW064D-MW102S)
- West Main Plant area (MW106S-MW106D-MW003S)

At select wells, the USGS program SeriesSEE will be used to evaluate time-series hydrographs in comparison to Menominee River hydrographs and barometric pressure time-series to evaluate whether there is any hydraulic response in these monitoring wells to river fluctuations and the magnitude of response. This analysis will be performed on the following wells:

- Shallow monitoring wells MW003S, MW100S, MW104S, and MW048S outside the VBW
- Shallow monitoring wells MW107S, MW108S, MW117S, MW118S, MW121S, MW122S, MW123S, and MW124S in the Main Plant, adjacent to the river
- Bedrock wells MW107D, MW108D, MW117D, and MW118D

SeriesSEE is a Microsoft Excel Add-In developed by USGS to view time-series and model water levels (USGS 2016). SeriesSEE originally was developed to differentiate pumping responses from natural water level changes to assist in analyzing multiple well aquifer tests. During water level modeling, synthetic water level time-series are created that represent the cumulative effects of different forces that can affect water levels (such as earth tides, pumping, barometric pressure responses, and precipitation recharge). The Menominee River level generally fluctuates 0.5 to 1.0 foot per day in apparent response to upstream dam releases or seiches. Each fluctuation of the river is in effect a pumping test; therefore, using this program is appropriate for VBW effectiveness monitoring. The groundwater flow model indicates that, even when operating as designed, there will be some minor level of hydraulic connection between the river and the area inside the VBW. Therefore, the goal of the SeriesSEE analysis is to correlate the magnitude of any observed hydraulic response to the VBW condition as determined by the visual underwater survey (Section 2 of this addendum) and monitor any changes in these responses going forward. For example, if a breach is observed during the visual underwater survey, the SeriesSEE analysis will be used to determine if there are any differences in the magnitude of the observed hydraulic responses in wells located in the vicinity of the observed breach relative to those located farther afield.

Hydrographs from shallow monitoring wells will be compared to synthetic water level time-series created by SeriesSEE using barometric pressure and river level data. The program will be used to determine the phase-shift (lag in response) and amplitude (degree of response) that best fits the observed shallow monitoring well hydrographs. If all other factors, such as river level fluctuation, are equal, a higher magnitude response of a well inside the VBW to river level fluctuations system would indicate a higher degree of hydraulic connection across the wall. It is expected that monitoring wells outside the VBW system will exhibit a higher response to river level changes than wells inside the VBW system. By repeating the SeriesSEE analysis through time, spatial and temporal trends in hydraulic response can be analyzed to evaluate whether leakage through the VBW may be developing.

3.3.1 SeriesSEE Data Set Selection

One time-series interval of data will be evaluated annually for each well (additional time-series may be evaluated if deemed necessary by Tyco as discussed below). The goal of selecting a time-series interval for SeriesSEE analysis will be to identify periods when external influences on water levels (such as recharge events) are minimized but river level fluctuations are occurring. Meteorological records from nearby weather stations will be reviewed to identify data sets with the following characteristics:

- No snow on ground (per meteorological records and/or site observation)
- No precipitation for previous 3 days
- River record indicates at least 0.5 foot of periodic river level variations (with larger variations preferred)
- A 72- to 120-hour period

If available, additional time-series evaluations may be conducted if significant changes in head differences between the river and Main Plant groundwater are observed or a seasonal pattern is apparent.

To conduct the SeriesSEE evaluation, the following information is required:

- River water level time-series from the onsite stream gage. If data from the gage are not available, water level records from a nearby National Oceanic and Atmospheric Administration (NOAA) gage (9087088), approximately 1 mile downstream and which historically has exhibited similar river level fluctuations as observed at the site, may be substituted.
- Barometric pressure time-series from the onsite barometric pressure transducer. If data from the barometric pressure transducer are not available, barometric pressure records from the NOAA gage or from one of the nearby meteorological stations will be used.

Although the effects of pumping of the onsite groundwater collection and treatment system initially will not be included in the SeriesSEE analyses, pumping records from these wells will be evaluated to determine whether they may be affecting water levels. The only extraction well near the monitoring well network is EW-04, approximately 70 feet southwest of MW108S. Since January 2016, the monthly average pumping rates at EW-04 have ranged from 0.00 gallons per minute (gpm) to 0.20 gpm; therefore, it is expected that there would be minimal or no influence on water levels near the VBW. Based on discussions at the May 13, 2019 meeting, multiple data sets representing different antecedent precipitation conditions (such as no rain for 1 day, 3 day, 7 days) at one inside well and one outside well will be analyzed in the 2019 annual report to evaluate the range of SeriesSEE results (including root-mean square [RMS] errors and amplitude factors) and optimal data set selection parameters. Additionally, these wells will be analyzed for up to 5 different periods in 2019 to evaluate variability in the results.

3.3.2 SeriesSEE Analysis Steps

The following steps are proposed for the SeriesSEE analysis; however, as data are collected and analyzed, adjustments may be made to improve the analysis. The steps used in the SeriesSEE analysis, and any changes from those outlined in this addendum or previous reports, will be provided in each annual report.

In the SeriesSEE evaluation, several synthetic water level time-series, using barometric pressure only, river level only, and barometric pressure plus river level, will be created to “fit” the groundwater level time-series from the monitoring well. By evaluating the amount of error associated with the synthetic water level series compared to the actual groundwater time-series, whether the “fit” of the synthetic water level time-series is improved by inclusion of the river level time-series, and the reported amplitude factor, an assessment of the degree of hydraulic connection between the river and groundwater can be made.

Some example analyses using August 2017 time-series data are included in Attachment 1. Bedrock wells, such MW117D, show an improved fit with the inclusion of the river level time series and an amplitude factor of approximately 1, indicating bedrock groundwater rises about the same level that the river rises (that is, if the river rises 0.5 foot, the hydraulic head in bedrock groundwater rises 0.5 foot). Shallow monitoring well MW100S, located outside the VBW, showed an improved fit with the inclusion of the river level time series and an amplitude factor of 0.37, indicating water levels fluctuated approximately 37% of the river level fluctuation. Conversely, shallow monitoring well MW117S inside the VBW did not show an improved fit with the inclusion of the river level time series. Barometric pressure-only RMS errors in August 2017 for wells inside the barrier wall ranged from 0.017 to 0.035 foot (average of 0.026 foot)

and were in all cases lower than RMS errors for river-only analyses, indicating the SeriesSEE fit does not improve with inclusion of the river and there is minimal or no connectivity across the VBW. Conversely, outside the wall the river-only RMS errors were lower than the barometric pressure-only RMS errors. River plus barometric errors for outside wells ranged from 0.012 to 0.049 foot, with an average value of 0.021 foot. Thus, for the wells outside the wall, it is concluded that a hydraulic connection to the river is present and improves the fit of the SeriesSEE model. Lower RMS errors, typically aiming for 0.03 foot or less, indicate a better fit. Higher RMS errors suggest additional influence(s) on groundwater levels that are not included in the SeriesSEE model.

The following steps will be undertaken:

- Time-series for monitoring well water levels, barometric pressure, and river water level will be loaded for the period of analysis. Water levels will be standardized to the average water level during the period of analysis.[8]
- Earth tide effects (which are calculated by the SeriesSEE program) will be included in all analyses.
- A synthetic water level time series using barometric pressure only will be created that attempts to best-fit the observed water levels at the monitoring well being analyzed. The RMS value, a measure of error, will be recorded as will the time lag and amplitude factors.
- A synthetic water level time series using river water level only will be created that attempts to best fit the observed water levels at the monitoring well being analyzed. The RMS value, a measure of error, will be recorded as will the time lag and amplitude factors.
- A synthetic water level time series using river water levels and barometric pressure will be created that attempts to best-fit the observed water levels at the monitoring well. The RMS value, a measure of error, will be recorded as will the time lag and amplitude factors.
- The RMS values and visual fit of the three synthetic water level time-series will be compared to the observed groundwater elevation time-series to determine whether the fit markedly improves with addition of the river level time-series.[9]
- Analysis will be conducted for each shallow monitoring well located adjacent to the VBW in the Main Plant (Table 2-1). If an unexpected degree (or lack thereof, where expected) of hydraulic connection between the river and the groundwater system is shown, additional time-series may be analyzed to evaluate whether a hydraulic connection is consistently shown (as would be expected if there was a leak) or not shown.
- The 2019 SeriesSEE analysis will be used as a baseline to evaluate whether there is an observable river influence and the observed river amplitude factor.[10]
  - If issues with barrier wall effectiveness are identified during the visual survey, or evaluation of other lines of evidence, these conditions will be taken into consideration and incorporated as part of the baseline review of SeriesSEE results.[11]
  - For those wells where a hydraulic connection between the river and groundwater system is determined, the river amplitude factor will be noted and the current year's observations will be

[8] For example, if the average water level was 578 feet above mean sea level (amsl) during the period being analyzed, this water level would be assigned a relative elevation of 0 feet. A water level of 578.5 feet amsl would be assigned a relative elevation of 0.5 feet, while a water level of 577.3 feet amsl would be assigned a relative elevation of -0.7 foot. Barometric pressure will be converted to feet of water and similarly the average pressure will be used to calculate relative barometric pressures for the period of analysis.

[9] Because of the nature of the SeriesSEE fitting routine, addition of river levels to barometric pressure should result in a slightly improved fit; a marginal improvement in fit does not necessarily indicate that the VBW is not operating as designed. Ideally, RMS errors will be 0.03 foot or less, with higher RMS errors indicating other (non-modelled) influences are affecting the hydrograph. Evaluation of additional time-series and conditions will be conducted on 2019 data to evaluate the RMS error ranges.

[10] Groundwater flow model indicates that, even when operating as designed, there is minor hydraulic connection between the river and the area inside the VBW. Therefore, the goal of the SeriesSEE analysis is to correlate the magnitude of the observed hydraulic response to the observed barrier wall condition as determined by the visual underwater survey, and to monitor any changes in magnitude over time.

[11] For example, if a breach is observed during the visual survey, SeriesSEE results from the nearest wells will be used to evaluate whether a hydraulic connection exists between the river and groundwater inside the VBW.

compared to the baseline. Additional periods will be assessed to determine if the observed river influence is consistently observed at the well.[12]

- If there is an observable river influence, then it will be assessed whether the river amplitude factor has increased through time. If the baseline did not show a hydraulic connection, then the observation of a hydraulic connection would indicate that the hydraulic connection has increased, regardless of the river amplitude factor. If a hydraulic connection has been previously indicated, then statistical tests may be conducted to determine if there is a statistically significant increase in river amplitude factor. Statistical analyses that may be conducted include:
  - A Wilcoxon Rank Sum test (or similar) to compare whether the mean/median values of two populations are statistically the same or different, and/or
  - A Mann-Kendall trend analysis (or similar) to evaluate whether there is an increasing trend through time. Additional data sets may be evaluated to enable the statistical analysis.

A new decision tree figure summarizing evaluation steps for each line of evidence, including the new SeriesSEE evaluation, is provided on new Figure 2-4.

3.4 Main Plant Groundwater Elevation Assessment

Contour maps for the shallow and deep wells, as described in BWGMPU Section 2.2.5, will be produced in 2019. As discussed at the October 22, 2018 meeting, production of contour maps may be dropped in the future as part of the annual report review if results of the SeriesSEE analyses and VBW underwater inspection are deemed sufficient to evaluate VBW effectiveness by Tyco and the Agencies.

4. Multiple Lines of Evidence for Assessing Wall Effectiveness and Potential Corrective Actions (Updates to BWGMPU Sections 2.1.6, 2.2.6 and 2.3.6)

Potential corrective actions were provided in BWGMPU Sections 2.1.6, 2.2.6, and 2.3.6 (CH2M 2015). The following updates are provided to enhance and clarify these sections and accommodate the additional lines of evidence that will be generated. Figure 2-3, Barrier Wall Overall Effectiveness Evaluation Decision-Tree, also has been updated to reflect the overall effectiveness evaluations and potential responses, while new Figure 2-4, Barrier Wall Technical Evaluation Decision-Tree, has been created to provide details on how each individual line of evidence will be evaluated (including the new SeriesSEE analysis).

Multiple lines of evaluation will be used to determine whether the VBW is effective, including:

- Visual inspections and surveys above the waterline, as described in the BWGMPU
- Visual inspection below the waterline, as described in this addendum
- Groundwater elevation monitoring results, including:
  - Groundwater head differential comparisons inside/outside VBW (as described in BWGMPU Section 2.2.5 and summarized on new Figure 2-4)
  - Groundwater contour maps for shallow and deep monitoring wells (as described in BWGMPU Section 2.2.5) but may be dropped in the future if SeriesSEE and VBW underwater inspection are deemed sufficient to evaluate VBW effectiveness
  - Visual comparison of transducer hydrographs for wells distant from the river (as described in BWGMPU Section 2.2.5 and summarized on new Figure 2-4).
  - The new SeriesSEE transducer analysis for select Main Plant wells adjacent to the river (summarized on new Figure 2-4)

[12] If there is a hydraulic connection, it would be expected to be observable in all data sets from that well, unless the leak has recently developed or occurs near the water table.

- Groundwater arsenic monitoring, including temporal trend assessment, evaluation of hydraulic gradient direction and magnitude (if contour maps are produced), comparison of concentrations inside and outside wall, and evaluation of localized redistribution of arsenic outside VBW (as updated on new Figure 2-4)[13]

If multiple lines of evaluation indicate a potential leak in the VBW system, additional evaluation or mitigation, as necessary, will be pursued. The following provides additional clarification to potential corrective action steps indicated in BWGMPU Sections 2.1.6, 2.2.6, and 2.3.6 (CH2M 2015) and depicted on updated Figure 2-3.

Conditions considered requiring expedited corrective actions include observed leaks greater than 1 gpm, observed defect (such as separation of seams affecting an entire seam, or observed single defect greater than 6 square feet.[14] If conditions requiring expedited corrective actions are identified during the visual inspections or after supplemental evaluation of a VBW section with multiple lines of evidence indicating a concern, EPA will be notified within 24 hours. A proposed plan for corrective measures will be presented to EPA as quickly as possible and within 60 days, with corrective measures implemented within 60 days of EPA approval, if possible. For smaller leaks or defects, evaluation will still be completed to determine whether repairs are necessary.

Routine maintenance (such as bolt tightening or replacing missing wall markers) noted during the inspections or other times during the year will be completed as soon as practical and will generally be performed within 30 days. These routine maintenance and repair activities will be reported in the quarterly and/or annual reports submitted to EPA.

For data or inspections that indicate the VBW may not be effective, multiple lines of evidence listed in this addendum will be evaluated and results highlighted to EPA in the quarterly and/or annual report along with a plan for assessment or mitigation, as necessary. Potential additional assessment activities may include additional SeriesSEE analysis, additional above-water and below-waterline inspections, additional groundwater sampling, surface water sampling, or other evaluation methods to be described in the plan submitted to EPA. If the additional assessment confirms there is an issue with the VBW's effectiveness, corrective action will be undertaken. These could include repair or replacement of a section or sections of the wall. The type and scope of these actions will depend on the observed conditions and the nature and severity of the leakage. Details on corrective actions to be followed for the VBW are discussed in BWGMPU Section 2.1.6 (CH2M 2015). The schedule will depend on the type of wall section involved (vibrated beam slurry wall or sheet pile) and the location of that section.

5. References

CH2M HILL, Inc. (CH2M). 2015. *Final Revision 2, Revised Barrier Wall Groundwater Monitoring Plan Update*. September 3.

Jacobs Engineering Group, Inc. (Jacobs). 2018. *Five Year Technical Review, Version 0*. December.

Tyco Fire Products LP (Tyco). 2017. *2016 Barrier Wall Groundwater Monitoring Annual Report*. May.

Tyco Fire Products LP (Tyco). 2018a. *Barrier Wall Monitoring Program Enhancements*. Presentation to EPA and WDNR. October 22.

[13] Groundwater arsenic monitoring in the Main Plant, Wetlands Area, and areas adjacent to Main Plant and Wetlands Area will be conducted semiannually in 2019. If Mann-Kendall trend results indicate an increasing concentration; however, an evaluation of other factors that may be influencing arsenic concentrations outside the VBW indicates that leakage is not occurring (per the Figure 2-4 decision-tree), then sampling frequency will be reduced to annual in 2020, once in 2023 (Five-Year Review), and then twice per subsequent 5-year reporting periods.

[14] These conditions are based on recent groundwater flow modelling (presented at the October 22, 2018 meeting) that indicated a 4.5-inch gap along an entire seam (18 feet long, about 6.75 square feet), would result in a leak of about 1 gpm. A leak of this size should result in arsenic surface water concentrations, within 1 foot of the wall, below the acute surface water criteria and usually below the chronic surface water criteria. Additional details are provided in Attachment 2.

Tyco Fire Products LP (Tyco). 2018b. *Enhanced Monitoring Well Network Evaluation*. Presentation to EPA and WDNR. August 1.

Tyco Fire Products LP (Tyco). 2018c. *2017 Barrier Wall Groundwater Monitoring Annual Report*. June.

U.S. Environmental Protection Agency (EPA). 2009. *Resource Conservation and Recovery Act Administrative Order on Consent, Ansul, Incorporated*. EPA Docket No. RCRA -05-2009- 0007542-S-02-001. February 26.

U.S. Environmental Protection Agency (EPA). 2014. *Agreement on Resolution of 2013 Five Year Technical Issues, Ansul Incorporated Site, Marinette, WI*. RCRA Consent Order No. RCRA-05-2009-007. April 23.

U.S. Environmental Protection Agency (EPA). 2018. Email. September 4.

U.S. Geological Survey (USGS). 2016. *Advanced Methods for Modeling Water-Levels and Estimating Drawdowns with SeriesSEE, an Excel Add-In*. Techniques and Methods 4–F4 Version 1.1, July.

Tables

Table 1-1 (~~Revised~~ Addendum Update). Proposed Schedule for Barrier Wall Effectiveness Evaluation Activities and Reports

Tyco Fire Products LP, Marinette, Wisconsin

Element	Section	Area	Frequency/Timing	Status	Reporting
Barrier Wall Above Water-Line Visual Inspection	2.1	Main Plant Wetlands	Annually each spring ~~and fall~~ Frequency may be adjusted pending results of Barrier Wall Underwater Visual Inspection	Ongoing	Brief email report after each inspection or in Quarterly Report and Annual Inspection Report after fall inspection
Barrier Wall Underwater Visual Inspection	2.1	Main Plant	Once in 2019; subsequent frequency to be determined, but if effective expected to be every 5 years	Scheduled for 2019	2019 Quarterly Report
Barrier Wall Visual Inspection	2.1	Salt Vault 8th Street Slip	~~Each spring and fall until target elevation attained, then~~ Annually in the spring;	Ongoing	Brief email report after ~~each~~ inspection or in Quarterly Report and Annual Inspection Report ~~after fall inspection~~
Barrier Wall Survey	2.1	Main Plant Wetlands Salt Vault 8th Street Slip	~~Each spring:~~ Spring 2019, with subsequent frequency to be determined based on 5 years of data collected	Ongoing	Brief email report after ~~spring~~ inspection or in Quarterly Report and Annual Inspection Report ~~after fall inspection~~
Groundwater Elevation Monitoring	2.2	Main Plant Wetlands River Areas adjacent to Main Plant and Wetlands	~~Transducers will be installed in late summer/fall 2015 after completion of monitoring well installation*~~ For wells analyzed using SeriesSEE, measurements every 15 ~~30~~ minutes from transducers in wells and river downloaded ~~quarterly~~ 3 times per year (measurement frequency may be adjusted in Annual Reports) For wells not analyzed using SeriesSEE, measurements every 60 minutes (per previous EPA approval to change from 30 minutes), downloaded 3 times per year (measurement frequency may be adjusted in Annual Reports). Semiannual manual groundwater head measurements in 2019, then frequency reevaluated.	Ongoing; to be enhanced in 2019 with additional monitoring wells in Main Plant area and analysis of selected wells using SeriesSEE time-series analysis software	Annual Monitoring Report each winter
Groundwater Quality Monitoring - Arsenic	2.3	Main Plant Wetlands Areas adjacent to Main Plant and Wetlands Salt Vault 8th Street Slip	~~Fall 2015*~~ ~~Spring and fall in 2016~~ ~~Annually in 2017 and 2018~~ ~~Re-evaluate frequency in 2018 5 year technical review~~ Semi-Annual in 2019; re-evaluate frequency in Annual Reports	Ongoing	Annual Monitoring Report each winter (in years with sampling)
Groundwater Quality Monitoring - Other Parameters (VOCs)	2.3	Main Plant Wetlands Areas adjacent to Main Plant and Wetlands	~~Fall 2015*~~ ~~As part of annual sampling in 2018~~ ~~Re-evaluate frequency in 2018 5 year technical review~~ Every 5 Years prior to 5 year technical review	Ongoing	~~Annual Monitoring Report each winter~~ Five Year Review Reports
Groundwater Quality Monitoring - Arsenic	2.3	Salt Vault 8th Street Slip	~~Fall 2015*~~ ~~As part of annual sampling in 2018~~ ~~Re-evaluate frequency in 2018 5 year technical review~~ Consistent with 2015 BWGMPU schedule, every 5 Years prior to 5 year technical review (next in 2023)	Ongoing	~~Annual Monitoring Report each winter~~ Five Year Review Reports
Outfall Investigation	2.4	Main Plant	~~Spring 2015 and late summer 2015 initial evaluation~~	Complete. Results submitted 10/30/2015	~~Final report due 45 days after completion of late summer event~~
Outfall Monitoring Plan	2.4	Main Plant	~~TBD~~ Every 5 years prior to 5 year technical review	Improvement plan submitted in 9/7/2016, with response to EPA comments on 11/11/16. Improvements implemented 2016-2018. Follow up sampling occurred in October 2018 after repairs were complete.	
~~Dye Testing Scope of Work (SOW) and Request for Proposal (RFP)~~	~~3~~	~~Main Plant~~	~~Winter 2015/2016~~	Complete; draft submitted 3/30/2016	~~SOW and RFP with contractor/vendor list to Agency. Report to Agency selected contractor prior to initiating work.~~
~~Dye Testing Permitting and Application Fee~~	~~3~~	~~Main Plant~~	~~Submit 60 days prior to anticipated start date~~	Dye Testing component replaced by enhanced groundwater elevation monitoring	~~Permit application and fee~~
~~Dye Testing Investigation Work Start Notification~~		~~Main Plant~~	~~24 hours prior to the start of dye testing~~	Dye Testing component replaced by enhanced groundwater elevation monitoring	~~Tyco shall notify the City of Marinette (Brian Miller, DPW) and WDNR staff (Kristin DuFresne and Cheryl Bougie) to allow for staff notifications in the event dye is released to the Menominee River and inquiries are made from the public~~
~~Dye Testing Investigation~~	~~3~~	~~Main Plant~~	~~2016 (preferably July or August) with river sampling continuing into summer and fall 2016~~	Dye Testing component replaced by enhanced groundwater elevation monitoring	~~Brief report 60 days after completion of testing~~
~~Pump Down Program Drawdown Phase SOW and RFP Provided to Agency and Contractors/Vendors~~	~~4~~	~~Salt Vault~~ ~~8th Street Slip~~	~~Winter 2015/2016~~	Complete; submitted 6/10/2016	~~SOW and RFP with contractor/vendor list to Agency. Report to Agency selected contractor prior to initiating work.~~
Pump Down Program Drawdown Phase	4	Salt Vault 8th Street Slip	~~Anticipated to start in spring~~ Started in June 2016; Target elevation ~~should~~ was to be achieved by December 31, 2017. However, GWCTS testing and limited trucking and receiving of disposal facility in 2017, and 2018 extension of conveyance construction into 2019 has limited operations and required winter shutdown. Therefore have not been able to consistently maintain the target elevation. Groundwater elevation monitoring conducted weekly.	Temporary operations will begin in spring 2019 until the permanent conveyance system is built (currenlty on hold). Water levels will be measured weekly until target elevation is confirmed maintained.	Water elevation data in email updates or Quarterly Reports; Data will also be summarized in Annual Monitoring Report submitted each winter; Email notification when target elevation achieved
Pump Down Program Interim Phase Monitoring	4	Salt Vault 8th Street Slip	Starts if greater than 4 weeks of inactivity; Groundwater elevation monitoring conducted monthly	Ongoing during winter shutdown. Will be complete once permanent system is operational.	Water elevation data in email updates or Quarterly Reports; Data will also be summarized in Annual Monitoring Report submitted each winter; Email notification when target elevation achieved
Pump Down Program Post-Drawdown Phase	4	Salt Vault 8th Street Slip	Following attainment of target elevation; Groundwater elevation monitoring conducted quarterly	Once permanent system is operational	Water elevation data in Quarterly Reports; Data will also be summarized in Annual Monitoring Report submitted each winter; Immediate notification to EPA if target elevation exceeded;
Sediment Monitoring	5	Main River Channel Turning Basin	Summer ~~2018 and~~ 2023; Modifications to sediment sampling may be proposed in 2023 5 year technical review	Ongoing, 2018 complete	~~2018 and~~ 2023 5 year technical review report~~s~~

Notes:* ~~This work will start at the time indicated assuming the revised BWGMP Update is approved in time to allow for all new installations and repairs in 2015~~

Text deletions from 2015 BWGMPU in ~~strikethrough~~. Text additions in underlined red font

Table 2-1 (~~Revised~~ Addendum Update). Proposed Wells and Data Collection for Barrier Wall Monitoring

Tyco Fire Products LP, Marinette, Wisconsin

Well ID	Screened Unit	Proposed Data Collection and Frequency					Rationale for inclusion in Manual Head Measurement	Added to Program at Request of USEPA	New Well Install	Detailed Location Description
		Hydraulic Monitoring to Assess Fluctuations Relative to River, Bedrock and other Areas beyond Containment	BEDROCK Total Arsenic Concentration Trend Monitoring		UNCONSOLIDATED Total Arsenic Concentration Trend Monitoring	Additional Parameter Monitoring (added to program at request of USEPA)	Manual Head Measurements for Gradient and Flow Assessment			
			Leading Edge below Containment	Interior or Upgradient						
MW002S-R	Shallow Alluvial	continuous****					measured as part of pump-down program	Flow direction and water levels along eastern portion of Salt Vault area			Eastern side of Salt Vault
MW003S	Shallow Alluvial	continuous (SeriesSEE)			semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across western VBW in Main Plant area; compare to MW106S			Outside northwest property boundary, outside of Main Plant Area barrier wall
MW009S	Shallow Alluvial						semiannual in 2019 then re-evaluate	Flow direction inside Main Plant Area near western VBW			Western portion of property, inside Main Plant Area
MW012S	Shallow Alluvial						semiannual in 2019 then re-evaluate	Water levels across VBW separating Salt Vault and Main Plant areas; compare to MW001S; flow direction in Main Plant Area			Central portion of property, inside Main Plant Area, south of Salt Vault
MW013S	Shallow Alluvial						semiannual in 2019 then re-evaluate	Water levels upgradient (south) of Main Plant			Southwestern portion of the property, outside barrier wall, background/upgradient
MW021S-R	Shallow Alluvial				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across eastern VBW in Wetlands area; compare to MW101S; flow direction outside VBW		~~X~~**	Outside southern portion of property boundary, outside of Wetlands Area barrier wall
MW022S	Shallow Alluvial						semiannual in 2019 then re-evaluate	Flow direction outside VBW (east of Wetlands)			Southeastern portion of Wetlands Area, upgradient of contained area
MW032S	Shallow Alluvial						semiannual in 2019 then re-evaluate; part of pump-down program interim and drawdown phase measurements	Water levels across VBW separating Salt Vault and Main Plant areas; compare to MW031S; flow direction in eastern Main Plant area			Central portion of property, inside Main Plant, adjacent to Salt Vault
MW040S	Shallow Alluvial	~~continuous~~ (moved to MW003S with agency approval)			semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across western VBW in Main Plant area; compare to MW105S			Southwestern side of Main Plant Area, outside contained area
MW041S	Shallow Alluvial				semiannual in 2019 then re-evaluate	VOCs every 5 years*	semiannual in 2019 then re-evaluate	Flow direction in Main Plant Area near northern VBW (river)			North-central portion of site, within contained area
MW044S	Shallow Alluvial						semiannual in 2019 then re-evaluate	Provide water level/flow direction in middle of Main Plant Area			Central portion of property, inside Main Plant
MW045S	Shallow Alluvial					VOCs every 5 years*	semiannual in 2019 then re-evaluate	Flow direction in Main Plant Area near northern VBW (river)			North-central portion of site, within contained area
MW047S	Shallow Alluvial	continuous			semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across northern and eastern VBW in Wetlands area; compare to MW100S; flow direction in northern Wetlands			Northern portion of Wetlands Area, within contained area
MW048S	Shallow Alluvial	continuous (SeriesSEE); if accessible***					semiannual in 2019 then re-evaluate	Flow direction outside Wetlands area VBW (east of Wetlands)			East of Wetlands Area, outside contained area; accessibility will be evaluated in Spring 2019 and if inaccessible will not be included in monitoring
MW064S	Shallow Alluvial	continuous			semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across southern VBW in Main Plant area; compare to MW102S; flow direction in southern Main Plant area			Southern portion of Main Plant Area, within contained area
MW067S	Shallow Alluvial						semiannual in 2019 then re-evaluate	Flow direction in northwestern Main Plant Area near northern VBW			Western portion of property, inside Main Plant
MW068S	Shallow Alluvial						semiannual in 2019 then re-evaluate	Flow direction in Main Plant area near eastern VBW (river/Turning Basin)			Central portion of property, inside Main Plant
MW100S	Shallow Alluvial	continuous (SeriesSEE)			semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across eastern VBW in Wetlands area; compare to MW047S			Eastern portion of property in Wetlands area, east of contained area
MW101S	Shallow Alluvial				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across eastern Wetlands VBW; compare to MW021S-R; flow direction in southern Wetlands area			Within southern portion of Wetlands area, within contained area
MW102S	Shallow Alluvial	continuous			semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across southern VBW in Main Plant area; compare to MW064S; flow direction outside contained area			Outside southern boundary of barrier wall, upgradient of contained zone
MW103S	Shallow Alluvial				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across southern VBW of Main Plant Area; compare to MW104S; flow direction in southern Main Plant area			South-southwest portion of Main Plant Area, within contained area
MW104S	Shallow Alluvial				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across southern VBW of Main Plant Area; compare to MW103S; flow direction outside contained area			South-southwestern portion of the Main Plant Area, outside contained area
MW105S	Shallow Alluvial	~~continuous~~ (moved to MW106S with agency approval)			semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across western VBW of Main Plant area; compare to MW040S; flow direction in southwestern Main Plant area			Southwestern portion of the Main Plant Area, within contained area
MW106S	Shallow Alluvial	continuous			semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels across western VBW of Main Plant area; compare to MW003S; flow direction in western Main Plant area			Northwestern portion of the Main Plant Area, within contained area
MW107S	Shallow Alluvial	continuous (SeriesSEE)					semiannual in 2019 then re-evaluate	Water levels and flow direction in Main Plant Area near eastern VBW (River)	X	X	North portion of the Main Plant Area, adjacent to river, within contained area
MW108S	Shallow Alluvial	continuous (SeriesSEE)			semiannual in 2019 then re-evaluate	VOCs every 5 years*	semiannual in 2019 then re-evaluate	Water levels and flow direction in Main Plant Area near eastern VBW (River)			Northern portion of the Main Plant Area, within contained area
MW109S	Shallow Alluvial	continuous			semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels and flow direction in Wetlands area near northern VBW (River)			Northwest portion of the Wetlands Area, within contained area
MW115P ~~(in lieu of MW119S)~~	Shallow Alluvial				~~annual*~~ every 5 years (next in 2023)*		~~semiannual in 2019 then re-evaluate;~~ part of pump-down program interim and drawdown phase measurements	Water levels and flow direction in Salt Vault area near northern VBW (River)	X		Salt Vault between EW-13 and EW-14 along the river
MW117S	Shallow Alluvial	continuous (SeriesSEE)			semiannual in 2019 then re-evaluate	VOCs every 5 years*	semiannual in 2019 then re-evaluate	Water levels and flow direction in Main Plant Area near northern VBW (River)		~~X~~	Northern portion of the Main Plant Area, within contained area near river
MW118S	Shallow Alluvial	continuous (SeriesSEE)			semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels and flow direction in Main Plant Area near northern VBW (River)		~~X~~	Northern portion of the Main Plant Area, within contained area near river
MW120S	Shallow Alluvial	continuous****			~~annual*~~ every 5 years (next in 2023)*		measured as part of pump-down program	Water levels and flow direction in 8th Street Slip area, near northern VBW (River)	X	~~X~~	8th Street Slip just inside the tie-backs for the sheet pile wall
MW121S	Shallow Alluvial	continuous (SeriesSEE)					semiannual in 2019 then re-evaluate	Water levels and flow direction in Main Plant Area near northern VBW (River)	X	X	Main Plant area along river
MW122S	Shallow Alluvial	continuous (SeriesSEE)					semiannual in 2019 then re-evaluate	Water levels and flow direction in Main Plant Area near northern VBW (River)	X	X	Main Plant area along river
MW123S	Shallow Alluvial	continuous (SeriesSEE)					semiannual in 2019 then re-evaluate	Water levels and flow direction in Main Plant Area near eastern VBW (River)	X	X	Main Plant area along river
MW124S	Shallow Alluvial	continuous (SeriesSEE)					semiannual in 2019 then re-evaluate	Water levels and flow direction in Main Plant Area near eastern VBW (River)	X	X	Main Plant area along river
MW003M	Till				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across western VBW in Main Plant area; compare to MW106M			Outside northwest property boundary, outside of Main Plant Area barrier wall
MW013M	Till						semiannual in 2019 then re-evaluate	Vertical gradient; Water levels upgradient (south) of Main Plant			Southwestern portion of the property, outside barrier wall, background/upgradient
MW021M	Lacustrine				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across eastern VBW in Wetlands area; compare to MW101M	X		Outside southern portion of property boundary, outside of Wetlands Area barrier wall
MW022M	Lacustrine						semiannual in 2019 then re-evaluate	Vertical gradient; Flow direction outside VBW (east of Wetlands)			Southeastern portion of Wetlands Area, upgradient of contained area
MW040M-R	Till				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across western VBW in Main Plant area			Southwestern side of Main Plant Area, outside of contained area
MW041M	Till				semiannual in 2019 then re-evaluate	VOCs every 5 years*	semiannual in 2019 then re-evaluate	Vertical gradient; Flow direction in Main Plant Area near northern VBW (river)			North-central portion of Main Plant Area, within contained area
MW045M	Till					VOCs every 5 years*	semiannual in 2019 then re-evaluate	Vertical gradient; Flow direction in Main Plant Area near northern VBW (river)			North-central portion of site, within contained area
MW047M	Till				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across northern and eastern VBW in Wetlands area; compare to river and MW100M			Northern portion of Wetlands Area, within contained
MW064M	Lacustrine				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across southern VBW in Main Plant area; compare to MW102M			Southern portion of Main Plant Area, within contained area
MW100M	Lacustrine				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across eastern VBW in Wetlands area; compare to MW047M			Eastern portion of property in Wetlands Area, east of contained area
MW101M	Lacustrine				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across eastern Wetlands VBW; compare to MW021M-R			Within southern portion of Wetlands area, within contained area
MW102M	Lacustrine				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across southern VBW in Main Plant area; compare to MW064M			Outside southern boundary of Main Plant barrier wall, upgradient of contained zone
MW103M	Lacustrine				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across southern VBW of Main Plant Area; compare to MW104M			South-southwest portion of Main Plant Area, within contained area
MW104M	Lacustrine				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across southern VBW of Main Plant Area; compare to MW103M			South-southwestern portion of the Main Plant Area, outside contained area
MW105M	Till				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across western VBW of Main Plant area; compare to MW040M			Southwestern portion of the Main Plant Area, within contained area
MW106M	Till				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels across western VBW of Main Plant area; compare to MW003M			Northwestern portion of the Main Plant Area, within contained area
MW108M	Till				semiannual in 2019 then re-evaluate	VOCs every 5 years*	semiannual in 2019 then re-evaluate	Vertical gradient; Water levels and flow direction in Main Plant Area near eastern VBW (River)			Northern portion of the Main Plant Area, within contained area
MW109M	Lacustrine				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Vertical gradient; Water levels and flow direction in Wetlands area near northern VBW (River)			Northwest portion of the Wetlands Area, within contained area
MW115S ~~(in lieu of MW119M)~~	Lacustrine	continuous****			~~annual*~~ every 5 years (next in 2023)*		measured as part of pump-down program	Water levels and flow direction in Salt Vault area near northern VBW (River)	X		Salt Vault between EW-13 and EW-14 along the river
MW117M	Alluvial/Till				semiannual in 2019 then re-evaluate	VOCs every 5 years*	semiannual in 2019 then re-evaluate	Water levels and vertical gradient in Main Plant Area near northern VBW (River)	X	~~X~~	Northern portion of the Main Plant Area, within contained area near river
MW118M	Alluvial/Till				semiannual in 2019 then re-evaluate		semiannual in 2019 then re-evaluate	Water levels and vertical gradient in Main Plant Area near northern VBW (River)	X	~~X~~	Northern portion of the Main Plant Area, within contained area near river
MW120M	Alluvial/Till				~~annual*~~ every 5 years (next in 2023)*		measured as part of pump-down program	Water levels and vertical gradient in 8th Street Slip area, near northern VBW (River)	X	~~X~~	8th Street Slip just inside the tie-backs for the sheet pile wall
MW003D	Bedrock			semiannual in 2019 then re-evaluate			semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Outside northwest property boundary, outside of Main Plant Area barrier wall
MW013D	Bedrock						semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Southwestern portion of the property, outside barrier wall, background/upgradient

Table 2-1 (~~Revised~~ Addendum Update). Proposed Wells and Data Collection for Barrier Wall Monitoring
Tyco Fire Products LP, Marinette, Wisconsin

Well ID	Screened Unit	Proposed Data Collection and Frequency					Rationale for inclusion in Manual Head Measurement	Added to Program at Request of USEPA	New Well Install	Detailed Location Description
		Hydraulic Monitoring to Assess Fluctuations Relative to River, Bedrock and other Areas beyond Containment	BEDROCK Total Arsenic Concentration Trend Monitoring		UNCONSOLIDATED Total Arsenic Concentration Trend Monitoring	Additional Parameter Monitoring (added to program at request of USEPA)	Manual Head Measurements for Gradient and Flow Assessment			
			Leading Edge below Containment	Interior or Upgradient						
MW040D	Bedrock			semiannual in 2019 then re-evaluate			semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Southwestern side of Main Plant Area, outside of contained area
MW047D	Bedrock	continuous	semiannual in 2019 then re-evaluate				semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Northern portion of Wetlands Area, within contained area
MW064D	Bedrock	continuous		semiannual in 2019 then re-evaluate			semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Southern portion of Main Plant Area, within contained area
MW100D	Bedrock			semiannual in 2019 then re-evaluate			semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Eastern portion of property in Wetlands area, east of contained area
MW102D	Bedrock			semiannual in 2019 then re-evaluate			semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Outside southern boundary of Main Plant barrier wall, outside of contained area
MW105D	Bedrock	~~continuous~~ (moved to MW106D with agency approval)		semiannual in 2019 then re-evaluate			semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Southwestern portion of the Main Plant Area, within contained area
MW106D	Bedrock	continuous		semiannual in 2019 then re-evaluate			semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Northwestern portion of the Main Plant Area, within contained area
MW107D	Bedrock	continuous (SeriesSEE)	semiannual in 2019 then re-evaluate				semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Northern portion of the Main Plant Area, within contained area
MW108D	Bedrock	continuous (SeriesSEE)	semiannual in 2019 then re-evaluate				semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Northern portion of the Main Plant Area, within contained area
MW109D	Bedrock	continuous	semiannual in 2019 then re-evaluate				semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock			Northwest portion of the Wetlands Area, within contained area
MW117D	Bedrock	continuous (SeriesSEE)	semiannual in 2019 then re-evaluate				semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock	X	~~X~~	Northern portion of the Main Plant Area, within contained area near river
MW118D-R*****	Bedrock	continuous (SeriesSEE)	semiannual in 2019 then re-evaluate				semiannual in 2019 then re-evaluate	Groundwater flow direction in bedrock	X	X	Northern portion of the Main Plant Area, within contained area near river
MW119D	Bedrock	continuous****	~~annual*~~ every 5 years (next in 2023)				measured as part of pump-down program	Groundwater flow direction in bedrock	X	~~X~~	Salt Vault between EW-13 and EW-14 along the river
MW120D	Bedrock	continuous****	~~annual*~~ every 5 years (next in 2023)				measured as part of pump-down program	Groundwater flow direction in bedrock	X	~~X~~	8th Street Slip just inside the tie-backs for the sheet pile wall
SG4	River	continuous (SeriesSEE)					semiannual in 2019 then re-evaluate	Hydraulic gradient across VBW			Turning Basin

Notes:
*Baseline event ~~will occur~~ occurred in fall 2015, with ~~additional sampling in 2016, 2017, 2018, and 2023~~ the 5 year events prior to 5 Year Reviews (e.g. in 2023). (Arsenic sampling frequencies were updated for wells in the former Salt Vault and 8th Street Slip areas to reflect that the 2015 Barrier Wall Groundwater Monitoring Plan Update would be sampled annually in 2016, 2017, and 2018 and thereafter prior to every Five Year Review, beginning in 2023)
**MW021S was damaged and ~~will be~~ replaced with a new monitoring well, MW021S-R
*** Accessibility of MW048S (due to potential dense vegetation and river levels) will be determined in 2019
**** These wells are equipped with transducers in the former Salt Vault/8th Street Slip areas to monitor the pump down program and will be evaluated annually to determine whether transducers at these monitoring well locations are still needed.
***** MW118D was damaged and subsequently abandoned in 2018. It was replaced with MW118D-R in June 2019.
Continuous hydraulic monitoring at wells scoped for SeriesSEE analysis will be obtained with a pressure transducer that will record water levels every ~~30~~ 15 minutes (measurement frequency may be changed after 2019) and be downloaded three times a year; manual water levels will be measured at the time of each download; wells requiring SeriesSEE analysis will be re-evaluated annually.
Continuous hydraulic monitoring at other wells scoped will be obtained with a pressure transducer that will record water levels every 60 minutes (previously changed from 30 minutes with agency approval) (measurement frequency may be changed after 2019) and be downloaded three times a year; manual water levels will be measured at the time of each download; wells in program will be re-evaluated annually
Semiannual arsenic monitoring will be conducted through 2019. Frequency will be re-evaluated in annual reports.
Wells in and near the Salt Vault and 8th Street Slip that are part of all phases of the pump down program will have water levels measured contemporaneously with the sitewide synoptic survey. Wells that are only part of the pump down program interim and drawdown phase will only be measured contemporaneously with the sitewide synoptic survey during those phases. See Table 4-1 for these wells.
Wells in manual head measurement program will be re-evaluated annually.
VOCs - Volatile organic compounds; VBW - vertical barrier wall
USEPA - U.S. Environmental Protection Agency
Text deletions from 2015 BWGMPU in ~~strikethrough~~. Text additions in red font.

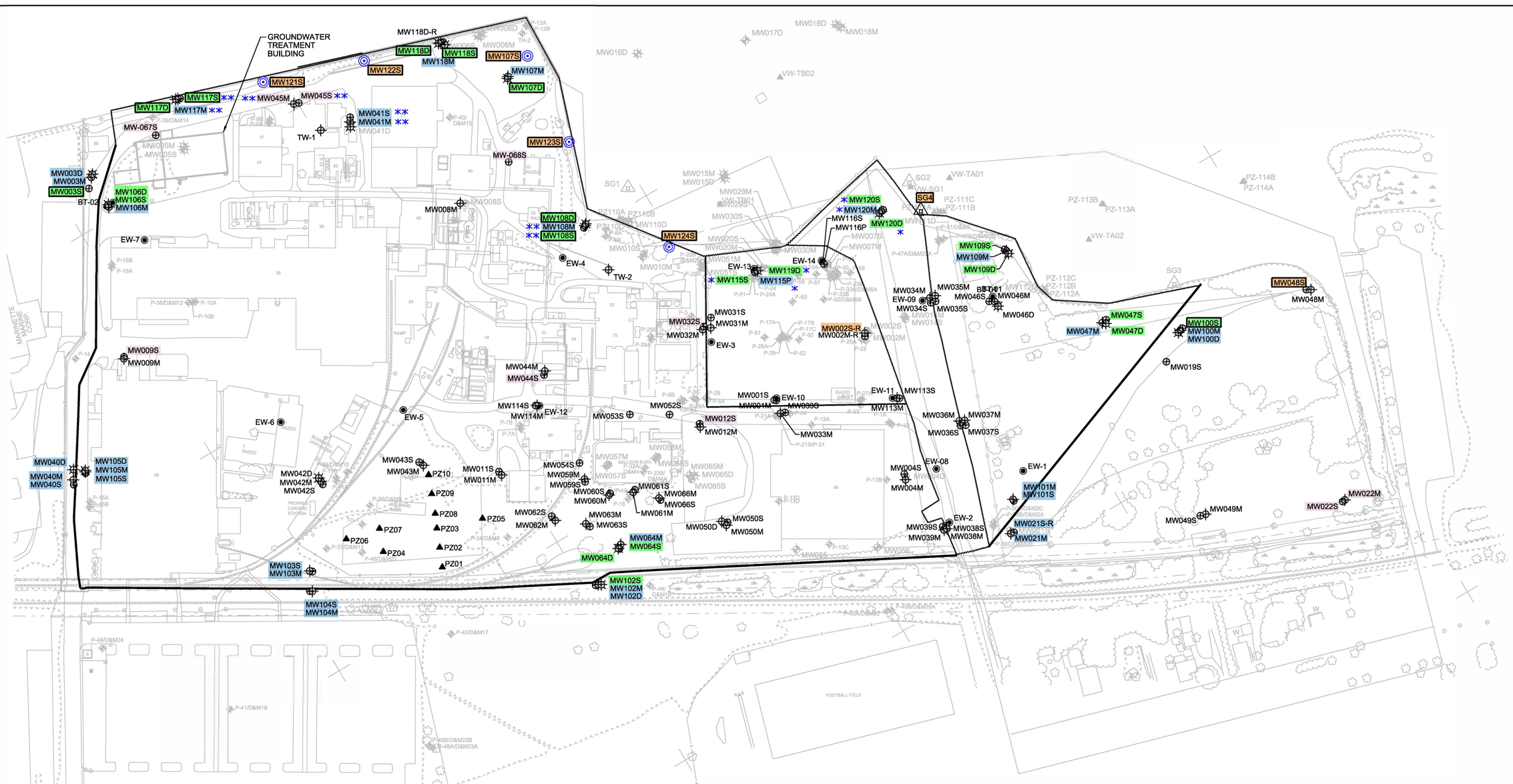
Table 4-1 (~~Revised~~ Addendum Update). Proposed Wells for Groundwater Elevation Monitoring at the Former Salt Vault and 8th Street Slip
Tyco Fire Products LP
Marinette, Wisconsin

Well ID	Screened Interval	Site Location	Use to Calculate Target Elevation*	Drawdown Phase	Interim Phase	Post-Drawdown Phase	Rationale/Notes
MW001S	Shallow alluvial	Salt Vault	x	x	x	x	Water levels in southern portion of Salt Vault; compare to MW033S
MW001M	Lacustrine	Salt Vault	x	x	x	x	Water levels in southern portion of Salt Vault
MW002S	Shallow alluvial	Salt Vault	x	x	x	x	Transducer; Water levels in eastern portion of Salt Vault
MW002M	Lacustrine	Salt Vault	x	x	x	x	Water levels in eastern portion of Salt Vault
MW031S	Shallow alluvial	Salt Vault	x	x	x	x	Water levels in western portion of Salt Vault; compare to MW032S
MW031M	Lacustrine	Salt Vault	x	x	x	x	Water levels in western portion of Salt Vault; compare to MW032S
MW113S	Shallow alluvial	Salt Vault	x	x	x	x	Water levels in southeastern portion of Salt Vault
MW113M	Lacustrine	Salt Vault	x	x	x	x	Water levels in southeastern portion of Salt Vault
MW115S	Shallow alluvial	Salt Vault	x	x	x	x	Transducer; water levels in northern portion of Salt Vault
MW116S	Shallow alluvial	Salt Vault	x	x	x	x	Well condition being assessed; may use MW116P instead
MW115P	Peat	Salt Vault		x	x	x	Record response of perched water above peat layer in northern Salt Vault
MW116P	Peat	Salt Vault		x	x	x	Record response of perched water above peat layer in northeastern Salt Vault
MW032S	Shallow alluvial	Main Plant		x	x		Water levels in eastern portion of Main Plant Area; Comparison to MW031S elevation
MW033S	Shallow alluvial	Main Plant		x	x		Water levels in eastern Main Plant Area, just south of Salt Vault; Comparison to MW001S elevation
MW034S	Shallow alluvial	8th Street Slip	x	x	x	x	Water levels in eastern portion of Salt Vault; Comparison to MW031S elevation
MW034M	Lacustrine	8th Street Slip	x	x	x	x	Water levels in eastern portion of Salt Vault
MW036S	Shallow alluvial	8th Street Slip	x	x	x	x	Water levels in eastern portion of Salt Vault; Comparison to MW037S elevation
MW036M	Lacustrine	8th Street Slip	x	x	x	x	Water levels in eastern portion of Salt Vault
MW038S	Shallow alluvial	8th Street Slip	x	x	x	x	Water levels in southwestern portion of 8th Street Slip; Comparison to MW039S
MW038M	Lacustrine	8th Street Slip	x	x	x	x	Water levels in southwestern portion of 8th Street Slip
MW120S	Shallow alluvial	8th Street Slip	x	x	x	x	Transducer; Newly installed well; water levels in northern portion of 8th Street Slip
MW120M	Lacustrine/Till	8th Street Slip	x	x	x	x	Newly installed well; water levels in northern portion of 8th Street Slip
MW004S	Shallow alluvial	Main Plant		x	x		Water levels in eastern Main Plant Area; Comparison to MW038S
MW035S	Shallow alluvial	Wetlands		x	x		Water levels in western portion of Wetlands; Comparison to MW034S
MW037S	Shallow alluvial	Wetlands		x	x		Water levels in western portion of Wetlands; Comparison to MW036S
MW039S	Shallow alluvial	Main Plant		x	x		Water levels in eastern portion of Main Plant area; Comparison to MW038S
Staff Gauge	River	River		x	x	x	Transducer measurements of river elevation for comparison to Salt Vault and 8th Street Slip groundwater elevations

Notes:
ID - Identification
*Wells identified for target elevation calculation are for during the drawdown and interim phases. Only wells outside the steepest portion of the cone of depression will be included in the calculation of the average elevations. The average elevation of all suitable measured wells will be considered the calculated elevation to compare against the target elevation. The number of post-drawdown phase wells used for this calculation may be reduced and will be determined based on results observed during the drawdown phase.

Text deletions from 2015 BWGMPU in ~~strikethrough~~. Text additions in red font.

Figures



NOTES:

1. TRANSDUCERS IN MW040S, MW105S, AND MW105D WERE MOVED, PER AGENCY APPROVAL, TO MW003S, MW106S, AND MW106D.
2. ACCESSIBILITY OF MW048S WILL BE EVALUATED IN SPRING 2019.
3. EXCEPT FOR THE SALT VAULT AND 8TH STREET SLIP, ARSENIC SAMPLING WILL BE CONDUCTED SEMI-ANNUALLY IN 2019 AND FREQUENCY RE-EVALUATED IN ANNUAL REPORTS. ARSENIC SAMPLING IN THE SALT VAULT AND 8TH STREET SLIP WILL BE CONDUCTED EVERY 5 YEARS, WITH THE NEXT EVENT IN 2023.
4. MW002S, MW115S, MW119D, MW120S, AND MW120D ARE EQUIPPED WITH TRANSDUCERS IN THE FORMER SALT VAULT/8TH STREET SLIP AREAS TO MONITOR THE PUMP DOWN PROGRAM AND WILL BE EVALUATED ANNUALLY TO DETERMINE WHETHER TRANSDUCERS AT THESE MONITORING WELL LOCATIONS ARE STILL NEEDED.
5. SEE FIGURE 4-1 OF 2015 BWGMPU FOR WELL LOCATIONS MONITORED AS PART OF PUMP DOWN PROGRAM.

LEGEND

- EW-5 OR BT-02 — EXTRACTION WELL OR TEST WELL
- MW002S OR MW115P — MONITORING WELL - SHALLOW OR PEAT
- MW002M — MONITORING WELL - MEDIUM
- MW002D — MONITORING WELL - DEEP (BEDROCK)
- PZ04 — PIEZOMETER
- VW-TB01 — VIBRATING WIRE PIEZOMETER
- SG1 — STAFF GAUGE
- WELLS PREVIOUSLY ABANDONED OR DESTROYED
- INSTALLED NEW MONITORING WELL
- SHEET PILE WALL
- SLURRY WALL
- * — ARSENIC SAMPLING EVERY 5 YEARS
- ** — VOC SAMPLING EVERY 5 YEARS

- ARSENIC SAMPLING LOCATION AND MANUAL WATER LEVEL MEASUREMENT
- TRANSDUCER GROUNDWATER ELEVATION MEASUREMENT LOCATION AND ARSENIC SAMPLING LOCATION
- BOX AROUND HIGHLIGHTING INDICATES TRANSDUCER DATA WILL BE ANALYZED USING SERIES SEE
- TRANSDUCER WATER LEVEL MEASUREMENT AND MANUAL WATER ELEVATION MEASUREMENT AT TIME OF ARSENIC SAMPLING
- MANUAL GROUNDWATER ELEVATION MEASUREMENT ONLY AT TIME OF ARSENIC SAMPLING EVENTS

N

0 100 200 300

SCALE IN FEET

FIGURE 2-1 (ADDENDUM UPDATE)
PROPOSED GROUNDWATER ELEVATION AND TOTAL ARSENIC MONITORING WELLS

TYCO FIRE PRODUCTS LP
MARINETTE, WISCONSIN

JACOBS

FILENAME: PGETAMW_704683.dgn PLOT DATE: 2019\06\21 PLOT TIME: 7:50:16 AM

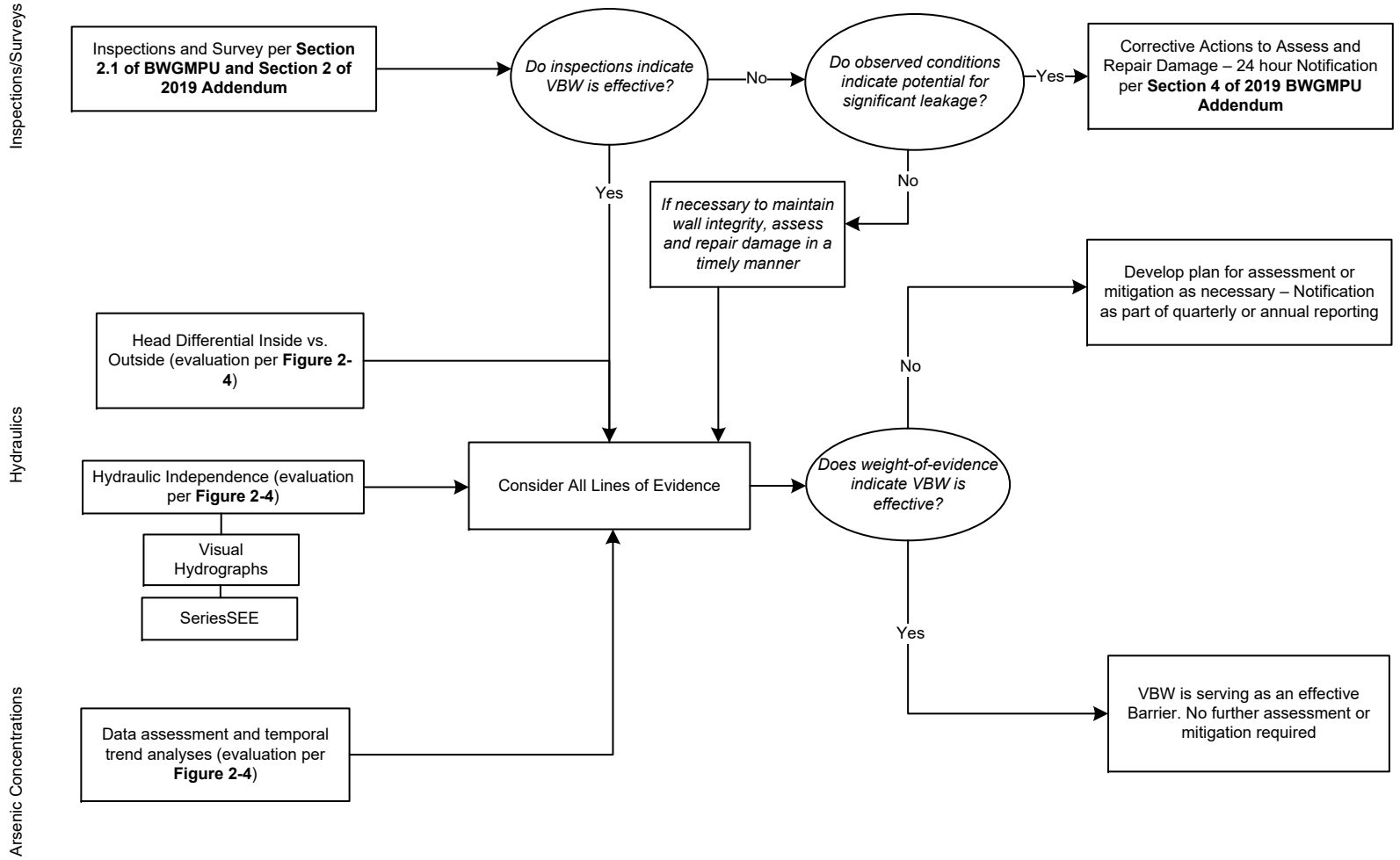


Figure 2-3. (Addendum Update) Vertical Barrier Wall Overall Effectiveness Evaluation Flow Chart
Tyco Fire Products LP Facility, Marinette, WI

BWGMPU – Barrier Wall Groundwater Monitoring Plan Updated
VBW – Vertical Barrier Wall

JACOBS

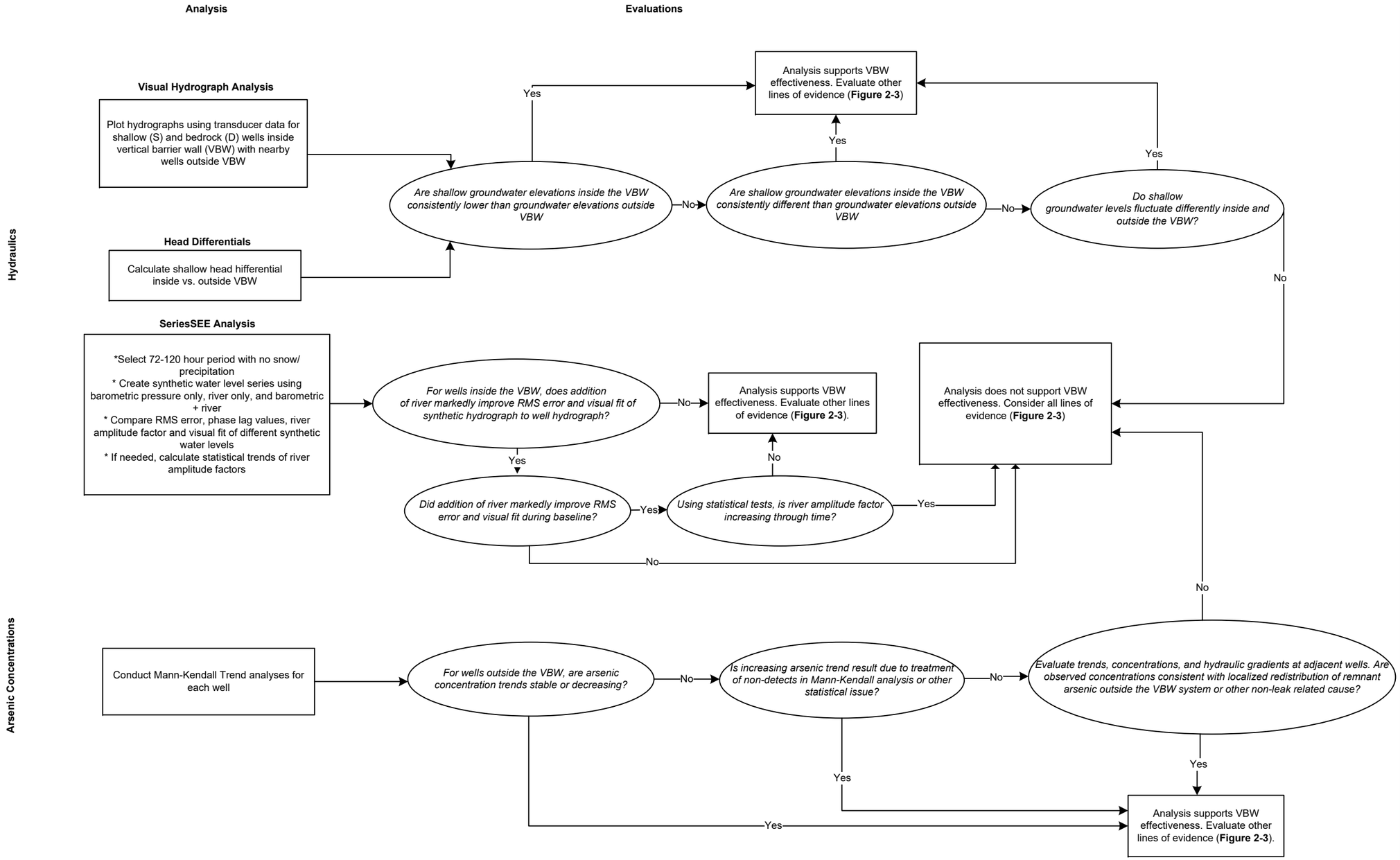
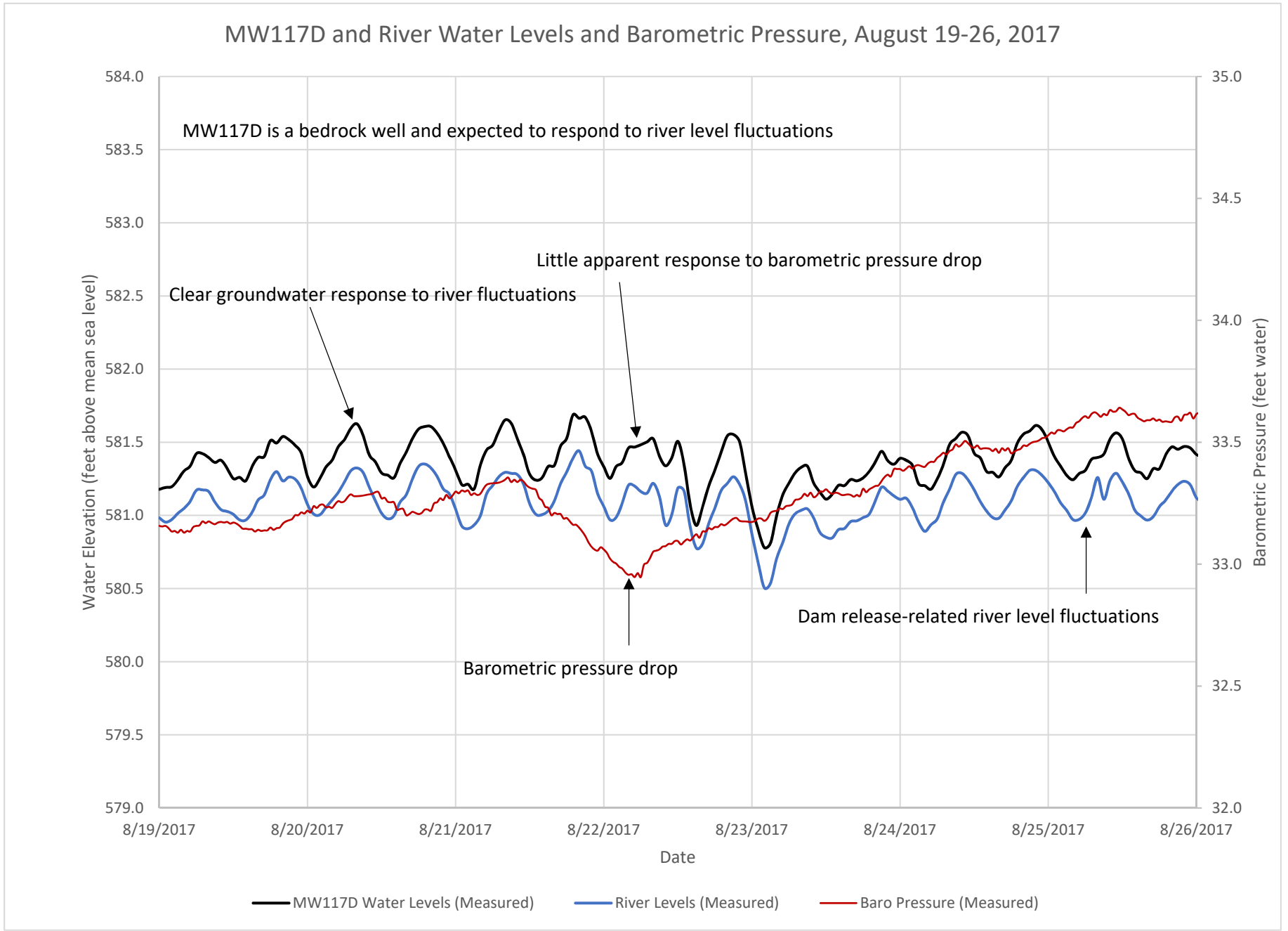


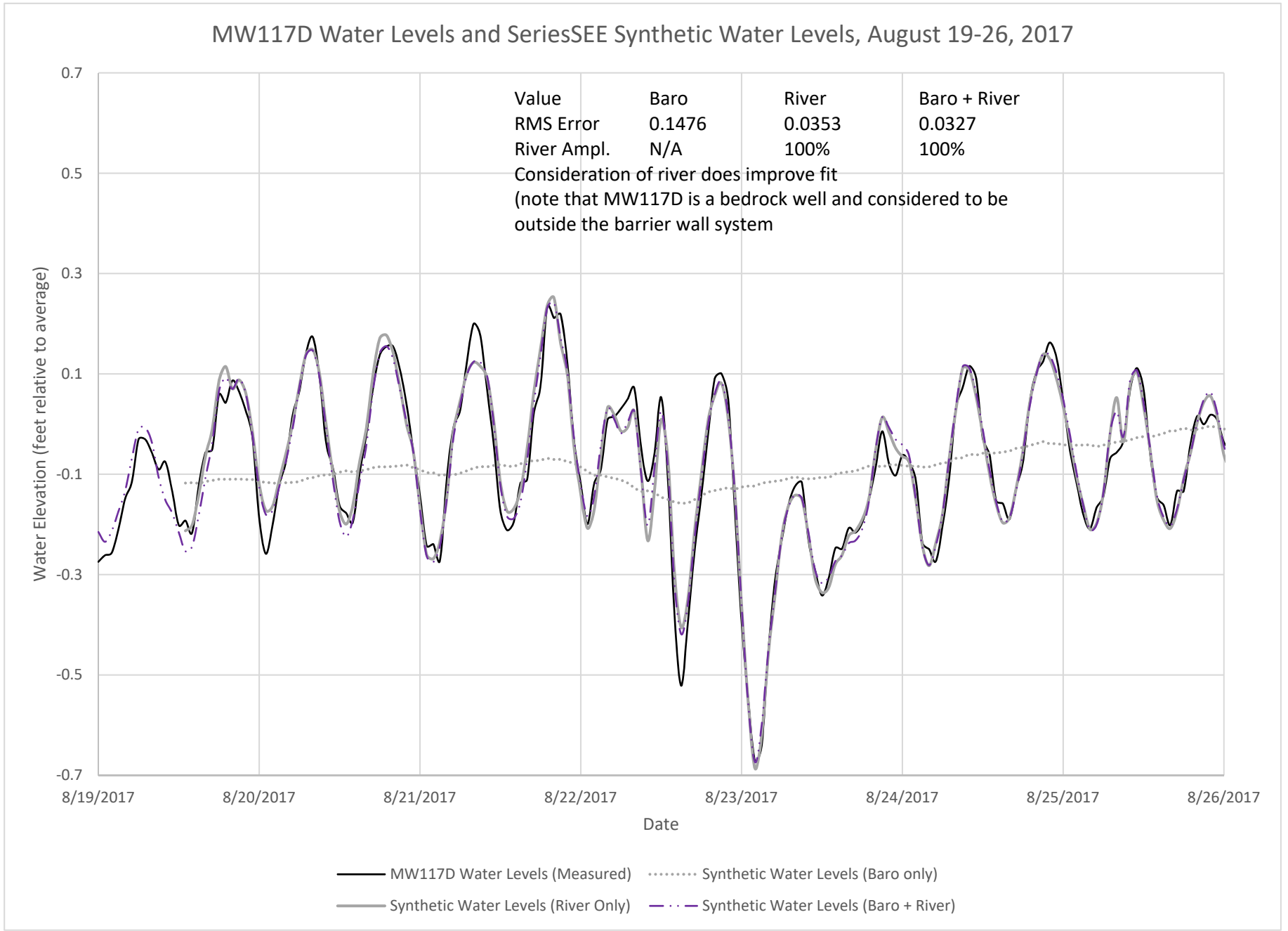
Figure 2-4. Vertical Barrier Wall Technical Evaluations Flow Chart
Tyco Fire Products LP Facility, Marinette, WI

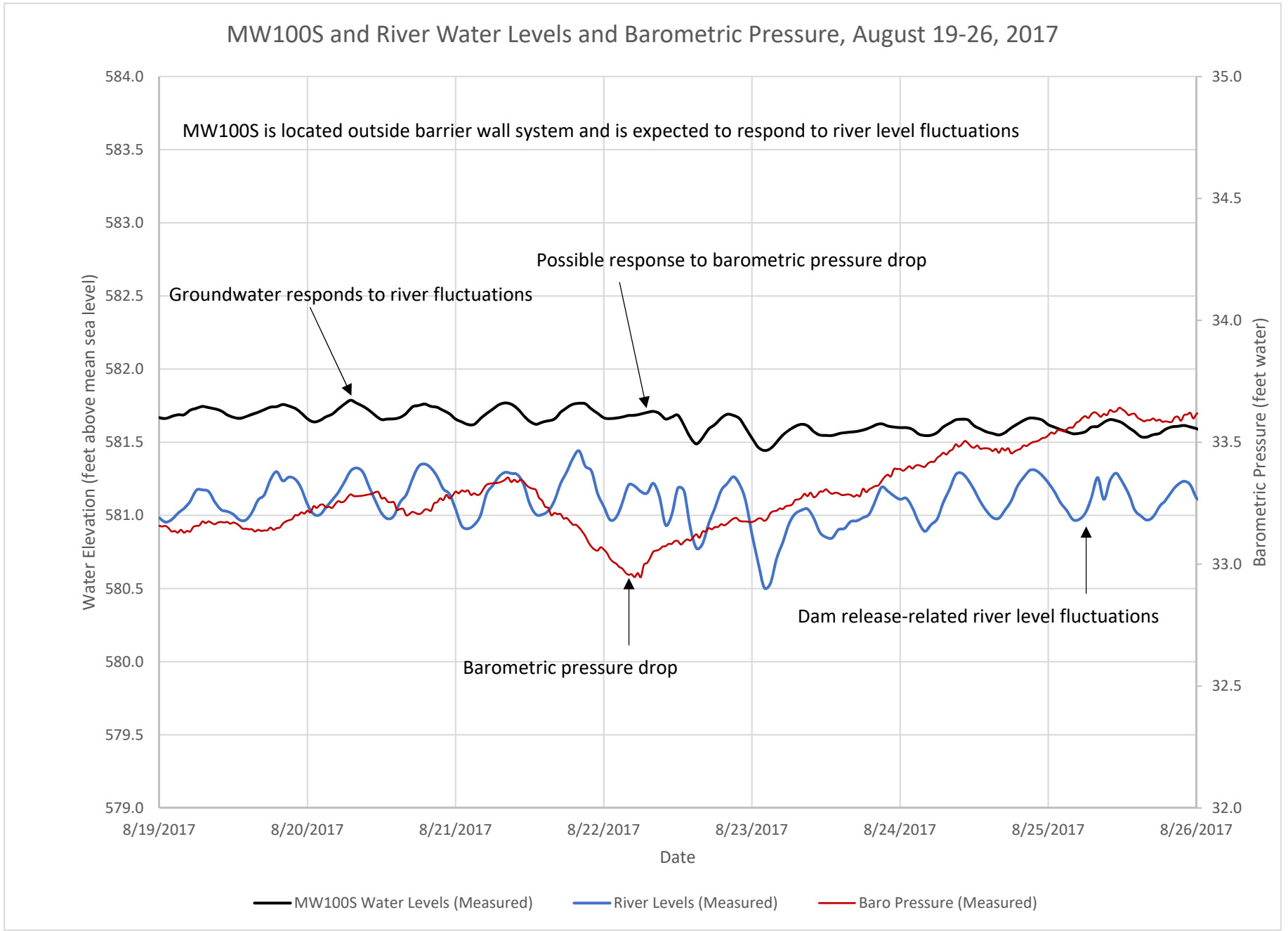
BWGMPU – Barrier Wall Groundwater Monitoring Plan Updated
VBW – Vertical Barrier Wall

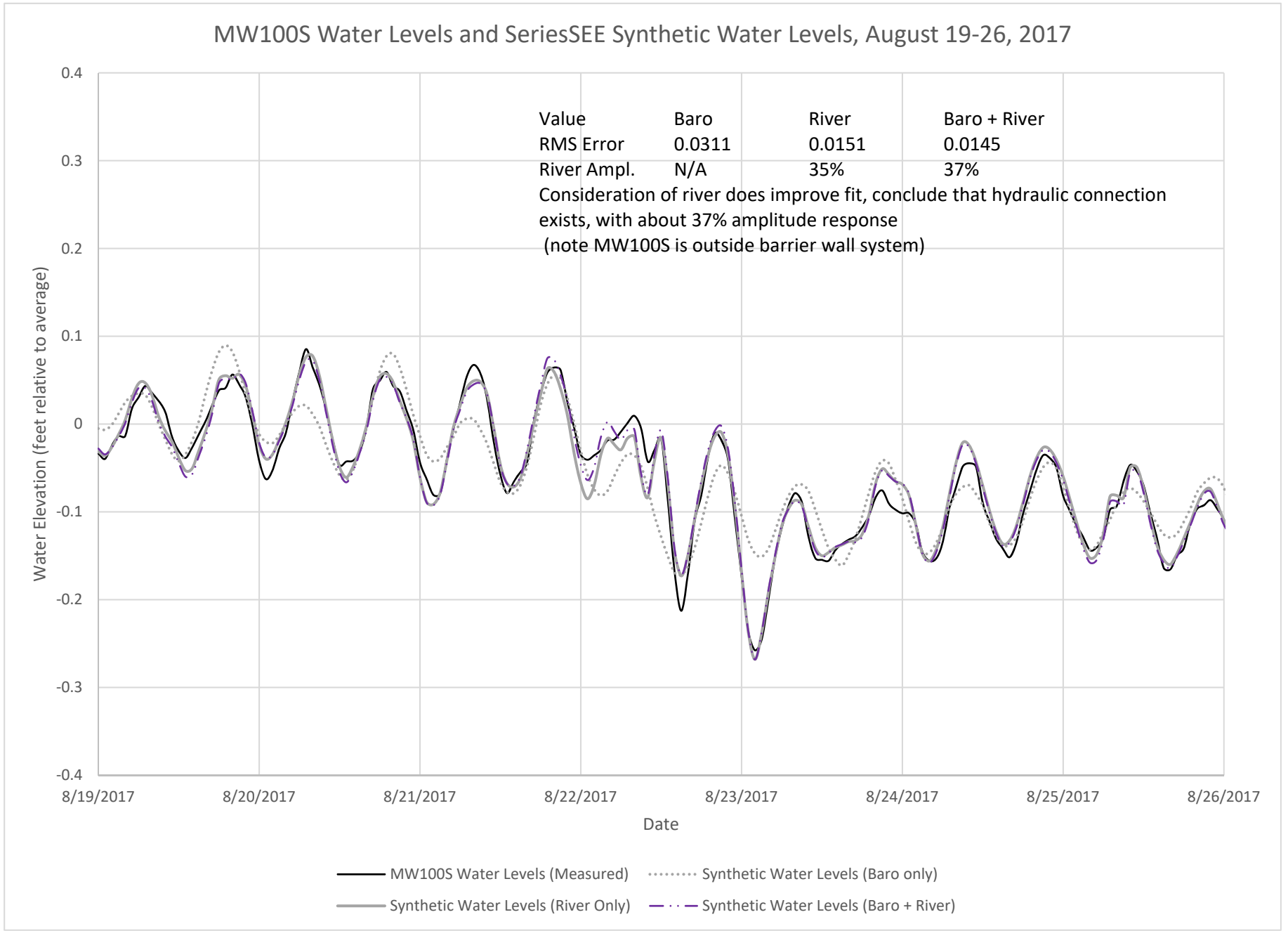
JACOBS

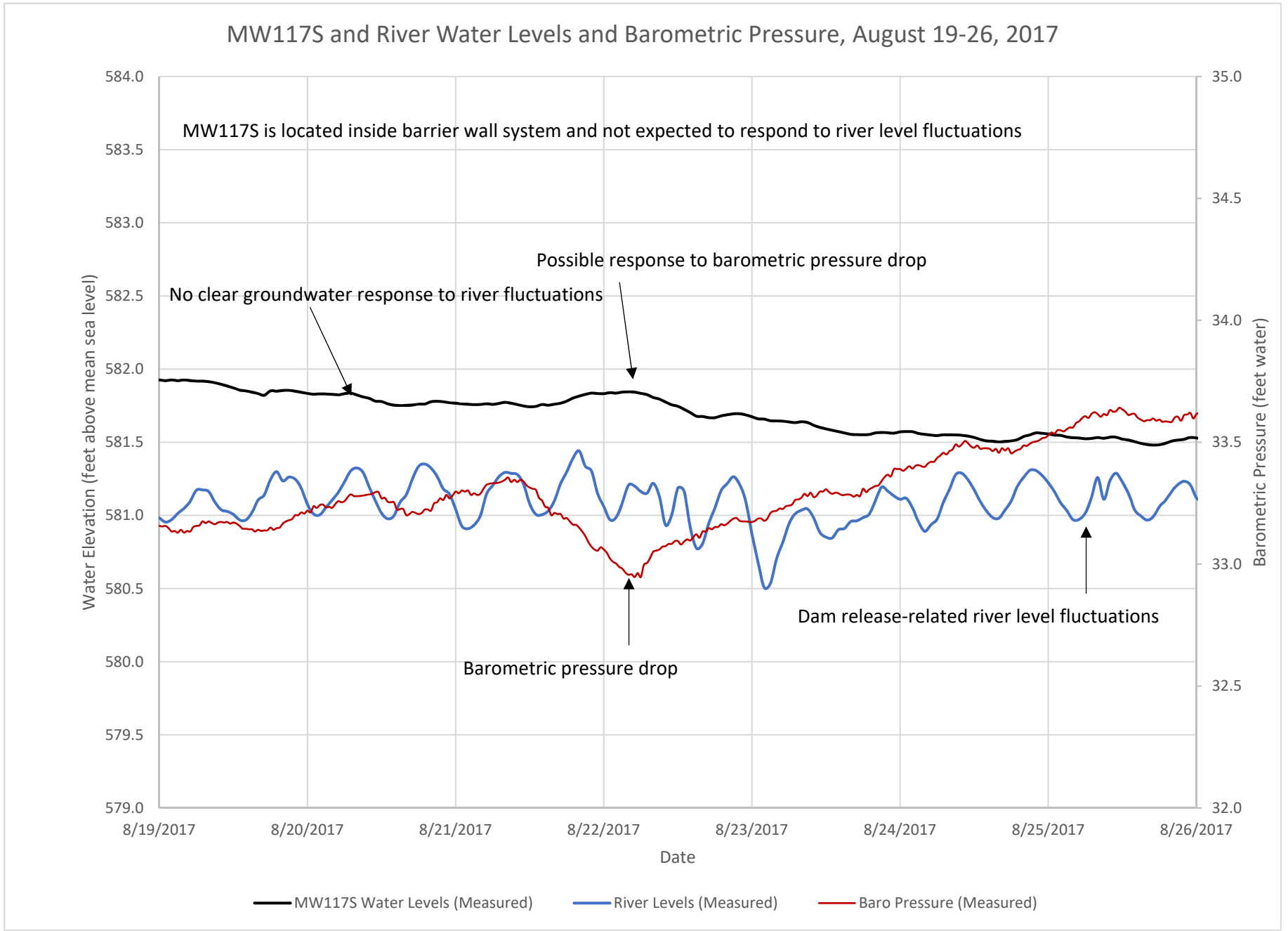
Attachment 1

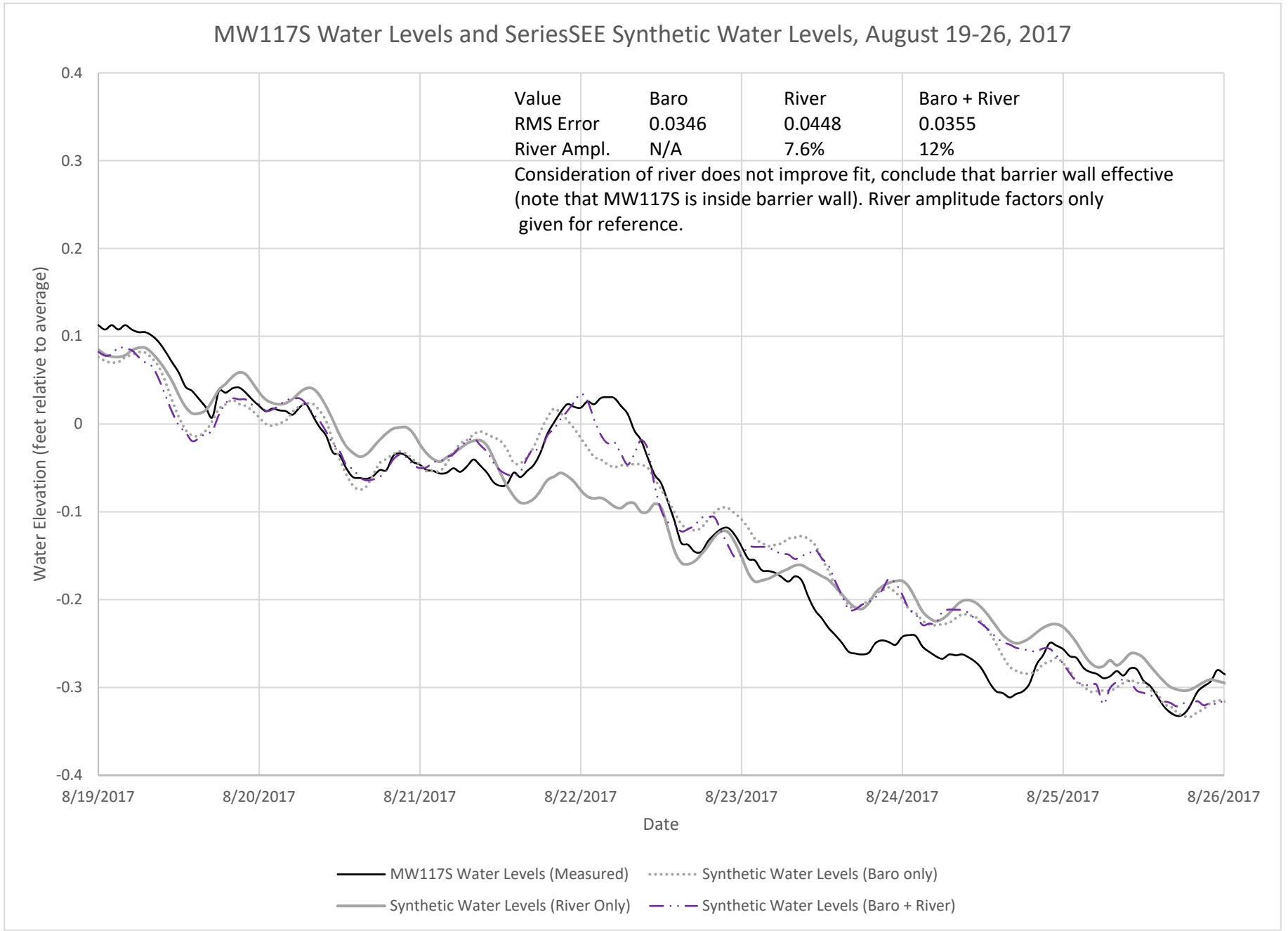

MW117D and River Water Levels and Barometric Pressure, August 19-26, 2017
MW117D is a bedrock well and expected to respond to river level fluctuations
Clear groundwater response to river fluctuations
Little apparent response to barometric pressure drop
Barometric pressure drop
Dam release-related river level fluctuations
Water Elevation (feet above mean sea level)
Barometric Pressure (feet water)
Date
584.0
583.5
583.0
582.5
582.0
581.5
581.0
580.5
580.0
579.5
579.0
35.0
34.5
34.0
33.5
33.0
32.5
32.0
8/19/2017
8/20/2017
8/21/2017
8/22/2017
8/23/2017
8/24/2017
8/25/2017
8/26/2017
MW117D Water Levels (Measured)
River Levels (Measured)
Baro Pressure (Measured)


MW117D Water Levels and SeriesSEE Synthetic Water Levels, August 19-26, 2017
Value Baro River Baro + River
RMS Error 0.1476 0.0353 0.0327
River Ampl. N/A 100% 100%
Consideration of river does improve fit
(note that MW117D is a bedrock well and considered to be outside the barrier wall system
Water Elevation (feet relative to average)
0.7
0.5
0.3
0.1
-0.1
-0.3
-0.5
-0.7
8/19/2017
8/20/2017
8/21/2017
8/22/2017
8/23/2017
8/24/2017
8/25/2017
8/26/2017
Date
MW117D Water Levels (Measured)
Synthetic Water Levels (Baro only)
Synthetic Water Levels (River Only)
Synthetic Water Levels (Baro + River)


MW100S and River Water Levels and Barometric Pressure, August 19-26, 2017
MW100S is located outside barrier wall system and is expected to respond to river level fluctuations
Groundwater responds to river fluctuations
Possible response to barometric pressure drop
Barometric pressure drop
Dam release-related river level fluctuations
Water Elevation (feet above mean sea level)
Barometric Pressure (feet water)
Date
584.0
583.5
583.0
582.5
582.0
581.5
581.0
580.5
580.0
579.5
579.0
35.0
34.5
34.0
33.5
33.0
32.5
32.0
8/19/2017
8/20/2017
8/21/2017
8/22/2017
8/23/2017
8/24/2017
8/25/2017
8/26/2017
MW100S Water Levels (Measured)
River Levels (Measured)
Baro Pressure (Measured)


MW100S Water Levels and SeriesSEE Synthetic Water Levels, August 19-26, 2017
Value Baro River Baro + River
RMS Error 0.0311 0.0151 0.0145
River Ampl. N/A 35% 37%
Consideration of river does improve fit, conclude that hydraulic connection exists, with about 37% amplitude response
(note MW100S is outside barrier wall system)
Water Elevation (feet relative to average)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
8/19/2017
8/20/2017
8/21/2017
8/22/2017
8/23/2017
8/24/2017
8/25/2017
8/26/2017
Date
MW100S Water Levels (Measured)
Synthetic Water Levels (Baro only)
Synthetic Water Levels (River Only)
Synthetic Water Levels (Baro + River)


MW117S and River Water Levels and Barometric Pressure, August 19-26, 2017
MW117S is located inside barrier wall system and not expected to respond to river level fluctuations
No clear groundwater response to river fluctuations
Possible response to barometric pressure drop
Barometric pressure drop
Dam release-related river level fluctuations
Water Elevation (feet above mean sea level)
Barometric Pressure (feet water)
Date
584.0
583.5
583.0
582.5
582.0
581.5
581.0
580.5
580.0
579.5
579.0
35.0
34.5
34.0
33.5
33.0
32.5
32.0
8/19/2017
8/20/2017
8/21/2017
8/22/2017
8/23/2017
8/24/2017
8/25/2017
8/26/2017
MW117S Water Levels (Measured)
River Levels (Measured)
Baro Pressure (Measured)


MW117S Water Levels and SeriesSEE Synthetic Water Levels, August 19-26, 2017
Value Baro River Baro + River
RMS Error 0.0346 0.0448 0.0355
River Ampl. N/A 7.6% 12%
Consideration of river does not improve fit, conclude that barrier wall effective (note that MW117S is inside barrier wall). River amplitude factors only given for reference.
Water Elevation (feet relative to average)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
8/19/2017
8/20/2017
8/21/2017
8/22/2017
8/23/2017
8/24/2017
8/25/2017
8/26/2017
Date
MW117S Water Levels (Measured)
Synthetic Water Levels (Baro only)
Synthetic Water Levels (River Only)
Synthetic Water Levels (Baro + River)

Attachment 2

JACOBS®

Attachment 2

1610 N. 2nd Street, Suite 201
Miwaukee, Wisconsin 53212
United States
T +1.414.272.2426
F +1.414.272.4408
www.jacobs.com

Subject	**Attachment 2: Calculation of arsenic concentrations in surface water based on different potential groundwater seepage rates**
Project Name	Tyco Fire Products LP, Marinette, Wisconsin
Attention	Tyco Fire Products LP
From	Jacobs Engineering Group Inc.
Date	June 2019
Copies to	U.S. Environmental Protection Agency Wisconsin Department of Natural Resources
Document Control No.	704683CH.264

Per Figure 2-3 of the *Addendum to 2015 Barrier Wall Groundwater Monitoring Plan Update*, a significant leak will require notification to the U.S. Environmental Protection Agency (EPA) within 24 hours. In the March 25, 2019 response to comments, EPA Comment 13 regarding Figure 2-3 requested "[s]pecify what conditions would need to be observed to indicate the potential for significant leakage. List all possible conditions and include them in this addendum." At the May 13, 2019 meeting, Tyco Fire Products LP (Tyco) presented information, based on previous groundwater flow modeling, that a 1 gallon per minute (gpm) observed leak rate, 6-square-foot defect, or a defect affecting an entire seam would qualify as a significant leak. Based on discussion at the meeting, it was agreed that Tyco would review information from the pilot dye test to assess the potential effect of various wall leakage rates on arsenic concentrations in surface water in reference to the Wisconsin chronic and acute surface water criteria.

Effect of different hypothetical wall leakage rates on surface water arsenic concentrations

River velocity information from the 2017 pilot dye test was used to calculate expected surface water concentrations given a variety of groundwater leakage rates. Surface water concentrations were estimated using the equation:

$$C_{river} = \frac{Q_{sw} * C_{sw} + Q_{gw} * C_{gw}}{Q_{sw} + Q_{gw}}$$

where,

C_{river} = Concentration in river (micrograms/liter; µg/L)
Q_{sw} = Upstream surface water discharge (cubic feet per second)
C_{sw} = Concentration in upstream surface water (µg/L)
Q_{gw} = Groundwater discharge (cubic feet per second)
C_{gw} = Concentration in groundwater (µg/L)

Upstream surface water discharge was calculated using the following formula:

$$Q_{sw} = A * V$$

where,

A = Area (square feet)
V = Velocity (feet per second)

The area was calculated using a depth of 18 feet and a width (perpendicular to wall) of 1 foot. Along the Main Channel, the average river velocity in Test 2 was 0.47 foot per second, and in Test 3, it was 0.27 foot per second; the result from Test 3 was used as a conservative velocity. Along the Turning Basin, the average river velocity in Test 3 was 0.03 foot per second.

Surface water arsenic concentrations collected from an upgradient location in June, September, and November 2017 were used to calculate an average upstream C_{sw} of 0.95 micrograms per liter (µg/L). The 2018 groundwater arsenic concentrations from wells adjacent to the barrier wall were used to calculate ranges of C_{river} for the river for hypothetical groundwater leaks ranging from 0.1 to 10 gpm. Additionally, the theoretical leakage rate needed to exceed the surface water criteria was calculated for both the Main Channel and the Turning Basin. A weighted-average arsenic groundwater concentration of 22,125 µg/L was calculated using 2018 arsenic sampling data from wells adjacent to the river and used in the calculations.

The estimated surface water concentrations were compared to the warm-water Wisconsin surface water chronic criteria of 152.2 µg/L and acute criteria of 339.8 µg/L. As shown in Table 1,

- In the Main Channel, the estimated average arsenic concentration within 1 foot of the wall would be 11 µg/L for a 1 gpm leak. A leak of 15 gpm would be required to exceed the chronic criteria, while a leak of at least 34 gpm would be required to exceed the acute criteria.
- In the lower velocity Turning basin, the estimated average arsenic concentration within 1 foot of the wall would be 87 µg/L for a 1 gpm leak. A leak of 1.8 gpm would be required to exceed the chronic criteria and 4 gpm to exceed the acute criteria.

Conclusion

Based on this information, it appears that selecting a significant leakage value of 1 gpm is protective of surface water.

Table

Attachment 2, Table 1

Calculated arsenic concentrations in surface water for different groundwater seepage rates

Location	Area-Weighted Average Groundwater Arsenic Concentration (µg/L)	River Cross-Sectional Area (ft^2)	River Velocity (ft/sec)	River Flow Rate (gpm)	River Background Arsenic Concentration (µg/L)	Calculated arsenic concentration in river adjacent to wall for different groundwater seepage rates (µg/L)							Required groundwater seepage rate (gpm) to exceed surface water criteria for arsenic	
						0.1 gpm	0.2 gpm	0.5 gpm	1.0 gpm	2.0 gpm	5.0 gpm	10.0 gpm	Chronic (152.2 µg/L)	Acute (339.8 µg/L)
Main Channel	22,125	18	0.27	2,177	0.9	1.9	3	6	11	21	52	102	15	34
Turning Basin	22,125	18	0.03	256	0.9	9.5	18	44	87	**172**	**425**	**832**	1.8	4.0

Bold groundwater concentrations indicate chronic criteria of 152.2 ug/L exceeded
Underlined groundwater concentrations indicate acute criteria of 339.8 ug/L exceeded
µg/L - micrograms per liter
ft - feet
gpm - gallons per minute
sec - second
Groundwater arsenic concentration is weighted-average groundwater concentration from 2018 sampling
Background surface water concentration is average of 3 rounds of 2017 surface water sampling