



January 16, 2018

Jennifer Borski  
Wisconsin Department of Natural Resources  
625 E. County Rd Y, Suite 700  
Oshkosh, WI 54901

**Re: Remedial Action Options Report  
Former Appleton Wire Chrome Plant  
908 North Lawe Street  
Appleton, Wisconsin 54911  
BRRTS# 02-45-000015**

Dear Ms. Borski:

EnviroForensics, LLC (EnviroForensics) is pleased to submit the Remedial Action Options Report (Report) for the former Appleton Wire chrome plant located at 908 North Lawe Street in Appleton, Wisconsin. One hardcopy of the Report is enclosed, and an electronic copy has been sent to the northeast region mailbox. The Report has been prepared in accordance with the requirements of Wisconsin Administrative Code (WAC) Chapter NR 722. On behalf of the Albany International Corporation, EnviroForensics is requesting a written response to the recommendations contained in the Report. The Technical Assistance review fee was submitted with the copy of this letter sent to Ms. Danelski.

Sincerely,  
**EnviroForensics, LLC**

A handwritten signature in cursive script that reads "Wayne P. Fassbender".

Wayne Fassbender, PG  
*Senior Project Manager*

cc: Joe Gaug, Albany International Corp.  
Denise Danelski, WDNR

enclosures



## REMEDIAL ACTION OPTIONS REPORT

**APPLETON WIRE (FORMER)  
908 NORTH LAWE STREET  
APPLETON, WISCONSIN  
WDNR BRRTS# 02-45-000015**

January 16, 2018

*Prepared For:*

Albany International Corporation  
P.O. Box 1907  
Albany, NY 12201-1907

*Prepared By:*

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

## TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY.....</b>	<b>E-1</b>
<b>1.0 INTRODUCTION.....</b>	<b>1</b>
<b>2.0 BACKGROUND AND CURRENT CONDITIONS.....</b>	<b>2</b>
2.1 Site and Surrounding Property Information.....	2
2.2 Site History .....	2
2.3 Hydrogeology .....	3
2.4 Nature and Extent of Impacts .....	4
2.5 Chromium Species, Reduction and Fixation Principles, and Site Geochemistry ...	5
2.5.1 Chromium Species.....	5
2.5.2 Reduction of Hexavalent Chromium .....	6
2.5.3 Fixation .....	6
2.5.4 Site Geochemistry.....	9
2.6 Conceptual Site Model.....	10
2.7 Statement of Remedial Objectives.....	11
<b>3.0 IDENTIFICATION OF REMEDIAL ACTION OPTIONS.....</b>	<b>13</b>
3.1 Likely Remedial Action Options .....	14
<b>4.0 FURTHER EVALUATION OF REMEDIAL ACTION OPTIONS .....</b>	<b>15</b>
4.1 Technical Feasibility .....	16
4.1.1 Effectiveness.....	16
4.1.2 Ability to Implement.....	16
4.1.3 Restoration Time Frame .....	17
4.2 Economic Feasibility .....	17
4.3 Continuing Obligations.....	18
4.4 Additional Remedial Action Options Eliminated .....	18
4.5 Remedial Action Options Selected.....	19
4.5.1 Option 1 – Abandon Basement, Permeable Reactive Barrier.....	19
4.5.2 Option 2 – Treat and Abandon Basement, Source Area Injection, Limited Interior Soil Excavation .....	20
4.5.3 Option 3 – Treat and Abandon Basement, Limited Interior Soil Excavation with Ex-Situ Treatment and Disposal, Exterior Soil Mixing and Injection....	21
4.5.4 Option 4 – Excavate and Abandon Basement, Interior Soil Excavation with Ex-Situ Treatment and Disposal, Exterior Excavation .....	22
<b>5.0 RECOMMENDATION.....</b>	<b>24</b>
<b>6.0 REFERENCES.....</b>	<b>26</b>

## **TABLES**

- 1 Soil Geochemical Analytical Results
- 2 Groundwater Geochemical Analytical Results
- 3a Remedial Action Options Screening – Unsaturated Zone
- 3b Remedial Action Options Screening – Saturated Zone

## **FIGURES**

- 1 Site Location Map
- 2 Site Aerial Photograph
- 3 Soil Analytical Results Map Showing the Extent of Hexavalent Chromium Above the Industrial Residual Contaminant Level
- 4 Groundwater Analytical Results Map Showing Concentrations Exceeding Regulatory Standards and Distribution of Impacts
- 5 Total Chromium Isoconcentration Contours in Soil 0-5 feet
- 6 Total Chromium Isoconcentration Contours in Soil 5-10 feet
- 7 Total Chromium Isoconcentration Contours in Soil 10-15 feet
- 8 Total Chromium Isoconcentration Contours in Soil 15-20 feet
- 9 Map Showing Wells Sampled for Total Volatile Organic Compounds and Analytical Results

## CERTIFICATIONS


I, Andrew Horwath, 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.

Senior Engineer, P.E. No. E-43831-6

\_\_\_\_\_  
Senior Engineer

\_\_\_\_\_  
P.E. stamp

I, Wayne Fassbender, 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 Project Manager

1/16/2018

Date

### Document Reference:

Remedial Action Options Report  
Appleton Wire (Former)  
908 North Lawe Street  
Appleton, Wisconsin  
BRRTS# 02-45-000015

## EXECUTIVE SUMMARY

Past chromium plating operations were performed by the Appleton Wire Division of Albany International Corporation in a portion of their building located at 908 N. Lawe Street, Appleton, Wisconsin. This portion of the building is now a warehouse and is now owned by Luvata Appleton, LLC. Chromic acid containing hexavalent chromium was used in the plating process. Chromic acid and waste return lines fed two chromium plating lines. The piping was laid in concrete trenches to act as secondary containment. Chromic acid supply and waste tanks were located in a partial basement of the warehouse. Over time, the piping and concrete trenches became corroded from the chromic acid and releases occurred to the subsurface in spots along the trenches and in the basement area. Additional surface spills to the concrete floor slab breached the slab through joints and cracks.

Interim remedial actions included collecting groundwater within the basement sump and treating the water by precipitation before discharging to the sanitary sewer system via permit from the City of Appleton. Later, a French drain was added on the north side of the warehouse to collect and treat contaminated groundwater detected in this outside area, and the old precipitation treatment equipment was upgraded to a system using ion-exchange resin. The remedial “pump and treat” system has been operational for 30 years and has recovered a significant amount of hexavalent chromium over this period. However, significant chromium contamination continues to exist in shallow unsaturated soil and in groundwater. Continued operation of the pump and treat system is not expected to reduce groundwater concentrations to a significant extent over a reasonable amount of time. Therefore, alternative remedial actions are needed to reduce chromium concentrations to levels that will naturally attenuate.

There are six possible ionic species of chromium; however, trivalent chromium (valence state of +3) and hexavalent chromium (valence state of +6) are the most common under normal conditions. In the uncontaminated subsurface, trivalent chromium is naturally occurring with only trace concentrations of the hexavalent variety. Hexavalent chromium is highly toxic and is very mobile, while trivalent chromium is relatively non-toxic and tends to form immobile hydroxyl species.

Methods for remediation of subsurface hexavalent chromium impacts are limited. The two main types are removal and fixation. As mentioned, removal by pumping and treating is not practical for the subsurface conditions at this site. Removal by excavating is practical, but expensive, and may require additional treatment before disposal. Fixation does not remove chromium from the environment, but instead is the process of converting hexavalent chromium to trivalent

chromium under reducing conditions, and then providing electron donors and/or organics to enhance the production of insoluble and immobile precipitates.

We have evaluated likely remedial actions for the site and developed four (4) options for remediation. All of them utilize varied amounts of active remedial measures including excavation to remove the majority of soil impacts, along with the addition of reducing agents to fixate remaining chromium impacts. The use of engineered barriers and institutional controls will be needed with all options to prevent future exposure to residual chromium impacts. It is likely that residual concentrations of chromium will remain following active remediation. Therefore, an assessment of the subsurface environment to naturally attenuate the remaining residual impacts will be needed.

We are proposing to implement Option 2, which includes excavation of the shallow unsaturated soil in areas of heavy chromium contamination, and in-situ treatment of contamination in the saturated zone via injection. The excavated soil will be consolidated within the basement area and mixed with a dry reducing compound. Injections will occur in areas having significant groundwater impacts. The expectation is that the injected fluids will permeate the clay to a degree that will allow a practical application of reducing agent.

We intend to perform injection pilot testing to determine the effective radius of influence within the clay soil and effectiveness that the compound has on reducing hexavalent chromium to trivalent precipitates. We will test two (2) different proprietary blends of remedial compounds. Both products combine a nutrient source for enhanced microbial growth, and a source of iron.

If injection of reducing compounds is not practical for the subsurface conditions, then we propose to default to Option 3 following the pilot testing. This option involves excavating more of the contaminated soil and the addition of dry reducing compound with the overall goal to lower concentrations within the saturated zone and produce reducing conditions that will support natural attenuation.



## **1.0 INTRODUCTION**

EnviroForensics, LLC (EnviroForensics) has prepared this Remedial Action Options Report (Report) for the former Appleton Wire chrome plant located at 908 North Lawe Street in Appleton, Wisconsin (Site). The responsible party is Albany International Corporation (Albany). Albany performed past chromium plating operations within a portion of the existing building (now a warehouse area) and releases of chromic acid plating solution containing hexavalent chromium occurred to the subsurface. This Report follows guidelines for selecting remedial actions set forth in the Wisconsin Administrative Code (WAC) Chapter NR 722 and other associated Chapter NR 700 series rules. This Report is being submitted subsequent to the Site Investigation Report dated October 19, 2017.



## 2.0 BACKGROUND AND CURRENT CONDITIONS

### 2.1 Site and Surrounding Property Information

The former Appleton Wire Division of Albany International Corporation manufacturing facility (Site) is located at 908 North Lawe Street in Appleton, Wisconsin. The location of the Site is depicted on **Figure 1**. The Site is situated in a mixed area of industrial and residential properties as seen on the aerial photograph, **Figure 2**.

Currently, the Site property is owned by Luvata Appleton, LLC and consists of one (1) single-story slab-on-grade manufacturing building of approximately 42,500 square feet and an attached warehouse of approximately 10,500 square feet. The warehouse has a partial basement in the southeast corner that has an approximate area of 1,300 square feet and is 11 feet below grade. As seen on **Figure 2**, the Site is nearly completely under roof or paved. Adjacent properties to the north, west, and south are industrial, while adjacent properties to the east are residential.

### 2.2 Site History

The Site was operated by the Appleton Wire Division of Albany International Corporation from 1963 to 1981. An eastern portion of the facility (now a warehouse) housed a chrome plating operation. The operation was discontinued in 1981 and the chrome plating equipment was dismantled and sold in 1982 as part of the decommissioning process. In 1985, the northern portion of the facility including the warehouse was sold to Valley Cast. The southern portion of the facility including an office building and parking lot were sold to Appleton Papers. Subsequently, Valley Cast sold their portion of the property to Luvata Appleton, LLC in 2006.

In 1985, a sump pump in the partial basement failed and flooding occurred in the warehouse basement. Facility employees of Valley Cast noticed that the water was tainted yellow and notified Albany International. Initial testing showed that the water was contaminated with chromium. A groundwater recovery and treatment system was subsequently installed to collect and treat groundwater from the sump. This system was enhanced in 1992 to include a French drain and groundwater collection trench located outside on the north side of the warehouse.

From 1985 to 2017, several rounds of subsurface investigations were performed by multiple consultants to better determine the extent of chromium impacts in soil and groundwater. Subsurface data indicates that releases of chromic acid containing hexavalent chromium to the subsurface have occurred along deteriorated sections of the supply piping and associated

concrete secondary containment raceways. Additional releases occurred within the partial basement that housed the supply tanks for the chromic acid. Air scrubbing units designed to remove chromium vapor from work areas inside the warehouse were located outside on the north and south sides of the warehouse. Leakage from these units likely contributed to the impacts seen outside to the north, and possibly to a lesser degree outside to the south.

### **2.3 Hydrogeology**

Soil beneath the Site consists of a relatively homogenous blanket of reddish-brown lean clay, having trace amounts of sand to the maximum sampling depth of 60 feet. The clay soil is of very low permeability and does not readily transmit water. Discontinuous seams of clayey, medium to coarse sand and fine to medium gravel were observed in boring MW-19C (14-inches thick at a depth of 35 feet), and MW-24A (4-feet thick at a depth of 32-36 feet). Based on the boring logs of past consultants, there appears to be some sand and gravel fill within a few feet of the warehouse foundation. In addition, 2-3 feet of sand and fine gravel fill was observed in soil samples collected behind the east and south concrete basement walls. The basement was constructed after the warehouse was built. As such, similar fill materials on all sides of the basement are expected. The clay soil overlies dolomite bedrock which is encountered at approximately 120-130 feet below ground surface (bgs).

The shallow water table is encountered at the Site within the glacial clay overburden at between approximately 3-6 feet bgs. Recharge of groundwater to Site monitoring wells is extremely slow due to the very low hydraulic conductivity of the clay soil. Groundwater in the unconsolidated clay is unconfined and not a useable resource for domestic applications. Pumping in the sump and French drain affect localized groundwater flow and directs flow towards them. However, based on local topography and drainage features, it is expected that the direction of shallow groundwater flow is to the east towards a drainage channel following the slope of topography, or to the southeast towards the Fox River, which is the primary discharge point in this area for groundwater within the shallow unconsolidated soil.

Horizontal hydraulic conductivity values for the clay based on slug test data ranged between  $9.7 \times 10^{-6}$  and  $1.4 \times 10^{-7}$  centimeters per second, decreasing with depth. The groundwater flow velocity is estimated at between 1.6 feet per year for the upper 20 feet of saturated soil and 0.023 feet per year for the silty clay below 20 feet.

## 2.4 Nature and Extent of Impacts

The Site contaminant of concern is hexavalent chromium, which is highly mobile and toxic. The lateral extent of expected hexavalent chromium at concentrations exceeding the industrial residual contaminant level (RCL) of 6.36 milligrams per kilogram (mg/kg) is depicted on **Figure 3**. Both hexavalent chromium and total chromium results were utilized to construct **Figure 3**, which reflects the lateral distribution of all chromium impacts in soil. The extent of hexavalent chromium impacts in shallow soil above the industrial RCL is limited to within the warehouse and beneath a limited portion of the asphalt parking lot on the north side of the warehouse.

Higher concentrations of total chromium exist in soil beneath the warehouse floor and are generally concentrated along the old piping trench and basement area, and extend to the west within the footprint of the primary plating line. Soil impacts continue to exist in the north parking lot area in close proximity to the French drain. Concentrations are greatest between the French drain and the foundation of the warehouse and appear to decrease substantially to the north of the French drain.

Chromium impacts in groundwater above the enforcement standard (ES) of 100 micrograms per liter ( $\mu\text{g/l}$ ) are depicted on **Figure 4**. Concentrations exceeding the ES are limited to the Site, except for beneath the parking lot on Appvion property to the south of the warehouse. The extension of groundwater impacts to the area outside of the warehouse near MW-5 is likely due to sand and gravel fill around the basement. This fill appears to extend around the outside foundation of the warehouse in the area of MW-5 and could have acted as a preferential migration pathway for groundwater impacts from within the warehouse to this outside area.

The distribution of impacts with depth are depicted taking horizontal slices through the contaminant plume at the depth intervals of 0-5 feet, 5-10, 10-15, and 15-20. These depictions are presented on **Figures 5, 6, 7, and 8**, respectively. As can be seen on these figures, the vertical extent of chromium impacts in groundwater above regulatory standards diminishes rapidly with depth, and is generally limited to the depth of water table observation wells which are screened between 4-21 feet. Groundwater impacts generally coincide with the distribution of soil impacts, which appear limited to depths of approximately 15 feet.

Various chlorinated volatile organic compounds (CVOCs) were also detected in shallow groundwater samples. Tetrachloroethene (PCE) and trichloroethene (TCE) were detected in monitoring well MW-19 at concentrations above the ES for both compounds of 5  $\mu\text{g/l}$ . Dichloroethene (DCE) and vinyl chloride degradation products were detected in concentrations

exceeding the ES for these compounds at monitoring well MW-21. Vinyl chloride was detected at concentrations exceeding the ES at MW-25 and MW-26 (**Figure 9**).

There does not appear to be a major source area for the CVOCs. The only detection of CVOCs in soil (above laboratory detection limits) was PCE at a concentration of 104  $\mu\text{g}/\text{kg}$  at the location of MW-25. According to testimony of past employees, PCE was not used in past manufacturing processes or as a widespread cleaning compound. PCE may have had limited use as a degreaser for cleaning equipment or hand tools. The PCE likely entered the subsurface in dilute form through cracks or joints in the floor slab as the cleaning compound splashed off equipment and spilled onto the floor. There is evidence that the subsurface environment is optimum for natural attenuation of these CVOCs and it is expected that the process of dehalogenation will continue to degrade these compounds.

## **2.5 Chromium Species, Reduction and Fixation Principles, and Site Geochemistry**

### **2.5.1 Chromium Species**

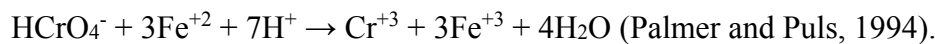
Under normal conditions, chromium exists in two oxidation states: hexavalent chromium ( $\text{Cr}^{+6}$ ), and trivalent chromium ( $\text{Cr}^{+3}$ ).  $\text{Cr}^{+6}$  is not typically present in the natural, uncontaminated environment, unless in trace concentrations.  $\text{Cr}^{+6}$  is highly mobile and acutely toxic, whereas  $\text{Cr}^{+3}$  has relatively low toxicity and forms insoluble and immobile hydroxide precipitates under moderately alkaline to slightly acidic conditions (Palmer and Puls, 1994).

$\text{Cr}^{+6}$  can exist in solution as monomeric ions of the form  $\text{H}_2\text{CrO}_4^0$ ,  $\text{HCrO}_4^-$  (bichromate), or  $\text{CrO}_4^{2-}$  (chromate). It can also exist as the dimeric ion  $\text{Cr}_2\text{O}_7^{2-}$  (Richard and Bourg, 1991). At concentrations above 1.0 milligrams per liter (mg/l), the monomeric ions impart a yellow color to water. High concentrations of the dimeric ion impart an orange color. Above a pH of 6.5, chromate generally dominates (Palmer and Puls, 1994). Yellow staining of water and on the concrete block walls of the basement have been observed on Site.

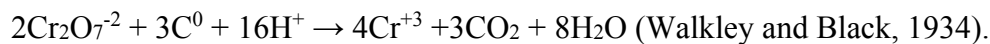
By comparison,  $\text{Cr}^{+3}$  forms hydroxide ions through hydrolysis at pH conditions above 3.5. With increasing pH, the ions produced include:  $\text{CrOH}^{+2}$ ,  $\text{Cr}(\text{OH})_2^+$ , and  $\text{Cr}(\text{OH})_4^-$  (Rai, et al., 1987). These hydroxide ions impart a green color when in solution. Green staining of new cement around newly installed groundwater monitoring wells has been observed on Site.  $\text{Cr}(\text{OH})_3^0$  is the only solid hydroxyl species, and exists as an amorphous precipitate (EPA, 2000). However,  $\text{Cr}^{+3}$  can form solid precipitates in the presence of oxidized iron ( $\text{Fe}^{+3}$ ).

### 2.5.2 *Reduction of Hexavalent Chromium*

Cr<sup>+6</sup> is a strong oxidant and is reduced to Cr<sup>+3</sup> complexes in the presence of electron donors including those found naturally in soil such as ferrous iron minerals, reduced sulfur, and soil organic matter (humic and fulvic acids). There must be sufficient electron donors present in the subsurface for complete reduction of the Cr<sup>+6</sup> contaminant mass. Ferrous iron is an especially efficient reducing agent. The reduction of Cr<sup>+6</sup> by ferrous iron is written as:



Reduction reactions with organic matter takes the form of:



In addition, reduction can also occur through the metabolic actions of soil microbes, mainly under anaerobic conditions; however, the actual mechanisms of biological reduction are not well known. It appears that microorganisms can reduce Cr<sup>+6</sup> by both metabolic processes and absorption within the cell mass that is independent of metabolism (Krauter et al., 1996). These processes work slowly. A more typical biological approach is to add organic nutrients to the subsurface which acts as a food source for the native sulfur-reducing microbes. The consumption of the food source and growth of the microbial population depletes oxygen from the subsurface causing reducing conditions that are conducive for chromium reduction (Suthersan, 1997).

The goal of reduction is to initially convert Cr<sup>+6</sup> to Cr<sup>+3</sup> and then to form insoluble and non-reactive Cr<sup>+3</sup> precipitates in a process called fixation. Cr<sup>+6</sup> is not removed from the subsurface environment, but instead is converted to stable, immobile Cr<sup>+3</sup> compounds and essentially “fixed” in place.

### 2.5.3 *Fixation*

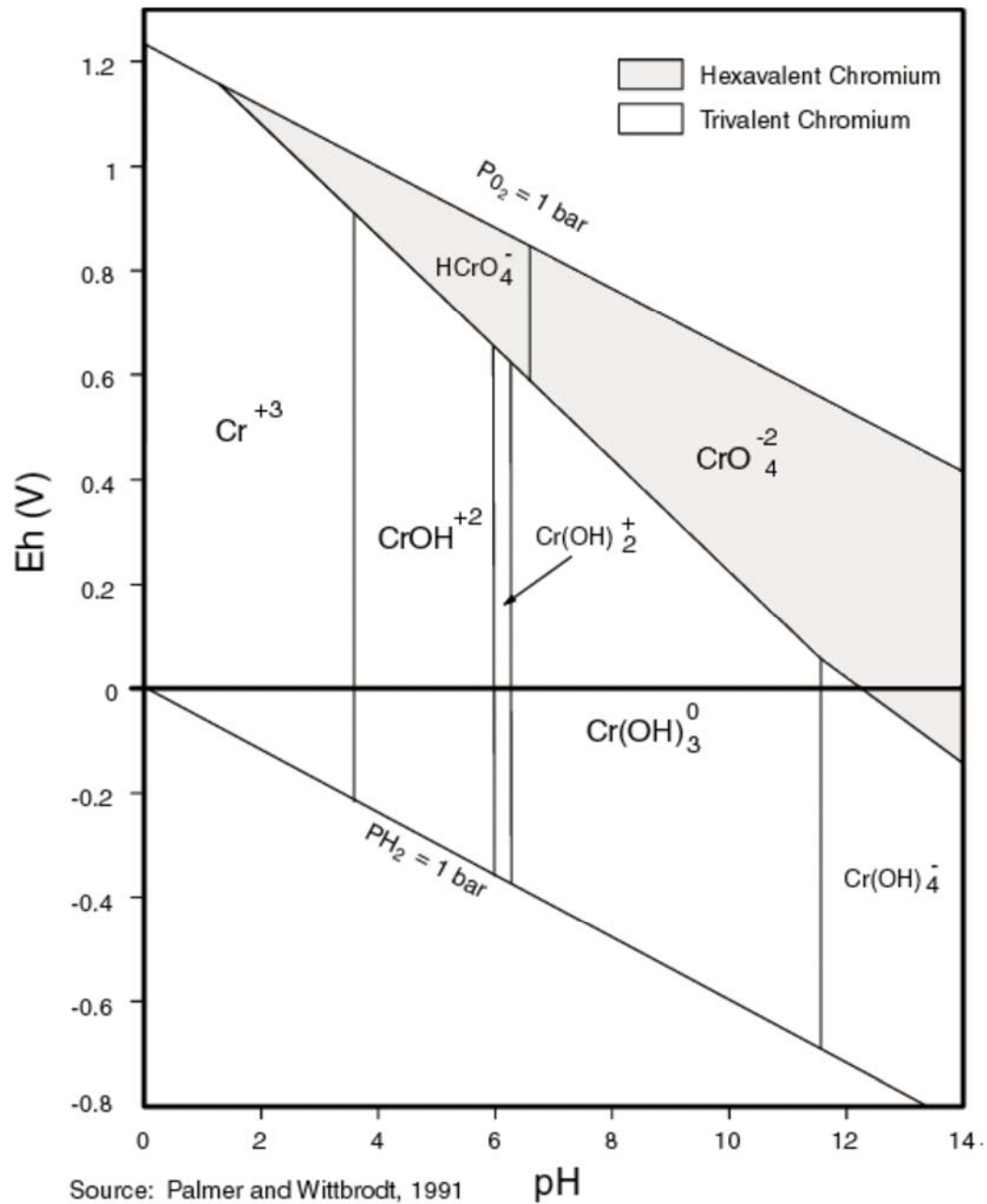
Stable Cr<sup>+3</sup> compounds come in three forms: the amorphous precipitate Cr(OH)<sub>3</sub><sup>0</sup>; metal co-precipitates such as Cr<sub>x</sub>Fe<sub>1-x</sub>(OH)<sub>3</sub>, and organic complexes of high molecular weight (Palmer and Wittbrodt, 1991). The iron complex is a particularly important chemical reaction because ferrous iron (Fe<sup>+2</sup>) is the most common oxidation state of dissolved iron in subsurface water and

is a source of ferric iron ( $\text{Fe}^{+3}$ ) for complexing with  $\text{Cr}^{+3}$  to form the metal co-precipitate. The reaction occurs as follows:



In addition, the formation of organic complexes binds  $\text{Cr}^{+3}$  tightly and prevents oxidation back to  $\text{Cr}^{+6}$ .

The stability of  $\text{Cr}^{+3}$  compounds is dependent on the pH, Eh, and the amount of manganese dioxide present in the subsurface environment. Manganese dioxide can oxidize  $\text{Cr}^{+3}$  with  $\text{Cr}^{+6}$  oxides as the result. However, this typically occurs where soil is in partial equilibrium with atmospheric oxygen (EPA, 2000). The theoretical range of Eh/pH resulting in stable  $\text{Cr}^{+3}$  compounds is shown on the figure below. As can be seen on this figure,  $\text{Cr}^{+3}$  ions and hydroxides can exist over a wide range of Eh and pH values. Chromate exists over a much narrower range and predominantly at positive Eh. Site soil Eh is in the range of 0.16 to 0.20 Eh, which indicates slight oxidizing conditions and soil pH is between 8.5 and 8.9, which is slightly alkaline. Under these Site soil conditions, the amorphous precipitate  $\text{Cr}(\text{OH})_3^0$  should be stable.



The cation/anion exchange capacity (CEC/AEC) of the soil can have an effect on efforts to form insoluble precipitates. Higher values of CEC can indicate that some Cr<sup>+3</sup> hydroxyl ions will bind to the soil and may not form precipitates. In addition, Cr<sup>+6</sup> can also adsorb to soil, typically in the form of chromate (HCrO<sub>4</sub><sup>-</sup>) because it competes with other anions such as chloride, nitrate,

and phosphate. For remediation purposes, it is not advantageous for  $\text{Cr}^{+6}$  to adsorb. The reduction reaction occurs in solution; therefore, it is important that  $\text{Cr}^{+6}$  remain mobile to be reduced to  $\text{Cr}^{+3}$ . According to studies by Zachara et al. (1988), chromate adsorption increased with decreasing pH, soils containing higher concentrations of aluminum and iron oxides showed greater adsorption of  $\text{Cr}^{+6}$ , and chromate binding is depressed in the presence of dissolved sulfate and inorganic carbon (EPA, 2000).

#### **2.5.4**      *Site Geochemistry*

During recent Site investigations, geochemical baseline parameters were established for soil and groundwater both in and out of the hexavalent chromium source area. These geochemical parameters are presented in **Table 1** for soil, and **Table 2** for groundwater. For **Table 1**, well locations MW-19C and MW-20C are in contaminant source areas. For **Table 2**, well clusters MW-21 and MW-28 are on the fringe of the contaminant plume, and well cluster MW-22 is outside the plume.

The baseline parameters are not useful for determining the actual stoichiometry or individual chemical reactions taking place in the subsurface, but instead allow us to assess the general existing subsurface conditions favorable to reduction and fixation, and help resolve appropriate remedial actions that will help us meet remedial objectives. These baseline parameters also allow us to monitor changes in the subsurface during and after remedial activities to determine effectiveness of the remedial applications and prospect for natural attenuation.

Since baseline parameters were analyzed both in and out of the source area, there are some general observations that can be made at this time. The ranges of Eh and pH in Site soil should allow formation of the amorphous precipitate  $\text{Cr}(\text{OH})_3^0$ . However, the Eh could be lowered by adding reducing agents, which would enhance reduction of  $\text{Cr}^{+6}$  and provide a more stable reducing environment to prohibit the oxidation of  $\text{Cr}^{+3}$  through chemical interactions with manganese oxides.

Some general observations can be made from the data contained in the tables. Some soil observations in **Table 1** are as follows:

- The Site soil has a fair amount of organic carbon;
- ORP values for soil are positive and indicate weak oxidizing conditions;
- There are good concentrations of electron donors present (metals);



- pH is slightly alkaline, increasing very slightly with depth; and
- The cation exchange capacity of the soil is relatively low, or in the range of a typical Kaolinite clay between 3-15 millequivalents per 100 grams.

Some general observations made from the groundwater data in **Table 2** are as follows:

- Iron and aluminum depletion appears to have occurred within the plume of shallow groundwater impacts;
- There is appreciable sulfate present. Sulfate competes for adsorption sites with chromate; and
- Manganese depletion appears to have occurred within the most highly contaminated portion of the plume at MW-20 and may indicate that some oxidation of  $\text{Cr}^{+3}$  to  $\text{Cr}^{+6}$  may be occurring at this location.

## 2.6 Conceptual Site Model

The pattern of chromium impacts in soil is consistent with the locations of past chromium plating machinery and ancillary piping feeding and discharging chromic acid from aboveground tanks located in the basement, downward seepage of chromic acid through the clay soil, and transport along and within sandy fill along the basement foundation. Migration of impacts within the clay soil is very limited with most lateral distribution occurring along the man-made artificial pathways. High concentrations of chromium are in contact with the high water table and will continue to provide a source of impact to the groundwater.

Operation of the current groundwater recovery and treatment system has acted to capture groundwater and direct it to flow towards the basement sump and French drain within the immediate area of the warehouse. As previously described, the velocity of groundwater flow in the clay soil is expected to be less than 1.6 feet per year under natural groundwater flow conditions (i.e., without the influence of pumping) and is expected to flow south to southeast. The migration of hexavalent chromium in groundwater is expected to be somewhat slower primarily due to dispersion.

The groundwater recovery and treatment system has been in operation for approximately 30 years, and has removed considerable chromium from the subsurface environment. However, significant impacts remain in unsaturated soil and shallow groundwater beneath the warehouse. The groundwater recovery and treatment system will not effectively remove these remaining

impacts within a reasonable amount of time due to the low permeability of clay soil and associated slow recovery of groundwater pore volumes. Alternate remedial actions are needed to reduce these chromium concentrations to below groundwater enforcement standards, or to levels that will naturally attenuate.

There are concentrations of hexavalent chromium that exceed the industrial RCL within the upper four feet of soil within the warehouse and in the outside area to the north in close proximity to the French drain. These areas of shallow subsurface soil impacts are covered by impervious surfaces (e.g. buildings, concrete, and asphalt). Therefore, as long as these engineered barriers remain, direct contact with contaminated soil is not a potential exposure pathway.

The City of Appleton is supplied by municipal drinking water that is drawn from Lake Winnebago located approximately four miles south of the site. The dolomite aquifer is protected by over 90 feet of clay having low permeability, and there are no sensitive receptors located nearby that could be affected by site contaminants.

The geochemistry of soil and groundwater at the Site appears to be supportive of the reduction of hexavalent chromium to immobile and insoluble trivalent compounds, more specifically amorphous chromium hydroxide of the form  $\text{Cr}(\text{OH})_3^0$  and ferric iron co-precipitates. However, positive ORP and Eh indicate oxidizing conditions may be causing the oxidation of trivalent chromium back to the hexavalent state. Soil modifications in the saturated zone are needed to lower the Eh of the subsurface environment and to provide additional compounds such as organic matter and iron to support the formation of immobile and insoluble chromium precipitates.

Chromium concentrations at some locations are overwhelming the ability of the natural environment to reduce hexavalent chromium. Unsaturated soil heavy with chromium impacts must be removed to decrease contaminant loading to the shallow groundwater.

## **2.7 Statement of Remedial Objectives**

The remedial objectives for the Site are to:

- Eliminate the existing groundwater treatment system which is inefficient, costs between \$30,000 to \$50,000 per year to operate and maintain, will not address high concentrations

of hexavalent chromium in unsaturated soil, and will not reduce concentrations in groundwater significantly within a reasonable time frame;

- Reduce contaminant mass in unsaturated soil that continues to be a source of hexavalent chromium loading to groundwater;
- Reduce groundwater concentrations of chromium to below the groundwater enforcement standard of 100 parts per million, or to levels that will allow the residual chromium to naturally attenuate; and
- Mitigate exposure pathways.

The objectives are likely to be achieved through an integrated closure strategy consisting of active remediation and risk management steps that are consistent with current and anticipated future land use.

### 3.0 IDENTIFICATION OF REMEDIAL ACTION OPTIONS

This section presents the remedial action options identified for control, removal, containment, and/or treatment of impacted media at the Site. The initial identification and screening of remedial action options is based on information generated during site investigation activities, including the nature and extent of contamination and the hydrogeological conditions at the Site and surrounding areas. Remediation of contaminants in soil and groundwater drives the remedial options evaluation.

Initial screening for remedial technologies under general remedial response actions was completed as shown in **Tables 3a**, and **3b**. The following general response actions were identified:

- Unsaturated Zone (0-5 feet)
  - No Remediation;
  - Institutional Controls;
  - Engineering Controls;
  - In-Situ Remediation; and
  - Removal and landfill disposal, or removal, ex-situ treatment and disposal.
  
- Saturated Zone
  - Monitored natural attenuation;
  - Institutional Controls;
  - Engineering Controls;
  - In-Situ Remediation;
  - Removal and treatment (pump, treat, and discharge, or pump, treat, and re-infiltrate);
  - Removal and landfill disposal, or removal, ex-situ treatment and disposal; and
  - Contain and treat using a reactive barrier wall.

Chromium in any state does not cause impacts to soil gas. Therefore, remediation of vapor phase contamination was not considered during this evaluation. Tetrachloroethene (PCE) and other CVOCs associated with the natural degradation of PCE were detected in soil and groundwater at relatively low concentrations. PCE was detected at one location in soil and does not appear to be widespread. The risk of vapor intrusion is very low given the concentrations detected and dilution capabilities of the warehouse area. However, treatment options have been evaluated keeping in mind the presence of these CVOCs.

### 3.1 Likely Remedial Action Options

Under the response action scenarios, the following remedial approaches were considered likely to meet Site remedial objectives and selected for further evaluation. These options are identified by highlighting in **Tables 3a**, and **3b**:

- Unsaturated Zone (0-5 feet)
  - Institutional control – GIS Registry (in conjunction with other options);
  - Engineering control - soil cover (in conjunction with other options);
  - In-situ remediation – soil mixing: in-situ chemical reduction;
  - In-situ remediation – soil mixing: solidification and stabilization; and
  - Removal – excavation and disposal (with or without ex-situ treatment).
  
- Saturated Zone
  - Monitored natural attenuation – (in conjunction with other options);
  - Institutional control – GIS Registry (in conjunction with other options);
  - Engineering control - soil cover (in conjunction with other options);
  - In-situ remediation – injection: in-situ chemical reduction;
  - In-situ remediation – soil mixing: in-situ chemical reduction;
  - In-situ remediation – soil mixing: solidification and stabilization;
  - Removal – excavation and disposal (with or without ex-situ treatment); and
  - Containment – permeable reactive barrier.

Continued pumping and treatment of groundwater, with or without re-infiltration, was not further considered. This is because treatment of the overlying five to six feet of unsaturated soil needs to occur to reduce loading to groundwater, or the pump and treat system will need to operate indefinitely. At sites with more permeable soils, this may be accomplished by re-infiltration of treated groundwater to essentially flush the hexavalent chromium contamination out of the unsaturated zone and into the groundwater for further groundwater recovery, treatment, and re-infiltration (treatment loop). However, for this Site, a treatment loop like this is not practical due to the low permeability of the clay soil and limited ability to recover or infiltrate solutions under normal atmospheric pressures.

#### 4.0 FURTHER EVALUATION OF REMEDIAL ACTION OPTIONS

The potentially feasible remedial actions were evaluated according to specific criteria associated with each technology as follows:

- Technical Feasibility
  - Short-Term Effectiveness;
  - Long-Term Effectiveness;
  - Ability to Implement; and
  - Restoration Time Frame.
  
- Economic Feasibility
  - Initial Costs;
  - Capital Costs;
  - Annual Operation and Maintenance; and
  - Future Liability.

Additionally, the need for continuing obligations after completion of a remedial action, such as maintenance of an engineering control and long-term groundwater monitoring, were considered.

Typically the evaluation is documented and quantified using ranking matrices to identify the most suitable action for soil and groundwater remediation that are applicable in all areas of site impacts. However, in this case there are several areas of impact that will require differing treatment methods to achieve remedial objectives. These areas consist of:

- The basement which is 11 feet deep, has soil impacts five feet below it, and is currently de-watered via the active pump and treat system;
- Other interior areas which have limited access and are utilized by the current owner for warehousing;
- Exterior immediately north of the warehouse building;
- Exterior immediately south of the building in the vicinity of monitoring well MW-5; and
- The French drain and groundwater collection trench which is also part of the active pump and treat system.

Access, depth of impacts, subsurface features, and existing treatment infrastructure all affect the evaluation. Each area of concern may be best addressed by a different action or combination of

actions. Therefore, a Site-wide ranking and selection process is not appropriate. Instead, all remedial actions highlighted in **Tables 3a**, and **3b** are evaluated separately for each area of concern. The evaluation criteria are discussed in more detail below.

## **4.1 Technical Feasibility**

The feasibility of a technology to remediate impacted areas at any specific site is evaluated with regard to the following specific considerations:

- Proven technology: when a technology is fully developed and historical success case histories are available;
- Emerging technology: when a technology is not fully developed and may not be reliable;
- Inappropriate technology: when Site conditions are not technically suitable for the application of the technology; and
- Potential additional liability: whether the treatment technology may add additional liability.

### **4.1.1 Effectiveness**

The key aspect of evaluation is the effectiveness of each remedial action in preventing exposure to contaminants and protecting the environment. Each potential remedial action is evaluated as to its effectiveness in providing protection and the reductions in toxicity, mobility, or volume of contamination that it would achieve. Both short- and long-term components of effectiveness are evaluated; short-term referring to the construction and implementation period until case closure, and long-term referring to the period after remediation is complete. Reduction of toxicity, mobility, or volume refers to changes in one or more characteristics of the contaminated media by the use of treatment that decreases the inherent threats. Any remedial action option under consideration should minimize adverse impacts to Site workers, visitors, the surrounding population, and the environment. Community impact is also important and the technology is considered a disadvantage if the application of the technology could be perceived as negatively impacting the local community or environment.

### **4.1.2 Ability to Implement**

The ability to implement a remedial action is a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action option, and is used to

evaluate combinations of remedial actions with respect to conditions at a specific site. The determination that an option is not readily implementable would usually preclude it from further consideration unless steps can be taken to change the conditions responsible for the determination.

The technical aspects related to the ability to implement refers to the ability to construct, reliably operate, and meet technology- specific regulations for remedial actions until remediation is complete. It also includes operation, maintenance, replacement, and monitoring of technical components of an action, if required, into the future after the remedial action is complete. The evaluation also considers the ability to obtain approvals and permitting from other offices and agencies, the availability of treatment, storage, and disposal services and capacity, disturbance to current operations, and the requirements for, and availability of, specific equipment and technical specialists.

#### **4.1.3            *Restoration Time Frame***

Restoration time frame relates to the time required to sever the exposure pathway and complete the remedial action. The estimated time for completion of a remedial action and restoration of the environment is based on the information available from vendor(s) with experience in remediating similar sites, and EnviroForensics' past experience using technologies in similar settings. Contaminant degradation rates, both naturally and under treatment conditions, are assumed based on experience to estimate the duration of remedial actions. If necessary, the time frame for continuing obligations is also considered.

#### **4.2                *Economic Feasibility***

The cost to implement various options is not an exact cost, but represents a combination of typical contractor costs and consultant efforts coupled with the estimated time to achieve remedial endpoints. This is inherent because uncertainties associated with the definition of options often remain, and it may not be possible or practical to collect all of the data needed to further refine costs.

The focus is on comparative estimates of costs between options so that if costs go up or down during the remedial process, that they remain relative. The following cost factors are considered during the evaluation of options:

- Initial costs: those costs incurred for design and testing of the remedial action,



- Capital costs: the cost to construct, install, or otherwise implement the remedial action,
- Operation and maintenance (O&M) costs: the costs to operate and maintain the remedial system or technology. The evaluation includes those O&M costs that would be incurred for as long as necessary, even after the initial remedial action is complete, and
- Future liability: includes potential additional remedial action costs and costs for property re-development are considered during evaluation to the extent they can be estimated.

#### **4.3 Continuing Obligations**

The involvement of continuing obligations in the closure strategy is considered in the evaluation process. Post-closure obligations may include activities such as annual cover inspections, groundwater monitoring, and operation, maintenance and inspections of any remedial treatment systems. These activities may be required for indefinite period of time following case closure. A remedial action is considered more advantageous if the resulting need for continuing obligations is limited or eliminated.

#### **4.4 Additional Remedial Action Options Eliminated**

Upon further evaluation, the following remedial actions were eliminated from the likely options listed on **Tables 3a**, and **3b**:

- In-situ remediation – soil mixing: solidification and stabilization.

The addition of cement or clay minerals to lower the permeability of the soil matrix and effectively bind the chromium contamination in place would require heavy, and bulky equipment to operate within the warehouse. The areas of impact and height of the warehouse ceiling would not accommodate the type of equipment needed to mix soil to a depth of 15 feet. In addition, the natural clay already has low permeability and complete stabilization using cement or bentonite would not be expected due to difficulties in getting a homogeneous distribution of the stabilizing compound throughout the clay soil.

- In-situ remediation – soil mixing: in-situ chemical reduction (inside the warehouse).

Although possible in outside areas, the addition of reducing compounds by mixing in-place was not feasible for inside the warehouse area. This is because of the requirement for heavy equipment with high ceiling requirements that would not be achievable in some

areas of the warehouse. Also, this would produce a slurry that would not structurally support the concrete slab. Significant time may be needed to allow the treated material to settle before the addition of structurally sound engineered fill and subsequent repair of the concrete floor slab. Disruption to the active warehouse operations would be maximized and operations would need to be shut down for an extended period.

## **4.5 Remedial Action Options Selected**

Four (4) remedial option scenarios were developed combining selected remedial actions for soil and groundwater. All of the remedial options contain an element of excavating to remove hexavalent chromium mass, active or passive treatment of the impacts by introducing reducing agents to convert hexavalent chromium to immobile and insoluble trivalent compounds, and engineering and institutional controls.

Conceptual costs for each scenario were also calculated. All options rely on a combination of risk management strategies and remediation to bring the Site to regulatory closure. For each option, risk associated with exposure to any residual contamination would be managed with engineering and institutional controls. Engineering controls would physically limit contact with contamination and would be achieved through maintenance of the existing/replaced asphalt and building floor to prevent direct contact with the underlying soil and groundwater. Institutional controls would consist of adding the Site to the WDNR's GIS Registry database of properties with residual contamination.

The introduction of reducing amendments will have a secondary remedial effect on the chlorinated volatile organic compounds that were detected during the Site investigation by enhancing the reducing environment and stimulating further reductive de-chlorination.

### **4.5.1 Option 1 – Abandon Basement, Permeable Reactive Barrier**

Option 1 is focused on preventing off-Site exposures by implementing a containment action. Option 1 consists of the following actions:

- Decommission the existing groundwater treatment system;
- Backfill the basement with low permeability material mixed with an amendment to reduce hexavalent chromium; and

- Install a permeable reactive barrier (PRB) constructed with a zero-valent iron (ZVI)/sand mixture along the entire east property boundary and south of the basement area.

The barrier would be designed to intercept all chromium contaminated groundwater. Total length of the PRB would approximately 230 feet and the treatment interval would be from 5 feet (the water table) to 20 feet bgs. It would most likely be installed by trenching between the building/parking lot and Meade Street.

This option has the least initial cost, in the range of \$350,000 to \$400,000. However, the long-term liability is highest with Option 1 because Albany would have continued responsibility to maintain the PRB. It would be in place indefinitely, and may require replenishment of the ZVI over time which could double the cost.

#### **4.5.2            *Option 2 – Treat and Abandon Basement, Source Area Injection, Limited Interior Soil Excavation***

Option 2 addresses source area contamination while minimizing the amount of time that warehouse operations would be disrupted. Option 2 consists of the following actions:

- Decommission the existing groundwater treatment system;
- Advance boreholes on a grid arrangement through the basement floor to approximately 5 feet and add a reducing amendment to the boreholes;
- Inject an amendment solution in interior source areas from approximately 5 to 20 feet bgs.
- Excavate from surface to 5 feet bgs along the former chrome plating lines and backfill the basement with the excavated soil, mixed with an amendment to reduce hexavalent chromium;
- Backfill interior excavation from 0 to 5 feet with compacted fill and replace concrete;
- Fill the French drain/collection trench with an amendment solution and abandon the associated piping; and
- Evaluate the enhanced and natural subsurface chemistry for long-term conversion of hexavalent chromium to trivalent precipitates (natural attenuation potential).

Option 2 relies on the ability to effectively inject into the native clay soil under pressure to achieve a practical lateral radius of influence. A pilot test would be conducted to evaluate the feasibility of this approach and to conduct a performance comparison of two (2) different

amendments. The pilot test would consist of advancing several direct push borings near existing monitoring wells and injecting the amendment solutions through specialized direct-push tooling. Assuming the injection approach is determined to be feasible, the full-scale injection would be performed in areas that exhibit the highest concentrations of chromium in groundwater. Details on the injection pilot test design will be presented under a separate cover in the form of an injection permit application.

Following injection activities, soil would be excavated to a depth of 5 feet inside the warehouse along the two (2) former plating lines to remove the most contaminated and unsaturated soil. This shallow excavation could be accomplished by smaller equipment, potentially utilizing the existing access. All excavated soil would be transferred to the basement and mixed with a reducing amendment for treatment.

The cost for this option would be approximately \$550,000 to \$600,000. Long-term liability is less than Option 1, but the duration of post-remediation monitoring could be longer than other options that include more extensive removal of source area soil.

#### **4.5.3      *Option 3 – Treat and Abandon Basement, Limited Interior Soil Excavation with Ex-Situ Treatment and Disposal, Exterior Soil Mixing and Injection***

Option 3 replaces injection with deeper source area excavation, and adds in-situ mixing to treat contaminated areas outside and north of the warehouse. Option 3 consists of the following actions:

- Decommission the existing groundwater treatment system;
- Advance boreholes on a grid arrangement through the basement floor to approximately 5 feet and add a reducing amendment to the boreholes;
- Excavate from surface to 10 feet bgs along the former chrome plating lines;
- Backfill interior excavation from 5 to 10 feet bgs with a reducing amendment mixture;
- Backfill excavation from 0 to 5 feet with compacted fill and replace concrete;
- Backfill the basement with approximately half of the excavated soil, mixed with an amendment to reduce hexavalent chromium;
- Treat the remaining excavated soil ex-situ to non-hazardous concentrations and transport to a landfill for disposal;
- Perform in-situ mixing to treat impacts in the outside area between the north warehouse wall and the French drain (near boring GP-23);

- Limited injection of reducing amendment within the basement foundation fill located outside the south wall of the warehouse in the vicinity of MW-5;
- Fill the french drain/collection trench with an amendment solution and abandon the associated piping; and
- Evaluate the natural subsurface geochemistry for continued conversion of hexavalent chromium to trivalent precipitates.

This option would remove over 80% of the contaminant mass from both the unsaturated and saturated zones and leave a reducing amendment in place below the water table to address lower chromium concentrations in soil adjacent to the excavation areas. Approximately half of the soil excavated from the interior of the building would be transferred to the basement and mixed with a reducing amendment. The other half of the soil will be treated ex-situ in roll-off containers and sampled to confirm that chromium concentrations are reduced to below the toxicity characteristic leachate procedure (TCLP) threshold of 5 mg/L. The treated soil would then be landfilled as non-hazardous waste. This option also includes in-place soil mixing outside on the north side of the warehouse and targeted treatment on the south side of the warehouse in the vicinity of MW-5.

The cost for this option would be approximately \$750,000 to \$800,000. Option 3 would be more disruptive to current warehouse operations than Option 2 and likely require that an overhead door be installed on the north side of the warehouse to allow access for larger excavating equipment. Current warehouse operations would be discontinued for a longer period of time.

#### **4.5.4      *Option 4 – Excavate and Abandon Basement, Interior Soil Excavation with Ex-Situ Treatment and Disposal, Exterior Excavation***

Option 4 is the most aggressive and costly remedial approach. The goal of Option 4 is to remove all soil containing chromium concentrations above the state-established background value of 44 mg/kg. Option 4 consists of the following actions:

- Decommission the existing groundwater treatment system;
- Excavate in the basement to approximately 5 feet below the floor to permit layering a reducing amendment with the highly contaminated soil;
- Excavate from surface to depths up to 15 feet bgs at interior and exterior areas containing chromium concentrations above background;

- Backfill the basement with a portion of the excavated soil, mixed with an amendment to reduce hexavalent chromium;
- Treat the remaining excavated soil ex-situ to non-hazardous concentrations and transport to a landfill for disposal;
- Limited injection of reducing amendment in the vicinity of MW-5;
- Fill the french drain/collection trench with an amendment solution and abandon the associated piping; and
- Evaluate the natural subsurface geochemistry for continued conversion of hexavalent chromium to trivalent precipitates.

The volume of soil excavated with Option 4 is approximately four (4) times more than with Option 3. Some of the soil would still be transferred to the basement, but the majority would be treated on-site and then transported off-site to a landfill. Excavation of soil on the north side of the warehouse would be performed rather than in-situ mixing.

This option has the highest cost, in the range of \$1.1 to \$1.2 million, and may be unnecessarily extensive to achieve closure goals.

## 5.0 RECOMMENDATION

It is our recommendation to pursue Option 2, as this option provides for targeted source area remediation at lower cost and has the potential to be as effective as more extensive and costly excavation. Option 2 includes the excavation and on-site treatment of the greatest contaminant mass located in shallow unsaturated soil along the old plating lines. Of the remedial options with interior actions, Option 2 is also the least disruptive to current warehouse operations because it can be done in phases with excavating taking less time, and injections performed in roughly one-half of the warehouse at a time, allowing for partial active use.

Excavating the upper five feet of soil is recommended because fixation of hexavalent chromium by reduction will likely not work effectively under unsaturated conditions. Stable chemical reduction actions are water reliant and are most effective in saturated soil. In moist but unsaturated soil, the reduction process may take place, but to a much lesser degree. In addition, injecting under pressure this close to the surface in clay soil of low permeability may cause the injected material to “short circuit” up the injection borehole rather than dispersing out laterally within the soil. Hexavalent chromium impacts are generally dispersed across the property; therefore, consolidation of this excavated material for treatment in the basement area is allowed under the Area of Contamination Policy established by the U.S. Environmental Protection Agency and adopted in principal by the WDNR as described in PUB RR-705, Section III, subsection D.

Injection pilot testing will be needed. The details of pilot testing will be presented within the injection and WPDES permit application. In general, we are planning to perform pilot testing in the two (2) areas inside the warehouse having the greatest detected groundwater concentrations of hexavalent chromium, namely at the locations of MW-20 and MW-19. We will test two (2) different proprietary blends of remedial compounds. Both products combine an organic nutrient source for enhanced microbial growth, and a source of iron. We will evaluate the effectiveness of each product to produce reducing conditions and convert hexavalent chromium to immobile precipitates, and we will determine the effective lateral distribution of injected solution within the subsurface obtained at various injection pressures (radius of influence).

We expect that there will be a few months of groundwater sampling to verify the results of pilot testing. If successful, the pilot test will reduce the overall amount of soil needing treatment during full-scale remedial applications.

For all options, it is expected that groundwater use restrictions will need to be listed on the GIS registry for the Site and adjacent Appvion property. Likewise, Appvion and the City of Appleton will be notified of residual concentrations of hexavalent chromium in soil on their properties.

If the injection pilot test does not produce reliable or practical results, then we would defer to Option 3. Excavation performed in Option 3 would remove over 80% of the contaminant mass in unsaturated and saturated soil. Application of a reducing compound below the water table within the excavations will disperse over time, create reducing conditions, and stabilize residual hexavalent chromium concentrations. After removing the bulk of the contaminated soil, the existing natural subsurface geochemistry should be adequate to support natural attenuation. We would test soil remaining within the footprint of the excavations to determine the remaining residual concentrations of chromium, perform additional geochemical analyses, and sample groundwater to determine if natural attenuation will achieve Site remedial goals.



## 6.0 REFERENCES

Krauter, P., R. Martinelli, K. Williams and S. Martins, *Removal of Cr(VI) from Ground Water by Saccharomyces cerevisiae*, *Biodegradation* 7: 277-286, March 1996.

Palmer, C.D. and R.W. Puls, *Natural Attenuation of Hexavalent Chromium in Groundwater and Soils*, EPA Groundwater Issue, October 1994.

Rai, D., B.M. Sass, and D. A. Moore, 1987, *Chromium (III) Hydrolysis Constants and Volubility of Chromium (III) Hydroxide*, *Inorg.* 26(3): 249-345.

Richard F.C. and A.C.M. Bourg, 1991, *Aqueous Geochemistry of Chromium: A Review*, *Water Research*, 25(7): 807-816.

Suthersan, S., *Remediation Engineering Design Concepts*, Lewis Publishers, Boca Raton, 1997.  
U.S. Environmental Protection Agency, *In-situ Treatment of Soil and Groundwater Contaminated with Chromium: Technical Resource Guide*, EPA/825/R-00/005, October 2000.

Walkley, A. and L.A. Black, 1934, *An Examination of the Degtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method*, *Soil Science*, 37: 29-38.

## **TABLES**

**TABLE 1**  
**SOIL GEOCHEMICAL ANALYTICAL RESULTS**  
Former Appleton Wire Division of Albany International Corporation  
908 North Lawe Street, Appleton, Wisconsin

Monitoring Well Identification	Sample Depth (feet)	Sample Date	Metals				Fractional Organic Carbon (FOC)	pH	Cation Exchange Capacity	Oxidation Reduction Potential (ORP)
			Magnesium	Barium	Iron	Aluminum				
Reporting Units			mg/kg	mg/kg	mg/kg	mg/kg	% (w/w)	std. units	meq/100g	mV
MW-1B	5-10	05/17/17	27,300	67.2	17,100	15,000	0.59	8.47	11.3	199
	20-25	05/17/17	28,300	72.6	17,400	15,000	0.50	8.59	8.8	169
MW-19C	5-10	05/08/17	28,600	70.9	19,200	14,600	0.58	8.48	8.2	164
	20-25	05/08/17	31,500	68.2	17,600	13,700	0.48	8.70	5.8	172
MW-20C	5-10	05/15/17	26,600	53.8	15,200	10,800	0.39	8.73	9.1	195
	20-25	05/15/17	27,000	75.7	17,800	15,200	0.45	8.87	4.6	175
MW-22A	5-10	05/16/17	27,200	55.1	15,800	11,600	0.46	8.78	14.4	202
	20-25	05/16/17	29,400	65.2	16,700	13,900	0.40	8.94	8.8	180

**Notes:**

mg/kg= milligrams per kilogram

meq = milliequivalents

g = grams

mV = millivolts

**TABLE 2**  
**GROUNDWATER GEOCHEMICAL ANALYTICAL RESULTS**  
Former Appleton Wire Division of Albany International Corporation  
908 North Lawe Street, Appleton, Wisconsin

Monitoring Well Identification	Screen Interval	Sample Date	Dissolved Metals				Inorganic/Physical Parameters						Field Parameters					
			Aluminum	Chromium	Iron	Manganese	Nitrate	Nitrite	Sulfate	Chemical Oxygen Demand	Total Organic Carbon	Dissolved Organic Carbon	Temperature	pH	Specific Conductance	Oxidation Reduction Potential	Turbidity	Dissolved Oxygen
Reporting Units			µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Celsius	S.U.	µS/cm	mV	NTU	mg/L
MW-19	10.3 - 20.3	6/29/2017	<55.5	<b>23,600</b>	<15.5	<b>36.7</b>	<b>6.9</b>	<0.80	<b>51.4 J</b>	<b>15.3</b>	<0.25	<0.25	<b>19.90</b>	<b>7.59</b>	<b>1.24</b>	<b>174</b>	<b>22.4</b>	<b>9.18</b>
MW-19A	37.5 - 42.5	6/29/2017	<55.5	<b>8.1 J</b>	<b>29.0 J</b>	<b>17.8</b>	<0.38	<0.20	<b>9.7 J</b>	<b>19.9 J</b>	<b>4.0</b>	<b>3.9</b>	<b>18.44</b>	<b>8.04</b>	<b>0.439</b>	<b>4</b>	<b>26.3</b>	<b>9.75</b>
MW-20	4.4 - 14.4	06/28/17	<1,110	<b>265,000</b>	<680	<36.6	<b>15.9</b>	<0.80	<b>103</b>	<b>31.4 J</b>	<0.76	<b>1.1 J</b>	<b>17.42</b>	<b>7.15</b>	<b>2.72</b>	<b>171</b>	<b>70.8</b>	<b>11.04</b>
MW-20A	29.7 - 34.7	06/28/17	<b>1,480</b>	<b>6.5 J</b>	<b>2,060</b>	<b>78.6</b>	<380	<200	<b>45.4</b>	<b>139</b>	<b>4.9</b>	<b>4.4</b>	<b>15.88</b>	<b>7.83</b>	<b>0.656</b>	<b>-2</b>	<b>0.0</b>	<b>11.67</b>
MW-21	4.4 - 14.4	06/28/17	<55.5	<b>16.1</b>	<b>46.8 J</b>	<b>27.7</b>	<b>0.24</b>	<0.040	<b>194</b>	<13.4	<b>0.88</b>	<b>0.92</b>	<b>19.40</b>	<b>7.17</b>	<b>1.55</b>	<b>160</b>	<b>27.5</b>	<b>10.43</b>
MW-21A	29.4 - 34.4	06/28/17	<b>74.7 J</b>	<b>6.1 J</b>	<b>814</b>	<b>72.7</b>	<0.075	<0.040	<b>204</b>	<b>15.3 J</b>	<b>3.7</b>	<b>3.9</b>	<b>17.56</b>	<b>7.84</b>	<b>0.964</b>	<b>57</b>	<b>308</b>	<b>11.52</b>
MW-22	4.0 - 14.0	06/29/17	<55.5	<2.5	<15.5	<b>4.3 J</b>	<b>1.2</b>	<0.20	<b>76.2</b>	<b>50.0</b>	<0.25	<0.25	<b>20.56</b>	<b>7.67</b>	<b>2.83</b>	<b>144</b>	<b>0.0</b>	<b>8.89</b>
MW-22A	35.0 - 40.0	06/29/17	<55.5	<2.5	<b>107</b>	<b>29.3</b>	<0.075	<b>0.13 J</b>	<b>56.1</b>	<b>15.3 J</b>	<b>6.0</b>	<b>5.9</b>	<b>19.40</b>	<b>8.15</b>	<b>0.556</b>	<b>172</b>	<b>200</b>	<b>9.30</b>
MW-28	4.0 - 14.0	06/28/17	<55.5	<b>3,890</b>	<b>53.6 J</b>	<b>43.2</b>	<0.38	<0.040	<b>22.6</b>	<b>24.5 J</b>	<0.25	<0.25	<b>17.43</b>	<b>7.27</b>	<b>1.88</b>	<b>194</b>	<b>33.7</b>	<b>11.29</b>
MW-28A	35.0 - 40.0	06/28/17	<55.5	<b>8.4 J</b>	<15.5	<b>32.8</b>	<0.075	<0.040	<b>6.2</b>	<b>15.3 J</b>	<b>4.3</b>	<b>4.0</b>	<b>16.54</b>	<b>7.96</b>	<b>0.492</b>	<b>170</b>	<b>13.0</b>	<b>11.83</b>

**Notes:**

Only detected compounds are listed

**Bolded** values are above laboratory detection limits

J = Analyte concentration detected between the laboratory Reporting Limit and the laboratory Method Detection Limit

NA = Not Analyzed

S.U. = Standard Units

µS/cm = Microsiemens per centimeter

mV = Millivolt

NTU = Nephelometric Turbidity Unit

mg/L = Milligram per liter

**TABLE 3a**  
**REMEDIAL ACTION OPTIONS SCREENING - UNSATURATED ZONE**

Former Appleton Wire Division of Albany International Corporation  
908 North Lawe Street, Appleton, Wisconsin

General Response Action	Remedial Approach	Description	Protective of Human Health and the Environment?	Applicable and Appropriate?	Further Evaluation Warranted
No Remediation	No Action	No further action	No	No	High concentrations likely make this option null.
Institutional Controls	GIS Registry	Add the site to the GIS Registry database to notify future owners/users of the property of residual contamination and/or continuing obligations.	Yes, in conjunction with other options	Yes	Yes, in conjunction with other options
Engineering Controls	Vapor Mitigation System (VMS)	Installation and operation of vapor mitigation systems at affected properties.	No	No	VMS systems are utilized for mitigation of volatile compounds in the vapor phase. Hexavalent chromium is not volatile; no vapor intrusion risk.
	Soil Cover	Cap or cover that is constructed and maintained to prevent direct contact with residual soil contamination.	Yes, in conjunction with other options	Yes	Yes, in conjunction with other options. Building and parking lots act as a cover. Potential need for maintenance agreement with current owner.
In-Situ Remediation	Soil Vapor Extraction (SVE)	Volatilization of contaminant mass in unsaturated zone and removal via vacuum extraction.	Yes	No	Not applicable for conditions at this site. Primary impact is not volatile compounds.
	Multi-Phase Extraction	Removal of contaminants in aqueous and liquid phases via vacuum extraction, combined with soil vapor extraction.	Yes	No	Not applicable for conditions at this site. Primary impact is not volatile compounds.
	Thermal Desorption	Removal of contaminants in aqueous, liquid, and sorbed phases by heating and volatilization, with subsequent vacuum extraction.	Yes	No	Not applicable for conditions at this site. Primary impact is not volatile compounds.
	Soil Mixing: In-Situ Chemical Oxidation (ISCO)	Involves the addition of oxidation reagents to a contaminated material (e.g. soil or sludge) to facilitate oxidative destruction of contaminants. Mixing is performed using heavy equipment such as augers or specialized soil mixing tools.	Yes	No	No, hexavalent chromium will not be destroyed by oxidation.
	Soil Mixing: In-Situ Chemical Reduction (ISCR)	Involves the addition of reductive reagents to a contaminated material (e.g. soil or sludge) to facilitate reductive treatment of contaminants. Mixing is performed using heavy equipment such as augers or specialized soil mixing tools. Under reducing conditions, hexavalent chromium alters to trivalent chromium, which is non-soluble and stable.	Yes	Yes	Yes, for exterior areas only. Interior mixing would create unsuitable soil conditions for immediate reuse of the building.
	Soil Mixing: Solidification and Stabilization	Stabilization involves the addition of reagents to a contaminated material (e.g. soil or sludge) to produce more chemically stable constituents. Solidification involves the addition of cement or clay minerals to a contaminated material to impart physical/dimensional stability to contain contaminants in a solid product and reduce access by external agents (e.g. air, rainfall). Mixing is performed using heavy equipment such as augers or specialized soil mixing tools.	Yes	Yes	Yes, for exterior areas only. Interior mixing would create unsuitable soil conditions for immediate reuse of the building.
	Phytoremediation	Use of plants to remove through uptake, contain, and/or degrade contaminants.	Yes	No	No. Impacts are primarily beneath a building floor.
Removal	Excavation and Disposal	Removal of contaminated soil using excavation equipment.	Yes	Yes	Yes. May be limited by access restrictions and maintaining the structural integrity of the building.

*Note:*

Highlighted boxes indicate that this technology will move forward in the screening process

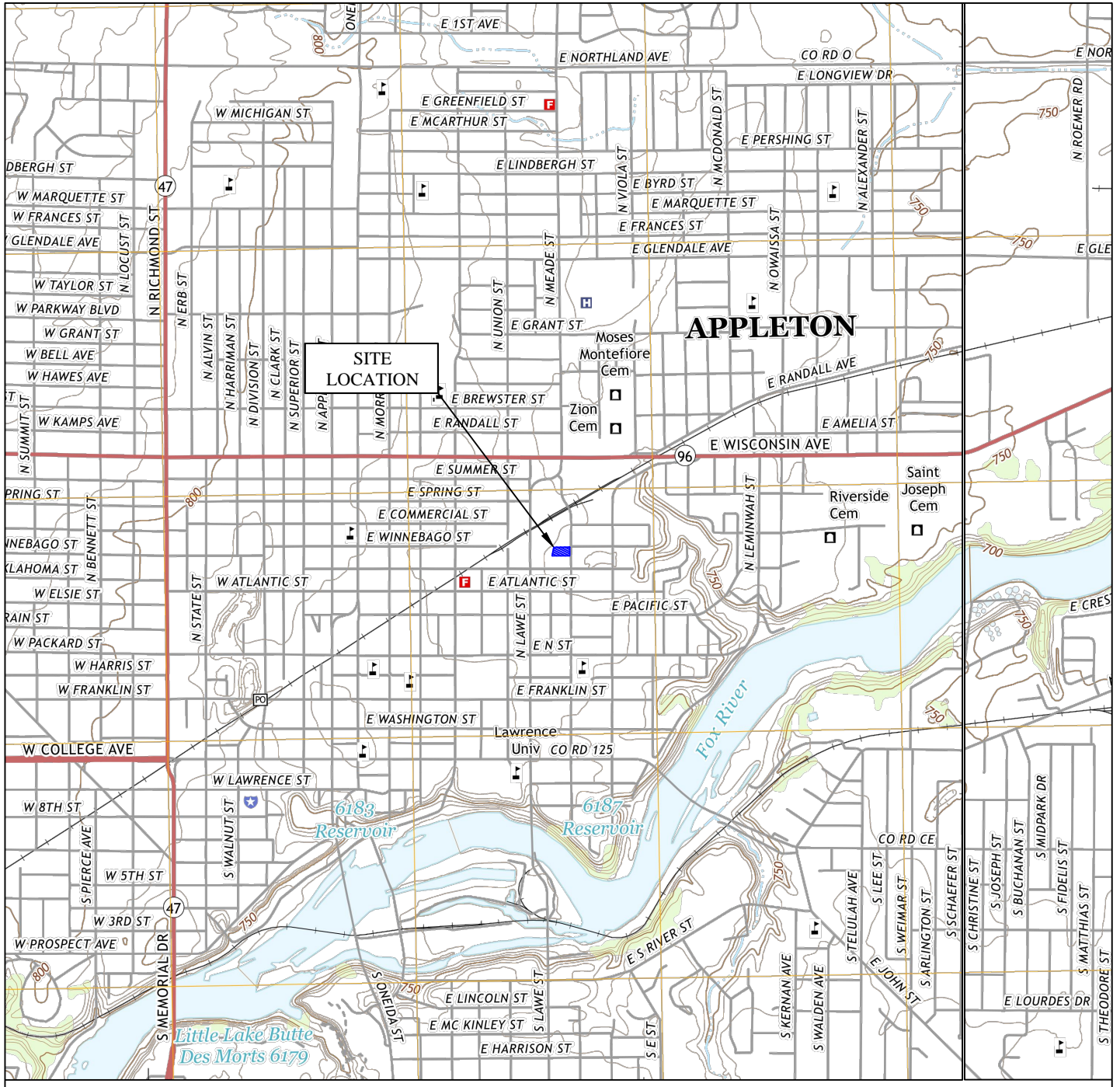
**TABLE 3b**  
**REMEDIAL ACTION OPTIONS SCREENING - SATURATED ZONE**  
Former Appleton Wire Division of Albany International Corporation  
908 North Lawe Street, Appleton, Wisconsin

General Response Action	Remedial Approach	Description	Protective of Human Health and the Environment?	Applicable and Appropriate?	Further Evaluation Warranted
No Remediation	No Action	No further action	No	No	Impact at this site is significant. Some active remediation will be required.
	Monitored Attenuation	Monitor to confirm adequate attenuation of contaminant concentrations is occurring and screen for potential changes in exposure potential.	No	No	Only applicable as a post-remediation activity.
Institutional Controls	GIS Registry	Add the site to the GIS Registry database to notify future owners/users of the property of residual contamination and/or continuing obligations.	Yes, in conjunction with other options	Yes	Yes, in conjunction with other options
Engineering Controls	Soil Cover	Installation or maintenance of existing low permeability cap or cover to mitigate further contaminant migration from the unsaturated zone to groundwater by reducing infiltration of	Yes, in conjunction with other options	Yes	Yes, in conjunction with other options. Building and parking lots act as a cover. Potential need for maintenance agreement with current owner.
In-Situ Remediation	Multi-Phase Extraction	Removal of contaminants in aqueous and liquid phases via vacuum extraction, combined with soil vapor extraction.	Yes	No	No, hexavalent chromium is not volatile.
	Thermal Desorption	Removal of contaminants in aqueous, liquid, and sorbed phases by heating and volatilization, with subsequent vacuum extraction.	Yes	No	No, hexavalent chromium is not volatile.
	Injection: In-Situ Chemical Oxidation (ISCO)	Injection of chemically oxidative groundwater additives such as hydrogen peroxide, potassium permanganate, or persulfates to destroy contaminants.	Yes	No	Oxidation will not effectively remediate hexavalent chromium.
	Injection: In-Situ Chemical Reduction (ISCR)	Injection of chemically reductive additives such as zero-valent iron or other compounds or solutions to promote degradation of contaminants via reductive processes or alteration of impact	Yes	Yes	Yes, commonly used technology for treatment of hexavalent chromium.
	Injection: Enhanced Reductive Dechlorination (ERD)	Injection of an organic substrate to stimulate the growth of dehalogenating bacteria and, by extension, stimulate the degradation of chlorinated compounds via reductive dechlorination.	Yes	No	Technology not applicable for hexavalent chromium.
	Injection: Bioaugmentation	Injection of microorganisms to promote degradation of contaminants through direct or indirect biological processes.	Yes	No	Technology not applicable for hexavalent chromium.
	Injection: Air Sparging	Injection of air into the subsurface to promote volatilization and subsequent removal of contaminants via vapor extraction.	Yes	No	Technology not applicable for hexavalent chromium.
	Injection: Ozone Sparging	Combines air sparging with in-situ chemical oxidation. Ozone is added to air sparging injection stream to facilitate oxidative destruction of contaminants.	Yes	No	Technology not applicable for hexavalent chromium.
	Injection: Enhanced Aerobic Bioremediation	Application of nutrients and/or oxygen to the subsurface to accelerate naturally-occurring breakdown of contaminants via aerobic bacteria.	Yes	No	Technology not applicable for hexavalent chromium.
	Soil Mixing: In-Situ Chemical Oxidation	Involves the addition of oxidation reagents to a contaminated material (e.g. soil or sludge) to facilitate oxidative destruction of contaminants. Mixing is performed using heavy equipment such as augers or specialized soil mixing tools.	Yes	No	Technology not applicable for hexavalent chromium.
	Soil Mixing: In-Situ Chemical Reduction	Involves the addition of reductive reagents to a contaminated material (e.g. soil or sludge) to facilitate reductive treatment of contaminants. Mixing is performed using heavy equipment such as augers or specialized soil mixing tools. Under reducing conditions, hexavalent chromium alters to trivalent chromium, which is non-soluble and stable.	Yes	Yes	Yes, for exterior areas only. Interior mixing would create unsuitable soil conditions for immediate reuse of the building.
Removal	Soil Mixing: Solidification and Stabilization	Stabilization involves the addition of reagents to a contaminated material (e.g. soil or sludge) to produce more chemically stable constituents. Solidification involves the addition of cement or clay minerals to a contaminated material to impart physical/dimensional stability to contain contaminants in a solid product and reduce access by external agents (e.g. air, rainfall). Mixing is performed using heavy equipment such as augers or specialized soil mixing tools.	Yes	Yes	Yes, for exterior areas only. Interior mixing would create unsuitable soil conditions for immediate reuse of the building.
	Pump and Treat	Removal of contaminated groundwater via pumping and ex-situ treatment.	Yes	No	A pump and treat system has been operating for several years. The restoration timeframe for a pump and treat action is not acceptable.
Containment	Excavation and Disposal	Removal of contaminated soil using excavation equipment.	Yes	Yes	Yes. May be limited by access restrictions and maintaining the structural integrity of the building.
	Permeable Reactive Barrier (PRB)	Linear placement of chemically reductive additives such as zero-valent iron or other compounds or solutions to prevent contamination from migrating outside a given area. PRB installed by trenching or jetting.	Yes	Yes	Yes, specifically installation outside of basement walls.

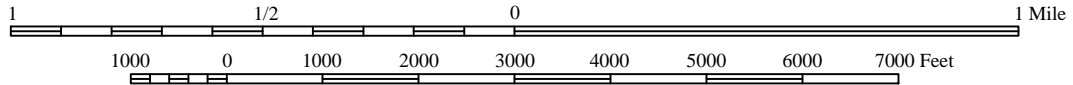
*Note:*

Highlighted boxes indicate that this technology will move forward in the screening process

## **FIGURES**



Scale 1:24,000



Source: US Geological Survey, Appleton, Wisconsin, 7.5 Minute Series, 2016  
 Source: US Geological Survey, Kaukauna, Wisconsin, 7.5 Minute Series, 2016

No.	Date	Revision	Approved

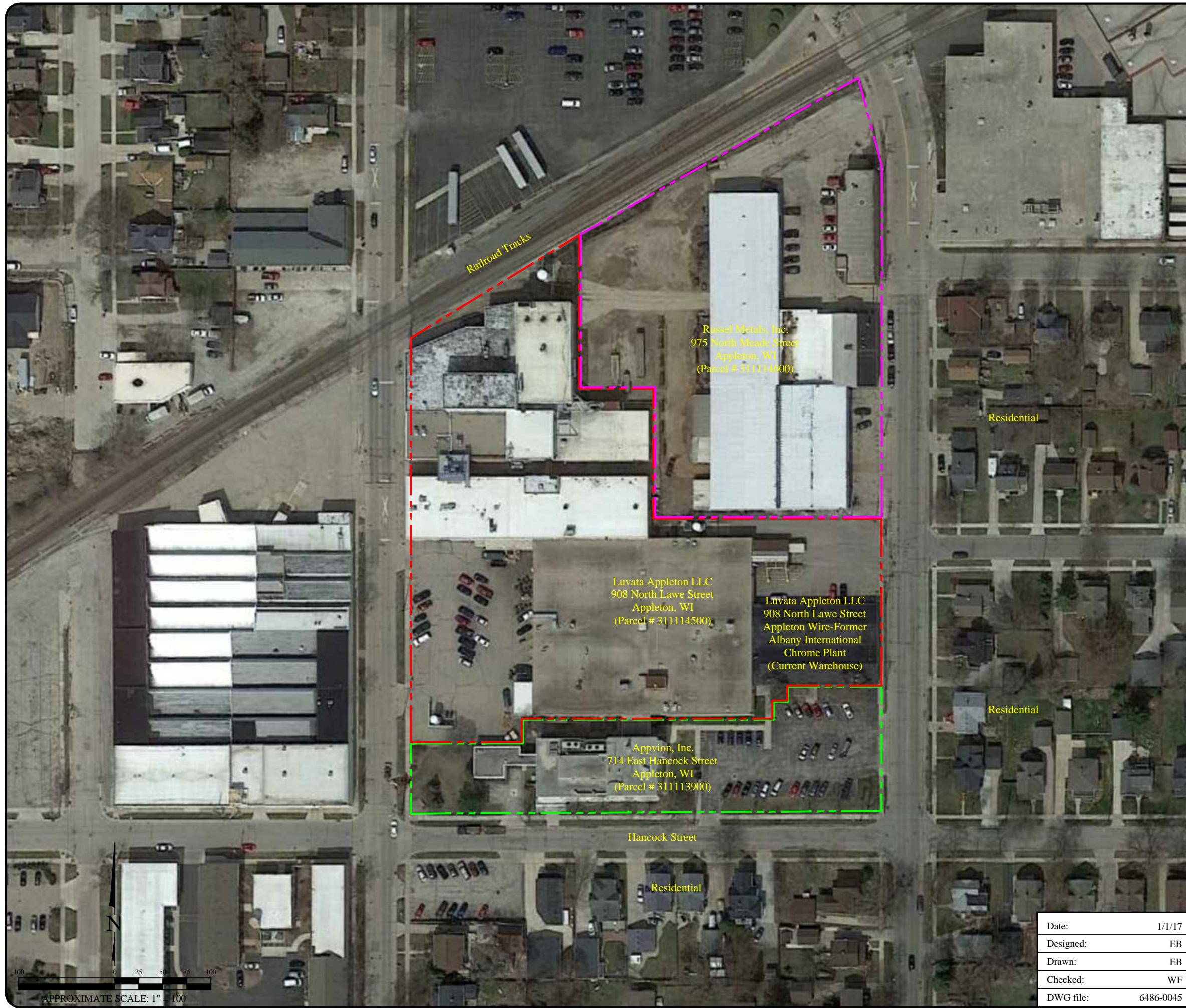
**ENVIROforensics**  
 825 North Capitol Avenue • Indianapolis, IN 46204  
 EnviroForensics.com

Date:	1/11/17
Designed:	EB
Drawn:	EB
Checked:	WF
DWG file:	6486-0044

**SITE LOCATION MAP**  
 Former Appleton Wire Division of Albany International Corporation  
 908 North Lawe Street  
 Appleton, Wisconsin

Figure	1
Project	6486





Legend

--- Property boundary

SITE AERIAL PHOTOGRAPH

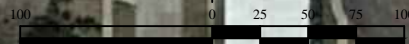
Former Appleton Wire Division of Albany International Corporation  
908 North Lawe Street  
Appleton, Wisconsin

Date:	1/1/17
Designed:	EB
Drawn:	EB
Checked:	WF
DWG file:	6486-0045



825 North Capitol Avenue • Indianapolis, IN 46204  
EnviroForensics.com

Figure	2
Project	6486



APPROXIMATE SCALE: 1" = 100'

**Legend**

- Property boundary
- Underground gas utility line
- Underground water utility line
- Underground sanitary utility line
- Fiber optics line
- Underground storm utility line
- Pipe chase
- French drain and associated piping
- Sump
- Floor drain
- Soil boring (STS)
- Soil boring (Badger)
- Soil samples collected through concrete floor (STS)
- Soil samples collected through concrete wall (STS)
- Monitoring well (STS)
- Monitoring well (McMahon)
- Monitoring well (Badger)
- Monitoring well abandoned (MW-10 in 1998) and (MW-11 in 1991)
- Monitoring well (EnviroForensics)
- Soil boring (EnviroForensics)
- Soil samples collected through concrete wall (EnviroForensics)
- Dairy tile floor

Analyte	Soil to Groundwater Residual Contaminant Level	Non-Industrial Residual Contaminant Level	Industrial Residual Contaminant Level
Total Chromium	NE	NE	NE
Cr(VI)	3.84*	0.301	6.36
PCE	4.5	33,000	145,000

**Note:**

- Bold shaded blue values exceed WDNR Soil to Groundwater Residual Contaminant Level
- Bold shaded green values exceed WDNR Non-Industrial Residual Contaminant Level
- Bold shaded orange values exceed WDNR Industrial Residual Contaminant Level
- Bold values exceed laboratory detection levels
- Cr and Cr (VI) standards and analytical results are reported in milligram per kilogram (mg/kg)
- PCE standards and analytical results are reported in micrograms per kilogram (µg/kg)
- Cr (VI) = Hexavalent Chromium
- Cr = Chromium
- PCE = Tetrachloroethene
- NA = Not analyzed
- NS = Not sampled
- Soil samples collected greater than 10 feet below ground surface are considered saturated soil samples
- \* = Calculated using EPA Risk-Based Screening Level Calculator
- Sample locations without data boxes are not sampled at this time

**Area of Hexavalent chromium exceeding Industrial Residual Contaminant Level (Dashed where inferred)**

- MW-19 ♦ Water table observation well (with 10 foot screen length)
- MW-19A ♦ Piezometer (with 5 foot screen length set within the 30-40' depth interval)
- MW-19B ♦ Piezometer (with 5 foot screen length set within the 40-50' depth interval)
- MW-19C ♦ Piezometer (with 5 foot screen length set within the 50-60' depth interval)

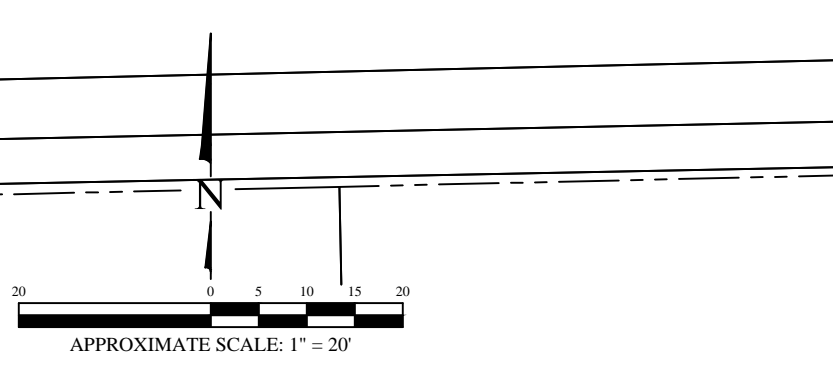
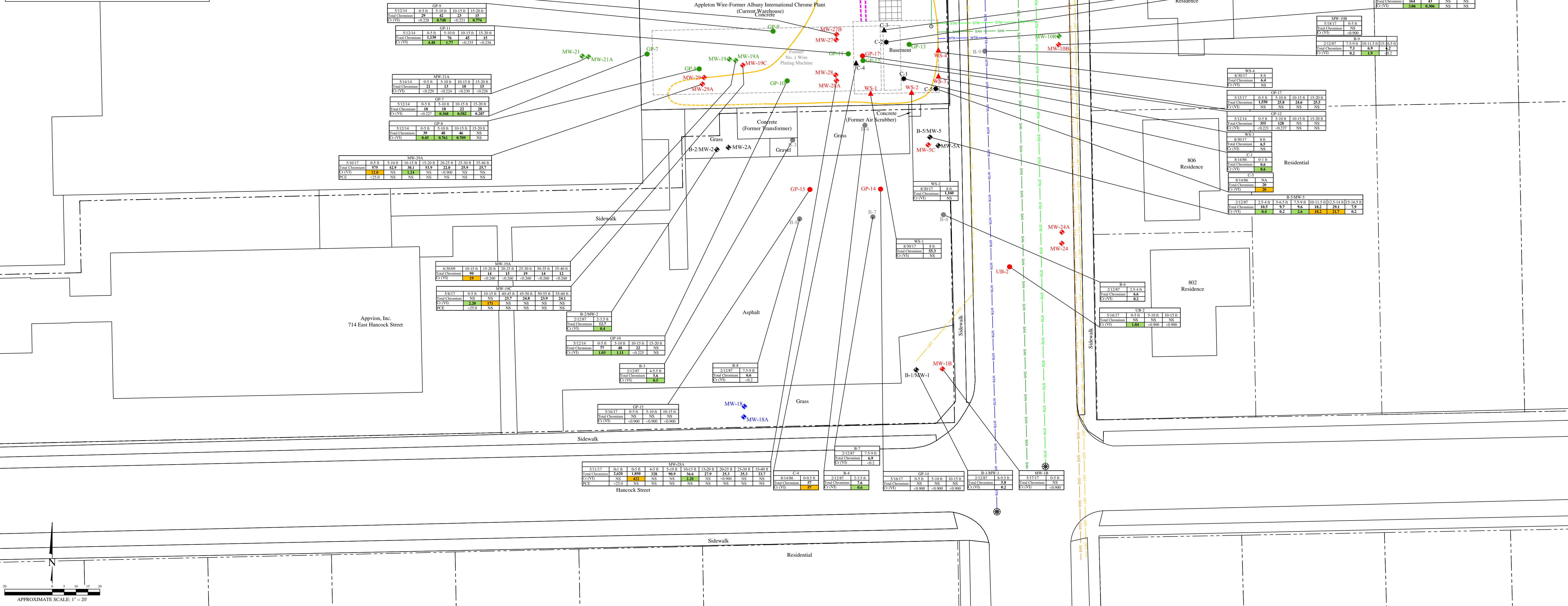


Figure 3  
Project 6486

**SOIL ANALYTICAL RESULTS MAP SHOWING THE EXTENT OF HEXAVALENT CHROMIUM ABOVE THE INDUSTRIAL RESIDUAL CONTAMINANT LEVEL**

Former Appleton Wire Division of Albany International Corporation  
908 North Lave Street  
Appleton, Wisconsin

Date: 6/29/17  
Designed: EB  
Drawn: EB  
Checked: WF  
DWG file: 6486-0894

**ENVIROforensics**  
825 North Capitol Avenue • Indianapolis, IN 46204  
EnviroForensics.com

No.	Date	Revision	Approved

### Legend

- Property boundary
- Underground gas utility line
- Underground water utility line
- Underground sanitary utility line
- Fiber optics line
- Underground storm utility line
- Pipe chase
- French drain and associated piping
- Well
- Former Well
- Floor drain
- Manhole
- Soil boring (STS) (TW = Temp well)
- Monitoring well (STS)
- Monitoring well (McMahon)
- Monitoring well (Badger)
- Abandoned Temp well (McMahon)
- Monitoring well (EnviroForensics)
- Temp Well (EnviroForensics)
- Dairy tile floor

Analyte	Public Health Preventive Action Limit	Public Health Enforcement Standard
Dissolved Cr	10	100
Cr (VI)	NE	NE

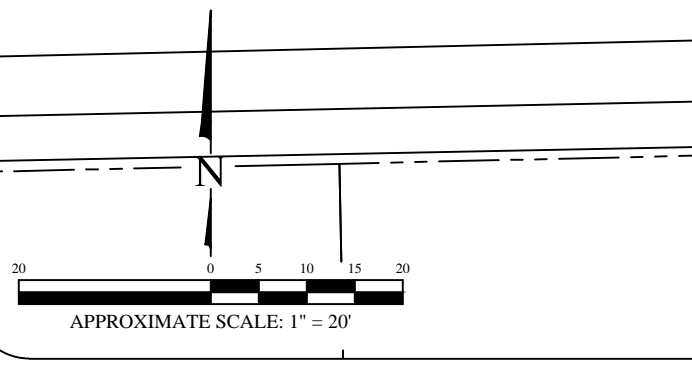
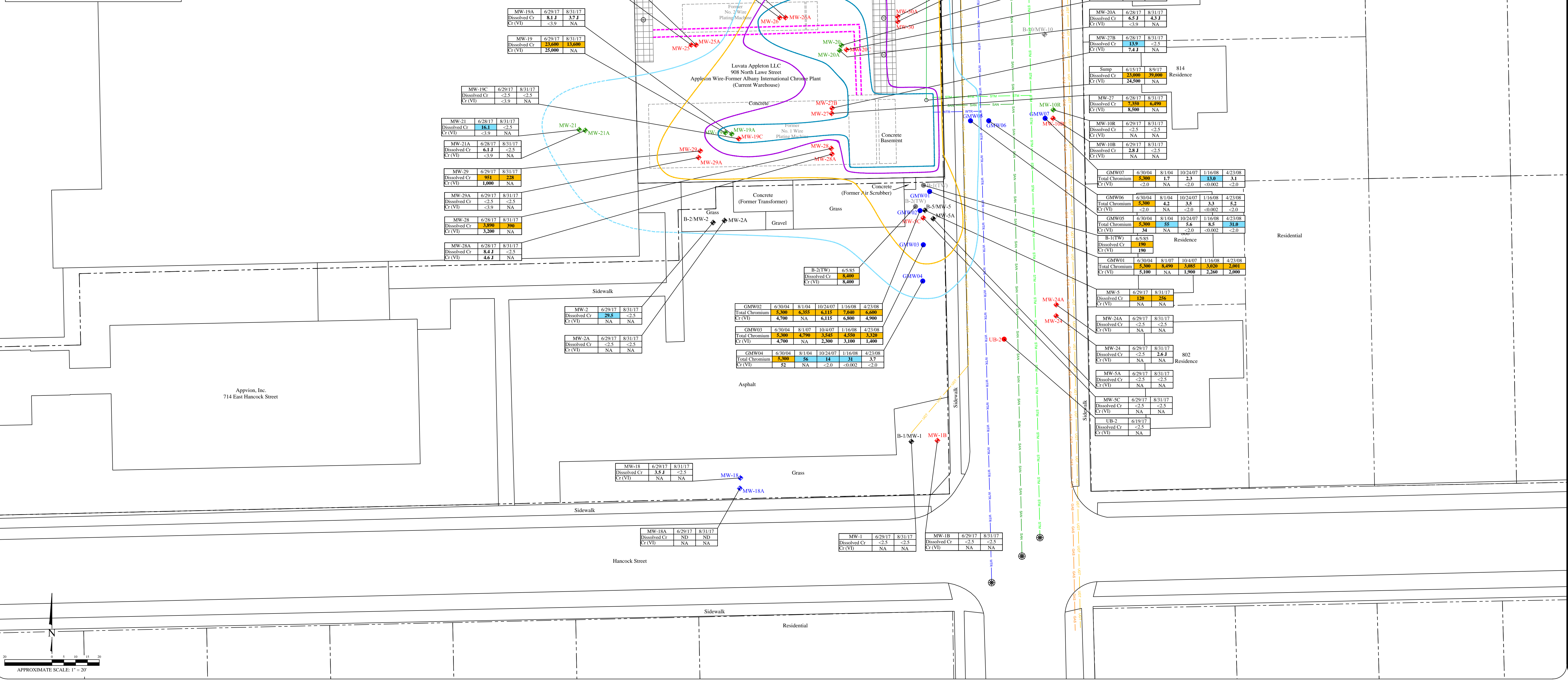
Note:

- Bolded and orange shaded values exceed the Public Health Enforcement Standard
- Bolded and blue shaded values exceed the Public Health Preventive Action Limit
- Bolded values are above detection limits
- J = Analyte concentration less than laboratory detection limits
- Samples analyzed using EPA SW-846 Method 8260
- All results reported in units of micrograms per liter (µg/L)
- Cr (VI) = Hexavalent Chromium
- Cr = Chromium
- ND = Not detected
- NA = Not analyzed
- NE = Not established

- Area exceeding ES for Total chromium >100 µg/L
- Area exceeding PAL for Total chromium >10 µg/L
- Total chromium concentrations >5,000 µg/L
- Total chromium concentrations >25,000 µg/L

Dashed boundaries are inferred

- MW-19 ♦ Water table observation well (with 10 foot screen length)
- MW-19A ♦ Piezometer (with 5 foot screen length set within the 30-40' depth interval)
- MW-19B ♦ Piezometer (with 5 foot screen length set within the 40-50' depth interval)
- MW-19C ♦ Piezometer (with 5 foot screen length set within the 50-60' depth interval)



**ENVIROforensics**  
 825 North Capitol Avenue • Indianapolis, IN 46204  
 EnviroForensics.com

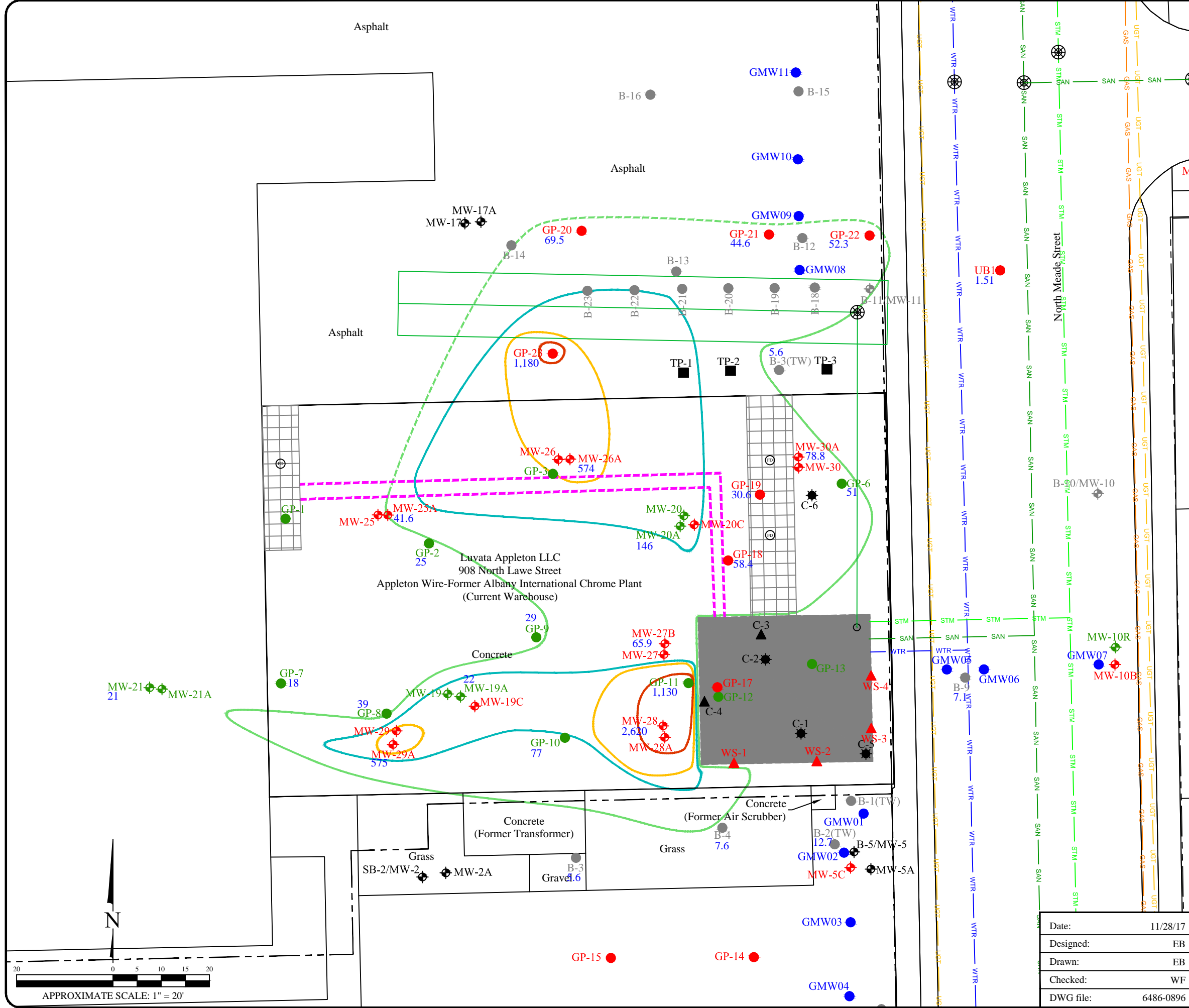
**GROUNDWATER ANALYTICAL RESULTS MAP**  
 SHOWING CONCENTRATIONS EXCEEDING REGULATORY STANDARDS AND DISTRIBUTION OF IMPACTS

Former Appleton Wire Division of Albany International Corporation  
 908 North Lave Street  
 Appleton, Wisconsin

Date: 9/21/17  
 Designed: EB  
 Drawn: EB  
 Checked: WF  
 DWG file: 6486-0895

Figure 4  
 Project 6486

No.	Date	Revision	Approved



**Legend**

- Property boundary
- GAS Underground gas utility line
- WTR Underground water utility line
- SAN Underground sanitary utility line
- UGT Fiber optics line
- STM Underground storm utility line
- Pipe chase
- French drain and associated piping
- Sump
- Former Sump
- Floor drain
- Manhole
- B-1 Soil boring (STS)
- GP-1 Soil boring (Badger)
- GMW01 Abandoned Temp well (McMahon)
- C-1 Concrete Floor Core samples (STS)
- C-3 Concrete Wall Core samples (STS)
- MW-1 Monitoring well (STS)
- MW-18 Monitoring well (McMahon)
- MW-19 Monitoring well (Badger)
- MW-10 Monitoring well abandoned (MW-10 in 1998) and (MW-11 in 1991)
- MW-4 Monitoring well (EnviroForensics)
- B-1 Soil boring (EnviroForensics)
- Dairy tile floor
- Total Chromium in soil >40 mg/kg
- Total Chromium in soil >100 mg/kg
- Total Chromium in soil >500 mg/kg
- Total Chromium in soil >1,000 mg/kg
- Dashed boundaries are inferred
- 41.6 Total Chromium concentration in soil sample mg/kg
- Concrete Basement 11 feet deep

- Note:
- Cr and Cr (VI) standards and analytical results are reported in milligram per kilogram (mg/kg)
  - Cr (VI) = Hexavalent Chromium
  - Cr = Chromium

**TOTAL CHROMIUM ISOCONCENTRATION  
CONTOURS IN SOIL 0-5 FEET**

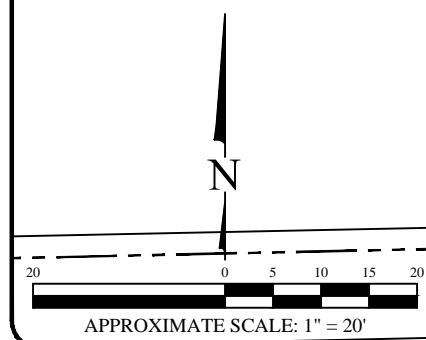
Former Appleton Wire Division of Albany International Corporation  
908 North Lawe Street  
Appleton, Wisconsin

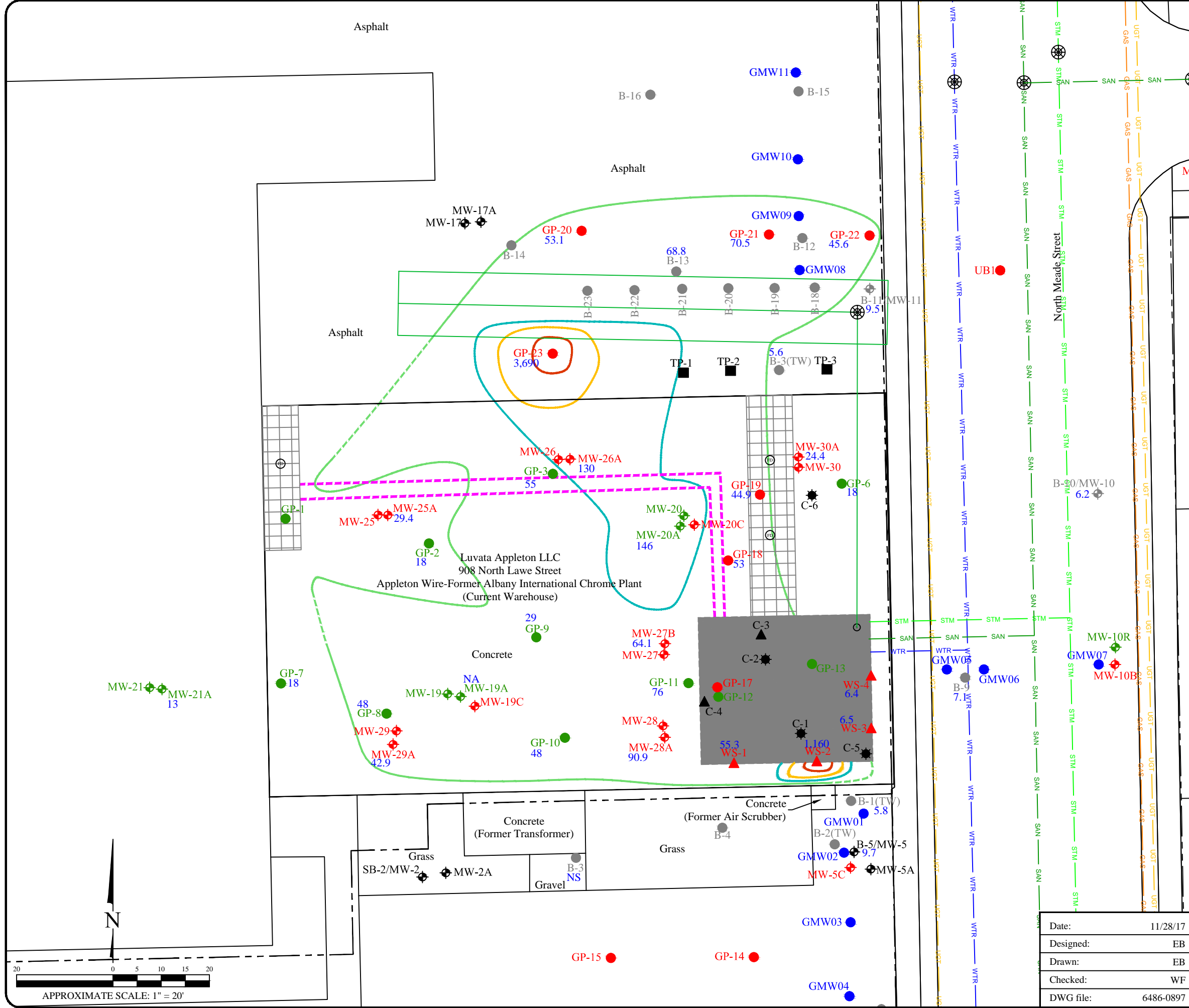
Date:	11/28/17
Designed:	EB
Drawn:	EB
Checked:	WF
DWG file:	6486-0896



825 North Capitol Avenue • Indianapolis, IN 46204  
EnviroForensics.com

Figure	5
Project	6486





**Legend**

- Property boundary
- GAS Underground gas utility line
- WTR Underground water utility line
- SAN Underground sanitary utility line
- UGT Fiber optics line
- STM Underground storm utility line
- Pipe chase
- French drain and associated piping
- Sump
- Former Sump
- Floor drain
- Manhole
- B-1 Soil boring (STS)
- GP-1 Soil boring (Badger)
- GMW01 Abandoned Temp well (McMahon)
- C-1 Concrete Floor Core samples (STS)
- C-3 Concrete Wall Core samples (STS)
- MW-1 Monitoring well (STS)
- MW-18 Monitoring well (McMahon)
- MW-19 Monitoring well (Badger)
- MW-10 Monitoring well abandoned (MW-10 in 1998) and (MW-11 in 1991)
- MW-4 Monitoring well (EnviroForensics)
- B-1 Soil boring (EnviroForensics)
- Dairy tile floor
- Total Chromium in soil >40 mg/kg
- Total Chromium in soil >100 mg/kg
- Total Chromium in soil >500 mg/kg
- Total Chromium in soil >1,000 mg/kg
- Dashed boundaries are inferred
- 41.6 Total Chromium concentration in soil sample mg/kg
- Concrete Basement 11 feet deep

- Note:
- Cr and Cr (VI) standards and analytical results are reported in milligram per kilogram (mg/kg)
  - Cr (VI) = Hexavalent Chromium
  - Cr = Chromium

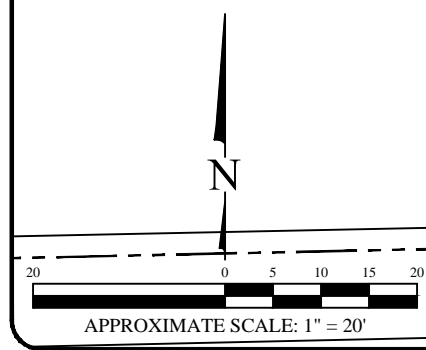
**TOTAL CHROMIUM ISOCONCENTRATION  
CONTOURS IN SOIL 5-10 FEET**

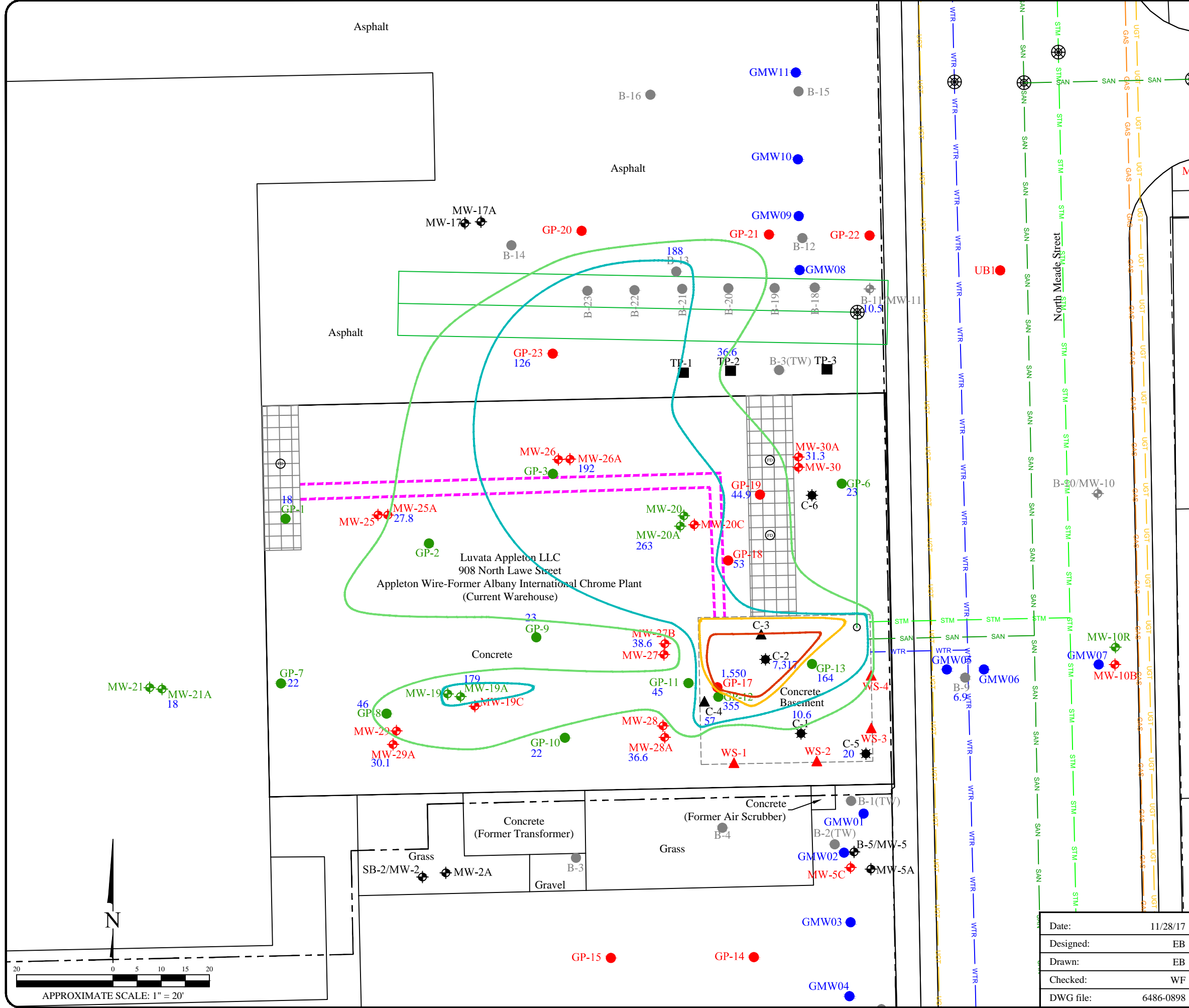
Former Appleton Wire Division of Albany International Corporation  
908 North Lawe Street  
Appleton, Wisconsin

Date:	11/28/17
Designed:	EB
Drawn:	EB
Checked:	WF
DWG file:	6486-0897

825 North Capitol Avenue • Indianapolis, IN 46204  
EnviroForensics.com

Figure	6
Project	6486





### Legend

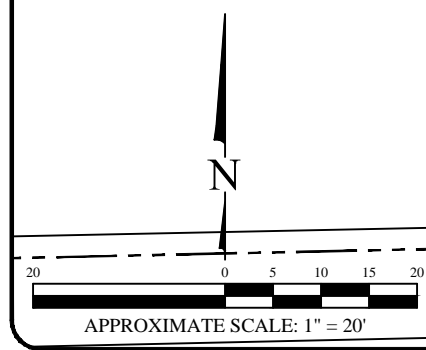
- Property boundary
  - GAS Underground gas utility line
  - WTR Underground water utility line
  - SAN Underground sanitary utility line
  - UGT Fiber optics line
  - STM Underground storm utility line
  - Pipe chase
  - French drain and associated piping
  - Sump
  - Former Sump
  - Floor drain
  - Manhole
  - B-1 Soil boring (STS)
  - GP-1 Soil boring (Badger)
  - GMW01 Abandoned Temp well (McMahon)
  - C-1 Concrete Floor Core samples (STS)
  - C-3 Concrete Wall Core samples (STS)
  - MW-1 Monitoring well (STS)
  - MW-18 Monitoring well (McMahon)
  - MW-19 Monitoring well (Badger)
  - MW-10 Monitoring well abandoned (MW-10 in 1998) and (MW-11 in 1991)
  - MW-4 Monitoring well (EnviroForensics)
  - B-1 Soil boring (EnviroForensics)
  - Dairy tile floor
  - Total Chromium in soil >40 mg/kg
  - Total Chromium in soil >100 mg/kg
  - Total Chromium in soil >500 mg/kg
  - Total Chromium in soil >1,000 mg/kg
  - Dashed boundaries are inferred
- 41.6 Total Chromium concentration in soil sample mg/kg
- Note:
- Cr and Cr (VI) standards and analytical results are reported in milligram per kilogram (mg/kg)
  - Cr (VI) = Hexavalent Chromium
  - Cr = Chromium

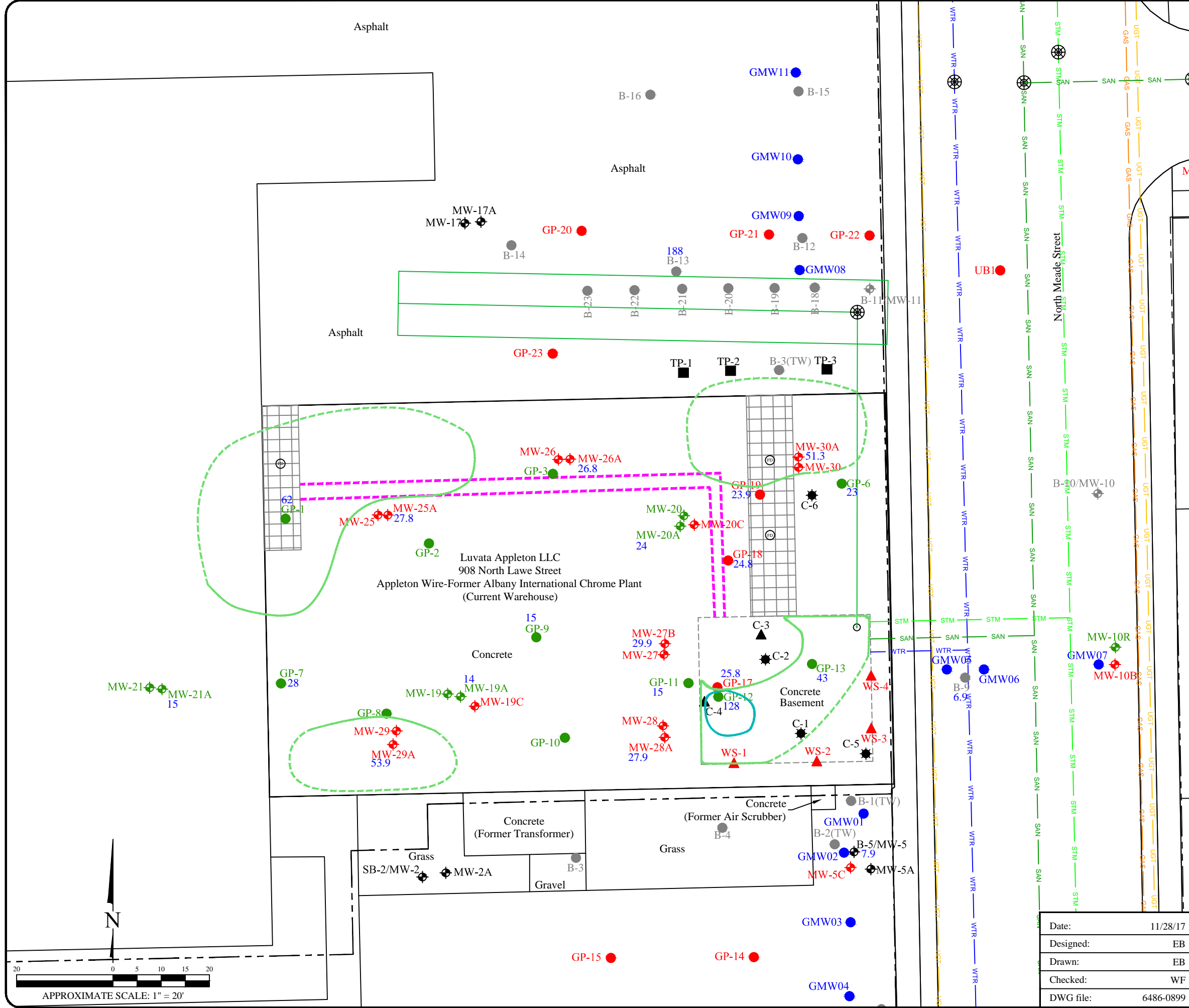
**TOTAL CHROMIUM ISOCONCENTRATION CONTOURS IN SOIL 10-15 FEET**  
 Former Appleton Wire Division of Albany International Corporation  
 908 North Lawe Street  
 Appleton, Wisconsin

Date:	11/28/17
Designed:	EB
Drawn:	EB
Checked:	WF
DWG file:	6486-0898



Figure	7
Project	6486





### Legend

- Property boundary
- GAS Underground gas utility line
- WTR Underground water utility line
- SAN Underground sanitary utility line
- UGT Fiber optics line
- STM Underground storm utility line
- Pipe chase
- French drain and associated piping
- Sump
- Former Sump
- Floor drain
- Manhole
- B-1 Soil boring (STS)
- GP-1 Soil boring (Badger)
- GMW01 Abandoned Temp well (McMahon)
- C-1 Concrete Floor Core samples (STS)
- C-3 Concrete Wall Core samples (STS)
- MW-1 Monitoring well (STS)
- MW-18 Monitoring well (McMahon)
- MW-19 Monitoring well (Badger)
- MW-10 Monitoring well abandoned (MW-10 in 1998) and (MW-11 in 1991)
- MW-4 Monitoring well (EnviroForensics)
- B-1 Soil boring (EnviroForensics)
- Dairy tile floor
- Total Chromium in soil >40 mg/kg
- Total Chromium in soil >100 mg/kg
- Total Chromium in soil >500 mg/kg
- Total Chromium in soil >1,000 mg/kg
- Dashed boundaries are inferred

**41.6** Total Chromium concentration in soil sample mg/kg

Note:

1. Cr and Cr (VI) standards and analytical results are reported in milligram per kilogram (mg/kg)
2. Cr (VI) = Hexavalent Chromium
3. Cr = Chromium

**TOTAL CHROMIUM ISOCONCENTRATION  
CONTOURS IN SOIL 15-20 FEET**

Former Appleton Wire Division of Albany International Corporation  
908 North Lawe Street  
Appleton, Wisconsin

Date:	11/28/17
Designed:	EB
Drawn:	EB
Checked:	WF
DWG file:	6486-0899

825 North Capitol Avenue • Indianapolis, IN 46204  
EnviroForensics.com

Figure	8
Project	6486

### Legend

- Property boundary
- GAS Underground gas utility line
- WTR Underground water utility line
- SAN Underground sanitary utility line
- UGT Fiber optics line
- STM Underground storm utility line
- Pipe chase
- French drain and associated piping
- Sump
- Floor drain
- Manhole
- MW-1 Monitoring well (STS)
- MW-18 Monitoring well (McMahon)
- MW-19 Monitoring well (Badger)
- MW-4 Monitoring well (EnviroForensics)
- Dairy tile floor

Analyte	Public Health Preventive Action Limit	Public Health Enforcement Standard
Chloromethane	<b>3</b>	<b>30</b>
1,1-DCA	<b>85</b>	<b>850</b>
cis-1,2-DCE	<b>7</b>	<b>70</b>
trans-1,2-DCE	<b>10</b>	<b>100</b>
PCE	<b>0.5</b>	<b>5</b>
1,1,1-TCA	<b>20</b>	<b>200</b>
TCE	<b>0.5</b>	<b>5</b>
Vinyl Chloride	<b>0.02</b>	<b>0.2</b>
MC	<b>0.5</b>	<b>5</b>

- Note:
- Bolded and orange shaded values exceed the Public Health Enforcement Standard
  - Bolded and blue shaded values exceed the Public Health Preventive Action Limit
  - Bolded values are above detection limits
  - J = Analyte concentration less than laboratory detection limits
  - Samples analyzed using EPA SW-846 Method 8260
  - All results reported in units of micrograms per liter (µg/L)
  - PCE = Tetrachloroethene
  - TCE = Trichloroethene
  - 1,1-DCA = 1,1-Dichloroethane
  - cis-1,2-DCE = cis-1,2-Dichloroethene
  - trans-1,2-DCE = trans-1,2-Dichloroethene
  - 1,1,1-TCA = 1,1,1-Trichloroethane
  - MC = Methylene Chloride
  - VOCs = Volatile Organic Compounds
  - ND = Not detected
  - NA = Not analyzed

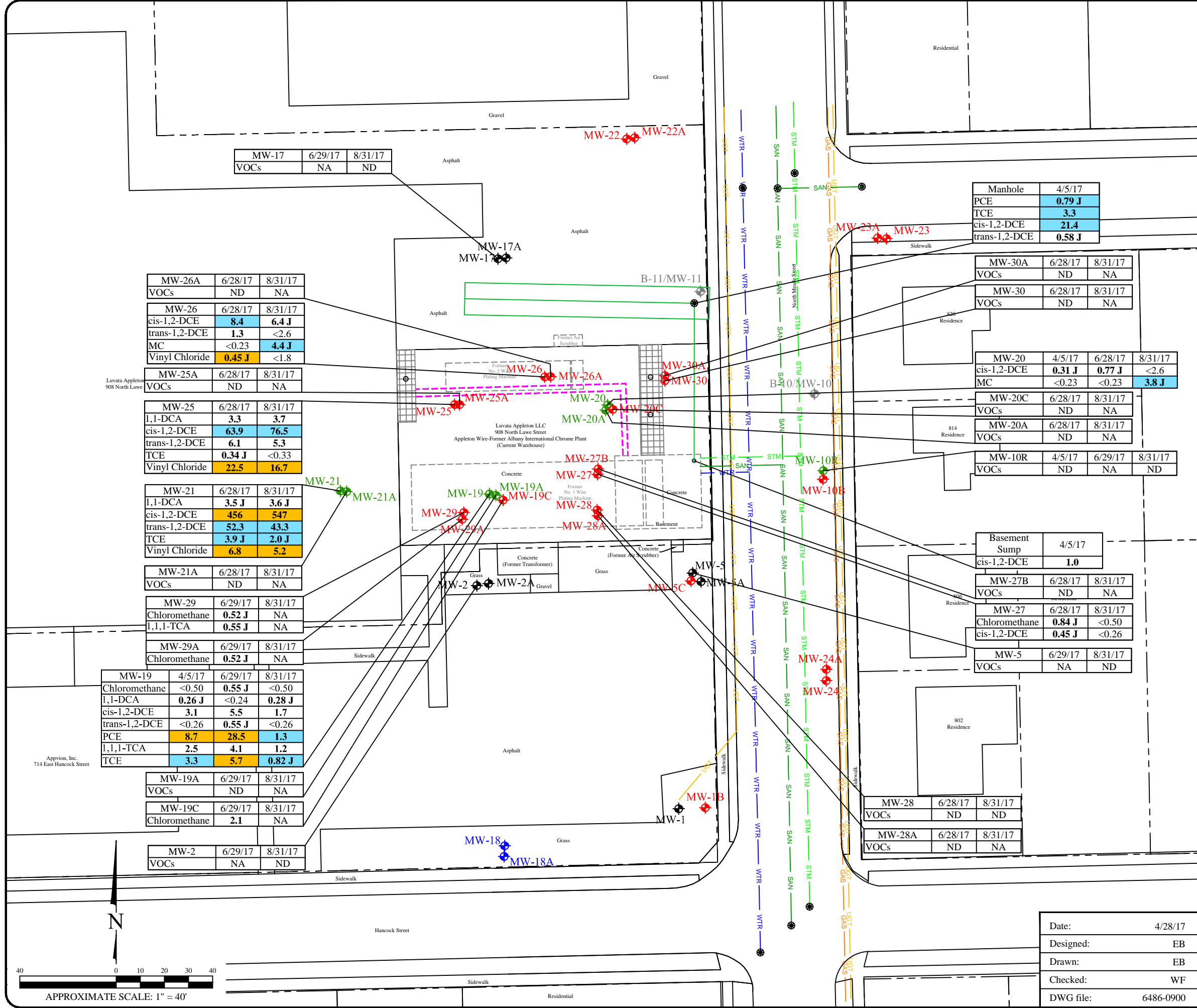
- MW-19 Water table observation well (with 10 foot screen length)
- MW-19A Piezometer (with 5 foot screen length set within the 30-40' depth interval)
- MW-1B Piezometer (with 5 foot screen length set within the 40-50' depth interval)
- MW-19C Piezometer (with 5 foot screen length set within the 50-60' depth interval)

**MAP SHOWING WELLS SAMPLED FOR TOTAL VOLATILE ORGANIC COMPOUNDS AND ANALYTICAL RESULTS**  
 Former Appleton Wire Division of Albany International Corporation  
 908 North Lawe Street  
 Appleton, Wisconsin

Date:	4/28/17
Designed:	EB
Drawn:	EB
Checked:	WF
DWG file:	6486-0900

825 North Capitol Avenue • Indianapolis, IN 46204  
 EnviroForensics.com

Figure	9
Project	6486



MW-17	6/29/17	8/31/17
VOCs	NA	ND

MW-26A	6/28/17	8/31/17
VOCs	ND	NA
MW-26	6/28/17	8/31/17
cis-1,2-DCE	<b>8.4</b>	<b>6.4 J</b>
trans-1,2-DCE	<b>1.3</b>	<b>&lt;2.6</b>
MC	<b>&lt;0.23</b>	<b>4.4 J</b>
Vinyl Chloride	<b>0.45 J</b>	<b>&lt;1.8</b>

MW-25A	6/28/17	8/31/17
VOCs	ND	NA

MW-25	6/28/17	8/31/17
1,1-DCA	<b>3.3</b>	<b>3.7</b>
cis-1,2-DCE	<b>63.9</b>	<b>76.5</b>
trans-1,2-DCE	<b>6.1</b>	<b>5.3</b>
TCE	<b>0.34 J</b>	<b>&lt;0.33</b>
Vinyl Chloride	<b>22.5</b>	<b>16.7</b>

MW-21	6/28/17	8/31/17
1,1-DCA	<b>3.5 J</b>	<b>3.6 J</b>
cis-1,2-DCE	<b>456</b>	<b>547</b>
trans-1,2-DCE	<b>52.3</b>	<b>43.3</b>
TCE	<b>3.9 J</b>	<b>2.0 J</b>
Vinyl Chloride	<b>6.8</b>	<b>5.2</b>

MW-21A	6/28/17	8/31/17
VOCs	ND	NA

MW-29	6/29/17	8/31/17
Chloromethane	<b>0.52 J</b>	NA
1,1,1-TCA	<b>0.55 J</b>	NA

MW-29A	6/29/17	8/31/17
Chloromethane	<b>0.52 J</b>	NA

MW-19	4/5/17	6/29/17	8/31/17
Chloromethane	<b>&lt;0.50</b>	<b>0.55 J</b>	<b>&lt;0.50</b>
1,1-DCA	<b>0.26 J</b>	<b>&lt;0.24</b>	<b>0.28 J</b>
cis-1,2-DCE	<b>3.1</b>	<b>5.5</b>	<b>1.7</b>
trans-1,2-DCE	<b>&lt;0.26</b>	<b>0.55 J</b>	<b>&lt;0.26</b>
PCE	<b>8.7</b>	<b>28.5</b>	<b>1.3</b>
1,1,1-TCA	<b>2.5</b>	<b>4.1</b>	<b>1.2</b>
TCE	<b>3.3</b>	<b>5.7</b>	<b>0.82 J</b>

MW-19A	6/29/17	8/31/17
VOCs	ND	NA

MW-19C	6/29/17	8/31/17
Chloromethane	<b>2.1</b>	NA

MW-2	6/29/17	8/31/17
VOCs	NA	ND

Manhole	4/5/17
PCE	<b>0.79 J</b>
TCE	<b>3.3</b>
cis-1,2-DCE	<b>21.4</b>
trans-1,2-DCE	<b>0.58 J</b>

MW-30A	6/28/17	8/31/17
VOCs	ND	NA
MW-30	6/28/17	8/31/17
VOCs	ND	NA

MW-20	4/5/17	6/28/17	8/31/17
cis-1,2-DCE	<b>0.31 J</b>	<b>0.77 J</b>	<b>&lt;2.6</b>
MC	<b>&lt;0.23</b>	<b>&lt;0.23</b>	<b>3.8 J</b>

MW-20C	6/28/17	8/31/17
VOCs	ND	NA

MW-20A	6/28/17	8/31/17
VOCs	ND	NA

MW-10R	4/5/17	6/29/17	8/31/17
VOCs	ND	NA	ND

Basement Sump	4/5/17
cis-1,2-DCE	<b>1.0</b>

MW-27B	6/28/17	8/31/17
VOCs	ND	NA

MW-27	6/28/17	8/31/17
Chloromethane	<b>0.84 J</b>	<b>&lt;0.50</b>
cis-1,2-DCE	<b>0.45 J</b>	<b>&lt;0.26</b>

MW-5	6/29/17	8/31/17
VOCs	NA	ND

MW-28	6/28/17	8/31/17
VOCs	ND	ND

MW-28A	6/28/17	8/31/17
VOCs	ND	NA