ARCADIS
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Primary Groundwater Source Area (AOI 7) Interim Measures Work Plan

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1. Introduction

A Supplemental Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) was completed for the General Motors Powertrain Group Moraine Engine Plant (Moraine Engine) and the General Motors Truck Group Moraine Assembly Plant (Moraine Assembly) in Moraine, Ohio (ARCADIS Geraghty & Miller 1999a and ENVIRON Corporation 1999). These investigations were designed to supplement investigations previously conducted for Delphi Harrison Thermal Systems Moraine Plant (Delphi Thermal Moraine) presented in the draft RCRA Facility Investigation Final Report (Geraghty & Miller, Inc. 1996 and ENVIRON Corporation 1996). The Supplemental RFI identified that the primary source area of volatile organic compounds (VOCs) in shallow groundwater at the three facilities is located at the Area of Interest (AOI) 7 - Former Oil House Area. The Supplemental RFI recommended that interim measures be initiated in the AOI 7 area.

The objectives of the interim measures are as follows:

1. to destroy VOC mass in the upper aquifer groundwater above the upper clay till in the primary source area in a relatively short period of time;
2. to limit future migration from the source area to downgradient portions of the upper aquifer and into the lower aquifer; and
3. to actively address VOCs that have already migrated downgradient from the source area in order to expedite remediation of the downgradient plume.

These objectives will be met by using a combination of in-situ technologies that have been selected for the site. The source area will be addressed using an in-situ oxidation technology and the downgradient plumes will be addressed using enhanced in-situ reductive dechlorination.

1.1 Site Background

The Moraine Engine and Moraine Assembly facilities occupy approximately 300 acres, while the adjacent Delphi Thermal Moraine occupies approximately 165 acres. The facilities are located in the City of Moraine in Montgomery County in southwestern Ohio. A small portion of the Moraine Assembly facility is located in the City of Kettering. Figure 1 presents the location of each facility, property boundaries, and site features.

The GMC site has been used for industrial purposes since the property was acquired in the mid-1920's. Frigidaire (a division of GMC) produced appliances from the late 1920's until 1979. GMC announced the shut down of all Frigidaire operations in January 1979. During 1980 and 1981, the majority of the former Frigidaire Plant 2 was converted to the Moraine Engine facility, and the former Frigidaire Plant 3 and the northeast corner of former Frigidaire Plant 2 were converted to the Moraine Assembly facility. Since 1981, Moraine Engine operations have included the machining, painting (this operation was discontinued in September 1995), and assembly of diesel truck engines. Since 1981, Moraine Assembly operations initially included the manufacture, assembly, and painting of small trucks, but currently Chevrolet Blazers, GMC Jimmies, and Oldsmobile Bravadas are produced at this facility. Delphi Thermal Moraine's major operations are the machining and assembly of automotive air conditioning compressors, accumulator dehydrators, and miscellaneous air conditioning valves.

1.2 Interim Measures Work Plan Organization

This Interim Measures Work Plan is organized as follows:

Section 1.0 presents the introduction.

Section 2.0 presents a description of the primary source area (AOI 7), including the nature and extent of contamination and hydrologic features.

Section 3.0 presents a description of the interim measures technologies (in-situ oxidation in the source area and in-situ enhanced reductive dechlorination downgradient) and discusses their applicability to AOI 7.

Section 4.0 presents the proposed remediation systems; permit requirements; and a monitoring plan to monitor the effectiveness of interim measures.

Section 5.0 presents the interim measures implementation schedule.

Section 6.0 presents the references.

In general, the Work Plan has been prepared in accordance with RCRA guidance for interim measures (U.S. EPA 1994).

2. Description of AOI 7

The location of AOI 7 - Former Oil House Area is presented on Figure 1 and the historic and current features at and in the vicinity of AOI 7 are presented on Figure 2. A detailed description of AOI 7 was presented in Section 3.2.7 of the Supplemental Description of Current Conditions (DOCC) (Geraghty & Miller, Inc. 1997a) and a detailed discussion of the Supplemental RFI investigation results and conclusions were presented in Sections 3.4, 4.4.3.2, and 6.0 of the Supplemental RFI Report (ARCADIS Geraghty & Miller, 1999a). The following sections present a summary of this information.

2.1 AOI 7 Background

The Former Oil House Building 7 was located north of the Moraine Engine Plant, and was built at least as early as 1949. The Former Oil House Area consisted of the Oil House (Building 7) and an outdoor area that contained underground storage tanks (USTs), aboveground storage tanks (ASTs), and a drum storage area. This AOI was removed from service in 1979 when at least three buildings were demolished and all tanks were removed. The Oil House Building 7 and associated outside structures covered a total area of approximately 48,000 square feet (ft). Based on data collected during the Supplemental RFI, AOI 7 was evaluated in the Supplemental Baseline Risk Assessment as an approximately 275,000 square ft area encompassing these structures.

Virgin paints and chemicals necessary for production were stored and mixed in the Oil House, and pumped or transferred to various production areas. Materials were stored in both drums and tanks. Virgin chemicals including oils, paints, thinners, solvents, acids, toluene diisocyanate (TDI) and resins were stored inside the Oil House. Alcohols were reclaimed and solvent blending activities were conducted at the Oil House. The outdoor area just north of the Oil House had seventeen 8,000 to 15,000-gallon ASTs used to store oil, solvents, acids and other production materials, and three 15,000-gallon USTs used to store oil. These tanks were located in a tank farm which had dikes (concrete or earthen) for spill containment and a gravel floor. A drummed waste storage area was also located just north of the Oil House and was used to store drummed waste oils, thinners, alcohols, and still bottoms from the Oil House and sludges containing chromium, nickel, and phosphorus.

AOI 7 is primarily covered with asphalt, concrete, and the Moraine Engine Tank Farm. This aboveground tank farm and pump house were constructed in 1980 over the footprint of the former Oil House tank farm. Figure 3 presents photographs of the current conditions at AOI 7.

2.2 AOI 7 Investigation Results

The hydrogeologic units beneath AOI 7 consist of the upper aquifer, the regional confining unit, and the lower aquifer. In addition, the upper aquifer beneath the AOI 7 area is divided into an upper and lower portion by the presence of an upper clay till. The upper clay till is continuous beneath the AOI 7 area at a depth ranging from approximately 25 ft to over 40 ft below land surface (bls). The water table is located approximately 4 to 12 ft above the top of the upper clay till. A contour map of the upper clay till surface is presented on Figure 4.

The average hydraulic conductivity of the upper aquifer across the site, based on pumping test data collected in 1985 and in 1989, is approximately 1,650 ft/day. The flow velocity in the upper aquifer ranges from approximately 1.9 to 7.3 feet/day (ARCADIS Geraghty & Miller 1999b). However, the hydraulic conductivities of the upper and lower portions of the upper aquifer in AOI 7 are much lower than the site-wide hydraulic conductivities, based on slug test data collected in 1998, at approximately 43 ft/day and 54 ft/day, respectively, and lower flow velocities would be expected in this area. The groundwater flow velocity in the lower aquifer across the site, ranges from approximately 0.7 to 1.4 ft/day (ARCADIS Geraghty & Miller 1999b).

The highest concentrations of VOCs in groundwater across the three facilities is present at AOI 7 in monitoring well GM-23. At this location, total VOC concentrations were 19,706 micrograms per liter (ug/L) in March 1998, with tetrachloroethene (PCE) at 11,200J ug/L, trichloroethene (TCE) at 3,870J ug/L, cis-1,2-dichloroethene (cis-1,2-DCE) at 3,870J ug/L, and vinyl chloride at 766J ug/L. The highest total VOC concentrations in a hydropunch sample were in OH-BH2A where 18,441 ug/L was detected in November 1998, with cis-1,2-DCE at 11,000 ug/L, vinyl chloride at 4,770J, PCE at 1,180J ug/L, TCE at 1,260J ug/L, and 1,1-dichloroethane (1,1-DCA) at 231 ug/L. In general, the area of highest VOC concentrations is centered around GM-23, as shown on Figure 5. This area is estimated to be approximately 750 feet in the north/south direction and 350 feet in the east/west direction. Figure 5 presents the distribution of total VOC concentrations in this area. Hydrophobic dye testing of saturated soil samples in the AOI 7 area indicated the potential presence of DNAPL. The dye test results are presented on Figure 4. The calculated total mass of dissolved VOCs within the 1,000 ug/L contour boundary identified on Figure 5, is approximately 95 pounds (or 7 gallons) based on a saturated thickness of 9 ft and a porosity of 0.3.

The concentrations of VOCs in groundwater within AOI 7 are much higher in the portion of the upper aquifer above the upper clay till. VOC concentrations are almost two orders of magnitude lower in upper aquifer groundwater below the upper clay till, ranging from 11,525.3 ug/L total VOCs just above the upper clay till to 101.5 ug/L just below the upper clay till in hydropunch samples collected during installation of GM-27. As a result, the interim measure within AOI 7 will focus on the upper portion of the upper aquifer. Downgradient from AOI 7, interim measures will focus on both the upper and lower portions of the upper aquifer, as VOCs have dispersed both horizontally and vertically in the upper aquifer as they have migrated downgradient from AOI 7.

3. Description of Interim Measures Technologies

Based on a review of potential remedial technologies which could be applied at the GMC site to address VOCs in groundwater at and emanating from AOI 7, two remediation technologies have been selected as the most likely to achieve the Interim Measures objectives. One of these is a chemical (non-biological) oxidation of the contaminants using hydrogen peroxide; the other is enhanced bioremediation, primarily via the reductive dechlorination process. The chemical oxidation technology will be implemented in the AOI 7 primary source area which contains the highest VOC concentrations because this technology is effective for rapidly reducing high VOC concentrations. The enhanced bioremediation technology will be implemented at downgradient areas affected by lower concentrations of VOCs from the AOI 7 source area because this technology is effective for reducing these VOC concentrations detected at the site.

3.1 Chemical Oxidation

Chemical oxidation as a remedial alternative is based on the introduction of an oxidant, such as hydrogen peroxide (H_2O_2), into the subsurface. The resulting hydroxyl radicals (OH^-), a strong chemical oxidizer, can create an environment which oxidizes organic compounds such as PCE and TCE (and their degradation daughter products 1,2-DCE and vinyl chloride). The reaction is a nearly instantaneous oxidation of these compounds upon contact with the hydroxyl radicals.

Fenton's reagent, a combination of hydrogen peroxide and ferrous salts, can be used to cost-effectively create hydroxyl radicals. The general chemistry for the creation of hydroxyl radicals with Fenton's reagent is shown in the following reaction (Suthersan, 1997):

$$Fe^{2+} + H_2O_2 \longrightarrow Fe^{3+} + OH^- + OH$$

The ultimate breakdown products of this reaction are water, oxygen, and iron. Fenton's reagent can be created immediately prior to injection into the subsurface or within the subsurface using successive injections of hydrogen peroxide and ferrous salts to maximize remedial effectiveness. In aquifers with high iron content, Fenton's reagent may be created naturally with the injection of hydrogen peroxide.

The oxidation of a PCE molecule occurs as the hydroxyl free radical (OH) breaks the chemical bonds between the carbon and chlorine atoms. The oxidation of PCE is shown below.

$$C_2Cl_4 \text{ (PCE)} + OH \longrightarrow$$
$$Cl^- + \text{mineralized end products (e.g., } CO_2) + H_2O$$

This oxidation reaction is similar for TCE, 1,2-DCE, and vinyl chloride. Chloride ions, carbon dioxide and water are the major end products of the complete oxidation process.

The use of this remedial technology as part of the AOI 7 Interim Measure is proposed to be implemented at areas within AOI 7 above the upper clay till with the most elevated concentrations of VOCs: 1) the areas around GM-23, OH-BH7, and OH-BH13 (Oxidation Area 1 [OA-1]) and 2) west, north and southeast of the Moraine Engine tank farm (OA-2). These areas are shown on Figures 6 and 7. The interim measure will involve the injection of hydrogen peroxide (with and/or without a ferrous salt catalyst) to facilitate the oxidation of the chlorinated VOCs. The iron concentrations in the upper aquifer above the upper clay till at AOI 7 (3.41 to 15.0 milligrams per liter [mg/L] at GM-23) may not be high enough to support creation of Fenton's reagent without the introduction of a ferrous salt catalyst, this will be further evaluated during implementation of this technology. Field data will be collected to verify the completeness of these reactions within the AOI 7 source area.

3.2 Enhanced Anaerobic Biodegradation

Enhanced anaerobic biodegradation is a remedial alternative which modifies the subsurface environment to provide conditions which accelerate the natural biodegradation of the chlorinated VOCs. This technology is recommended because site data indicates that natural degradation of the PCE to daughter products is already occurring at varying degrees, as discussed in Section 4.6.2 of the Supplemental RFI Report.

Naturally occurring bacteria use available carbon that exists in their environment for energy. During utilization of the available carbon, biodegradation of chlorinated VOCs can occur through various degradation pathways. The most important microbial pathway for degradation of the higher chlorinated VOC compounds (i.e., PCE and TCE) is reductive dechlorination (Wiedemeier et. al 1996). During reductive dechlorination, the chlorinated VOC is degraded via co-metabolism, whereby bacteria utilize another primary carbon substrate as a source of energy. This primary utilization produces enzymes and co-factors that can result in a chlorine atom on the VOC compound being subsequently replaced with a hydrogen atom. Thus, biodegradation through reductive dechlorination results in a step-wise dechlorination from PCE to TCE to DCE to vinyl chloride to ethene or ethane. Importantly, however, there must be an appropriate carbon source available for this degradation pathway to proceed. It is accepted that reductive dechlorination occurs under anaerobic conditions.

During co-metabolism, the microbial populations are able to metabolize chlorinated compounds even though they do not gain any significant energy from them, since the primary carbon source satisfies this need. Thus, co-metabolism (and degradation of contaminants) can occur at very low concentrations of chlorinated compounds, and the reactions tend to be stable as long as a primary carbon source is available.

Recent studies have also indicated that the chlorinated VOCs themselves can be used as an electron acceptor by bacteria. Thus, the bacteria can use the chlorinated VOCs as a means of "breathing" or metabolizing, just as they use nitrate, sulfate, iron, manganese and carbon dioxide for metabolizing carbon when oxygen is not present. This process is called dehalorespiration and results in the degradation of more chlorinated VOCs, such as TCE, proceeding directly to ethene, without the production of intermediates such as DCE and vinyl chloride. Other dehalorespiration reactions are most likely possible, and these reactions are currently being studied in laboratory environments. The important point to note is that dehalorespiring reactions are most prevalent in the reducing environments in groundwater that also support reductive dechlorination. Therefore, many dechlorination processes are most likely on-going at any site impacted with chlorinated VOCs where natural degradation is occurring.

Enhanced bioremediation, as proposed for the AOI 7 Interim Measures, increases the rate of intrinsic remediation by introducing a carbon source directly into the impacted areas of the saturated zone. This creates a chemically-enhanced anaerobic and reducing environment which follows groundwater movement (mobile reactive zone) where chlorinated VOCs can be degraded to innocuous end products consisting of chloride ions, carbon dioxide, and water. As the indigenous bacteria utilize the carbon source for energy, the available dissolved oxygen and other electron acceptors are depleted, and the subsurface environment is driven toward more anaerobic (reducing) conditions. Degradation of the chlorinated VOCs can then proceed by reductive dechlorination. The use of the carbon source within a mobile reactive zone provides a fundamental advantage over most treatment technologies in that it is not a diffusion-limited process which relies on the VOC desorption rate. The effects of bacteria can often act as a natural surfactant and desorb some VOCs which are attached to the aquifer matrix, thereby increasing the amount of mass which can be degraded through natural biological processes. Through the mobile reactive zone, the carbon source can become available to all portions of the aquifer through which water flows. In addition, due to the concentration gradient that develops across the mobile reactive wall, the carbon source is driven throughout the aquifer. Thus, the carbon source can access interstitial pore spaces and influence degradation of contaminants in areas generally not accessible through groundwater extraction techniques.

The use of this remedial technology as part of the AOI 7 Interim Measure is proposed in three areas: 1) at the southern boundary of AOI 7 (Reactive Zone 1 [RZ-1]), 2) at an intermediate downgradient barrier curtain south of AOI 7 in the ME well series area (RZ-2), and 3) at a downgradient barrier curtain south of the Moraine Engine and the Delphi Thermal Moraine plants (RZ-3). These areas are shown on Figures 5, 6, and 7. The pilot test will involve the introduction of a carbon source in the form of simple carbohydrates to allow the microbial population to develop the reducing conditions necessary to support the enhanced anaerobic biodegradation of the chlorinated VOCs. Field data collected during interim measures will verify the complete dechlorination process within these areas of the site which are downgradient of the AOI 7 source area and contain elevated concentrations of chlorinated VOCs.

4. Interim Measures System Design

The following sections present details of how the interim measures will be implemented for both the oxidation and enhanced biodegradation technologies. The locations of the OAs and RZs are presented on Figure 6. The proposed interim measures systems will be operated using a batch mode of operation where solutions are injected/introduced below the water table; therefore, permanent above ground equipment is not required and engineering design drawings and specifications are not necessary. The information provided in this section includes details on the installation of monitoring wells and injection/introduction points, a baseline groundwater sampling event, system implementation, system monitoring, permitting requirements, and reporting requirements.

4.1 Monitoring Well and Injection/Introduction Points Installation

All interim measures drilling and field work activities will be conducted in accordance with the approved Supplemental RFI Work Plan (Geraghty & Miller, Inc. 1997b), unless noted below.

4.1.1 Monitoring Wells

Two new shallow monitoring wells (GM-29 and GM-30) will be installed within the AOI 7 area as shown on Figure 7 to monitor effectiveness of the oxidation system. These wells will be drilled down to the upper clay till. New shallow monitoring wells will be installed in the RZ-2 area (GM-31) and south of RZ-3 (GM-32) to monitor effectiveness of interim measures in those zones. These wells will be drilled down to the regional confining unit. All wells will be drilled, constructed, and developed per the approved Supplemental RFI Work Plan (Geraghty & Miller, Inc. 1997b). During drilling, continuous headspace readings will be taken and a soil sample may be collected for laboratory analysis (VOCs by Method 8260) based on headspace readings or visual evidence of contamination. If all headspace readings are background levels or there is no visual evidence of contamination, a soil sample will not be collected.

4.1.2 Oxidation Injection Points

To implement the chemical oxidation system, injection points will be installed in the upper aquifer and screened above the upper clay till in two primary areas defined earlier as OA-1 and OA-2 (Figure 7). It is estimated that eight to ten injection points will be advanced within each area depending on the radius of influence that can be developed during injection and physical constraints of the existing operations (tank farm, unloading equipment, railroad tracks and buried utilities). However, initially, three injection points will be installed in each area, as shown on Figure 7. As the system implementation progresses, additional injection points will be installed in the most appropriate locations based on the radius of influence determined by monitoring of the initial points.

Each injection point will be drilled using hollow stem auger drilling techniques. The borings will be terminated at a depth of 1 foot into the upper clay till formation. Because AOI 7 was previously characterized during the Supplemental RFI, soil samples will not be collected for laboratory analysis during drilling. However, once the water table is encountered, the borings will be continuously sampled to characterize lithology until the upper clay till is encountered. A saturated soil sample collected from above the upper clay till within each boring will be field screened using the hydrophobic-dye test to assess the potential presence of DNAPL within AOI 7.

After each boring is completed, it will be converted into an oxidation injection point by installing a 2-inch diameter stainless steel casing. Each casing will be equipped with a screened section set into the upper clay till layer, with a 6-inch bottom sump to facilitate identification of a DNAPL, if present. The screen sections for the injection points will be approximately 5 ft. An example of typical injection point construction is presented in Figure 9.

4.1.3 Enhanced Bioremediation Introduction Points

The bioremediation delivery network will consist of newly installed introduction points for RZ-1 and RZ-3 and existing on-site monitoring wells in RZ-2 (Figure 6). Carbon source introduction points will be installed in areas RZ-1 and RZ-3 as a barrier (row of points) generally running west to east with an initial separation distance of approximately 25 ft. At RZ-1, the carbon source solution will be introduced within the upper aquifer above the upper clay till using approximately 13 introduction points (Figure 7), while at RZ-3, carbon will be introduced using approximately 43 introduction points (Figure 8) through the entire thickness of the upper aquifer as the upper clay till is not suspected to be present beneath this portion of the site. At RZ-2, six existing monitoring wells located along the western edge of the Moraine Engine Plant 3 building screened in the upper portion of the upper aquifer will be used for carbon source introduction points (Figure 6). Due to the availability of existing wells, no new introduction points will be initially installed at RZ-2, but installation of new introduction points will be further evaluated once the shallow monitoring well (GM-31) is installed and sampled.

Borings will be drilled using either hollow stem auger or percussion drilling methods. The borings will be terminated at a depth of 1 foot into the upper clay till formation in RZ-1 and a depth of 1 foot into the appropriate clay till formation in RZ-2 (if additional deeper introduction points are determined to be necessary) and RZ-3. Soil samples will not be collected for laboratory analysis during drilling in RZ-1. However, once the water table is encountered, the borings will be continuously sampled to characterize lithology until the upper clay till is encountered. A saturated soil sample collected from above the upper clay till within each boring will be field screened using the hydrophobic-dye test to assess the potential presence of DNAPL within AOI 7.

During drilling in RZ-2 (if additional deeper introduction points are determined to be necessary) and RZ-3, soil samples will not be collected for laboratory analysis. However, 5 of the 43 borings in RZ-3 will be selected for lithologic characterization until the regional confining unit is encountered. These logs will provide additional data regarding site stratigraphy in this area. Once the depth to the regional confining unit is determined from the initial 5 borings, the remaining 38 borings will be drilled to similar a depth.

After each boring is completed, it will be converted into a carbon source introduction point by installing a 3-inch diameter Schedule 80 polyvinyl chloride casing. Each casing will be equipped with a screened section set into the appropriate clay till layer, with a 6-inch bottom sump to facilitate identification of a DNAPL, if present. A 10-foot long screen section will be used for all introduction points in RZ-1. Introduction points to be installed within RZ-2 (if additional deeper introduction points are determined to be necessary) and RZ-3, will be screened over the entire saturated thickness (anticipated to be 30 to 40 ft). An example of a typical introduction point is presented in Figure 10.

4.2 Site-Wide Baseline Groundwater Sampling

Prior to implementing the proposed interim measures systems, baseline conditions will be determined through completion of a site-wide baseline groundwater sampling event in the upper and lower aquifers. Baseline groundwater conditions will be assessed by collecting groundwater samples for laboratory analysis and field measurements from 43 existing upper aquifer monitoring wells, 4 newly installed upper aquifer monitoring wells, 18 lower aquifer monitoring wells, 6 hydrogen peroxide injection points and 10 carbon source introduction points, as detailed on Table 1. Monitoring well locations are shown on Figure 6.

Groundwater samples will be collected using low-flow sampling procedures from the upper aquifer monitoring wells and injection/introduction points presented on Table 1. The groundwater samples will be submitted to TestAmerica, Inc. of Dayton, Ohio for analysis of Appendix IX VOCs and cis-1,2-DCE by Method 8260 and biogeochemical indicator parameters, except for the analysis of dissolved gases which will be performed by Microseeps, Ltd. of Pittsburgh, Pennsylvania. Groundwater samples collected from the lower aquifer monitoring wells will be analyzed for Appendix IX VOCs and cis-1,2-DCE by Method 8260. Table 1 lists specific field and laboratory parameters, analytical methods and laboratories.

Prior to sampling, depth-to-water measurements will be obtained from all wells. Field parameters including pH, conductivity, temperature, oxidation/reduction potential (ORP) and dissolved oxygen will be measured during purging of each upper aquifer well using a multi-parameter flow-through cell. In addition to indicating proper purging, these field parameters will be used to evaluate measurements periodically collected to assess the interim measures activities. Wells expected to have the lowest total concentrations of VOCs will be sampled first to reduce the risk of potential cross-contamination. All groundwater samples will be collected, managed under standard chain-of-custody procedures, and validated in accordance with the approved Supplemental RFI Work Plan (Geraghty & Miller, Inc. 1997b).

Data from the site-wide baseline sampling will be evaluated to assess the current VOC concentrations in light of the technologies proposed to be implemented as an interim measure to address VOCs from AOI 7. With respect to chemical oxidation, the evaluation will be used to assist in determining the presence and quantity of non-target compounds susceptible to oxidation, the anticipated quantity and spatial distribution of oxidizing agent to be injected and the anticipated quantity of additional compounds (i.e., iron salts) to be injected at the site. With respect to enhanced bioremediation, the baseline data will be used to compare the conditions before and after introduction of the carbon source. The VOC results will be evaluated to establish a site-specific parameter list for all future groundwater sampling events. The results of the VOC analysis, biogeochemical analysis and field data will be presented in the interim measures summary report, as discussed in Section 4.6.

4.3 Interim Measures Implementation

The AOI 7 interim measures activities described below will be implemented over a six-month period, with the exception of continuing batch injection/introduction activities. Once the six-month sampling event is completed, an interim measures summary report will be prepared.

4.3.1 Oxidation Activities

The oxidation system will consist of batch injections of a hydrogen peroxide solution diluted with potable water and an iron catalyst, if needed (Fenton's reagent), into an initial set of injection points (six points installed prior to the baseline sampling event). During each application, up to 500 gallons of solution will be injected for each test at a pressure of up to 100 pounds per square inch. The target concentration is expected to be 10% hydrogen peroxide with a 10:1 solution of iron catalyst (H_2O_2:Fe). Following injection activities, all wells will be sealed with a locking well cap to prevent other materials from entering the wells. The hydrogen peroxide solution injection standard operating procedure (SOP) #29 is presented in Appendix A.

Groundwater samples will be collected from select oxidation injection wells and associated monitoring wells prior (pre-test [baseline, Section 4.2]) and approximately one week after (post-test) the injections during the oxidation pilot test. Table 2 summarizes the monitoring and injection requirements for the oxidation wells and associated monitoring wells. These samples will be submitted for laboratory analysis of the site-specific parameter list using Method 8260 and oxidation indicators (chlorides, ethene, and ethane). Prior to sampling, depth-to-water measurements will be obtained from each well. Groundwater samples will be collected using the low-flow groundwater sampling procedure. Field parameters including pH, conductivity, temperature, ORP and dissolved oxygen will be measured during purging of each well using a multi-parameter flow-through cell. Multiple injection events and post sampling activities will likely be necessary within the six month implementation period. The requirements for additional injections will be based on field and analytical data from groundwater samples collected before, during and after the injections, as described below. Figure 11 presents the anticipated schedule of oxidation injection events. All activities will be recorded on the hydrogen peroxide solution injection log presented in Appendix A.

In addition to the pre-test and post-test sampling, samples will also be collected during the initial oxidation injection event for field parameters from selected wells as presented on Table 2. Field parameters will include pH, specific conductivity, temperature, ORP, and dissolved oxygen. In addition, samples may be field screened for dissolved CO_2, H_2O_2, chlorides and iron using appropriate meters or test kits. These field parameters may also be collected at monitoring wells during subsequent injection events, if deemed appropriate.

The results of field monitoring and groundwater sampling will be evaluated as they become available. Evaluation of these results will be used to adjust the Fenton's reagent solution concentration, feed rate, quantity, and introduction frequency to achieve the desired oxidation reaction in groundwater.

4.3.2 Enhanced Bioremediation Activities

The enhanced bioremediation system will consist of batch introductions of a carbon source solution. The carbon source will be mixed on site in a mixing vessel(s) and it will be introduced per the carbon source solution introduction SOP #28 (Appendix A). The carbon source solution will be mixed at a single location then transported to each introduction point via a tanker truck, tanker trailer or equivalent. Batch introductions will proceed, depending on how much solution can be delivered to the formation and the results of field parameter monitoring. The typical carbon source solution will contain food grade molasses which is fully soluble in water. The carbon source solution will be mixed and introduced on each scheduled introduction date. All activities will be recorded on the carbon source solution introduction log presented in Appendix A. The initial target volumes and strengths are as follows:

- 200 to 500 gallons of a 10:1 (water: molasses) carbon source solution per introduction well.

During the initial start-up, efforts will be made to introduce the solution slowly into the wells to determine acceptance rates by the formation. The formation is anticipated to be able to easily accept solution at a rate of several gallons per minute (gpm). However, if rates are below 7 gpm then wells may be modified to accept the solution under pressure using an above ground pump. Figure 11 presents the anticipated schedule of the introduction events.

To assess the performance of the mobile reactive zones throughout the initial six-month period, field monitoring of indicator parameters will be conducted at the introduction and monitoring wells, presented below:

- RZ-1 will be monitored using new monitoring well GM-29 (upgradient), GM-28 (downgradient), and through the sampling and analysis of three introduction points (RZ-1B, RZ-1G and RZ-1L);
- RZ-2 will be monitored using existing monitoring wells ME-3 (downgradient) and ME-6 (upgradient); and
- RZ-3 will be monitored using upgradient monitoring wells EAST, WEST and GM-22, downgradient monitoring wells GM-19S and GM-21, a new monitoring well GM-32, and through the sampling and analysis of seven introduction points (RZ-3E, RZ-3L, RZ-S, RZ-3Y, RZ-3FF, RZ-3KK, and RZ-3PP), shown on Figure 8.

The field monitoring will be conducted during the baseline sampling event (Section 4.2), then at two weeks and four weeks after initiation of the test, and approximately once every month thereafter (Figure 11). Indicator parameters measured during each monitoring event using field equipment include: water level; DO; ORP; pH; conductivity; and temperature. These measurements in the monitoring wells will be used to assess whether microbial-induced reducing conditions are being developed within the test area of the upper aquifer. Table 3 summarizes the introduction and field monitoring requirements for the reactive zone wells and associated monitoring wells.

4.3.3 Pilot Test 3 Month and 6 Month Groundwater Monitoring

After approximately three and six months of the interim measures, groundwater samples will be collected from select shallow monitoring wells (HR-3, GM-23, GM-27, GM-28, GM-29, GM-30, GM-31, GM-32, ME-1, ME-3, ME-6, GM-22, EAST, WEST, GM-19S, GM-21, GM-2, GM-8, GM-6, 4S, GM-17, GM-10, HR-1, W-1-S, GM-16), and the introduction points used for field monitoring (Table 1) for laboratory analysis of the site-specific parameter list using Method 8260 and biogeochemical indicator parameters. The Fenton's reagent injection and carbon source introduction will be stopped one week prior to the scheduled sampling event. The introduction wells will be purged according to the low flow groundwater sampling SOP (SOP #21 from the Supplemental RFI Work Plan). Table 1 lists specific laboratory parameters, analytical methods and laboratories. All groundwater samples will be collected, managed under standard chain-of-custody procedures, and validated in accordance with the approved Supplemental RFI Work Plan (Geraghty & Miller, Inc. 1997b).

The results of the field monitoring and groundwater sampling will be evaluated as they become available. Evaluation of these results will be used to adjust the Fenton's reagent injection and/or carbon source solution concentration, feed rate, and introduction frequency to achieve the desired oxidizing or reducing conditions in groundwater.

4.4 Permit Requirements

Prior to initiating the interim measures, a permit or permit waiver, if appropriate, will be obtained from the Ohio Environmental Protection Agency (Ohio EPA), Division of Underground Injection Control (UIC). This request for permit will be prepared to include the following information, as required by Ohio Administrative Code (OAC) 3745-34 and Ohio EPA UIC guidance (Ohio EPA Website):

- A summary of the interim measures for AOI 7,
- A description of site geology and hydrogeology,
- A description of the fluids to be injected,
- The proposed injection rate and volume, and
- The locations of the proposed injection/introduction points.

4.5 Health and Safety Plan

The approved Supplemental RFI Health and Safety Plan (Appendix E to the Supplemental RFI Work Plan) will be followed during drilling, sampling, and interim measures implementation. An addendum to the Supplemental RFI Health and Safety Plan has been prepared to address safe handling procedures for the hydrogen peroxide. This addendum is presented in Appendix B.

4.6 Interim Measures Summary Report

Data collected during implementation of the first six months of the interim measures systems will be evaluated to determine if any adjustments are necessary. The hydrogen peroxide solution mixture, feed rate, injection pressure, number of injection points, and radius of influence to achieve VOC mass reduction in the source area will be evaluated. The carbon source solution concentration, feed rate, introduction frequency to achieve the desired strongly reducing conditions in groundwater will be evaluated. All data collected during the first six months will be presented in this report, including validated laboratory data. During the time this report is being prepared and during agency review, the oxidation and bioremediation systems will continue to operate.

The summary report will contain an Operation, Maintenance and Monitoring (OM&M) Manual. This manual will contain information regarding any necessary modifications to the interim measures, introduction/injection point maintenance activities, and the long-term site-wide groundwater monitoring plan.

5. Interim Measures Implementation Schedule

A schedule for the implementation of the first six months of interim measures is presented on Figure 11. The schedule indicates when drilling, sampling, monitoring, and reporting activities will occur. As indicated previously, it is expected that the systems will continue to operate, as needed, after the six month assessment period.

6. References

ARCADIS Geraghty & Miller, Inc. 1999a. Supplemental RFI Report - Volume I (Methodologies and Results), General Motors Powertrain Group Moraine Engine Plant and General Motors Truck Group Moraine Assembly Plant, Moraine, Ohio. June 1999.

ARCADIS Geraghty & Miller, Inc. 1999b. Fifteenth Annual Groundwater Quality Assessment, North Settling Lagoon, January Through December 1998, Delphi Harrison Thermal Systems, Moraine, Ohio. February 1999.

ENVIRON Corporation, 1996. RCRA Facility Investigation Final Report Volume II (Baseline Risk Assessment), Delphi Harrison Thermal Systems, General Motors Corporation, Moraine, Ohio. February 1996.

ENVIRON Corporation, 1999. Supplemental Resource Conservation and Recovery Act Facility Investigation Report, Volume II Supplemental Baseline Risk Assessment, General Motors Powertrain Group Moraine Engine Plant and General Motors Truck Group Moraine Assembly Plant, Moraine, Ohio. June 1999.

Geraghty & Miller, Inc. 1996. Draft RCRA Facility Investigation Final Report Volume I (Methodologies and Results) Delphi Harrison Thermal Systems, General Motors Corporation, Moraine, Ohio. February 1996.

Geraghty & Miller, Inc. 1997a. Supplemental DOCC for General Motors Powertrain Group Moraine Engine Plant and General Motors Truck Group Moraine Assembly Plant, Moraine, Ohio. July 1997.

Geraghty & Miller, Inc. 1997b. Supplemental RFI Work Plan for General Motors Powertrain Group Moraine Engine Plant and General Motors Truck Group Moraine Assembly Plant, Moraine, Ohio. July 1997.

Ohio Environmental Protection Agency. 1999. Division of Drinking and Ground Water Underground Injection Control, Class V (5X26) Wells, Aquifer Remediation Projects, Website <http://www.epa.ohio.gov/ddagw/class5_5x26.html>

Suthersan, Suthan S., 1997. Remediation Engineering Design Concepts. CRC Press, Inc., Boca Raton, Florida.

United States Environmental Protection Agency (U.S. EPA). 1994. RCRA Corrective Action Plan (Final), Office of Waste Programs Enforcement, Office of Solid Waste, OSWER Directive 9902.3-2A. May 1994.

Wiedemeier, Todd H., et al. 1996. Overview of the Technical Protocol for Natural Attenuation of Chlorinated Solvents in Ground Water, U.S. Air Force Center for Environmental Excellence.

Table 1. Field and Laboratory Analytical Procedures for Groundwater, AOI 7 Interim Measures Work Plan, General Motors Corporation, Moraine, Ohio.

Site-wide Baseline Groundwater Sampling

Appendix IX VOCs and cis-1,2-DCE and field parameters will be analyzed during the baseline sampling event from the following list of upper aquifer monitoring wells while biogeochemical parameters will be analyzed at wells denoted with an asterisk(*):

W-1-N
W-2-N
W-3-N
W-4-N
HR-1*
HR-2
HR-3*
HR-4
HR-5
HR-6
HR-7
HR-8
HR-9
HR-11
HR-16
HR-17
W-1-S*
W-2-S
W-3-S
W-4-S
GM-2*
4S*
GM-6*
GM-8*
GM-10*
GM-16*
GM-17*
GM-18
GM-19S*
EAST*
WEST*
WSU-24
ME-1*
ME-3*
ME-6*
GM-21*
GM-22*
GM-23*
GM-24
GM-25
GM-26
GM-27*
GM-28*
GM-29*
GM-30*
GM-31*
GM-32*

Appendix IX VOCs and cis-1,2-DCE and field parameters will be analyzed during the baseline sampling event from the following list of lower aquifer monitoring wells:

HR-10
HR-12
HR-13
HR-14
HR-15
GM-1
GM-3
GM-4
GM-5
GM-7R
GM-9
GM-11
GM-13
GM-14
GM-15
GM-19D
GM-20D
MT69

Appendix IX VOCs and cis-1,2-DCE, field parameters (dissolved oxygen, reduction/oxidation potential, pH, and specific conductance) and biogeochemical parameters will be analyzed during the baseline sampling event from the following list of injection/introduction points:

OA-1	**OA-2**	**RZ-1**	**RZ-3**		
OW-1	OW-4	RZ-1B	RZ-3E	RZ-3Y	RZ-3PP
OW-2	OW-5	RZ-1G	RZ-3L	RZ-3FF	
OW-3	OW-6	RZ-1L	RZ-3S	RZ-3KK	

Table 1. Field and Laboratory Analytical Procedures for Groundwater, AOI 7 Interim Measures Work Plan, General Motors Corporation, Moraine, Ohio.

Pilot Test 3 Month and 6 Month Groundwater Sampling

The site-specific parameter list of VOCs, field parameters, and biogeochemical parameters presented above will be analyzed during the 3 month and 6 month sampling events from the following upper aquifer monitoring wells:

HR-1
HR-3
GM-2
GM-6
GM-8
GM-10
GM-16
GM-17
GM-19S
GM-21
GM-22
GM-23
GM-27
GM-28
GM-29
GM-30
GM-31
GM-32
EAST
WEST
4S
W-1-S
ME-1
ME-3
ME-6

Only the site-specific parameter list of VOCs, field parameters (dissolved oxygen, reduction/oxidation potential, pH, and specific conductance) and biogeochemical parameters will be analyzed during the 3 month and 6 month sampling events from the following list of injection/introduction points:

OA-1	**OA-2**	**RZ-1**	**RZ-3**		
OW-1	OW-4	RZ-1B	RZ-3E	RZ-3Y	RZ-3PP
OW-2	OW-5	RZ-1G	RZ-3L	RZ-3FF	
OW-3	OW-6	RZ-1L	RZ-3S	RZ-3KK	

G:\PUBLIC\GMOTORS\GMCRFI\AOI7\INTERIM\table-1.doc

Table 1. Field and Laboratory Analytical Procedures for Groundwater, AOI 7 Interim Measures Work Plan, General Motors Corporation, Moraine, Ohio.

Parameters	Method Number	Procedure
Appendix IX VOCs and cis 1,2-DCE	Method 8260	Laboratory(3)
Dissolved Oxygen	(1)	Field
Reduction/Oxidation Potential	(1)	Field
pH	(1)	Field
Specific Conductance	(1)	Field
Nitrate	Test Kit	Field
Nitrite	Test Kit	Field
Nitrogen, Ammonia	SM350.1	Laboratory(3)
Manganese (Total)	Method 6010A	Laboratory(3)
Manganese (Dissolved)	Method 6010A	Laboratory(3)
Iron (Total)	Method 6010A	Laboratory(3)
Iron (Dissolved)	Method 6010A	Laboratory(3)
Iron (Ferrous)	Test Kit	Field
Sulfate	SM 375.4	Laboratory(3)
Sulfide	SM 376.1	Laboratory(3)
Total Organic Carbon	SM 5310B	Laboratory(3)
Chlorides	SM 325.3	Laboratory(3)
Light Hydrocarbon Scan (Ethane, Ethene)	Method AM18G(2)	Laboratory(4)
Permanent Gases (Carbon Dioxide, Oxygen, Nitrogen, Methane and Carbon Monoxide)	Method AM15.01G(2)	Laboratory(4)

Method	Refers to U.S. Environmental Protection Agency SW 846.
SM	Standard Methods for the Evaluation of Water and Wastewater, 18th Edition, 1992.
(1)	Field parameters to be collected using a down-well or a flow-through meter.
(2)	Method numbers are laboratory-specific and developed for monitoring natural attenuation projects.
(3)	TestAmerica, Inc. - Dayton Division.
(4)	Microseeps, Pittsburgh, Pennsylvania.
cis-1,2-DCE	cis-1,2-Dichloroethene.
VOCs	Volatile organic compounds.

DRAFT

Table 2. Oxidation System Information, AOI 7 Interim Measures Work Plan, General Motors Corporation, Moraine, Ohio.

Well Designation	Pre-test Sampling	Oxidation Solution Injection	Field Monitoring	Post-Test Sampling
GM-23*			X(1,2)	
GM-29			X(2)	
GM-30			X(2)	
OW-1	X	X		X
OW-2	X	X	X(1)	X
OW-3	X	X	X(1)	X
OW-4	X	X		X
OW-5	X	X		X
OW-6	X	X		X
Additional Oxidation Wells[3]		X		

*Existing groundwater monitoring well.

[1] Field monitoring conducted during initial testing.

[2] Field monitoring may be conducted if deemed necessary during each injection event.

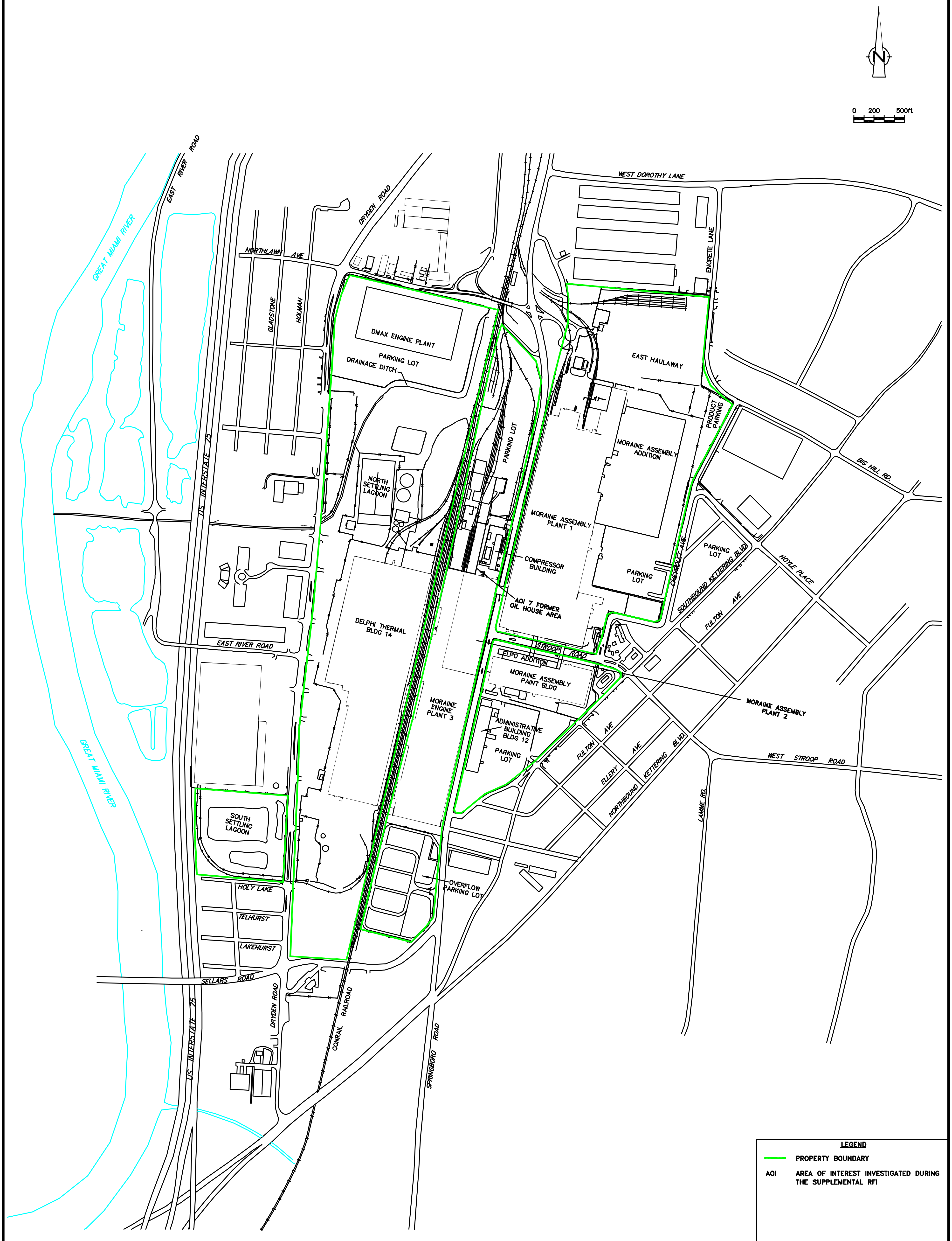
[3] Number of wells will be determined based on the initial oxidation testing results.

DRAFT

Table 3. Bioremediation Introduction and Monitoring Well Information, AOI 7 Interim Measures Work Plan, General Motors Corporation, Moraine, Ohio.

Well Designation	Enhanced Bioremediation Test		Well Casing Diameter (inches)
	Carbon Source Introduction	Carbon Source Field Monitoring	
GM-28*		X	2
GM-29		X	2
RZ-1B	X	X	3
RZ-1G	X	X	3
RZ-1L	X	X	3
Other RZ-1 Wells (10)	X		3
ME-1*	X		2
ME-2*	X		2
ME-3*	X	X	2
ME-4*	X		2
ME-5*	X		2
ME-6*	X	X	2
RZ-3E	X	X	3
RZ-3L	X	X	3
RZ-3S	X	X	3
RZ-3Y	X	X	3
RZ-3FF	X	X	3
RZ-3KK	X	X	3
RZ-3PP	X	X	3
Other RZ-3 Wells (36)	X		3
GM-22		X	2
EAST*		X	2
WEST*		X	2
GM-32		X	2
GM-19S*		X	2
GM-21*		X	2

*Existing groundwater monitoring well.



LEGEND

🟩 PROPERTY BOUNDARY

AOI AREA OF INTEREST INVESTIGATED DURING THE SUPPLEMENTAL RFI

ARCADIS GERAGHTY & MILLER

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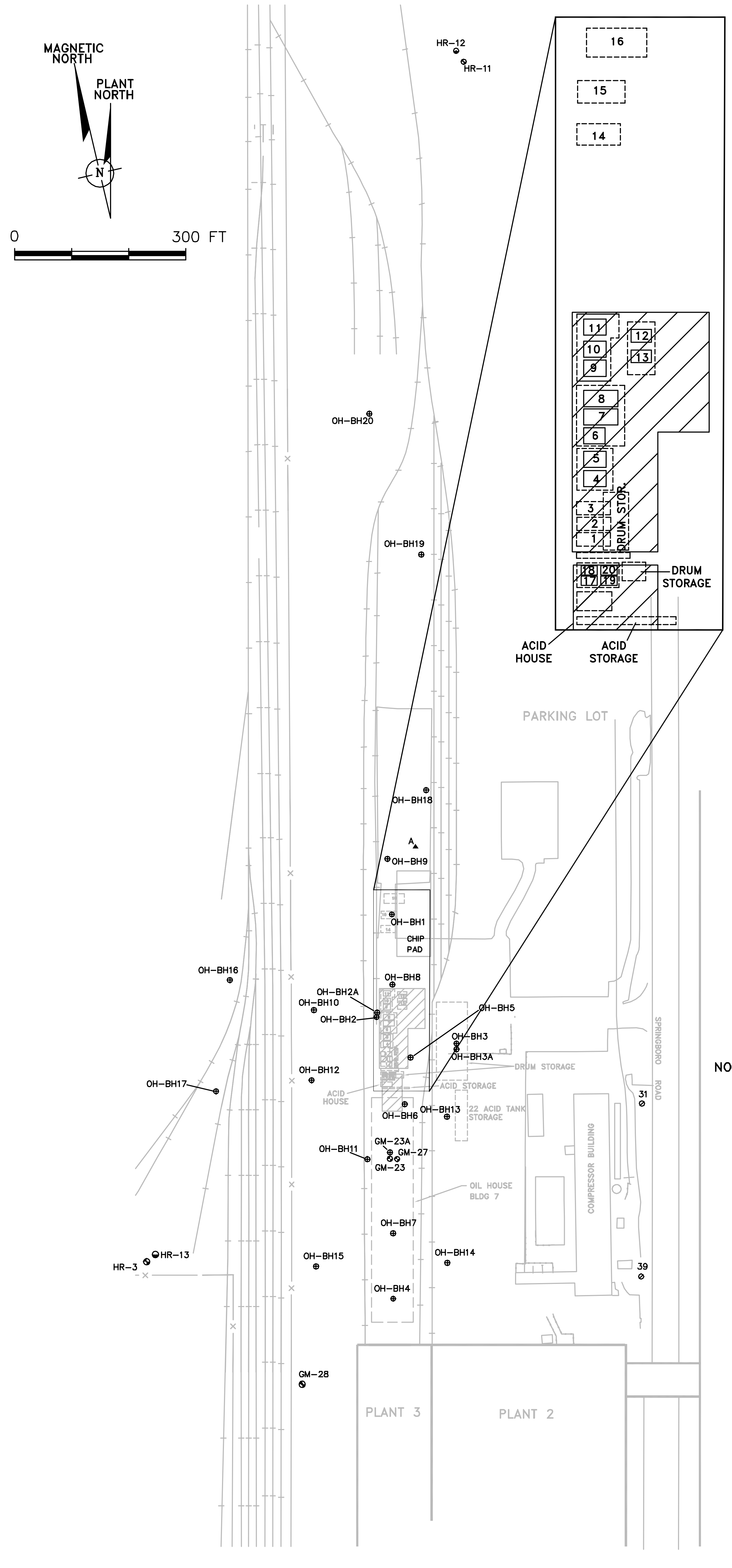
SITE LAYOUT
MORAINE ENGINE, MORAINE ASSEMBLY
AND DELPHI THERMAL FACILITIES
GENERAL MOTORS CORPORATION
MORAINE, OHIO

DATE 27APR99	PROJECT MANAGER J. REID	DRAWING NAME \CRA\IMWP\IMWP-01
DRAWN R. SMITH	LEAD DESIGN PROF. J. REID	CHECKED N. GILLOTTI
PROJECT NUMBER OH000294.0001.0002		FIGURE NUMBER 1



HISTORIC TANK No.	CONTENTS	CAPACITY
1	OIL	15,000 GALLONS
2	OIL	15,000 GALLONS
3	OIL	15,000 GALLONS
4	THINNER	8,000 GALLONS
5	REDUCER	8,000 GALLONS
6	ALCOHOL	8,000 GALLONS
7	KEROSENE	10,000 GALLONS
8	PERCHLOROETHENE	10,000 GALLONS
9	PERCHLOROETHENE	10,000 GALLONS
10	ALCOHOL	10,000 GALLONS
11	ALCOHOL	10,000 GALLONS
12	XYLOL	10,000 GALLONS
13	THINNER	10,000 GALLONS
14	FREON 12	160,000 LBS
15	FREON 12	160,000 LBS
16	OIL	30,000 GALLONS
17	ACID-HNO$_3$	11,000 GALLONS
18	ACID-HCI	10,000 GALLONS
19	ACID-H$_2$SO$_4$	13,000 GALLONS
20	ACID-H$_3$PO$_4$	11,000 GALLONS
21	DRUMS-OIL	300 BBL
22	ACID	-----

NOTE:

BORINGS OH-BH1 THROUGH OH-BH4 WERE INSTALLED IN FEBRUARY 1998. BORINGS OH-BH5 THROUGH OH-BH10 AND WELLS GM-27 AND GM-28 WERE INSTALLED IN AUGUST 1998. BORINGS OH-BH11 THROUGH OH-BH20, OH-BH2A, OH-BH3A, AND GM-23A WERE INSTALLED IN NOVEMBER 1998.

LEGEND

◑	MONITOR WELL (SHALLOW)
◒	MONITOR WELL (DEEP)
⊕	SOIL BORING
⊘	ACTIVE PRODUCTION WELL
▲	INACTIVE PRODUCTION WELL
OH	OIL HOUSE
BH	BORE HOLE
— — —	FORMER LOCATION OF OIL HOUSE STRUCTURES
▨	APPROXIMATE LOCATION OF CURRENT MORAINE ENGINE TANK FARM

ARCADIS GERAGHTY&MILLER

6397 Emerald Parkway
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Tel: 614/764-2310 Fax: 614/764-1270

AOI 7 – FORMER OIL HOUSE AREA

GENERAL MOTORS CORPORATION
MORAINE, OHIO

DATE MAR99	PROJECT MANAGER J. REID	DRAWING NAME \CRA\IMWP\IMWP-02
DRAWN R. SMITH	LEAD DESIGN PROF. J. REID	CHECKED N. GILLOTTI
PROJECT NUMBER OH000294.0001.0002		DRAWING NUMBER 2

1.

VIEW FACING SOUTH, WITH MORAINE ENGINE TANK FARM IN THE MIDDLE AND MORAINE ENGINE PLANT IN THE BACKGROUND.

2.

VIEW FACING SOUTH, WITH CHIP PAD IN THE FOREGROUND AND MORAINE ENGINE TANK FARM IN THE BACKGROUND.

3.

VIEW FACING NORTH, FROM DRIVEWAY WEST OF MORAINE ENGINE PLANT. MORAINE ENGINE TANK FARM PUMP HOUSE IN THE BACKGROUND.

4.

VIEW FACING NORTH, OF THE MORAINE ENGINE TANK FARM PUMP HOUSE.

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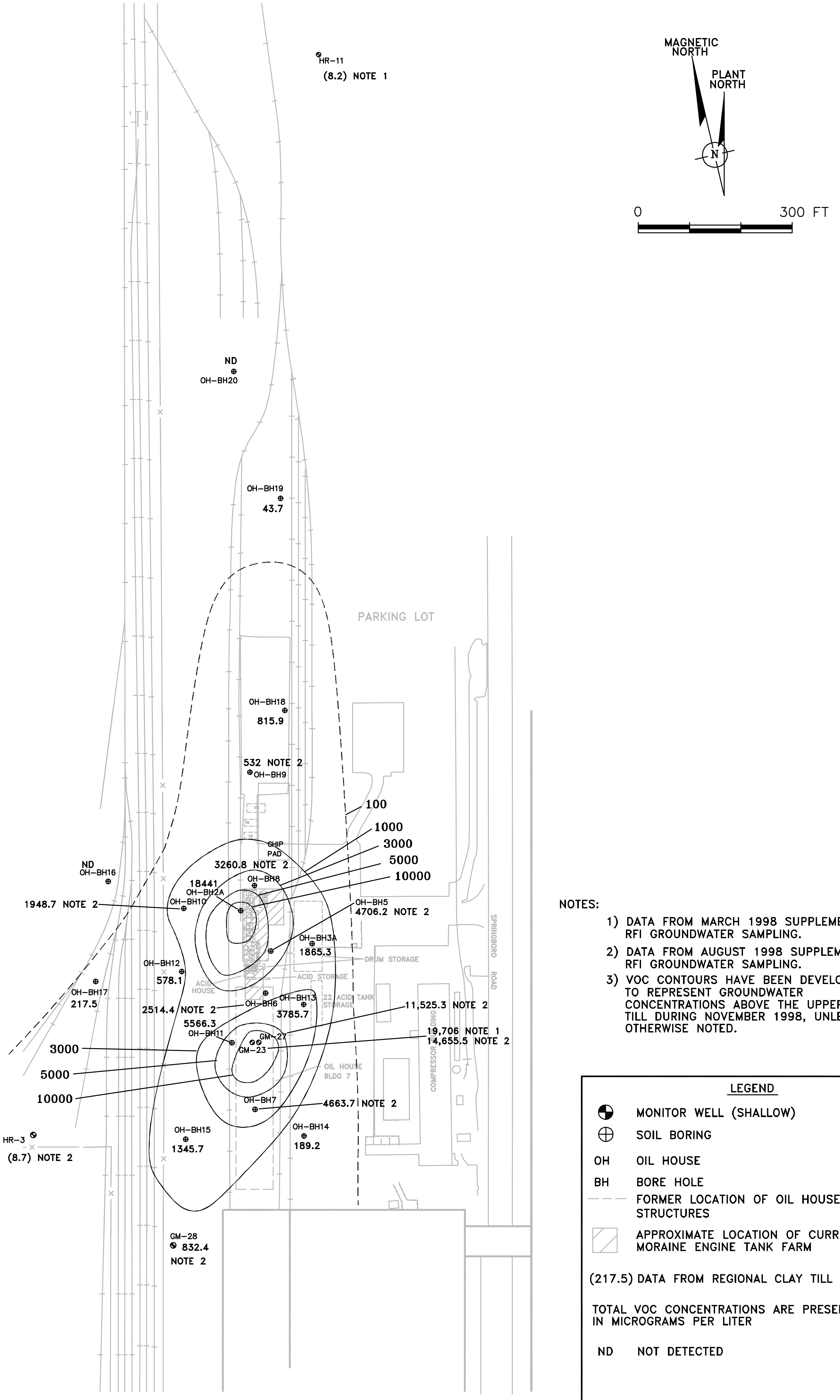
AOI 7 - FORMER OIL HOUSE AREA
CURRENT CONDITIONS
GENERAL MOTORS CORPORATION
MORAINE, OHIO

DRAWN R. SMITH	DATE 22JUN99	PROJECT MANAGER J.REID	DRAWING NAME CRA\AOI7JPG
		LEAD DESIGN PROF. J. REID	CHECKED N. GILLOTTI
		PROJECT NUMBER OH000294.01	FIGURE NUMBER 3



NOTES:

1) DATA FROM MARCH 1998 SUPPLEMENTAL RFI GROUNDWATER SAMPLING.
2) DATA FROM AUGUST 1998 SUPPLEMENTAL RFI GROUNDWATER SAMPLING.
3) VOC CONTOURS HAVE BEEN DEVELOPED TO REPRESENT GROUNDWATER CONCENTRATIONS ABOVE THE UPPER CLAY TILL DURING NOVEMBER 1998, UNLESS OTHERWISE NOTED.

LEGEND

◐	MONITOR WELL (SHALLOW)
⊕	SOIL BORING
OH	OIL HOUSE
BH	BORE HOLE
— — —	FORMER LOCATION OF OIL HOUSE STRUCTURES
▨	APPROXIMATE LOCATION OF CURRENT MORAINE ENGINE TANK FARM
(217.5)	DATA FROM REGIONAL CLAY TILL

TOTAL VOC CONCENTRATIONS ARE PRESENTED IN MICROGRAMS PER LITER

ND NOT DETECTED

ARCADIS GERAGHTY&MILLER

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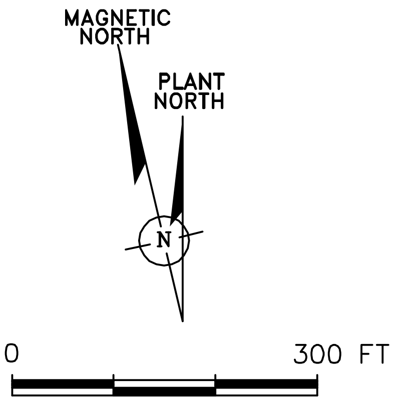
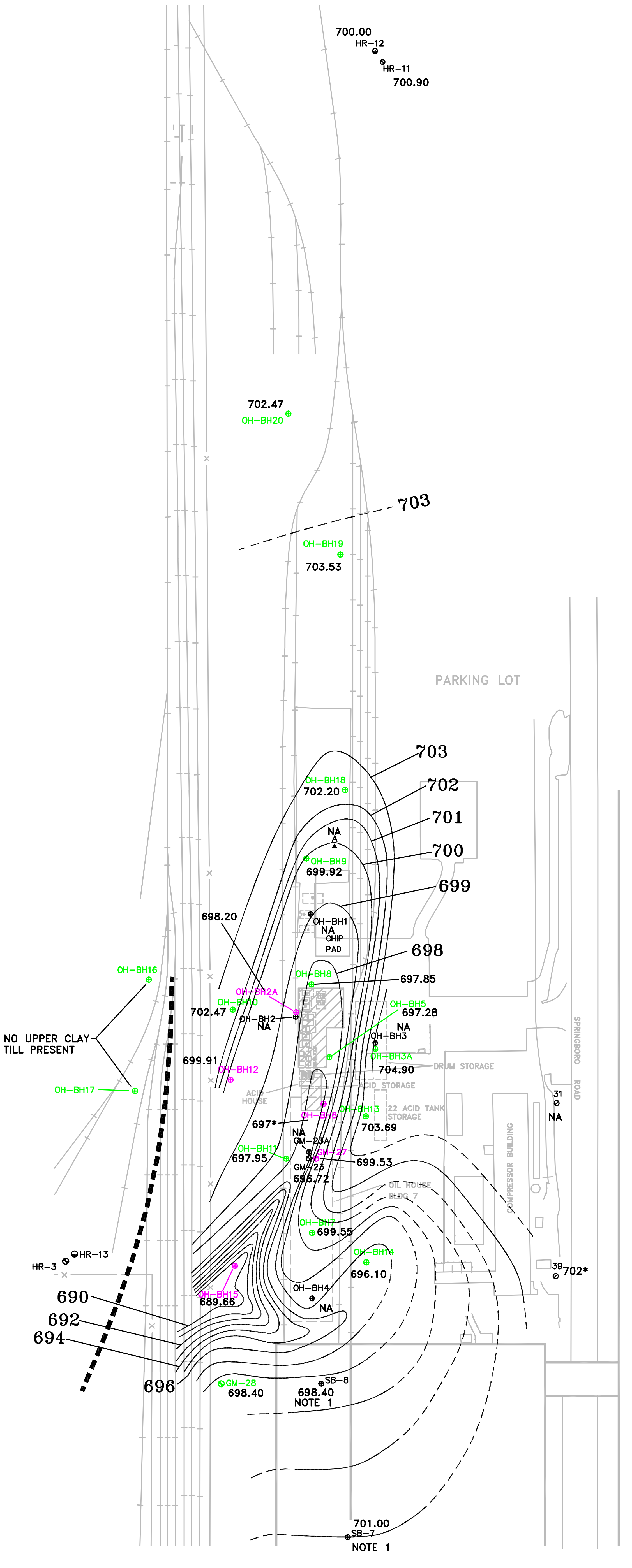
Suite 150, Dublin, OH 43016
Tel: 614/764-2310 Fax: 614/764-1270

TOTAL VOC CONCENTRATIONS IN SHALLOW GROUNDWATER FOR AOI 7 – FORMER OIL HOUSE AREA

GENERAL MOTORS CORPORATION
MORAINE, OHIO

DATE MAR99	PROJECT MANAGER J. REID	DRAWING NAME \CRA\IMWP\IMWP-04
DRAWN R. SMITH	LEAD DESIGN PROF. J. REID	CHECKED N. GILLOTTI
PROJECT NUMBER OH000294.0001.0002		DRAWING NUMBER 5





NOTE:

1) SOIL BORINGS SB-7 AND SB-8 WERE HISTORIC GEOTECHNICAL BORINGS AND NOT INSTALLED AS PART OF THE RFI THE LOGS WERE USED TO IDENTIFY THE UPPER CLAY TILL.

2) HYDROPHOBIC DYE TESTS WERE CONDUCTED ON SOIL SAMPLES TO EVALUATE THE PRESENCE OR ABSENCE OF DNAPL. THE DYE TESTS WERE PERFORMED ON A SATURATED SOIL SAMPLE COLLECTED FROM THE INTERVAL IMMEDIATELY ABOVE THE UPPER CLAY TILL.

LEGEND

◕	MONITOR WELL (SHALLOW)
◒	MONITOR WELL (DEEP)
⊕	SOIL BORING
⊕	SOIL BORING, DNAPL DYE TEST NEGATIVE
⊕	SOIL BORING, DNAPL DYE TEST POSITIVE
⊘	ACTIVE PRODUCTION WELL
▲	INACTIVE PRODUCTION WELL
OH	OIL HOUSE
BH	BORE HOLE
— — —	FORMER LOCATION OF OIL HOUSE STRUCTURES
▨	APPROXIMATE LOCATION OF CURRENT MORAINE ENGINE TANK FARM
━ ━ ━	EDGE OF UPPER CLAY TILL
NA	NOT AVAILABLE
*	ESTIMATED ELEVATION

ARCADIS GERAGHTY&MILLER

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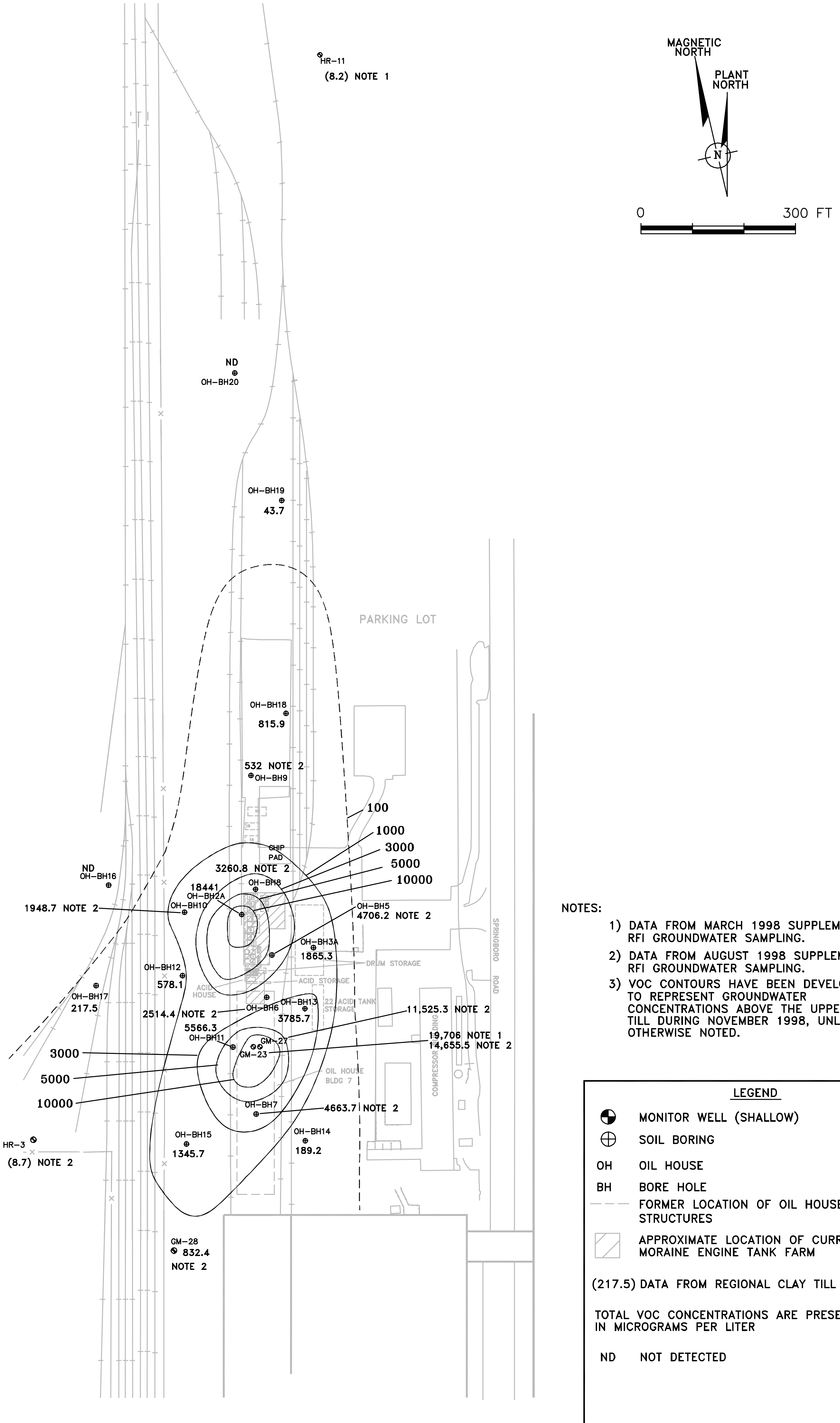
TOP OF UPPER CLAY TILL FOR AOI 7 - FORMER OIL HOUSE AREA

GENERAL MOTORS CORPORATION
MORAINE, OHIO

DATE MAR99	PROJECT MANAGER J. REID	DRAWING NAME \CRA\IMWP\IMWP-03
DRAWN R. SMITH	LEAD DESIGN PROF. J. REID	CHECKED N. GILLOTTI
PROJECT NUMBER OH000294.0001.0002		DRAWING NUMBER 4



NOTES:

1) DATA FROM MARCH 1998 SUPPLEMENTAL RFI GROUNDWATER SAMPLING.
2) DATA FROM AUGUST 1998 SUPPLEMENTAL RFI GROUNDWATER SAMPLING.
3) VOC CONTOURS HAVE BEEN DEVELOPED TO REPRESENT GROUNDWATER CONCENTRATIONS ABOVE THE UPPER CLAY TILL DURING NOVEMBER 1998, UNLESS OTHERWISE NOTED.

LEGEND

◕	MONITOR WELL (SHALLOW)
⊕	SOIL BORING
OH	OIL HOUSE
BH	BORE HOLE
— — —	FORMER LOCATION OF OIL HOUSE STRUCTURES
▨	APPROXIMATE LOCATION OF CURRENT MORAINE ENGINE TANK FARM
(217.5)	DATA FROM REGIONAL CLAY TILL

TOTAL VOC CONCENTRATIONS ARE PRESENTED IN MICROGRAMS PER LITER

ND	NOT DETECTED

ARCADIS GERAGHTY&MILLER

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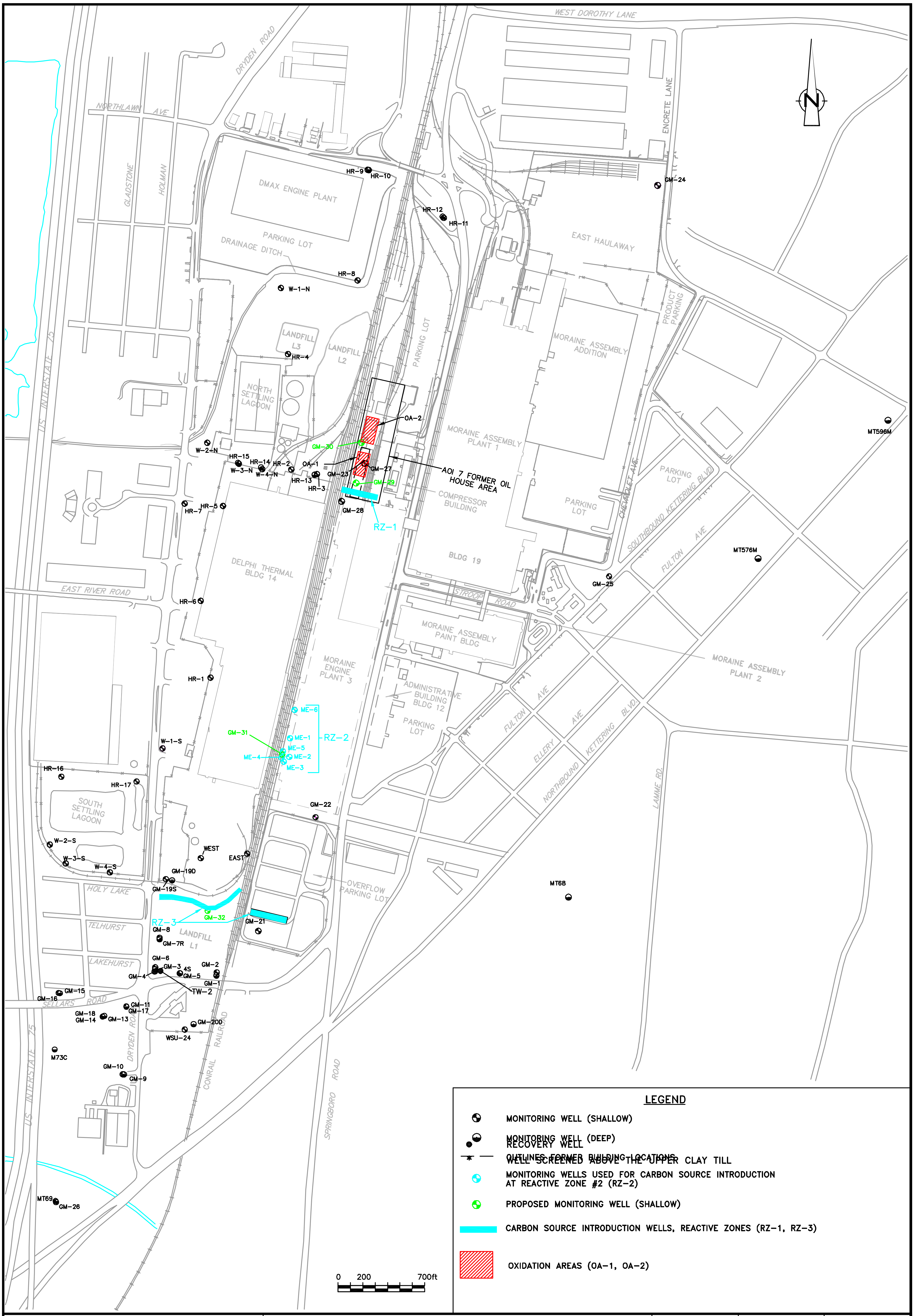
Suite 150, Dublin, OH 43016
Tel: 614/764-2310 Fax: 614/764-1270

TOTAL VOC CONCENTRATIONS IN SHALLOW GROUNDWATER FOR AOI 7 - FORMER OIL HOUSE AREA

GENERAL MOTORS CORPORATION
MORAINE, OHIO

DATE MAR99	PROJECT MANAGER J. REID	DRAWING NAME \CRA\IMWP\IMWP-04
DRAWN R. SMITH	LEAD DESIGN PROF. J. REID	CHECKED N. GILLOTTI
PROJECT NUMBER OH000294.0001.0002		DRAWING NUMBER 5



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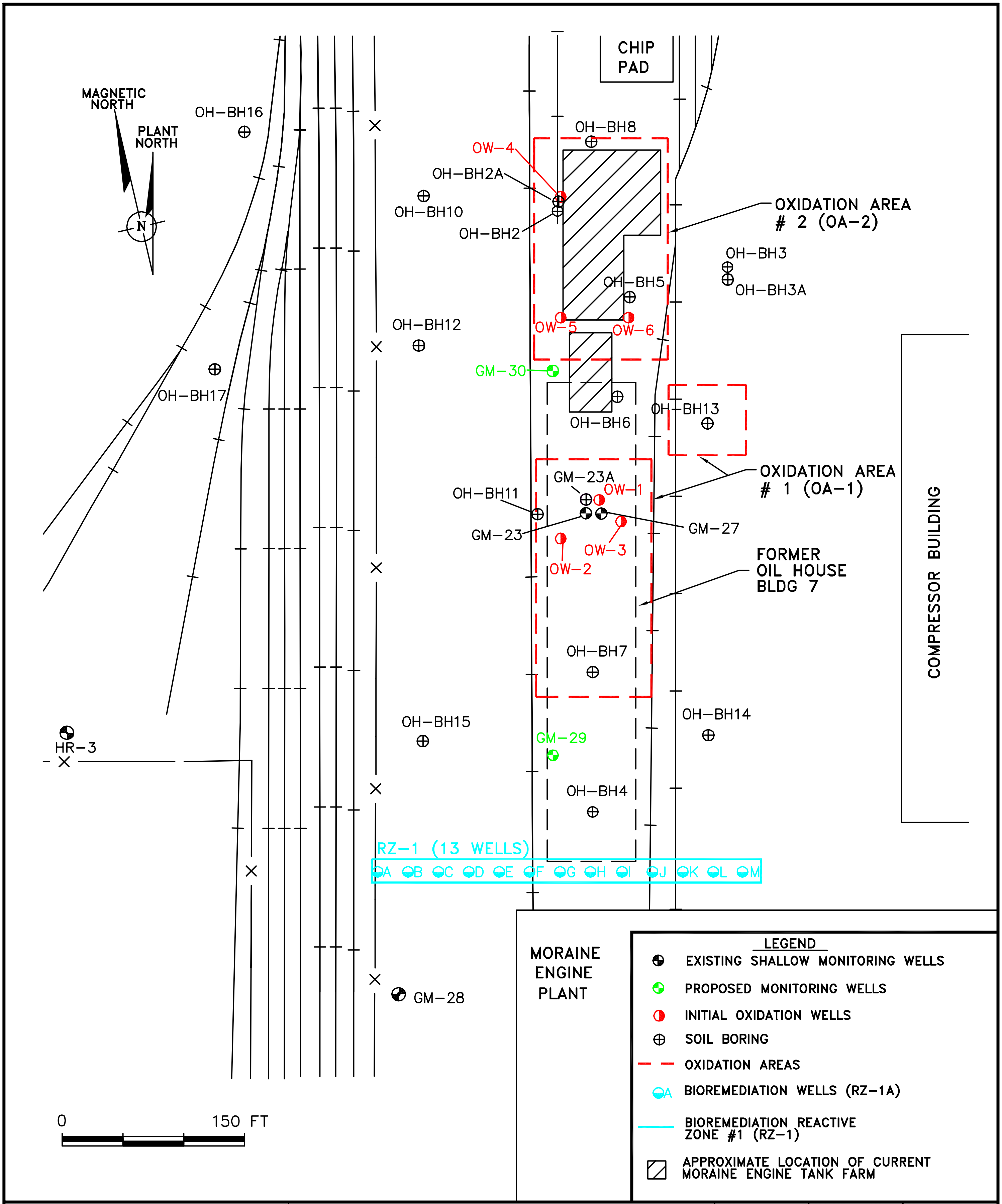
INTRODUCTION AND MONITORING WELLS
INTERIM MEASURES WORK PLAN
GENERAL MOTORS CORPORATION
MORAINE, OHIO

DATE 05MAY99	PROJECT MANAGER J. REID	DRAWING NAME \CRA\IMWP\IMWP-06
DRAWN R. SMITH	LEAD DESIGN PROF. J. REID	CHECKED N. GILLOTTI
PROJECT NUMBER OH000294.0001.0002		FIGURE NUMBER 6

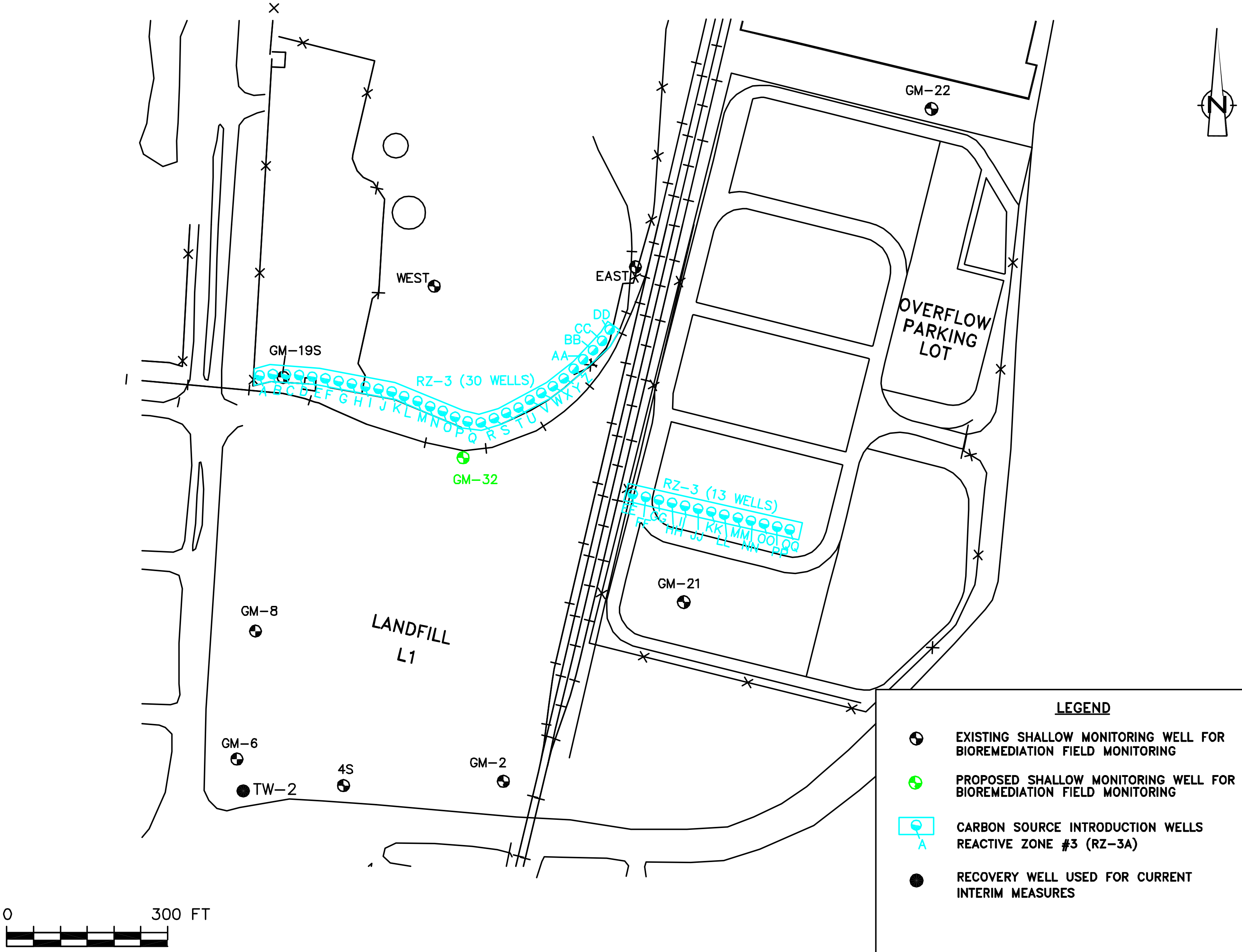


ARCADIS GERAGHTY & MILLER

[illegible]
[illegible] Indianapolis, Indiana 46204
Tel: [illegible] Fax: [illegible]

EXISTING AND PROPOSED WELLS
AOI 7 – FORMER OIL HOUSE AREA
GENERAL MOTORS CORPORATION
MORAINE, OHIO

DATE JUNE 7, 1999	PROJECT MANAGER GILLOTTI	DRAWING NAME \cra\IMWP\IMWP–07
DRAWN BGOLLA	LEAD DESIGN PROF. JREID	CHECKED BGOLLA
PROJECT NUMBER OH000294.001.002		FIGURE NUMBER 7



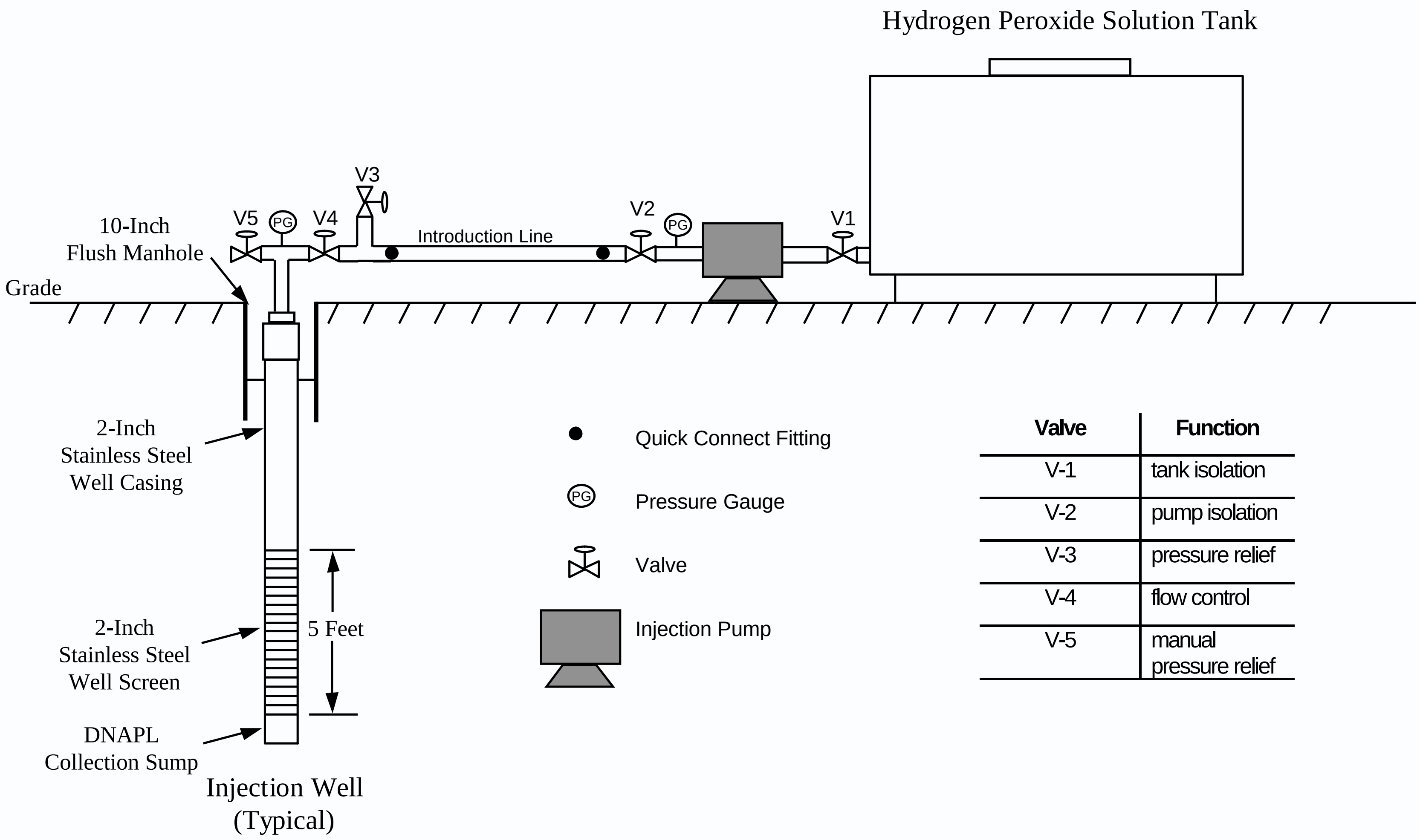
LEGEND

●	EXISTING SHALLOW MONITORING WELL FOR BIOREMEDIATION FIELD MONITORING
🟩	PROPOSED SHALLOW MONITORING WELL FOR BIOREMEDIATION FIELD MONITORING
A	CARBON SOURCE INTRODUCTION WELLS REACTIVE ZONE #3 (RZ–3A)
●	RECOVERY WELL USED FOR CURRENT INTERIM MEASURES

ARCADIS GERAGHTY&MILLER

EXISTING AND PROPOSED WELLS
BIOREMEDIATION REACTIVE ZONE #3
GENERAL MOTORS CORPORATION
MORAINE, OHIO

DATE 16JUN99	PROJECT MANAGER J.REID	DRAWING NAME \CRA\IMWP\IMWP–08
DRAWN R. SMITH	LEAD DESIGN PROF. J. REID	CHECKED B. GOLLA
PROJECT NUMBER OH000294.0001.0002		FIGURE NUMBER 8



Valve	Function
V-1	tank isolation
V-2	pump isolation
V-3	pressure relief
V-4	flow control
V-5	manual pressure relief

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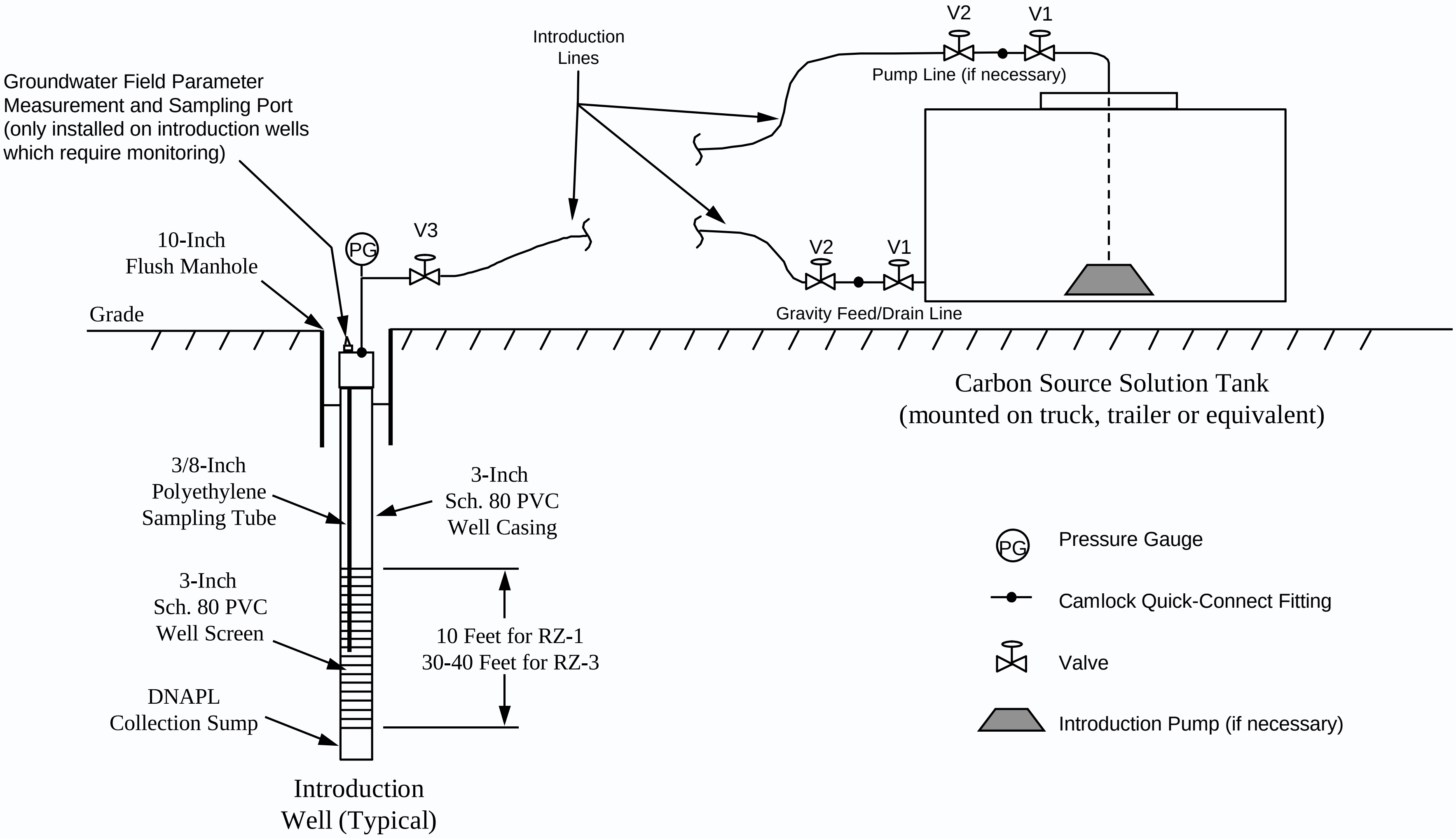
Schematic of the Oxidation System
AOI 7 Interim Measures Work Plan

General Motors Corporation
Moraine, Ohio

FIGURE
9



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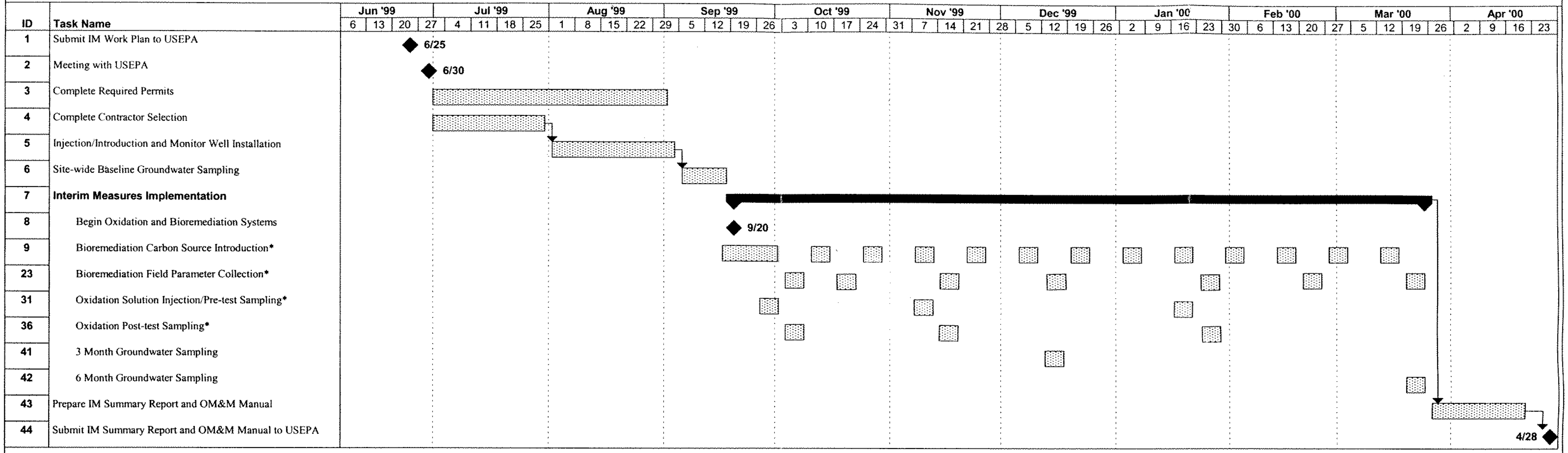
Schematic of the Carbon Source Solution Introduction System
AOI 7 Interim Measures Work Plan

General Motors Corporation
Moraine, Ohio

FIGURE
10

Figure 11. Interim Measures Implementation Schedule for AOI 7, General Motors Corporation, Moraine, Ohio.



DRAFT

Project: GMC RFI
Date: Thu 6/24/99

Task ▨ Milestone ◆ Summary ▬

IM Interim Measures OMM&M Operation, Maintenance & Monitoring Manual *Anticipated schedule, subject to revision based on field data results

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DRAFT

Appendix A

Interim Measures Standard Operating Procedures and Logs

SOP #28: CARBON SOURCE SOLUTION INTRODUCTION INTO BIOREMEDIATION SYSTEM INTRODUCTION POINTS

EQUIPMENT:

Well lock keys (Well box lid removal)
Introduction pump (if necessary)
Introduction tank and transport equipment (tanker, trailer or equivalent)
Tank dipstick
1- or 2-inch introduction hose with appropriate valves and fittings
Graduated mixing tank (if necessary)
Recirculation pump with hoses and piping or tank mounted mixing pump
Carbon source supply (likely contained in 55 gallon drums)
Drum unloading equipment
Introduction log (attached Table A-1)

PROCEDURES:

Pre-Event Preparation

1) Obtain Carbon Source Solution Introduction Log and Mixture Table for introduction points to record introduction activities (attached Table A-1).
2) Use Site map (Figures 6, 7, and 8) to locate introduction points. (Not all locations on Site map are used for carbon source solution introduction)
3) Close all valves on hoses or pumping equipment, where applicable.

Solution Mixing

1) Use the Mixture Recipe Table on the Carbon Source Solution Introduction Log (Table A-1).
2) First add some potable water to mixing or introduction tank (approximately 30% of the total volume).
3) Using drum unloading equipment, add required gallons of carbon source for mixture into top of tank.
4) Add remaining water according to Table A-1.
5) IF RECIRCULATING PUMP IS USED: Insert mixing pipes (suction or discharge) into tank. Discharge pipe should have a 90 degree elbow at bottom. Operate recirculating pump to allow for maximum mixing/swirling of solution.

   OR

   IF TANK MOUNTED MIXING PUMP IS USED: Operate mixing pump.
6) Mix until little or no molasses settles at bottom of tank. Verify proper mixing by inserting dipstick to bottom of tank.
7) Transfer water into introduction tank (if a separate mixing tank is used).
8) Close the top of tank.

Transport and Introduction Preparation

1) Check that all tank, hose, and pumping equipment valves are securely closed.
2) Use transport equipment (tanker, trailer or equivalent) to carefully move introduction tank and pumping apparatus to appropriate introduction point.
3) Open well box lid and remove dust cap.
4) Identify introduction port on well head.
5) Prepare introduction equipment at introduction point as follows:
    a) Connect 1or 2-inch hose to tank (or pump if pumping is required) using camlock fittings.
    b) Remove lid from tank.
    c) Connect introduction hose to well casing via camlock fitting.

Introduction of Carbon Source Solution

1) Operate introduction pump (or gravity feed system) with valves V-2 and V-3 closed, and valve V-1 open (Figure A-1).
2) Open valve V-2 completely (Figure A-1), check for leaks.
3) Open valve V-3 gradually to regulate flow (Figure A-1), check for leaks.
4) Regulate valve V-3 to maintain a pressure within well less than 40 psi. Monitor pressure with gauge on introduction line (Figure A-1)
5) Introduction should take approximately 15 to 45 minutes per well.
6) Monitor the flow rate and total flow by measuring tank drawdown over a period of time (or using an inline flow meter).
7) Use gradations on tank to observe tank level or use a level dipstick.
8) Periodically check all fittings for defects, leaks or freezing.
9) Complete Carbon Source Solution Introduction and Mixture Log (Table A-1).

CAUTION:

1. DO NOT leave process unattended. Closely watch introduction process at all times
2. DO NOT pump carbon source solution under excessive pressure (greater than 40 psi).
3. DO NOT stand over or look down into wells during introduction.

Shut Down of Equipment Between Introduction Points

1) Deactivate introduction pump (if applicable)
2) Close valves V-1 and V-2.
3) Disconnect introduction line from pump (from tank if gravity feed).
4) Drain introduction line into well by opening V-1 above wellhead elevation and walking line out to the wellhead.
5) Close valves V-2 and V-3.
6) Remove hose from introduction point. Place into bucket to recover any solution drips.
7) Replace dust cap and well box lid.
8) Move to next introduction point. Return to Step 1: Introduction of Carbon Source Solution

Shut Down of Equipment Between Daily Introduction Events

1) Pump or flush a minimum of 50 gallons of clean water through equipment (including pumps, hoses, and tanks). Cleaning will be considered complete when the majority of molasses has been rinsed off of the equipment.
2) Drain water from hoses and pump (if applicable) prior to storage.
3) Winter Only: Store pump and carbon source in a heated building between daily events.
4) Monitor inventory of carbon source.

Table A-1. Carbon Source Solution Introduction Log and Mixture Table, AOI 7 Interim Measures Work Plan, General Motors Corporation, Moraine, Ohio.

CARBON SOURCE SOLUTION INTRODUCTION LOG AND MIXTURE TABLE

Introduction Point ID	Introduction Well Diameter (in)	Solution Mixture Ratio[1]	Total Target Introduction Volume (gal)[2]	Introduction Date	Introduction Start Time	Introduction Completion Time	Actual Introduction Volume (gal)	Introduction Rate (gpm)	Comments
		10:1	200 - 500						
		10:1	200 - 500						
		10:1	200 - 500						
		10:1	200 - 500						
		10:1	200 - 500						
		10:1	200 - 500						
		10:1	200 - 500						
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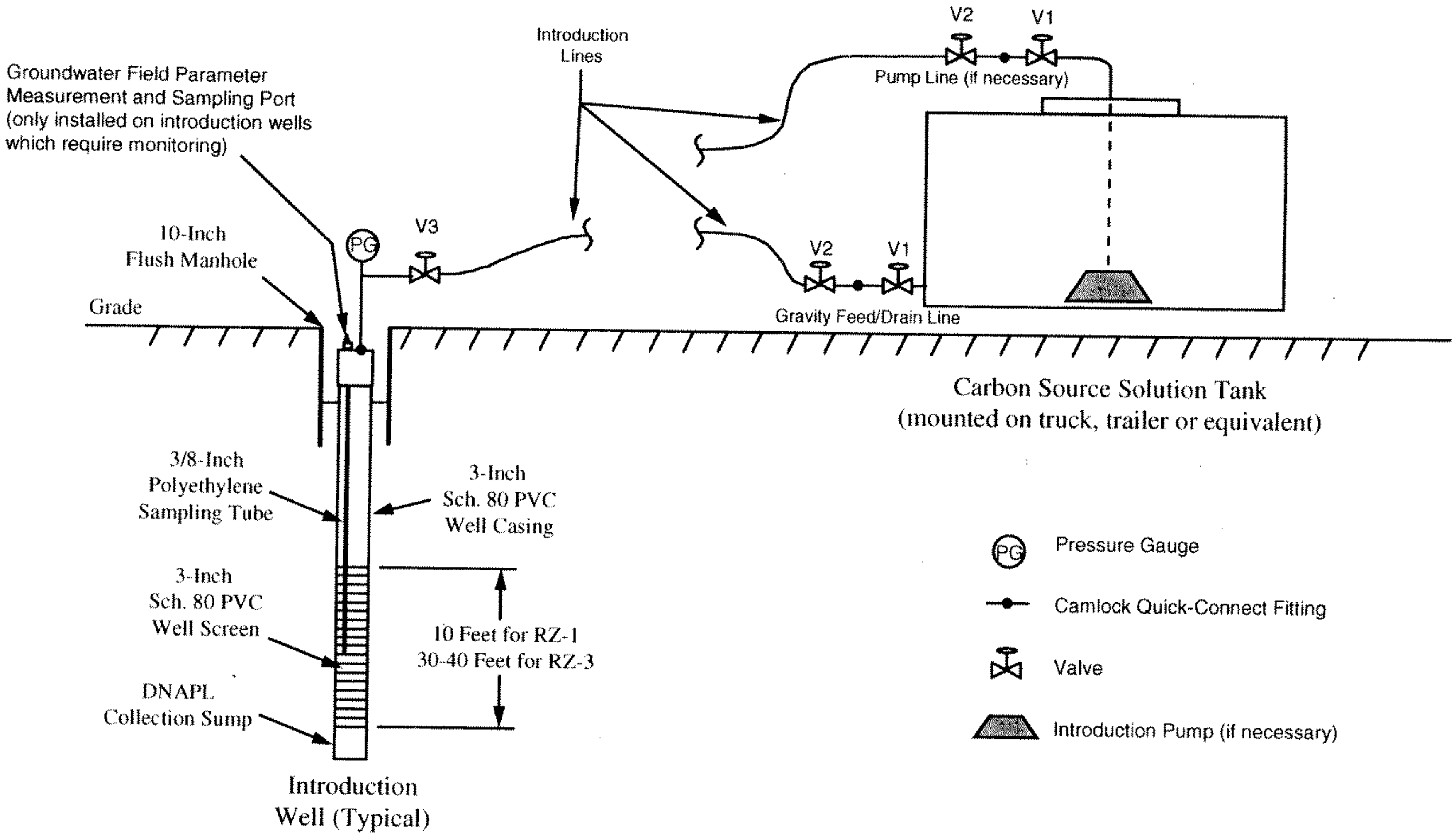
		10:1	200 - 500						
		10:1	200 - 500						
		10:1	200 - 500						
		10:1	200 - 500						
		10:1	200 - 500						

(1) Mixture Ratio = units of water (first number) mixed with units of molasses (second number).
(2) Target Introduction Volume of carbon source solution may be adjusted based on information collected in the field.

Approximate Mixture Recipe Table

Mixture Ratio	Gallons of Molasses	Gallons of Water	Gallons of Solution
10:1	20	200	220
10:1	50	500	550
10:1	100	1000	1100
10:1	200	2000	2200



ARCADIS Geraghty & Miller

Schematic of the Carbon Source Solution Introduction System
AOI 7 Interim Measures Work Plan

General Motors Corporation
Moraine, Ohio

FIGURE

A-1

SOP #29: HYDROGEN PEROXIDE INJECTION INTO OXIDATION INJECTION WELLS

INJECTION EQUIPMENT:

Well lock keys and necessary tools (Well box lid and well cap removal)
Injection pump
Hydrogen peroxide injection polytank (graduated)
Ferrous sulfate injection tank or drum (if required)
1-inch injection hose with appropriate valves and fittings
Hydrogen peroxide solution (35%) supply
Ferrous sulfate solution supply
Injection logs (Table A-2 or A-3)
Clean spill buckets

SAFETY EQUIPMENT:

Splash suit (made of polyester acrylic fiber, polyvinyl chloride, polyethylene, or neoprene)
Safety glasses
Splash shield
Surgical gloves
Neoprene gloves
Chemically resistant boots
Emergency spill water supply or water tank
Emergency spill water shower and eye wash stations

PROCEDURES:

Pre-Event Preparation

1) Obtain an Initial Hydrogen Peroxide Injection Log (Table A-2, used for the initial hydrogen peroxide injection event) or the Hydrogen Peroxide Injection Log for Multiple Injection Points (Table A-3, used for subsequent events) to record injection activities.
2) Use Site map (Figure 7) to locate injection points. (Not all locations on Site map are used for hydrogen peroxide injection)
3) Close all valves on hoses or pumping equipment, where applicable.

Ferrous Sulfate Mixing and Injection (IF NECESSARY)

The decision to inject ferrous sulfate and the selected ferrous sulfate injection methodology will be based on the initial oxidation injection event. A modification to this SOP will be made if ferrous sulfate is required to enhance the oxidation reaction. Ferrous sulfate will likely be injected prior to hydrogen peroxide injection. Equipment used for ferrous sulfate injection will not be used for hydrogen peroxide injection unless thoroughly cleaned.

Hydrogen Peroxide Solution Mixing

Based on the initial Hydrogen Peroxide injection event, mix the hydrogen peroxide solution as follows.

1) Check to ensure that the hydrogen peroxide tank is clean and free of dirt or debris that may contaminate the hydrogen peroxide.
2) Add the total volume of water required for the hydrogen peroxide solution.
3) Add the appropriate amount of hydrogen peroxide using a clean graduated 5 gallon bucket for measuring.
4) Stir solution gently with a plastic mixing stick. Mixing should be relatively easy since hydrogen peroxide is 100% soluble in water.

CAUTION: Be careful not to splash or spill any hydrogen peroxide. Splash suits, surgical and Neoprene gloves, chemical resistant boots, safety glasses, and a splash shield should be used during mixing. If splashing or spilling does occur, thoroughly dilute and wash equipment and PPE affected.

Transport and Injection Preparation

1) Check that all tank, hose, and pumping equipment valves are securely closed. Check that the tank lid is closed prior to moving.
2) Mobilize just the hydrogen peroxide injection hose to the injection well.

OR

3) Mobilize the hydrogen peroxide injection tank, hoses and pumping equipment to the injection well head. Careful consideration should be given to minimize the mobilization of the hydrogen peroxide injection tank to reduce the risk of spilling or splashing.
4) Open well box lid and remove dust cap.
5) Identify injection port on well head.
6) Prepare injection equipment at introduction point as follows:
    a) Connect 1-inch hose to the pump and tank using camlock fittings.
    b) Remove lid from tank.
    c) Connect introduction hose with the wellhead apparatus (including the control valve, manual pressure relief valve, automatic pressure relief valve, and pressure gauge.) to well casing via camlock fitting.

Injection of Hydrogen Peroxide Solution

1) Operate introduction pump with valves V-2, V-4 and V-5 closed, and valve V-1 open. V-3 will open automatically at a set pressure to eliminate the risk of high pressure explosion (Figure A-2).
2) Open valve V-2 completely (Figure A-2), check for leaks.
3) Open valve V-4 gradually to regulate flow (Figure A-2), check for leaks.
4) Regulate valve V-4 to maintain a pressure within well less than 80 psi. Monitor pressure with gauge on introduction line (Figure A-2).
5) Monitor the flow rate and total flow by measuring tank drawdown over a period of time.
6) Use gradations on tank to observe tank level or use a plastic level dipstick.

8) Periodically check all fittings for defects and leaks.
9) Complete Hydrogen Peroxide Solution Injection Log (Table A-2 or A-3).

CAUTION:

1. DO NOT leave process unattended. Closely watch injection process at all times.
2. DO NOT pump carbon source solution under excessive pressure (greater than 80 psi). If excessive pressure is encountered due to the subsurface reaction, open manual pressure relief valve into a pressure relief knockout bucket. Continue as necessary to maintain pressure below 80 psi.
3. DO NOT stand over or look down into wells during injection.

Shut Down of Equipment Between Injection Points

1) Deactivate injection pump (if applicable).
2) Open valve V-5 gradually to relieve pressure in well. DO NOT disconnect any hoses until the pressure at the wellhead is 0 psi.
3) Close valves V-1, V-2, and V-5.
4) Disconnect injection line from pump (disconnect over a spill bucket).
5) Drain injection line into well by opening V-2 above wellhead elevation and walking line out to the wellhead. DO NOT lift hose above head.
6) Close valves V-2 and V-4.
7) Remove hose from injection point (disconnect over a spill bucket).
8) Replace dust cap and well box lid.
9) Move to next injection point. Return to Step 1: Injection of Hydrogen Peroxide Solution

Shut Down of Equipment Between Daily Introduction Events

1) Pump or flush a minimum of 20 gallons of clean water through equipment (including pumps, hoses, and tanks).
2) Drain water from hoses and pump (if applicable) prior to storage.
3) Store hydrogen peroxide solution in cool (<35°C), well ventilated, and preferably dark area between daily events.
4) Monitor inventory of hydrogen peroxide.

Table A-2. Initial Hydrogen Peroxide Injection Log, AOI 7 Interim Measures Work Plan, General Motors Corporation, Moraine, Ohio.

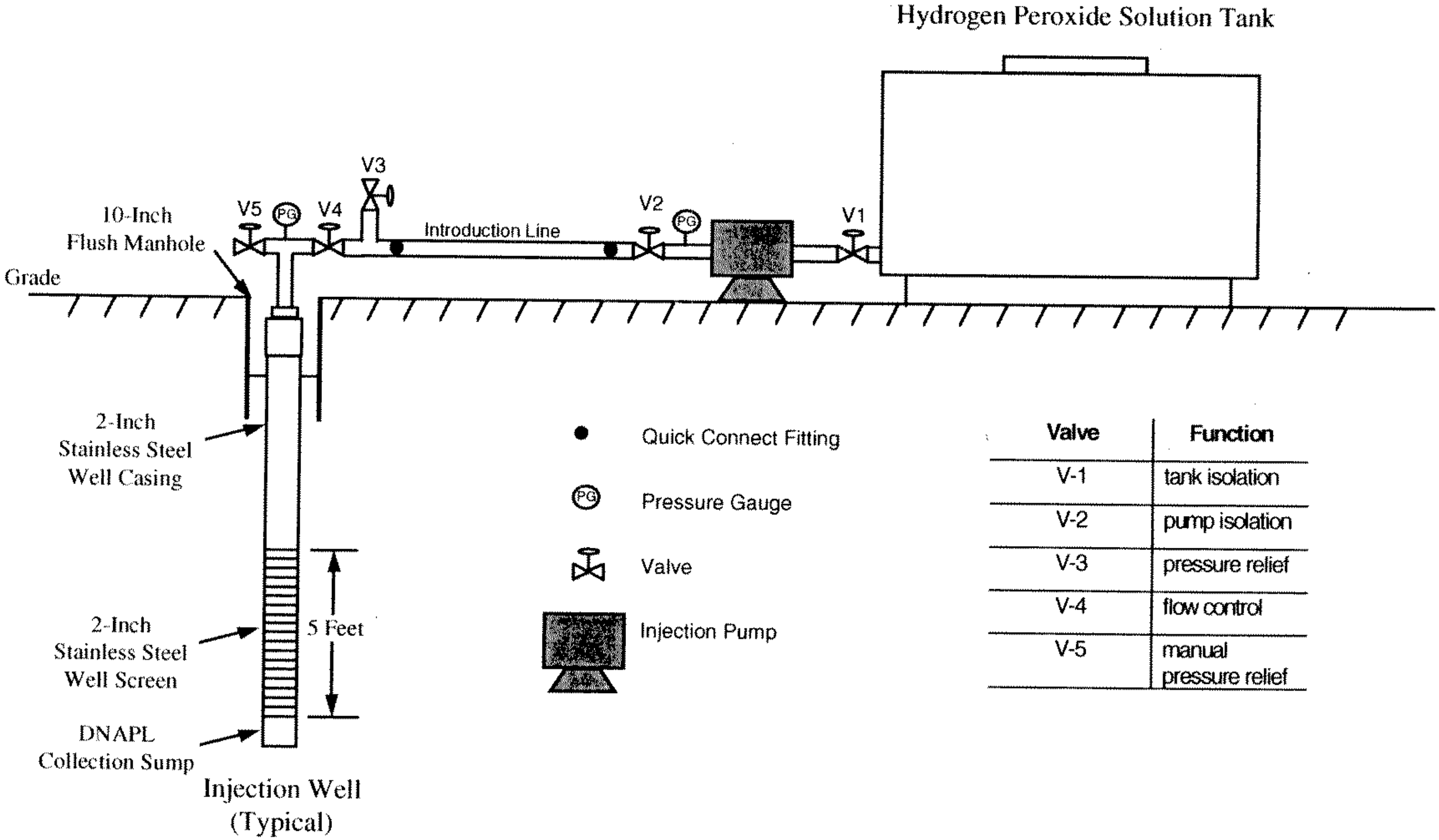
Injection Point Designation: ________________

Date: ________________

		Hydrogen Peroxide		Ferrous Sulfate				
Injection Start/Stop Time	Injection Fluid: H_2O_2 (HP) or Ferrous Sulfate	Cumulative Volume of H_2O_2 (Gal.)	Concentration of H_2O_2 (%)	Cumulative Volume of Ferrous Sulfate	Concentration of Ferrous Sulfate (%)	Estimated Injection Rate of Injection Fluid (gpm)	Pressure at Wellhead	Comments

Table A-3. Hydrogen Peroxide Injection Log for Multiple Injection Points, AOI 7 Interim Measures Work Plan, General Motors Corporation, Moraine, Ohio.

Injection Point Designation	Time		Injection Fluid: H_2O_2 (HP) or Ferrous Sulfate	Hydrogen Peroxide		Ferrous Sulfate		Estimated Injection Rate (gpm)	Pressure at Wellhead	Comments
	Start	Stop		Cumulative Volume of H_2O_2 (Gal.)	Concentration of H_2O_2 (%)	Cumulative Volume of Ferrous Sulfate	Concentration of Ferrous Sulfate (%)			



Valve	Function
V-1	tank isolation
V-2	pump isolation
V-3	pressure relief
V-4	flow control
V-5	manual pressure relief

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Schematic of the Oxidation System
AOI 7 Interim Measures Work Plan

General Motors Corporation
Moraine, Ohio

FIGURE

A-2

DRAFT

Appendix B

HASP Addendum

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Appendix B
HASP Addendum

General Motors Corporation
Moraine, Ohio

June 1999

PREPARED FOR

General Motors Corporation

Table of Contents

Tables

Appendix

1. Introduction

The following health and safety provisions have been developed as an addendum to the Supplemental RCRA Facility Investigation (RFI), Health and Safety Plan for General Motors Corporation, Moraine, Ohio (Appendix E to the Supplemental RFI Work Plan). These provision are specific for the Area of Interest (AOI) 7 Former Oil House Area Interim Measures Work Plan which involves the use of hydrogen peroxide and possibly ferrous sulfate to implement an in-situ oxidation remedial approach. Since hydrogen peroxide is an oxidizer, special caution and care instructions must be followed when handling the chemical.

The Supplemental RFI, Health and Safety Plan addresses those items specified under 29 CFR 1910.120 (b) Final Rule. The Supplemental RFI Health and Safety Plan and the Interim Measures Health and Safety Plan Addendum will be provided to all ARCADIS Geraghty & Miller and subcontractor personnel participating in the interim measures implementation.

2. Health & Safety Plan Enforcement

Refer to the Supplemental RFI Health and Safety Plan (Section 2.0) for information pertaining to health and safety plan enforcement.

3. Site Specific Hazard Evaluation

Substance(s) which may be managed during the interim measures activities include groundwater constituents, hydrogen peroxide, ferrous sulfate (if necessary), and a molasses solution. The site specific hazard evaluation for typical working hazards and exposure to groundwater constituents is included in the Supplemental RFI Health and Safety Plan (Section 3.0). A summary of additional potential exposure pathways, health effects, and physical hazards related to hydrogen peroxide and ferrous sulfate injection activities is presented in this section. Since the molasses solution is nonflammable and nontoxic and therefore presents little or no health risks, a hazard evaluation for the molasses solution is not included in this addendum.

Known Chemical Hazards:

Component	Location	Media	TWA* TLV	TWA STEL**
Hydrogen Peroxide	AOI 7 - Former Oil House Area	Aqueous and Air	1.4 mg/m^3 (airborne)	NA
Ferrous Sulfate	AOI 7 - Former Oil House Area	Aqueous and Air	1.0 mg/m^3 (airborne)	NA

Values per American Conference of Governmental Industrial Hygienists or 29 CFR 1910 (OSHA) whichever is most stringent.

mg/m - Milligram of chemical per meter of air.
NA - Not applicable

* The Threshold Limit Value (TLV) is the time weighted average (TWA) concentration for a normal eight-hour day and a forty-hour work week, to which all workers may be repeatedly exposed, day after day, without adverse effect.

** The Short-Term Exposure Limit (STEL) is the concentration at which workers can be exposed continuously for a short period of time. Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than four times in an eight-hour period. There should be at least one hour between each 15 minute exposure at the STEL.

3.1 Potential Exposure

Principal routes of exposure for hydrogen peroxide and ferrous sulfate are: eye and dermal contact, inhalation, and ingestion.

3.2 Health Effects

Hydrogen peroxide solutions above 8% are classified as an oxidizer by the U.S. Department of Transportation. The oxidizing nature of the hydrogen peroxide presents some serious health effects if exposure routes are complete. In addition, exposure to ferrous sulfate also may result in health effects.

Eye contact with concentrated vapors or solutions of hydrogen peroxide can cause discomfort (pain), redness and blurred vision. Contact of the eyes with hydrogen peroxide is particularly dangerous because corneal burns can occur very rapidly and can result in permanent tissue damage. Dermal contact with moderate concentrations of hydrogen peroxide will cause whitening of the skin and stinging sensations. Symptoms include redness, pain and burning. Highly concentrated hydrogen peroxide can cause blistering if left on skin surface for any length of time. Inhalation of hydrogen peroxide can cause irritation and inflammation of the respiratory tract. Inhalation of mist may burn the mucous membrane of the nose and throat. In severe cases, exposure may result in pulmonary edema and death. For this reason the airborne TLV value of hydrogen peroxide is 1.4 mg/m^3. Ingestion of hydrogen peroxide can be corrosive to the mouth, throat, and gastrointestinal tract. Large doses may cause symptoms of abdominal pain, vomiting, and diarrhea as well as blistering and tissue destruction. Injury to the extent of death is possible in severe cases.

Eye or dermal contact with ferrous sulfate may result in irritation, redness, pain and itching. Inhalation of ferrous sulfate can cause irritation to the respiratory tract including coughing and shortness of breath symptoms. Ingestion of large doses of ferrous sulfate may cause nausea, vomiting, diarrhea, and black stool. Pink urine discoloration is a strong indicator of iron poisoning. Liver damage, coma, and death from iron poisoning is possible. Chronic exposure to ferrous sulfate poisonings may damage blood vessels and the liver.

Worker exposure to hydrogen peroxide or ferrous sulfate will be controlled through the proposed use of personal protective equipment combined with atmospheric and visual monitoring for hydrogen peroxide.

3.3 Physical Hazards

Hydrogen peroxide and ferrous sulfate are not combustible or flammable, therefore, in pure form, the chemical presents a minimal fire or explosion hazards. However, the decomposition of hydrogen peroxide liberates oxygen which supports combustion. Decomposition of hydrogen peroxide is increased with solution contamination, alkalinity, contact with certain materials of construction, and increasing temperatures. Fires involving hydrogen peroxide are best controlled by using large quantities of water. Also when hydrogen peroxide is allowed to dry in fabric, a fire hazard may exist, therefore upon contact with fabric (i.e. clothing) a thorough flush with water is recommended.

When hydrogen peroxide and ferrous sulfate are combined, Fenton's reagent is created. The reaction that occurs when creating Fenton's reagent can result in high temperature and high pressure hazards. Either adequate venting or close monitoring of temperature and pressure should be conducted when mixing the two chemicals. In addition, Fenton's regent results in the formulation of hydroxyl radicals which are powerful oxidizers, therefore continued caution and care must be considered with the handling of Fenton's reagent. Since Fenton's reagent will likely be created within the subsurface, exposure to the oxidizing hazards of Fenton's reagent is unlikely.

4. Employee Training Requirements

Refer to the Supplemental RFI Health and Safety Plan (Section 4.0) for information pertaining to employee training requirements. Daily tailgate safety meetings will be held prior to interim measures activities at AOI 7 to address proper handling and precautions associated with hydrogen peroxide and ferrous sulfate.

5. Personal Protection Requirements

The following levels of personal protection equipment (PPE) only pertain to activities associated with the oxidation system. Refer to the Supplemental RFI Health and Safety Plan (Section 5.0) for all other activities including groundwater exposure and typical working hazards.

Location/Job Function	Levels of Protection
Handling of Hydrogen Peroxide	Modified Level D Level B if air exceeds 10 ppm or the TWA
Handling of Ferrous Sulfate	Modified Level D Level C if air exceeds TWA Level B if air exceeds 50 times TWA

Specific protective equipment for each level of protection is as follows:

Personal Protective Equipment	A	B	C	D	Special Instructions
Full Body					
Saranex, Poly Coated	( )	(o)	(o)	(o)	
Splash Suit (disposable)	( )	(x)	(x)	(x)	Made of polyester acrylic fiber, polyvinyl chloride, polyethylene, or neoprene.
Tyvek (disposable)	( )	( )	( )	( )	
Hard Hat	( )	(o)	(o)	(o)	

Personal Protective Equipment	A	B	C	D	Special Instructions
Eyes and Face					
Safety Glasses	( )	(x)	(x)	(x)	
Goggles	( )	( )	( )	( )	
Splash Shield	( )	(x)	(x)	(x)	
Hearing Protection	( )	( )	( )	( )	
Hand Protection					
Surgical Gloves (Inner)	( )	(x)	(x)	(x)	
Surgical Gloves (Outer)	( )	( )	( )	( )	
Neoprene Gloves (Outer)	( )	(x)	(x)	(x)	
________Gloves (Inner)	( )	( )	( )	( )	
Work (Cotton) Gloves	( )	(o)	(o)	(o)	
Insulated Gloves	( )	( )	( )	( )	
Foot Protection					
Steel toe/shank boots	( )	(x)	(x)	(x)	
Chemical protective boots	( )	(x)	(x)	(x)	
Respiratory Protection					
Half-face APR with cartridges	( )	( )	(x)	( )	If TWA for $FeSO_4$ is exceeded
Full-face APR with cartridges/canisters	( )	( )	(x)	( )	If 10 x TWA for $FeSO_4$ is exceeded
Dust filters	( )	( )	( )	( )	
HEPA combination filters	( )	( )	( )	( )	
______________ filters	( )	( )	( )	( )	
Supplied Air or Self Contained Breathing Apparatus (SCBA)	( )	(x)	( )	( )	If 10 ppm or TWA for H_2O_2 exceeded or 50 x TWA for $FeSO_4$ exceeded

x: Required for level of personnel protection
o: Optional equipment to be based upon existing site conditions

Standard splash suit coveralls are required for all levels of working activities. Protective eyewear will be worn at all times. Splashshields shall be worn when the potential for splashing of contaminated fluids exists.

6. Medical Surveillance

Refer to the Supplemental RFI Health and Safety Plan (Section 6.0) for information pertaining to medical surveillance. In addition, refer to symptoms discussed in Section 3.0 of this Health and Safety Plan Addendum.

7. Environmental Surveillance of Work Areas

Refer to the Supplemental RFI Health and Safety Plan (Section 7.0) for information pertaining to environmental surveillance of work areas. Additional chemicals (hydrogen peroxide and ferrous sulfate) that will be handled during interim measures oxidation injections are addressed below.

Activity	Device/Parameter	Frequency
Hydrogen Peroxide Mixing and Injection	Electrochemical Sensor	Periodically*
Ferrous Sulfate Mixing and Injection	Qualitative Monitoring	Periodically*
Subsurface Injection	Pressure, Temperature, Leaks	Continuously

* Readings to be taken more frequently in more contaminated areas

Detection Method/Parameters	Action Level	Action
Pressure	75-100 psi	Cease injection, open manual relief valve slightly
Temperature	150 °F	Cease injection, allow to cool
Observations of Leaking	any	Cease injection/mixing, fix leak
Hydrogen Peroxide	1 ppm (sustained reading)	Increase ventilation. Upgrade to Level C, if problem persists.
Ferrous Sulfate	Reasonable Vapor Detection	Increase ventilation. Upgrade to Level C, if problem persists.

8. Site Control

Refer to the Supplemental RFI Health and Safety Plan (Section 8.0) for information pertaining to site control.

9. Decontamination

Refer to the Supplemental RFI Health and Safety Plan (Section 9.0) for information pertaining to decontamination.

Although decontamination of PPE is not required during injection events, thorough rinsing with water to dilute hydrogen peroxide and ferrous sulfate solutions that may have contacted the PPE must be performed prior to storage or disposal.

10. Emergency Planning

Refer to the Supplemental RFI Health and Safety Plan (Section 10.0) for information pertaining to emergency planning.

The following first aid measures shall be implemented in case of eye contact, dermal contact, inhalation, or ingestion of hydrogen peroxide or ferrous sulfate:

Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes, lifting the lower and upper eyelids occasionally. Get medical attention immediately.

Dermal Contact: Immediately flush skin with plenty of water (and soap for ferrous sulfate) for at least 15 minutes. Remove contaminated clothing and shoes. Get medical attention. Wash clothing and shoes before reuse. Immediately wash clothing and shoes if in contact with hydrogen peroxide to minimize the risk of ignition.

Inhalation: Move to fresh air at once. If the inhalation has been prolonged, a physician should be consulted immediately.

Ingestion of hydrogen peroxide: Drink water immediately to dilute, and contact a physician. DO NOT INDUCE VOMITING.

Ingestion of ferrous sulfate: Induce vomiting immediately as directed by medical personnel. Consult a physician immediately.

An ample supply of potable water will be required on site. If an on-site continuous water supply is not available, a water tank of sufficient size and delivery system will be maintained. In addition, a shower rinse and eye wash station are recommended safety precautions that will be available on site in case of accidental spilling. A first aid kit and fire extinguisher shall also be readily accessible on site.

11. Additional References

Refer to the Supplemental RFI Health and Safety Plan (Section 11.0) for information pertaining to additional references.

12. Signatures

Project No.: OH000294.0001.0002

Project Name & Location: AOI 7 Interim Measures, north of the Moraine Engine Plant and west of Springboro Road, General Motors Corporation, Moraine, Ohio.

The undersigned have read and understood the Supplemental RFI Health and Safety Plan and this Health and Safety Plan Addendum for the Interim Measures activities.

Name	Signature	Date

Site Safety and Health Supervisor:

Name	Signature	Date

TABLE 3.2 (Cont.)

SUBSTANCES OF HEALTH AND SAFETY CONCERN

Hydrogen Peroxide Solution(0 to 40%)

SYNONYMS:	Peroxide, Hydrogen dioxide solution, H_2O_2
PERMISSIBLE EXPOSURE LIMIT:	1 ppm or 1.4 mg/m^3 (OSHA TWA Airborne exposure limit)
ODOR THRESHOLD:	Not available
PHYSICAL DESCRIPTION:	Colorless liquid
PERSONNEL PROTECTION AND SANITATION:	Respiratory Protection: Supplied air or SCBA for exposure greater than 10 ppm or TWA greater than 1ppm. Protective Clothing: Splash suit, surgical and neoprene gloves, chemical protective boots. Goggles/Glasses: safety glasses (and shield if necessary). Wash any contaminated clothing thoroughly.
ROUTES OF ENTRY:	Inhalation, ingestion, eye and dermal contact.
SYMPTOMS:	Pain and redness of eyes, blurred vision. Whitening, redness, pain and burning of skin. Blistering of skin for extreme dermal contact cases. Irritation and inflammation of respiratory tract and mucous membranes if inhaled. Abdominal pain, vomiting, diarrhea, blistering and tissue destruction if ingested at large doses.
FIRST AID:	Eyes and Skin: Immediately flush with water for 15 minutes. Inhalation: Move to fresh air at once, perform artificial respiration if necessary. Ingestion: Drink water immediately to dilute, DO NOT INDUCE VOMITING.
TARGET ORGANS:	Nose, mouth, throat, lungs, stomach, skin, eyes. Generally not a systematic threat except in extreme cases.
FLAMMABILITY:	Not flammable, but will decompose to oxygen, potentially causing a fire threat if ignited.

TABLE 3.2 (Cont.)

SUBSTANCES OF HEALTH AND SAFETY CONCERN

Ferrous Sulfate

SYNONYMS:	Iron (II) sulfate (1:1); heptahydrate; sulfuric acid, iron (2+) salt (1:1)
PERMISSIBLE EXPOSURE LIMIT:	1 ppm or 1.0 mg/m^3 (OSHA TWA Airborne exposure limit)
ODOR THRESHOLD:	Not available
PHYSICAL DESCRIPTION:	Blue green crystals
PERSONNEL PROTECTION AND SANITATION:	Respiratory Protection: Half-face APR with cartridges if TWA exceeded. Full-face APR if 10 x TWA exceeded. Supplied air or SCBA if 50 x TWA exceeded. Protective Clothing: Splash suit, surgical and neoprene gloves, chemical protective boots. Goggles/Glasses: safety glasses (and shield if necessary).
ROUTES OF ENTRY:	Inhalation, ingestion, eye and dermal contact.
SYMPTOMS:	Irritation, redness and itching of eyes and skin. Irritation including coughing, and shortness of breath if inhaled. Nausea, vomiting, diarrhea, black stool, pink urine if ingested.
FIRST AID:	Eyes and Skin: Immediately flush with water for 15 minutes. Inhalation: Move to fresh air at once, perform artificial respiration if necessary. Ingestion: Induce vomiting as directed by medical personnel.
TARGET ORGANS:	Nose, mouth, throat, lungs, stomach, skin, eyes, blood vessels, liver.
FLAMMABILITY:	Not flammable.

ARCADIS GERAGHTY & MILLER

Appendix B-1

Material Safety Data Sheets

Please reduce your browser font size for better viewing and printing.

MSDS Material Safety Data Sheet

From: **Mallinckrodt Baker, Inc.**
222 Red School Lane
Phillipsburg, NJ 08865

MALLINCKRODT J.T.Baker

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. and Canada
Chemtrec: 202-483-7616

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

HYDROGEN PEROXIDE SOLUTION, 30%

MSDS Number: H4065 — ***Effective Date: 09/08/97***

1. Product Identification

Synonyms: Peroxide; 100 volume peroxide; Hydrogen dioxide solution; Hydrogen peroxde, 30%, unstabilized; Hydrogen Peroxide, 30%, Ultrex(tm)
CAS No.: 7722-84-1
Molecular Weight: 34.01
Chemical Formula: H_2O_2
Product Codes:
J.T. Baker: 2186, 2189, 2190, 2200, 2201, 2204, 5170, 5369, 5816, 5836, 5846, 5899
Mallinckrodt: 5240, V340

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Hydrogen Peroxide	7722-84-1	29 - 32%	Yes
Water	7732-18-5	68 - 71%	No

3. Hazards Identification

Emergency Overview

DANGER! STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. CORROSIVE. CAUSES BURNS TO SKIN, EYES, AND RESPIRATORY TRACT. HARMFUL IF SWALLOWED OR INHALED.

J.T. Baker SAF-T-DATA$^{(tm)}$ Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate
Flammability Rating: 0 - None
Reactivity Rating: 3 - Severe (Oxidizer)
Contact Rating: 4 - Extreme (Corrosive)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES
Storage Color Code: Yellow (Reactive)

Potential Health Effects

Inhalation:
Vapors are corrosive and irritating to the respiratory tract. Inhalation of mist may burn the mucous membrane of the nose and throat. In severe cases, exposures may result in pulmonary edema and death.

Ingestion:
Corrosive and irritating to the mouth, throat, and abdomen. Large doses may cause symptoms of abdominal pain, vomiting, and diarrhea as well as blistering or tissue destruction. Stomach distention (due to rapid liberation of oxygen), and risk of stomach perforation, convulsions, pulmonary edema, coma, possible cerebral edema (fluid on the brain), and death are possible.

Skin Contact:
Corrosive. Symptoms of redness, pain, and severe burn can occur.

Eye Contact:
Vapors are very corrosive and irritating to the eyes. Symptoms include pain, redness and blurred vision. Splashes can cause permanent tissue destruction.

Chronic Exposure:
No information found.

Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

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4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Ingestion:
If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Contact:
Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention immediately. Wash clothing before reuse. Thoroughly clean shoes before reuse. If allowed to dry on clothing, evaporation leads to concentration and increasedpossibility of ignition.

Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Note to Physician:
Pulmonary edema may be delayed for 24 to 72 hours;keep under observation. Gastric lavage may be necessary if swallowed. Analysis of body fluids (particularly gastric aspirates) using the titanium chloride reaction, if done immediately, will reveal peroxides.

5. Fire Fighting Measures

Fire:
Not combustible, but substance is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition. Increases the flammability of combustible, organic and readily oxidizable materials.

Explosion:
Contact with oxidizable substances may cause extremely violent combustion. Drying of concentrated hydrogen peroxide on clothing or other combustible materials may cause fire or explosion. Sealed containers may rupture when heated.

Fire Extinguishing Media:
Water spray may be used to extinguish surrounding fire and cool exposed containers. Water spray will also reduce fume and irritant gases.

Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

CAUTION! Caustic material. Causes fires with organic material. Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Contain and recover liquid when possible. Do not return spilled material to original container. Larger Spills: Dilute with a large amount of water and hold in a pond or dyked area until the peroxide decomposes followed by discharge into a suitable treatment system. May be neutralized with sodium metabisulfite or sodium sulfite after diluting to 5-10% peroxide. Do not flush undiluted material to sewer. This oxidizing material can increase the flammability of adjacent combustible materials. Empty containers should be rinsed with water before discarding.

7. Handling and Storage

Store in a cool(< 35C), well-ventilated dark area separated from combustible substances, reducing agents, strong bases, organics.Do not store on wooden shelves or floors. Suggest rotation of stock. Containers must be vented, but check periodically for bulging containers which can burst from pressure. Protect containers from physical damage, contamination, heat and incompatibles.. Contamination from any source (dust, metals) may cause rapid decomposition with generation of large quantities of oxygen gas and high pressures. Rinse empty containers thoroughly with clean water. Glass, polyethylene, stainless steel and aluminum are recommended materials for storage containers. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

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8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
-OSHA Permissible Exposure Limit (PEL):
1 ppm (TWA).
-ACGIH Threshold Limit Value (TLV):
1 ppm (TWA), A3: Animal carcinogen.

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded, wear a supplied air, full-facepiece respirator, airlined hood, or full-facepiece self-contained breathing apparatus. This substance has unknown warning properties.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

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9. Physical and Chemical Properties

Appearance:
Clear, colorless liquid.
Odor:
Slight acrid odor.
Solubility:
Infinitely soluble.
Density:
1.11
pH:
3.3
% Volatiles by volume @ 21C (70F):
100
Boiling Point:

108C (226F)
Melting Point:
-25C (-13F)
Vapor Density (Air=1):
1.17
Vapor Pressure (mm Hg):
25 @ 30C (86F)
Evaporation Rate (BuAc=1):
< 1

10. Stability and Reactivity

Stability:
Normally stable if uncontaminated, but slowly decomposes to release oxygen. Unstable with heat, may result in dangerous pressures. A strong oxidizer, reacts violently upon contact with many organic substances, particularly textile and paper. Avoid light and keep in a closed but vented container to prevent evaporation (concentration) and contamination.
Hazardous Decomposition Products:
Decomposes to water and oxygen with rapid heat release. Use vented containers. The solution can decompose violently upon heating.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Heat, reducing agents, organic materials, dirt, alkalis, rust, and many metals. Spontaneous combustion may occur on standing in contact with readily flammable materials.
Conditions to Avoid:
Avoid excess heat and contact with combustible or organic materials. Light and incompatibles.

11. Toxicological Information

For Hydrogen peroxide: No LD50/LC50 information found relating to normal routes of occupational exposure. Investigated as a tumorigen and mutagen.

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--------\Cancer Lists\---------------------------------------------------
                                        ---NTP Carcinogen---
Ingredient                              Known    Anticipated    IARC Category
------------------------------------    -----    -----------    -------------
Hydrogen Peroxide (7722-84-1)            No         No               3
Water (7732-18-5)                        No         No              None
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12. Ecological Information

Environmental Fate:
No information found.

Environmental Toxicity:
No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dilute with water and flush to sewer if local ordinances allow, otherwise, whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: HYDROGEN PEROXIDE, AQUEOUS SOLUTION (WITH NOT LESS THAN 20% BUT NOT MORE THAN 40% HYDROGEN PEROXIDE)
Hazard Class: 5.1, 8
UN/NA: UN2014
Packing Group: II
Information reported for product/size: 470LB

International (Water, I.M.O.)

Proper Shipping Name: HYDROGEN PEROXIDE, AQUEOUS SOLUTION (WITH NOT LESS THAN 20% BUT NOT MORE THAN 40% HYDROGEN PEROXIDE)
Hazard Class: 5.1, 8
UN/NA: UN2014
Packing Group: II
Information reported for product/size: 470LB

15. Regulatory Information

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--------\Chemical Inventory Status - Part 1\---------------------------------
Ingredient                                       TSCA  EC   Japan  Australia
-----------------------------------------------  ----  ---  -----  ---------
Hydrogen Peroxide (7722-84-1)                     Yes  Yes   Yes      Yes
Water (7732-18-5)                                 Yes  Yes   Yes      Yes

--------\Chemical Inventory Status - Part 2\---------------------------------
                                                           --Canada--
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Ingredient	Korea	DSL	NDSL	Phil.
Hydrogen Peroxide (7722-84-1)	Yes	Yes	No	Yes
Water (7732-18-5)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------------

Ingredient	-SARA 302- RQ	 TPQ	------SARA 313------ List	 Chemical Catg.
Hydrogen Peroxide (7722-84-1)	1000	1000	No	No
Water (7732-18-5)	No	No	No	No

--------\Federal, State & International Regulations - Part 2\----------------

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Hydrogen Peroxide (7722-84-1)	1	No	No
Water (7732-18-5)	No	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: No Fire: Yes Pressure: No
Reactivity: Yes (Mixture / Liquid)

Australian Hazchem Code: 2P
Poison Schedule: S6
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: **3** Flammability: **0** Reactivity: **1** Other: **Oxidizer**
Label Hazard Warning:
DANGER! STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. CORROSIVE. CAUSES BURNS TO SKIN, EYES, AND RESPIRATORY TRACT. HARMFUL IF SWALLOWED OR INHALED.
Label Precautions:
Keep from contact with clothing and other combustible materials.
Do not store near combustible materials.
Do not get in eyes, on skin, or on clothing.
Do not breathe vapor or mist.
Store in a tightly closed container.
Use only with adequate ventilation.
Remove and wash contaminated clothing promptly.
Wash thoroughly after handling.
Avoid contamination from any source, metals, dust, and organic materials that may cause rapid decomposition, generation of large quantities of oxygen gas and high pressure. Drying of product on clothing or combustible materials may cause fire.
Label First Aid:
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. If inhaled,

remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. In all cases get medical attention immediately.

Product Use:

Laboratory Reagent.

Revision Information:

Disclaimer:

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Prepared by: Strategic Services Division
Phone Number: (314) 539-1600 (U.S.A.)

Please reduce your browser font size for better viewing and printing.

MSDS *Material Safety Data Sheet*

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. and Canada
Chemtrec: 202-483-7616

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865

MALLINCKRODT J.T.Baker

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

FERROUS SULFATE

MSDS Number: F1802 — *Effective Date: 03/05/97*

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1. Product Identification

Synonyms: Iron (II) sulfate (1:1), heptahydrate; sulfuric acid, iron (2+) salt (1:1), heptahydrate

CAS No.: 7720-78-7
Molecular Weight: 278
Chemical Formula: $FeSO_4 \cdot 7H_2O$
Product Codes: J.T. Baker: 2070, 2074, 2075, 5830 Mallinckrodt: 5055, 5056, 5401, 5572

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2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Ferrous Sulfate	7720-78-7	99 - 100%	Yes

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3. Hazards Identification

Emergency Overview

WARNING! HARMFUL IF SWALLOWED OR INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. AFFECTS THE LIVER.

J.T. Baker SAF-T-DATA$^{(tm)}$ Ratings (Provided here for your convenience)

Health Rating: 1 - Slight
Flammability Rating: 0 - None
Reactivity Rating: 0 - None
Contact Rating: 0 - None
Lab Protective Equip: GOGGLES; LAB COAT
Storage Color Code: Orange (General Storage)

Potential Health Effects

Inhalation:
Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath.

Ingestion:
Low toxicity in small quantities but larger dosages may cause nausea, vomiting, diarrhea, and black stool. Pink urine discoloration is a strong indicator of iron poisoning. Liver damage, coma, and death from iron poisoning has been recorded. Smaller doses are much more toxic to children.

Skin Contact:
Causes irritation to skin. Symptoms include redness, itching, and pain.

Eye Contact:
Causes irritation, redness, and pain.

Chronic Exposure:
Severe or chronic ferrous sulfate poisonings may damage blood vessels. Large chronic doses cause rickets in infants. Chronic exposure may cause liver effects. Prolonged exposure of the eyes may cause discoloration.

Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems, or impaired liver, kidney or respiratory function may be more susceptible to the effects of the substance.

4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Ingestion:
Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention.

Skin Contact:

Immediately flush skin with plenty of soap and water for at least 15 minutes. Remove contaminated clothing and shoes. Get medical attention. Wash clothing before reuse. Thoroughly clean shoes before reuse.

Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

5. Fire Fighting Measures

Fire:
Not considered to be a fire hazard.

Explosion:
Not considered to be an explosion hazard.

Fire Extinguishing Media:
Use any means suitable for extinguishing surrounding fire.

Special Information:
Use protective clothing and breathing equipment appropriate for the surrounding fire.

6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Pick up and place in a suitable container for reclamation or disposal, using a method that does not generate dust. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Maintain a constant temperature not to exceed 24 degrees centigrade (75 degrees fahrenheit). Fluctuating temperatures causes product oxidation. Do not use this product if coated with brownish-yellow basic ferric sulfate. Isolate from incompatible substances. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
-ACGIH Threshold Limit Value (TLV): 1 mg/m3 (TWA) soluble iron salt as Fe

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded, a half-face dust/mist respirator may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A full-face piece dust/mist respirator may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency, or respirator supplier, whichever is lowest. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or full face shield where dusting or splashing of solutions is possible. Maintain eye wash fountain and quick-drench facilities in work area.

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9. Physical and Chemical Properties

Appearance:
Blue green crystals.

Odor:
Odorless.

Solubility:
48.6 g/100 g water @ 50C (122F)

Density:
1.90

pH:
No information found.

% Volatiles by volume @ 21C (70F):
0

Boiling Point:
> 300C (> 572F) Decomposes.

Melting Point:
57C (135F) Loses water

Vapor Density (Air=1):
No information found.

Vapor Pressure (mm Hg):
No information found.

Evaporation Rate (BuAc=1):
No information found.

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10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage. Looses water in dry air and oxidizes upon exposure to moisture, forming a brown coating of extremely corrosive basic ferric sulfate.

Hazardous Decomposition Products:
Burning may produce sulfur oxides.

Hazardous Polymerization:
This substance does not polymerize.

Incompatibilities:
Alkalis, soluble carbonates, and oxidizing materials. Reacts in moist air to form ferric sulfate.

Conditions to Avoid:
Moisture.

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11. Toxicological Information

Oral rat LD50: 319 mg/kg. Investigated as a tumorigen and mutagen.

--------\Cancer Lists\--

Ingredient	---NTP Carcinogen--- Known	---NTP Carcinogen--- Anticipated	IARC Category
Ferrous Sulfate (7720-78-7)	No	No	None

12. Ecological Information

Environmental Fate:
No information found.

Environmental Toxicity:
No information found.

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13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

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14. Transport Information

Not regulated.

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15. Regulatory Information

--------\Chemical Inventory Status - Part 1\---------------------------------

Ingredient	TSCA	EC	Japan	Australia
Ferrous Sulfate (7720-78-7)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\---------------------------------

Ingredient	Korea	--Canada-- DSL	NDSL	Phil.
Ferrous Sulfate (7720-78-7)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------------

	-SARA 302-		------SARA 313------	
Ingredient	RQ	TPQ	List	Chemical Catg.
Ferrous Sulfate (7720-78-7)	No	No	No	No

--------\Federal, State & International Regulations - Part 2\----------------

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Ferrous Sulfate (7720-78-7)	1000	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No

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SARA 311/312:  Acute: Yes      Chronic: Yes  Fire: No  Pressure: No
Reactivity: No          (Mixture / Solid)
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Australian Hazchem Code: No information found.
Poison Schedule: No information found.

WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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16. Other Information

NFPA Ratings: Health: 1 **Flammability:** 0 **Reactivity:** 0

Label Hazard Warning:
WARNING! HARMFUL IF SWALLOWED OR INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. AFFECTS THE LIVER.

Label Precautions:
Avoid contact with eyes, skin and clothing. Wash thoroughly after handling. Avoid breathing dust. Keep container closed. Use only with adequate ventilation.

Label First Aid:
If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. In all cases, get medical attention.

Product Use:
Laboratory Reagent. Bulk pharmaceutical chemical.

Revision Information:
Mixture. New 16 section MSDS format, all sections have been revised.

Disclaimer:
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