



REMEDIAL ACTION IMPLEMENTATION REPORT

**JAGEMANN PLATING
1324 S. 26TH STREET
MANITOWOC, WISCONSIN
BRRTS# 02-36-555544**

January 5, 2023

Prepared For:

Mike Jagemann
Jagemann Plating Co., Inc.
1324 S. 26th Street
Manitowoc, WI 54224

Prepared By:

EnviroForensics, LLC
N16 W23390 Stone Ridge Drive, Suite G
Waukesha, WI 53188
Phone: (262) 290-4001
www.enviroforensics.com

Handwritten signature of Brian Kappen in blue ink.

Brian Kappen, PG
Senior Geologist

Handwritten signature of R. Scott Powell in blue ink.

R. Scott Powell, PE, LPG
Senior Engineer

TABLE OF CONTENTS

1.0	INTRODUCTION.....	1
1.1	Site Hydrogeology.....	1
1.2	Nature and Extent of Groundwater Impacts.....	2
1.3	Remediation Objective.....	2
2.0	GROUNDWATER REMEDIAL INJECTIONS	3
2.1	Permitting.....	3
2.2	Treatment Zone.....	3
2.3	Amendments and Dosing.....	3
2.4	Injection Activities.....	4
3.0	PERFORMANCE MONITORING AND REPORTING	6

FIGURES

1	Detailed Site Map
2	Isoconcentrations of TCE in Soil
3	Isoconcentrations of TCE in Groundwater
4	Injection Point Layout
5	Monitoring Well Locations

TABLES

1	Remediation Performance Monitoring Program
---	--

APPENDICES

A	Injection Summary Log
B	Photographs

CERTIFICATIONS

I, R. Scott Powell, hereby certify that I am a registered professional engineer in the State of Wisconsin, registered in accordance with the requirements of ch. A-E 4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch. A-E 8, Wis. Adm. Code; and that, to the best of my knowledge, all information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code.



R. Scott Powell, Senior Engineer, E-49589-6

Signature, Title, and P.E. No.



P.E. stamp

I, Brian Kappen, hereby certify that I am a hydrogeologist as that term is defined in s. NR 712.03 (1), Wis. Adm. Code, am registered in accordance with the requirements of ch. GHSS 2, Wis. Adm. Code, or licensed in accordance with the requirements of ch. GHSS 3, Wis. Adm. Code, and that, to the best of my knowledge, all of the information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code.



Senior Geologist

Signature and Title

1/5/2023

Date

Document Reference:

Remedial Action Implementation Report
Jagemann Plating
1324 S. 26th Street
Manitowoc, Wisconsin
BRRTS# 02-36-555544

1.0 INTRODUCTION

EnviroForensics, LLC (EnviroForensics) has prepared this *Remedial Action Implementation Report* on behalf of Jagemann Plating Co., Inc. (Jagemann) for the facility located at 1324 S. 26th Street, Manitowoc, Wisconsin (Site). This report meets the guidelines for documentation of remedial actions set forth in Wisconsin Administrative Code Chapter NR 724 and follows the *Remedial Action Design Report* dated November 10, 2022.

The Site encompasses approximately 4.58 acres between S. 26th Street to the east and Wisconsin Central Ltd. railroad to the west. Improvements include several connected industrial buildings and paved driveway, parking, and loading areas. The general layout of the Site, including Site features, and the surrounding area, is depicted on **Figure 1**. The

The data collected during the site investigation indicate that soil, groundwater, and soil vapor at the Site contain impacts as a result of historic releases of chlorinated solvents and plating solution that occurred during past operations. The primary contaminants of concern at the Site are chlorinated volatile organic compounds (CVOCs) including trichloroethene (TCE) and its associated degradation products including cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride. A secondary contaminant of concern is chromium, which has been detected at elevated concentrations in water collected from two basement sumps. The chromium impacts appears to be limited to an area around the basement beneath the southeast part of the facility. Per- and polyfluoroalkyl substances (PFAS) have also been detected in groundwater at the Site; however, the remedial action was not designed or intended to address PFAS impacts.

1.1 Site Hydrogeology

Soil encountered during investigation activities consisted primarily of silty clay and silt. Native sediments in the area consist of glacial till of the Two Rivers Member of the Kewaunee Formation. The Two Rivers Member consists primarily of pebbly and cobbly, sandy silt. Bedrock in the vicinity of the Site consists of Silurian-aged dolomite. Bedrock was not encountered during the completion of the soil borings at the Site. Bedrock is anticipated to be more than 100 feet below ground.

The shallow water table is encountered at the Site within the native sediments at an average depth of 4 feet below ground surface (bgs). The average hydraulic gradient across the Site is 0.018 ft/ft. The groundwater flow direction as indicated by measurements in site monitoring

wells is toward the northeast. The Manitowoc River at its closest point is approximately 1 mile to the northeast. Lake Michigan is approximately 1.37 miles east of the Site.

1.2 Nature and Extent of Groundwater Impacts

The primary source of CVOC contamination is beneath a former parts cleaning area in the south-central part of the facility. A secondary source area may exist in the vicinity of monitoring well MW-14, where outdoor solvent storage occurred prior to construction of the western part of the building. The magnitude and extent of TCE contamination in soil and groundwater as of March 2022 are depicted on **Figures 2 and 3**. The concentration of TCE in groundwater exceeds the enforcement standard (ES) of 5 micrograms per liter ($\mu\text{g/L}$) beneath the southern third of the facility. The extents of cis-1,2-DCE and vinyl chloride in groundwater are identical to that of TCE. At many monitoring locations, the pre-remediation concentration of cis-1,2-DCE was higher than the concentration of TCE, demonstrating that natural attenuation of TCE was progressing.

1.3 Remediation Objective

The objective of groundwater remediation was to reduce total CVOCs concentrations by at least 90% compared to pre-remediation values. Residual CVOC concentrations are likely to remain above regulatory standards in the most impacted areas; therefore, EnviroForensics anticipates that a combination of engineering and institutional controls will be utilized to complete Site closure while ensuring the adequate protection of public health, safety, and welfare, and the environment.

2.0 GROUNDWATER REMEDIAL INJECTIONS

Active groundwater remediation was implemented to treat CVOC contamination in groundwater using a combination of *in-situ* chemical reduction (ISCR) and bioaugmented enhanced reductive dechlorination (ERD) technologies. This combined treatment approach relies on synergistic biotic and abiotic reduction pathways to convert CVOCs to non-toxic compounds. The reduction processes have been initiated by injecting a specially formulated solution into the target treatment zone. The target compounds for treatment are TCE, cis-1,2-DCE, and vinyl chloride, identified in Site groundwater at concentrations up to 70, 160, and 40 milligrams per liter (mg/L), respectively.

2.1 Permitting

EnviroForensics submitted the required *Injection Request* to the WDNR on May 26, 2022 to obtain approval for conducting the injection pilot test. The *Injection Request* included preliminary large-scale injection design information, which was approved by WDNR. Wisconsin Pollutant Discharge Elimination System permit coverage for discharge to groundwater was authorized for the pilot study and remained valid for the full-scale injection.

2.2 Treatment Zone

The target treatment zone generally coincided with the 100 µg/L TCE groundwater contour shown on **Figure 3**; however, only certain areas within the target treatment zone were accessible to injection equipment because active metal plating lines, ancillary equipment, and subsurface utilities are present. The target depth interval for treatment was 4 to 14 feet bgs. Contaminant concentrations in deeper intervals monitored by piezometers are much lower than the concentrations within 10 feet of the water table.

2.3 Amendments and Dosing

The injection solution comprised potable water and the following products, manufactured by Regensis:

- 3-D Microemulsion (3DME®), an electron donor to promote ERD.
- Sulfidated Zero-Valent Iron (S-Micro ZVI), a colloidal ISCR reagent.
- Bio-DeChlor INOCULUM Plus (BDI Plus), an enriched culture of dechlorinating microbes.

All products were shipped directly to the Site and stored indoors until injection activities commenced. The total weight/amount of each product required to remediate the target treatment zone per design parameters was 6,800 pounds of 3DME, 5,100 pounds of S-Micro ZVI, and 21 liters of BDI Plus.

The number of points, spacing, mixing specifications, and volume of solution prescribed for each point was determined based on contaminant mass estimates, site-specific hydrogeological parameters, and the pilot study results. The remediation plan called for injection into a total of 111 points positioned in the accessible areas. The target injection volume ranged from 155 to 167 gallons of solution at each point, depending on location, consisting of approximately:

- 2.2% S-Micro ZVI
- 5.2% 3DME
- 0.04% BDI Plus
- 92.6% potable water from the municipality

In total, the plan specified delivery of 17,288 gallons of remedial solution into the target treatment zone.

2.4 Injection Activities

The remedial injection activities were performed by Regenesi Remediation Services (RRS), under the direction of EnviroForensics, from November 28 through December 8, 2022. Solution mixing was performed by pumping the concentrated S-Micro ZVI and 3DME from totes and drums into tanks mounted inside an RRS trailer. Water was sent to the mixing tanks from connections inside the Jagemann facility. Paddle mixing occurred continuously to ensure a homogeneous solution. The BDI Plus was added directly to the injection hoses during delivery of the solution to prevent exposure to oxygen.

The solution was pumped to direct-push rods with an expendable tip, advanced to 14 feet bgs. The solution was injected from the bottom up into three injection intervals of approximately 11-14 feet, 8 to 11 feet, and 5 to 8 feet. However, the shallow interval was skipped at some locations due to surfacing of groundwater and/or remedial solution during injection into the deeper two (2) intervals. Remedial solution that reached the surface was vacuumed up and dumped into the mixing tanks for re-injection. Boring refusal was encountered at two (2)

attempted locations. In these instances, the design volume of solution was redistributed to adjacent points.

For purposes of tracking and documentation, the treatment zone was divided into four (4) areas designated A through D. A total of 62 injection points were advanced at the locations shown on **Figure 4**. Pressure and flow rates were monitored and recorded to confirm that design parameters were met. Injection details for each area are summarized in the following table.

Area	# of injection points	Average Flow Rate (GPM)	Average Pressure (psi)
A	21	2.3	19
B	5	1.6	29
C	18	1.6	17
D	18	1.5	25

Injection intervals, flow rates, pressures, volume of solution and amendment amounts for each individual injection point are summarized in **Appendix A**. Photographs of injection activities are presented in **Appendix B**.

There were several deviations from the remediation plan due to fluid surfacing and achievable flow rate observed in the first 16 injection points (IP-1A through IP-16A):

- The distance between injection locations was doubled based on in-field observations of injectate radial travel distance and fluid daylighting;
- The number of injection points was reduced from 111 to 62 due to the increased distance between locations; and
- The concentration of the solution (i.e., the volume of amendments relative to the volume of water) was increased, which reduced the total volume of solution added to the subsurface by 20%.

Despite the implementation changes, the full design amount (by weight) of each remedial product was delivered to the treatment zone, as detailed in **Appendix A**.

The direct-push rods were removed from each location after injection and the boreholes were abandoned in accordance with NR 141.25 Wis. Adm. Code and patched with concrete.

3.0 PERFORMANCE MONITORING AND REPORTING

Groundwater monitoring will be conducted to evaluate the performance of the ISCR/ERD remedy. A quarterly groundwater monitoring program will be implemented that will include groundwater elevation measurements, groundwater quality measurements, and sample collection for laboratory analysis. The monitoring program is summarized on **Table 1**.

The duration of quarterly monitoring will depend on CVOC concentration trends identified through ongoing data evaluation; however, a minimum of eight (8) quarterly monitoring events are anticipated to comply with NR 726.09(e) Wis. Adm. Code. Purging and sampling will be completed using standard low-flow methods. Field parameters including pH, specific conductivity, temperature, ORP, and dissolved oxygen will be measured during purging and recorded on a sampling form.

One (1) duplicate sample and one (1) equipment blank will be collected for every 10 or fewer investigative samples, and one (1) trip blank sample will be analyzed per sample cooler for quality assurance/quality control purposes. Samples will be transmitted to a state-certified laboratory and analyzed for the following parameters as specified on **Table 1**:

- VOCs (Method 8260).
- Ethene, Ethane, Methane (Method 8015)
- Total Organic Carbon (Method 5310B)
- Dehalococoides population and functional genes (Microbial Insights Methods)
- Chromium (Method 200.7)
- Hexavalent chromium (Method SM3500)

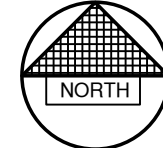
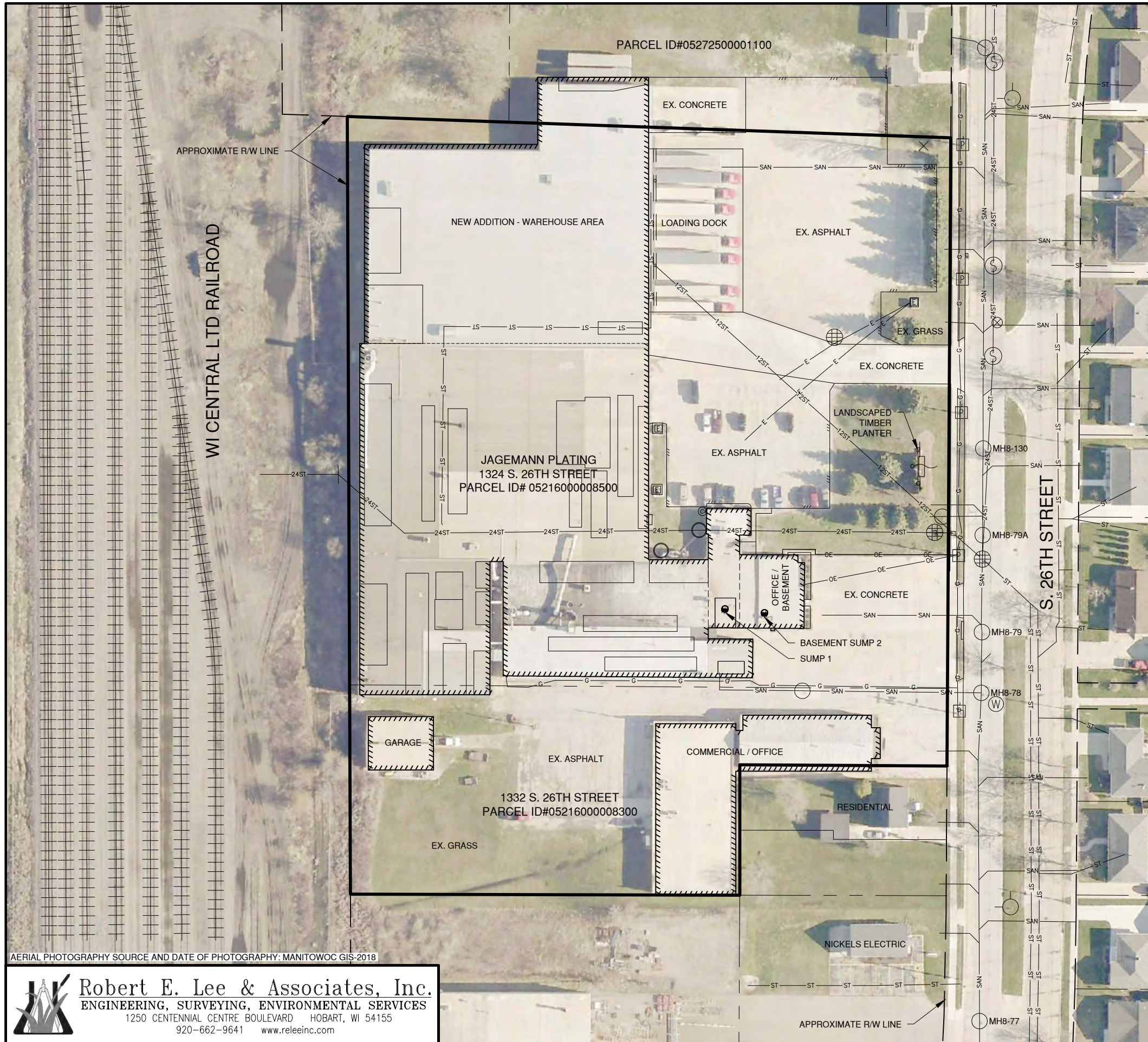
Investigation-derived media (IDM), including purge water and decontamination fluids, will be containerized in a 55-gallon drum and subsequently disposed of by Jagemann in the Site's wastewater treatment plant.

Methane is produced via methanogenesis during anaerobic biodegradation of CVOCs; therefore, monitoring is warranted to document total VOC vapors and methane gas to confirm that conditions in the subsurface do not pose a health risk. Vapor and gas concentrations will be measured during the performance monitoring events using a photo-ionization detector (PID) and portable gas analyzer at the shallow monitoring wells and sub-slab vapor ports in the Site building.

The areas of the facility where injections occurred utilize several mechanical systems that move indoor air out and fresh air into the facility. Air scrubbers, exhaust fans, and make up air units operate continuously to control steam/mist, particulates, and odors to maintain the interior environment for Site workers. These mechanical systems are considered permanent features that prevent exposure to CVOC vapors, and would also prevent methane accumulation inside the facility. However, if methane levels exceed 10% of the LEL (i.e., 0.5% by volume methane) at any monitoring point, vapors and gases will be evacuated using appropriate, intrinsically-safe equipment.

The groundwater analytical data will be analyzed to evaluate the performance of the treatment during the performance monitoring period. Performance monitoring data and analysis will be documented in Remediation Site Operation, Maintenance, Monitoring and Optimization Reports on a semi-annual basis, as required.

FIGURES



LEGEND

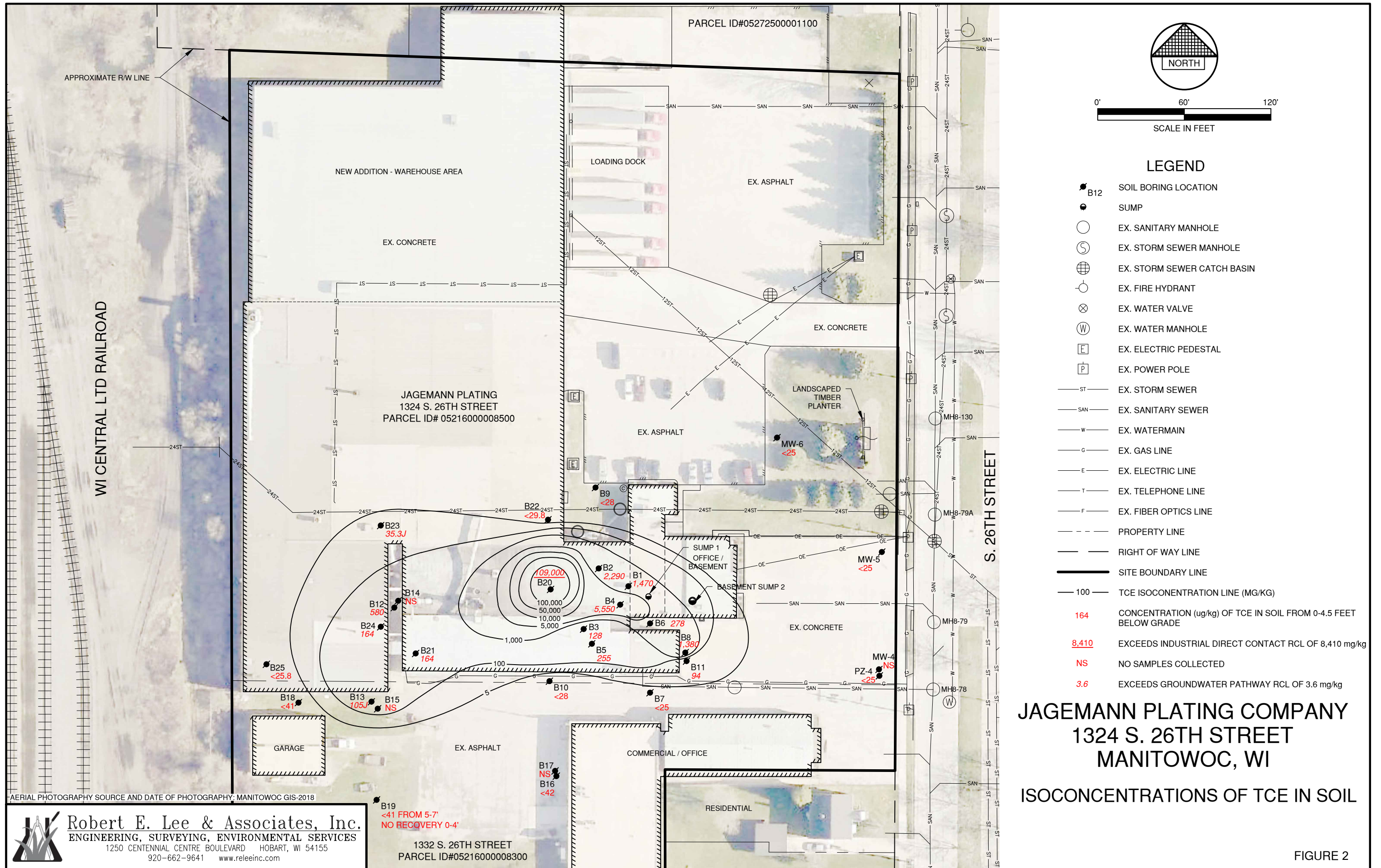
- SUMP
- EX. SANITARY MANHOLE
- ⊙ EX. STORM SEWER MANHOLE
- ⊕ EX. STORM SEWER CATCH BASIN
- ⊙ EX. FIRE HYDRANT
- ⊗ EX. WATER VALVE
- ⊙ EX. WATER MANHOLE
- ⊞ EX. ELECTRIC PEDESTAL
- ⊞ EX. POWER POLE
- ST— EX. STORM SEWER
- SAN— EX. SANITARY SEWER
- W— EX. WATERMAIN
- G— EX. GAS LINE
- E— EX. ELECTRIC LINE
- T— EX. TELEPHONE LINE
- F— EX. FIBER OPTICS LINE
- - - PROPERTY LINE
- — — RIGHT OF WAY LINE
- — — SITE BOUNDARY LINE

JAGEMANN PLATING COMPANY
1324 S. 26TH STREET
MANITOWOC, WI

FIGURE 1
DETAILED SITE MAP

AERIAL PHOTOGRAPHY SOURCE AND DATE OF PHOTOGRAPHY: MANITOWOC GIS-2018

Robert E. Lee & Associates, Inc.
 ENGINEERING, SURVEYING, ENVIRONMENTAL SERVICES
 1250 CENTENNIAL CENTRE BOULEVARD HOBART, WI 54155
 920-662-9641 www.releeinc.com



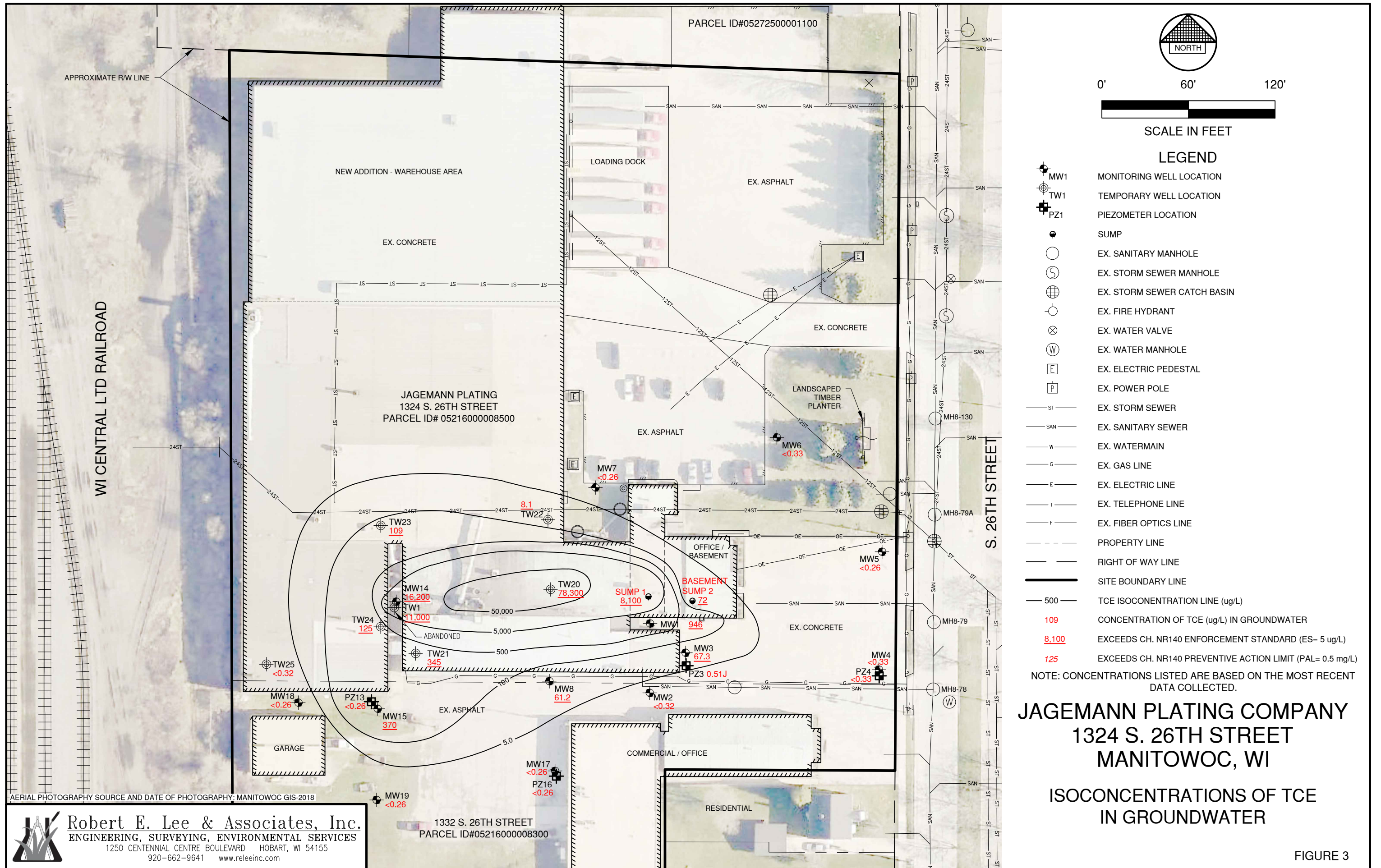
AERIAL PHOTOGRAPHY SOURCE AND DATE OF PHOTOGRAPHY: MANITOWOC GIS-2018

Robert E. Lee & Associates, Inc.
 ENGINEERING, SURVEYING, ENVIRONMENTAL SERVICES
 1250 CENTENNIAL CENTRE BOULEVARD HOBART, WI 54155
 920-662-9641 www.releeinc.com

B19 <41 FROM 5-7'
 NO RECOVERY 0-4'

1332 S. 26TH STREET
 PARCEL ID#05216000008300

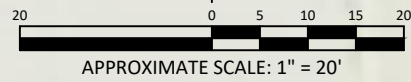
FIGURE 2



AERIAL PHOTOGRAPHY SOURCE AND DATE OF PHOTOGRAPHY: MANITOWOC GIS-2018


Robert E. Lee & Associates, Inc.
 ENGINEERING, SURVEYING, ENVIRONMENTAL SERVICES
 1250 CENTENNIAL CENTRE BOULEVARD HOBART, WI 54155
 920-662-9641 www.releeinc.com

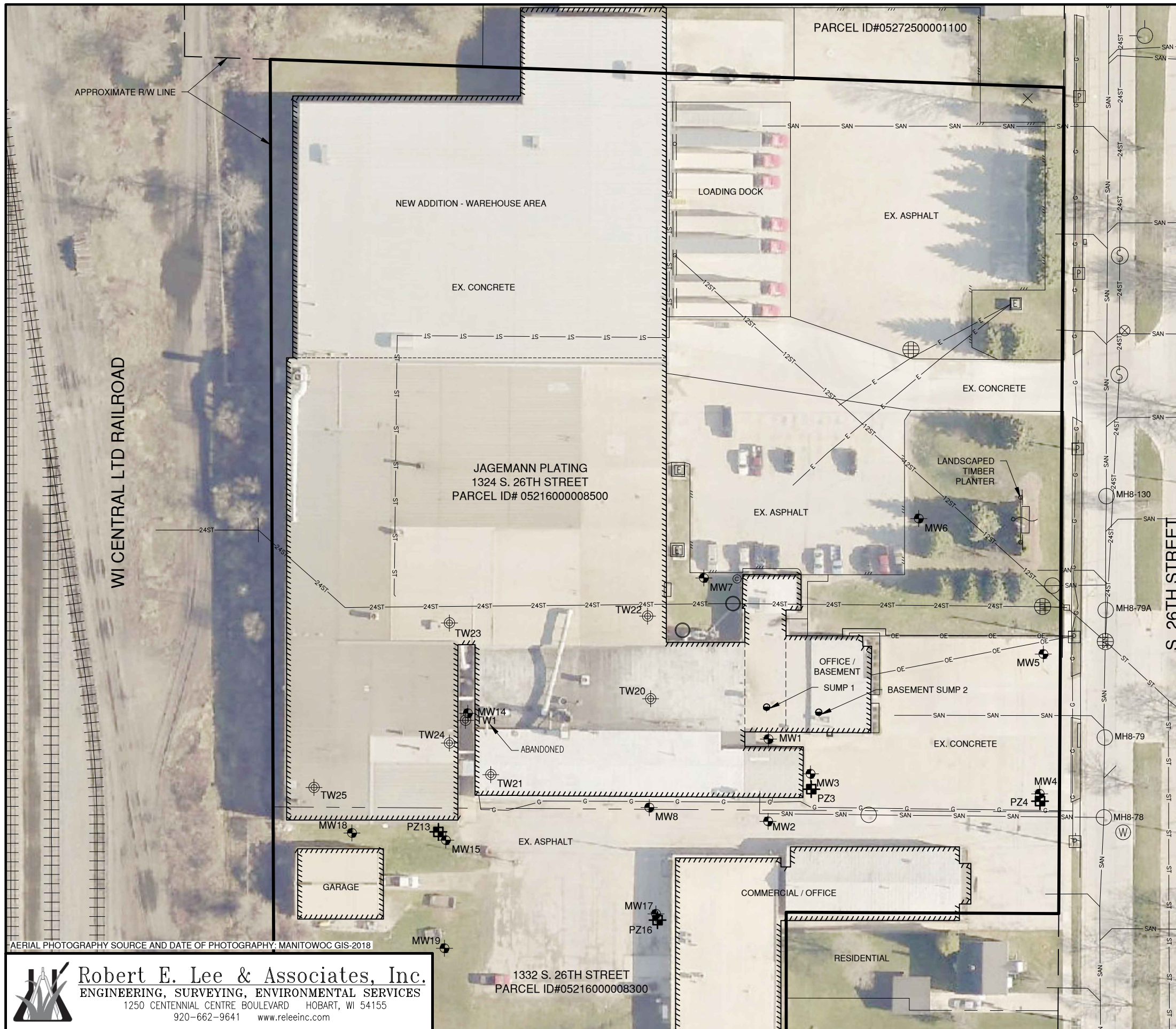
FIGURE 3



- Legend**
- MW1 Monitoring well
 - TW21 Temporary monitoring well
 - PZ3 Piezometer
 - IP-1A Injection location



INJECTION POINT LAYOUT											
Jagemann Plating Company 1324 South 26th Street Manitowoc, Wisconsin											
	Figure 4										
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Date:</td><td>12/15/22</td></tr> <tr><td>Designed:</td><td>EB</td></tr> <tr><td>Drawn:</td><td>EB</td></tr> <tr><td>Checked:</td><td>BK</td></tr> <tr><td>DWG file:</td><td>200032-0178</td></tr> </table>	Date:	12/15/22	Designed:	EB	Drawn:	EB	Checked:	BK	DWG file:	200032-0178	Project 200032
Date:	12/15/22										
Designed:	EB										
Drawn:	EB										
Checked:	BK										
DWG file:	200032-0178										
825 North Capital Avenue • Indianapolis, IN 46204 EnviroForensics.com											



0' 60' 120'



SCALE IN FEET

LEGEND

- MW1 MONITORING WELL LOCATION
- TW1 TEMPORARY WELL LOCATION
- PZ1 PIEZOMETER LOCATION
- SUMP
- EX. SANITARY MANHOLE
- EX. STORM SEWER MANHOLE
- EX. STORM SEWER CATCH BASIN
- EX. FIRE HYDRANT
- EX. WATER VALVE
- EX. WATER MANHOLE
- EX. ELECTRIC PEDESTAL
- EX. POWER POLE
- ST EX. STORM SEWER
- SAN EX. SANITARY SEWER
- W EX. WATERMAIN
- G EX. GAS LINE
- E EX. ELECTRIC LINE
- T EX. TELEPHONE LINE
- F EX. FIBER OPTICS LINE
- PROPERTY LINE
- RIGHT OF WAY LINE
- SITE BOUNDARY LINE

JAGEMANN PLATING COMPANY
1324 S. 26TH STREET
MANITOWOC, WI

MONITORING WELL LOCATIONS

AERIAL PHOTOGRAPHY SOURCE AND DATE OF PHOTOGRAPHY: MANITOWOC GIS-2018

Robert E. Lee & Associates, Inc.
 ENGINEERING, SURVEYING, ENVIRONMENTAL SERVICES
 1250 CENTENNIAL CENTRE BOULEVARD HOBART, WI 54155
 920-662-9641 www.releinc.com

1332 S. 26TH STREET
 PARCEL ID#05216000008300

FIGURE 5

TABLE

TABLE 1
REMEDIATION PERFORMANCE MONITORING PROGRAM

Jagemann Plating
 Manitowoc, Wisconsin

Parameter	VOCs	Ethene/Ethane/ Methane	TOC	DHC Population/ Functional Genes	Chromium	Hexavalent Chromium
MW-1	Q	Q	Q	A		
MW-3	Q	Q				
MW-8	Q	Q				
MW-14	Q	Q	Q	A		
MW-15	Q	Q				
TW-20	Q	Q	Q	A		
TW-21	Q	Q	Q	A		
TW-22	Q	Q				
TW-23	Q	Q				
TW-24	Q	Q				
Sump 1	Q				A	A
Sump 2	Q				A	A

Notes:

Monitoring will occur for eight (8) consecutive quarters, with the first monitoring event performed approximately 2 months after injections

Q = Sample collected for analysis quarterly

A = Sample collected for analysis annually

DHC = Dehalococcoides

TOC = Total organic carbon

VOCs = Volatile Organic Compounds

APPENDIX A

Injection Summary Log

Enviroforensics-Jagemann Plating
Injection Summary Log



Injection Point	Date	Time	Injection Depth (feet)	Injection Pressure (psi)	Flow Rate (gpm)	Volume of 3DME Injected			Pounds of 3DME per Interval	Pounds of MicroZVI per Interval	Total Gallons Per Location	Pounds of 3DME Injected Per Location	Pounds of S-Micro ZVI Per Location	Liters of BDI Per Interval	Comments	Injection Tooling	
						Beginning Flow Meter (gal)	Ending Flow Meter (gal)	Gallons Injected Per Interval									
1A	11/29/2022	12:24	14-11	38	3.70	0.0	46.4	46.4	18	13	132.7	51	38	0.053	2 gal of surfacing coming from bore hole. Packed with benseal and resumed flow	Expendable Tip	
	11/29/2022	12:58	11-8	13	5.40	46.4	88.0	41.6	16	12				0.053			
	11/29/2022	13:28	8-5	5	2.00	88.0	132.7	44.7	17	13				0.071			10 gal of surfacing coming from bore hole and cracks in the pavement. Flow stopped. Continued to surface, but surfaced fluids were recirculated into injectate. Point abandoned, volume redistributed
2A	11/29/2022	12:24	14-11	39	3.50	0.0	46.4	46.4	18	13	154.2	59	44	0.053	10 gal of surfacing coming from bore hole and cracks in the pavement. Flow stopped. Continued to surface, but surfaced fluids were recirculated into injectate. Next interval abandoned	Expendable Tip	
	11/29/2022	12:51	11-8	9	4.00	46.4	92.8	46.4	18	13				0.053			
	11/29/2022	13:28	8-5	0	1.70	92.8	154.2	61.4	24	18				0.053			
3A	11/29/2022	12:24	14-11	36	3.70	0.0	50.2	50.2	19	14	169.6	65	49	0.053	10 gal of surfacing coming from bore hole and cracks in the pavement. Flow stopped. Continued to surface, but surfaced fluids were recirculated into injectate. Next interval abandoned. Received additional volume due to abandoning IP-1	Expendable Tip	
	11/29/2022	12:51	11-8	8	4.00	50.2	92.8	42.6	16	12				0.053			
	11/29/2022	13:28	8-5	0	1.70	92.8	169.6	76.8	30	22				0.053			
4A	11/29/2022	12:24	14-11	37	3.20	0.0	47.6	47.6	18	14	162.1	62	47	0.053	10 gal of surfacing coming from bore hole and cracks in the pavement. Flow stopped. Continued to surface, but surfaced fluids were recirculated into injectate. Next interval abandoned. Received additional volume due to abandoning IP-1	Expendable Tip	
	11/29/2022	12:51	11-8	27	4.30	47.6	92.8	45.2	17	13				0.053			
	11/29/2022	13:28	8-5	5	1.20	92.8	162.1	69.3	27	20				0.053			
5A	11/30/2022	9:58	14-11	36	2.60	0.0	77.3	77.3	30	22	154.9	59	45	0.081	Received additional volume due to preemptively abandoning top top intervals	Expendable Tip	
	11/30/2022	10:52	11-8	11	2.00	77.3	154.9	77.6	30	22				0.081			Received additional volume due to preemptively abandoning top top intervals. Surfacing from MW-14 6' away
	11/30/2022	9:39	14-11	25	2.00	0.0	77.3	77.3	30	22				0.081			Received additional volume due to preemptively abandoning top top intervals
6A	11/30/2022	10:53	11-8	18	21.00	77.3	154.0	76.7	29	22	154.0	59	44	0.081	Received additional volume due to preemptively abandoning top top intervals. Surfacing from MW-14 6' away	Expendable Tip	
	11/30/2022	9:58	14-11	17	2.30	0.0	77.4	77.4	30	22				0.081			Received additional volume due to preemptively abandoning top top intervals
	11/30/2022	10:53	11-8	15	2.40	77.4	155.8	78.4	30	23				0.081			Received additional volume due to preemptively abandoning top top intervals
7A	11/29/2022	16:09	14-11	45	3.40	0.0	103.0	103.0	40	30	154.6	59	44	0.081	Received additional volume due to preemptively abandoning top top intervals	Expendable Tip	
	11/30/2022	10:53	11-8	20	2.00	0.0	51.6	51.6	20	15				0.081			Received additional volume due to preemptively abandoning top top intervals
	11/29/2022	16:02	14-11	46	3.00	0.0	103.2	103.2	40	30				0.081			Received additional volume due to preemptively abandoning top top intervals
8A	11/30/2022	9:54	11-8	12	2.60	0.0	51.4	51.4	20	15	154.6	59	44	0.081	Received additional volume due to preemptively abandoning top top intervals	Expendable Tip	
	11/29/2022	16:01	14-11	55	2.70	0.0	103.1	103.1	40	30				0.081			Received additional volume due to preemptively abandoning top top intervals
	11/30/2022	9:53	11-8	15	2.50	0.0	51.6	51.6	20	15				0.081			Received additional volume due to preemptively abandoning top top intervals
9A	11/30/2022	12:34	14-11	30	2.20	0.0	57.7	57.7	22	17	108.2	59	44	0.081	Injected with higher concentration of product to combat surfacing	Expendable Tip	
	11/30/2022	13:23	11-8	23	2.00	57.7	108.2	50.5	19	15				0.081			Injected with higher concentration of product to combat surfacing
	11/30/2022	12:32	14-11	30	1.80	0.0	58.9	58.9	23	17				0.081			Injected with higher concentration of product to combat surfacing
10A	11/30/2022	13:23	11-8	13	2.00	58.9	108.2	49.3	19	14	108.2	59	44	0.081	Injected with higher concentration of product to combat surfacing	Expendable Tip	
	11/30/2022	12:32	14-11	30	1.80	0.0	58.9	58.9	23	17				0.081			Injected with higher concentration of product to combat surfacing
	11/30/2022	13:23	11-8	13	2.00	58.9	108.2	49.3	19	14				0.081			Injected with higher concentration of product to combat surfacing
11A	11/30/2022	12:32	14-11	30	1.80	0.0	58.9	58.9	23	17	108.2	59	44	0.081	Injected with higher concentration of product to combat surfacing	Expendable Tip	
	11/30/2022	13:23	11-8	23	2.00	57.7	108.2	50.5	19	15				0.081			Injected with higher concentration of product to combat surfacing
	11/30/2022	12:32	14-11	30	1.80	0.0	58.9	58.9	23	17				0.081			Injected with higher concentration of product to combat surfacing
12A	11/30/2022	13:23	11-8	13	2.00	58.9	108.2	49.3	19	14	108.2	59	44	0.081	Injected with higher concentration of product to combat surfacing	Expendable Tip	
	11/30/2022	12:32	14-11	30	1.80	0.0	58.9	58.9	23	17				0.081			Injected with higher concentration of product to combat surfacing
	11/30/2022	13:23	11-8	13	2.00	58.9	108.2	49.3	19	14				0.081			Injected with higher concentration of product to combat surfacing
13A	11/30/2022	12:32	13-10	23	1.30	0.0	61.3	61.3	24	18	108.9	60	45	0.081	ice frozen in rod, had to lift up extra ft. injected with higher concentration of product to combat surfacing	Expendable Tip	
	11/30/2022	13:23	11-8	14	2.00	61.3	108.9	47.6	18	14				0.081			Injected with higher concentration of product to combat surfacing
	11/30/2022	12:31	14-11	23	1.40	0.0	60.3	60.3	23	17				0.081			Injected with higher concentration of product to combat surfacing
14A	11/30/2022	13:23	11-8	6	2.00	60.3	108.2	47.9	18	14	108.2	59	44	0.081	Injected with higher concentration of product to combat surfacing	Expendable Tip	
	11/30/2022	13:58	14-11	12	2.00	0.0	53.7	53.7	21	15				0.081			Injected with higher concentration of product to combat surfacing
	11/30/2022	13:47	14-11	21	1.50	0.0	54.5	54.5	21	16				0.081			Injected with higher concentration of product to combat surfacing
15A	11/30/2022	14:23	11-8	12	2.10	53.7	108.2	54.5	21	16	108.2	57	43	0.081	Surfacing from several cracks in pavement within a 12ft radius. Injected with higher concentration of product to combat surfacing	Expendable Tip	
	11/30/2022	13:47	14-11	21	1.50	0.0	54.5	54.5	21	16				0.081			Injected with higher concentration of product to combat surfacing
	11/30/2022	14:23	11-8	14	1.70	54.5	108.2	53.7	21	15				0.081			Surfacing from several cracks in pavement within a 12ft radius. Injected with higher concentration of product to combat surfacing
16A	11/30/2022	14:23	11-8	14	1.70	54.5	108.2	53.7	21	15	108.2	61	46	0.081	Surfacing from several cracks in pavement within a 12ft radius. Injected with higher concentration of product to combat surfacing	Expendable Tip	
	11/30/2022	14:23	11-8	14	1.70	54.5	108.2	53.7	21	15				0.081			Surfacing from several cracks in pavement within a 12ft radius. Injected with higher concentration of product to combat surfacing
	11/30/2022	14:23	11-8	14	1.70	54.5	108.2	53.7	21	15				0.081			Surfacing from several cracks in pavement within a 12ft radius. Injected with higher concentration of product to combat surfacing
17A	12/1/2022	17:08	14-11	20	1.70	0.0	92.6	92.6	47	36	274.8	140	105	0.143	Received 12/5 worth of product, concentration of 3DME increased to 6.25%	Expendable Tip	
	12/2/2022	9:27	11-8	26	1.30	0.0	94.6	94.6	48	36				0.143			
	12/2/2022	11:00	8-5	7	1.60	94.6	182.2	87.6	45	34				0.143			
18A	12/1/2022	16:57	14-11	33	3.00	0.0	93.1	93.1	48	36	276.2	141	106	0.143	Received 12/5 worth of product, concentration of 3DME increased to 6.25%	Expendable Tip	
	12/2/2022	9:17	11-8	5	2.00	0.0	92.6	92.6	47	36				0.143			
	12/2/2022	11:01	8-5	2	1.20	92.6	183.1	90.5	46	35				0.143			
19A	12/1/2022	16:53	14-11	45	2.80	0.0	93.1	93.1	48	36	276.2	141	106	0.143	Received 12/5 worth of product, concentration of 3DME increased to 6.25%	Expendable Tip	
	12/2/2022	9:17	11-8	7	2.00	0.0	92.6	92.6	47	36				0.143			
	12/2/2022	11:01	8-5	3	1.20	92.6	183.1	90.5	46	35				0.143			
20A	12/1/2022	16:53	14-11	40	1.40	0.0	93.1	93.1	48	36	277.0	141	106	0.143	Received 12/5 worth of product, concentration of 3DME increased to 6.25%	Expendable Tip	
	12/2/2022	9:27	11-8	11	1.30	0.0	92.8	92.8	48	36				0.143			
	12/2/2022	11:01	8-5	2	1.20	92.8	183.9	91.1	47	35				0.143			
21A	12/1/2022	16:42	14-11	16	2.50	0.0	92.2	92.2	47	35	287.9	147	110	0.143	Received 12/5 worth of product, concentration of 3DME increased to 6.25%	Expendable Tip	
	12/2/2022	9:33	11-8	6	2.00	0.0	91.3	91.3	47	35				0.143			
	12/2/2022	11:01	8-5	4	0.90	91.3	195.7	104.4	53	40				0.143			
1C	12/5/2022	11:04	14-11	14	1.50	0.0	78.6	78.6	40	30	235.2	120	90	0.120	Received 12/5 worth of product, concentration of 3DME increased to 6.25%	Expendable Tip	
	12/5/2022	12:07	11-8	9	1.60	78.6	156.8	78.2	40	30				0.120			
	12/5/2022	13:09	8-5	6	1.50	156.8	235.2	78.4	40	30				0.120			
2C	12/5/2022	11:04	14-11	11	1.50	0.0	78.4	78.4	40	30	235.2	120	90	0.120	Received 12/5 worth of product, concentration of 3DME increased to 6.25%	Expendable Tip	
	12/5/2022	12:08	11-8	16	1.50	78.4	156.8	78.4	40	30				0.120			
	12/5/2022	13:10	8-5	14	1.50	156.8	235.2	78.4	40	30				0.120			
3C	12/5/2022	11:04	14-11	12	1.50	0.0	78.5	78.5	40	30	235.2	120	90	0.120	Received 12/5 worth of product, concentration of 3DME increased to 6.25%	Expendable Tip	
	12/5/2022	12:09	11-8	7	1.50	78.5	156.8	78.3	40	30				0.120			
	12/5/2022	13:10	8-5	5	1.50	156.8	235.2	78.4	40	30				0.120			
4C	12/5/2022	11:05	14-11	25	1.50	0.0	78.4	78.4	40	30	235.2	120	90	0.120	Received 12/5 worth of product, concentration of 3DME increased to 6.25%	Expendable Tip	
	12/5/2022	12:09	11-8	21	1.70	78.4	156.8	78.4	40	30				0.120			
	12/5/2022	13:10	8-5	5	1.60	156.8	235.2	78.4	40	30				0.120			

Enviroforensics-Jagemann Platting
Injection Summary Log



Injection Point	Date	Time	Injection Depth (feet)	Injection Pressure (psi)	Flow Rate (gpm)	Volume of 3DME Injected			Pounds of 3DME per Interval	Pounds of MicroZVI per Interval	Total Gallons Per Location	Pounds of 3DME Injected Per Location	Pounds of S-Micro ZVI Per Location	Liters of BDI Per Interval	Comments	Injection Tooling
						Beginning Flow Meter (gal)	Ending Flow Meter (gal)	Gallons Injected Per Interval								
5C	12/5/2022	11:05	14-11	12	1.50	0.0	78.4	78.4	40	30	235.2	120	90	0.120		Expendable Tip
	12/5/2022	12:08	11-8	17	1.50	78.4	156.8	78.4	40	30				0.120		
	12/5/2022	13:10	8-5	15	1.50	156.8	235.2	78.4	40	30				0.121		
6C	12/5/2022	11:05	14-11	10	1.50	0.0	78.4	78.4	40	30	235.2	120	90	0.120		Expendable Tip
	12/5/2022	12:08	11-8	15	1.50	78.4	156.8	78.4	40	30				0.120		
	12/5/2022	13:10	8-5	13	1.50	156.8	235.2	78.4	40	30				0.121		
7C	12/5/2022	15:41	14-11	45	2.00	0.0	78.4	78.4	40	30	229.6	117	88	0.120	20 gal of clear water surfacing from crack in concrete. Volume diverted to other IPs	Expendable Tip
	12/5/2022	16:50	11-8	27	1.60	78.4	156.8	79.8	41	31				0.120		
	12/5/2022	18:13	8-5	13	1.40	158.2	229.6	71.4	37	27				0.121		
8C	12/5/2022	15:36	14-11	31	1.70	0.0	78.4	78.4	40	30	229.6	117	88	0.120	20 gal of clear water surfacing from crack in concrete. Volume diverted to other IPs	Expendable Tip
	12/5/2022	16:50	11-8	20	1.60	78.4	156.8	79.8	41	31				0.120		
	12/5/2022	18:14	8-5	9	1.40	158.2	229.6	71.4	37	27				0.121		
9C	12/5/2022	15:34	14-11	32	1.50	0.0	78.4	78.4	40	30	229.6	117	88	0.120	20 gal of clear water surfacing from crack in concrete. Volume diverted to other IPs	Expendable Tip
	12/5/2022	16:50	11-8	20	1.60	78.4	156.8	79.8	41	31				0.120		
	12/5/2022	18:14	8-5	9	1.40	158.2	229.6	71.4	37	27				0.121		
10C	12/5/2022	16:51	14-11	19	1.50	0.0	78.4	78.4	40	30	239.4	122	92	0.120		Expendable Tip
	12/5/2022	16:51	11-8	17	1.50	78.4	156.8	79.8	41	31				0.120		
	12/5/2022	18:14	8-5	7	1.5	158.2	239.4	81.2	42	31				0.121		
11C	12/5/2022	16:51	14-11	18	1.40	0.0	78.4	78.4	40	30	242.6	124	93	0.120	Received additional volume due to abandoning IPs 7D, 8D, and 9D	Expendable Tip
	12/5/2022	16:51	11-8	15	1.40	78.4	159.3	80.9	41	31				0.120		
	12/5/2022	18:14	8-5	9	1.60	159.3	242.6	83.3	43	32				0.121		
12C	12/5/2022	16:51	14-11	22	1.70	0.0	78.4	78.4	40	30	240.2	123	92	0.120	Received additional volume due to abandoning IPs 7D, 8D, and 9D	Expendable Tip
	12/5/2022	16:51	11-8	10	1.70	78.4	157.1	78.7	40	30				0.120		
	12/5/2022	18:15	8-5	7	1.60	157.1	240.2	83.1	43	32				0.121		
13C	12/8/2022	10:06	14-11	30	1.50	0.0	78.5	78.5	40	30	238.4	122	91	0.120		Expendable Tip
	12/8/2022	11:21	11-8	20	1.50	78.5	156.8	78.3	40	30				0.120		
	12/8/2022	12:32	8-5	7	1.50	156.8	238.4	81.6	42	31				0.121		
14C	12/8/2022	10:09	14-11	26	1.50	0.0	78.5	78.5	40	30	234.0	120	90	0.120		Expendable Tip
	12/8/2022	11:21	11-8	19	1.60	78.5	156.9	78.4	40	30				0.120		
	12/8/2022	12:32	8-5	4	1.70	156.9	234.0	77.1	39	30				0.121		
15C	12/8/2022	10:13	14-11	36	1.10	0.0	79.1	79.1	40	30	237.9	122	91	0.120	<1 gal of surfacing from bore hole. Packed with benseal and flow slowed	Expendable Tip
	12/8/2022	11:22	11-8	20	1.50	79.1	157.1	78.0	40	30				0.120		
	12/8/2022	12:33	8-5	6	1.60	157.1	237.9	80.8	41	31				0.121		
16C	12/8/2022	10:14	14-11	44	2.30	0.0	79.1	79.1	41	30	237.9	122	91	0.120	2 gal of clear water surfacing from crack in concrete 1' E of IP	Expendable Tip
	12/8/2022	11:22	11-8	24	1.60	79.1	157.1	78.0	40	30				0.120		
	12/8/2022	12:33	8-5	8	1.60	157.1	237.9	80.8	41	31				0.121		
17C	12/8/2022	10:03	14-11	40	1.50	0.0	78.5	78.5	40	30	225.1	115	86	0.120		Expendable Tip
	12/8/2022	11:22	11-8	10	1.60	78.5	156.9	78.4	40	30				0.120		
	12/8/2022	12:32	8-5	5	1.50	156.9	225.1	68.2	35	28				0.121		
18C	12/8/2022	10:14	14-11	48	2.30	0.0	79.1	79.1	41	30	237.9	122	91	0.120	<1 gal of surfacing from bore hole. Packed with benseal and flow slowed. Surfacing u	Expendable Tip
	12/8/2022	11:21	11-10	29	1.60	79.1	157.1	78.0	40	30				0.120		
	12/8/2022	12:33	8-5	9	1.60	157.1	237.9	80.8	41	31				0.121		
1D	12/8/2022	10:26	14-11	31	0.70	0.0	94.1	94.1	48	36	271.4	139	104	0.144	Received additional volume due to abandoning the bottom intervals of IP-3D	Expendable Tip
	12/8/2022	12:00	11-10	27	1.60	94.1	190.1	96.0	49	37				0.144		
	12/8/2022	13:25	8-5	27	1.50	190.1	271.4	81.3	42	31				0.144		
2D	12/8/2022	10:29	14-11	28	1.30	0.0	94.1	94.1	48	36	271.4	139	104	0.144	Received additional volume due to abandoning the bottom intervals of IP-3D	Expendable Tip
	12/8/2022	12:00	11-10	22	1.60	94.1	190.1	96.0	49	37				0.144		
	12/8/2022	13:26	8-5	22	1.50	190.1	271.4	81.3	42	31				0.144		
3D	12/8/2022	14-11				0.0	0.0	0.0	0	0	38.2	20	15	0.000	hit refusal at 7'; interval abandoned, volume redistributed	Expendable Tip
	12/8/2022	11-10				0.0	0.0	0.0	0	0				0.000		
	12/8/2022	13:20	8-5	100	0.70	0.0	38.2	38.2	20	15				0.144		
4D	12/8/2022	10:32	14-11	35	1.50	0.0	94.1	94.1	48	36	271.5	139	104	0.144	Received additional volume due to abandoning the bottom intervals of IP-3D	Expendable Tip
	12/8/2022	12:00	11-10	27	1.60	94.1	190.1	96.0	49	37				0.144		
	12/8/2022	13:26	8-5	27	1.50	190.1	271.5	81.4	42	31				0.144		
5D	12/8/2022	11:04	14-11	33	1.80	0.0	94.1	94.1	48	36	287.2	147	110	0.144	Received additional volume due to abandoning the bottom intervals of IP-3D	Expendable Tip
	12/8/2022	11:51	11-10	14	1.60	94.1	188.2	94.1	48	36				0.144		
	12/8/2022	13:25	8-5	7	1.60	188.2	287.2	99.0	51	38				0.144		
6D	12/8/2022	10:36	14-11	35	1.50	0.0	94.1	94.1	48	36	271.5	139	104	0.144	Received additional volume due to abandoning the bottom intervals of IP-3D	Expendable Tip
	12/8/2022	12:00	11-10	26	1.60	94.1	190.1	96.0	49	37				0.144		
	12/8/2022	13:26	8-5	26	1.55	190.1	271.5	81.4	42	31				0.144		
7D	12/8/2022	10:26	14-11	41	1.30	0.0	78.4	78.4	40	30	235.6	120	90	0.120		Expendable Tip
	12/8/2022	10:26	11-8	16	1.40	78.4	156.8	78.4	40	30				0.120		
	12/8/2022	10:26	8-5	7	1.60	156.8	235.6	78.8	40	30				0.121		
8D	12/8/2022	10:26	14-11	35	1.50	0.0	78.4	78.4	40	30	235.6	120	90	0.120		Expendable Tip
	12/8/2022	10:26	11-8	21	1.50	78.4	156.8	78.4	40	30				0.120		
	12/8/2022	10:26	8-5	8	1.60	156.8	235.6	78.8	40	30				0.121		
9D	12/8/2022	10:26	14-11	40	1.30	0.0	78.5	78.5	40	30	234.3	120	90	0.120		Expendable Tip
	12/8/2022	10:26	11-8	22	1.60	78.5	156.8	78.3	40	30				0.120		
	12/8/2022	10:26	8-5	9	1.60	156.8	234.3	77.5	40	30				0.121		
10D	12/8/2022	10:26	14-11	30	1.50	0.0	78.5	78.5	40	30	235.2	120	90	0.120	Surfacing from annulus of TW-21 5' east. Annulus packed with benseal	Expendable Tip
	12/8/2022	10:26	11-8	28	1.70	78.5	159.5	81.0	41	31				0.120		
	12/8/2022	10:26	8-5	23	1.50	159.5	235.2	75.7	39	29				0.121		

Enviroforensics-Jagemann Plating
Injection Summary Log



Injection Point	Date	Time	Injection Depth (feet)	Injection Pressure (psi)	Flow Rate (gpm)	Volume of 3DME Injected			Pounds of 3DME per Interval	Pounds of MicroZVI per Interval	Total Gallons Per Location	Pounds of 3DME Injected Per Location	Pounds of S-Micro ZVI Per Location	Liters of BDI Per Interval	Comments	Injection Tooling
						Beginning Flow Meter (gal)	Ending Flow Meter (gal)	Gallons Injected Per Interval								
11D	12/6/2022	14:34	14-11	30	2.00	0.0	88.4	88.4	45	34	240.2	123	92	0.120		Expendable Tip
	12/6/2022	15:57	11-8	19	1.50	88.4	156.8	68.4	35	26				0.120		
	12/8/2022	10:26	8-5	8	1.50	0.0	83.4	83.4	43	32				0.121		
12D	12/8/2022	10:26	14-11	26	1.50	0.0	78.5	78.5	40	30	235.2	120	90	0.120	1 gal of surfacing from bore hole. Repacked with benseal	Expendable Tip
	12/8/2022	10:26	11-8	25	1.70	78.5	159.4	80.9	41	31				0.120		
	12/8/2022	10:26	8-5	20	1.50	159.4	235.2	75.8	39	29				0.121		
13D	12/6/2022	14:35	14-11	30	1.50	0.0	78.8	78.8	40	30	240.4	123	92	0.120		Expendable Tip
	12/6/2022	15:53	11-8	17	1.50	78.8	156.8	78.0	40	30				0.120		
	12/8/2022	10:26	8-5	13	1.50	0.0	83.6	83.6	43	32				0.120		
14D	12/8/2022	10:26	14-11	25	1.50	0.0	78.5	78.5	40	30	235.2	120	90	0.120		Expendable Tip
	12/8/2022	10:26	11-8	24	1.70	78.5	159.5	81.0	41	31				0.120		
	12/8/2022	10:26	8-5	19	1.50	159.5	235.2	75.7	39	29				0.121		
15D	12/6/2022	14:34	14-11	32	2.50	0.0	88.4	88.4	45	34	241.0	123	92	0.120	>1 gal surfacing from borehole	Expendable Tip
	12/6/2022	15:57	11-8	8	1.50	88.4	156.8	68.4	35	26				0.120		
	12/8/2022	10:26	8-5	18	1.50	0.0	84.2	84.2	43	32				0.121		
16D	12/6/2022	14:46	14-11	50	1.50	0.0	78.8	78.8	40	30	240.4	123	92	0.120	Significant back pressure when pulling rod. 15 gal of surfacing	Expendable Tip
	12/8/2022	15:53	11-8	32	1.40	78.8	156.8	78.0	40	30				0.120		
	12/8/2022	10:26	8-5	15	1.50	0.0	83.6	83.6	43	32				0.121		
17D	12/6/2022	14:45	14-11	35	1.80	0.0	78.8	78.8	40	30	240.4	123	92	0.120		Expendable Tip
	12/6/2022	15:52	11-8	22	1.50	78.8	156.8	78.0	40	30				0.120		
	12/8/2022	10:26	8-5	11	1.50	0.0	83.6	83.6	43	32				0.121		
18D	12/6/2022	14:34	14-11	44	1.50	0.0	88.4	88.4	45	34	239.7	122	92	0.120		Expendable Tip
	12/6/2022	15:57	11-8	23	1.50	88.4	156.8	68.4	35	26				0.120		
	12/8/2022	10:26	8-5	3	1.50	0.0	82.9	82.9	42	32				0.121		
											Total Gallons:	Total Lbs. of 3DME	Total Lbs. of S-Micro ZVI	Total Litres of BDI:		
											12087.0	6000.0	4500.0	18		

**Enviroforensics-Jagemann Plating
Injection Summary Log**



Injection Point	Date	Time	Injection Depth (feet)	Injection Pressure (psi)	Flow Rate (gpm)	Volume of 3DME Injected			Pounds of 3DME per Interval	Pounds of MicroZVI per Interval	Total Gallons Per Location	Pounds of 3DME Injected Per Location	Pounds of S-Micro ZVI Per Location	Liters of BDI Per Interval	Comments	Injection Tooling
						Beginning Flow Meter (gal)	Ending Flow Meter (gal)	Gallons Injected Per Interval								
1B	12/1/2022	10:10	14-11	42	2.00	0.0	166.8	166.8	80	60	337.8	162	122	0.300	10 gallons of clear water surfaced on shop floor 20' W of injection line	Expendable Tip
	12/1/2022	12:35	11-8	29	1.60	166.8	337.8	171.0	82	62						
2B	12/1/2022	10:30	14-11	32	2.30	0.0	166.8	166.8	80	60	327.2	157	118	0.300	10 gallons of clear water surfaced on shop floor 20' W of injection line	Expendable Tip
	12/1/2022	12:36	11-8	13	1.60	166.8	327.2	160.4	77	58						
3B	12/1/2022	10:23	14-11	50	2.20	0.0	166.8	166.8	80	60	327.2	157	118	0.300	10 gallons of clear water surfaced on shop floor 20' W of injection line	Expendable Tip
	12/1/2022	12:36	11-8	20	1.60	166.8	327.2	160.4	77	58						
4B	12/1/2022	10:10	14-11	28	0.50	0.0	168.0	168.0	81	60	351.4	169	126	0.300	10 gallons of clear water surfaced on shop floor 20' W of injection line	Expendable Tip
	12/1/2022	12:36	11-8	17	1.70	168.0	351.4	183.4	88	66						
5B	12/1/2022	10:10	14-11	31	0.60	0.0	166.8	166.8	80	60	324.3	156	117	0.300	10 gallons of clear water surfaced on shop floor 20' W of injection line	Expendable Tip
	12/1/2022	12:36	11-8	29	1.70	166.8	324.3	157.5	76	57						
											Total Gallons:	Total Lbs. of 3DME	Total Lbs. of S-Micro ZVI	Total Litres of BDI:		
											1668.0	800	600	3.000		

APPENDIX B

Photographs



Photo #1. Concrete coring was completed at each injection point inside the facility in preparation for advancement of the direct-push tooling.



Photo #2. View of typical injection points connected to individual hoses delivering the solution. Injection points IP-1C and IP-3C are visible, facing north.



Photo #3. View of injection points IP-8C and IP-10C, facing east. The direct-push rig is positioned over IP-9C.