FOCUSED FEASIBILITY STUDY REPORT
FF/NN LANDFILL NPL SITE
Ripon, Wisconsin

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1.0 EXECUTIVE SUMMARY

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During routine groundwater monitoring in the fall of 2001, vinyl chloride was detected in two private drinking water wells located in the sandstone aquifer and approximately 1,500 feet down gradient of the FF/NN Landfill. Immediately, the residents were provided with safe drinking water and interim point of entry treatment systems were installed and operated until the City (with FF/NN Landfill PRP group funding) extended municipal water to the affected residences. As a result of the vinyl chloride detections, the Wisconsin Department of Natural Resources (WDNR) requested that the PRP group evaluate alternatives to remediate groundwater at the site.

In October, 2005, a Focused Feasibility Study (FFS) was prepared to evaluate actions for remediating groundwater at the site using CERCLA guidelines. These guidelines emphasize the use of treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of waste. Appropriate technologies were initially screened based on short- and long-term effectiveness, implementability and cost. Alternatives were developed from the screened technologies and evaluated using the nine criteria specified in the CERCLA guidelines. Alternatives that were evaluated included municipal water supply, source control and deep aquifer remediation technologies. A source control alternative that included active gas extraction from the existing passive vents and leachate collection wells was implemented as an interim action in March, 2006. Based on the amount of time that has passed since preparation of the October 2005 FFS the WDNR requested that the FFS be updated again.

The alternatives evaluated under this updated FFS include:

- Alternative A – No Action
- Alternative B1 – Existing Gas Control with MNA
- Alternative B2 – Existing Gas Control with MNA and Municipal Water Contingency
- Alternative B3 – Existing Gas Control with Groundwater Pump & Treatment
- Alternative B4 – Existing Gas Control with In-Situ Groundwater Treatment and MNA
- Alternative C1 – Expanded Gas Control with MNA
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- Alternative C4 – Expanded Gas Control with In-Situ Groundwater Treatment and MNA

2.0 INTRODUCTION

2.1 Purpose

In 1994, a Feasibility Study (FS) was prepared for the FF/NN Landfill in Ripon, Wisconsin, which was based on the results of a Remedial Investigation (RI) that had been performed at the site. That FS examined landfill capping, leachate and gas extraction alternatives. It also looked at several groundwater pumping and treatment alternatives for shallow groundwater. The Record of Decision (ROD) issued by the WDNR in 1994 required the construction of a composite landfill cap and passive gas collection system; this work was completed in 1996. The ROD did not require the active remediation of groundwater because groundwater contamination that had migrated from the landfill did not present a significant enough risk to warrant active groundwater remedial measures.

During routine groundwater monitoring in the fall of 2001, a low concentration of vinyl chloride was detected in one private drinking water supply well located in the sandstone aquifer and approximately 1,500 feet down gradient of the FF/NN Landfill. Additional monitoring at a new home adjacent to this well indicated that its water supply well was also impacted. Immediately, the residents were provided with safe drinking water and interim point of entry treatment systems were installed and operated until the City extended municipal water to the affected residences. As a result of the vinyl chloride detections, the Wisconsin Department of Natural Resources (WDNR) requested that the PRP group evaluate alternatives to remediate groundwater at the site.

In October, 2005, a Focused Feasibility Study (FFS) was prepared to evaluate actions for remediating groundwater at the site using CERCLA guidelines. These guidelines emphasize the use of treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of waste. Appropriate technologies were initially screened and alternatives were identified and screened using the nine criteria specified in the CERCLA guidelines. Alternatives that were evaluated included municipal water supply, source control and deep aquifer remediation technologies. A source control alternative that included active gas extraction from the existing passive vents and leachate collection wells was implemented as an interim action in March, 2006. Based on the amount of time that has passed since preparation of the October 2005 FFS the WDNR requested that the FFS be updated again.

An FS is the mechanism for developing, screening, and evaluating in detail alternatives for remedial actions. The primary objective of this Focused FS for the FF/NN Landfill is to develop and evaluate remedial action alternatives that are capable of mitigating unacceptable environmental risks from impacted groundwater. The approach and structure of the Focused FS are in accordance with the U.S. Environmental Protection Agency's (EPA) *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (1988) and *Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites* (1991).

2.2 Background

2.2.1 Landfill History

Landfilling activities occurred at the site from 1967 to 1983. The land was leased from the property owner, Mr. Lyle Sauer, and subsequently, Mrs. Arlene Sauer. In 1967, Speed Queen leased the property for disposal of wastes from its facility in Ripon, Wisconsin. In 1968, the City of Ripon (City) leased the property. In 1978, the City and Town of Ripon (Town) were signatory to the lease. A license to operate the landfill (#467) was issued by the WDNR to the City in 1969. In 1970, the City and Town contracted to share the costs of operating the landfill. The landfill was operated by the City and Town from 1970 to 1983. Throughout its 16-year history, the landfill accepted municipal, commercial, and industrial solid waste. After landfill operations ceased, the site was capped with a clay cap in 1985. The City of Ripon is the current owner of the site.

2.2.2 NPL Inclusion

In 1982, the WDNR began evaluating the landfill for possible inclusion on the federal National Priorities List (NPL). In 1993, the FF/NN Landfill was proposed for listing on the NPL by the USEPA and was officially listed on May 31, 1994.

2.2.3 Remedial Investigation

A Remedial Investigation (RI) was conducted at the site by the PRP group and the final RI Report was completed in August, 1994. The RI found that five VOCs exceeded NR 140 Preventive Action Limits (PALs) and two, vinyl chloride and cis-1,2-dichloroethene, were present at concentrations which exceeded NR 140 Enforcement Standards (ESs). The lateral extent of shallow groundwater contamination was approximately 500 feet downgradient of the landfill and was limited to wells located immediately adjacent to or downgradient of the landfill. Contaminants present in the deeper groundwater were not shown to extend more than 1000 feet to the south of the landfill. No VOCs were present in any private water supply wells except at the former Bosveld residential well, which was located about 200 feet south of the landfill. Subsequently, this property was purchased by the City of Ripon and the well was properly abandoned.

2.2.4 Feasibility Study

In December, 1994, a Feasibility Study (FS) was completed for the site based on the results of the RI. The FS examined alternatives for landfill capping, leachate and gas extraction, and shallow groundwater extraction and treatment.

2.2.5 Record of Decision

A ROD was issued for this site on March 27, 1996. Specifically, the ROD describes the selected remedy as follows:

> *The Department of Natural Resources has evaluated remedial alternatives for two operable units at the site: a source control operable unit and a groundwater operable unit. The selected source control remedy is Alternative O, Composite Landfill Cap and Passive Gas Venting in conjunction with a groundwater monitoring plan. Details of the selected source control operable unit remedy can be found in the Feasibility Study. The specific components of the source control operable unit remedy include:*

- *constructing a composite landfill cover (i.e. a landfill cap made with both a plastic membrane and soil materials) over the entire landfill;*
- *installing a passive landfill gas venting system as part of the composite cap to effectively vent landfill gas from the waste;*
- *monitoring of the groundwater quality to determine the effectiveness of the landfill cap towards improving groundwater quality;*
- *monitoring the landfill gas probes around the landfill to make sure that landfill gas is not migrating away from the site in an uncontrolled manner;*
- *maintenance of the landfill cap to repair erosion that may develop;*
- *a deed restriction prohibiting disturbing the landfill cap except for maintenance purposes; and*
- *fencing of the landfill perimeter to restrict access.*

For the groundwater operable unit, the Department has selected Alternative A, the No Action Alternative. The groundwater contamination that has migrated from this landfill is not severe enough to warrant active groundwater remedial measures to restore groundwater quality. The implementation of the source control operable unit remedy will result in decreased migration of contaminants from the landfill to the groundwater.

2.2.6 Remedial Action

In 1996, in compliance with the ROD for this site, a composite membrane/clay cap was constructed on top of the existing clay cap. In addition, a passive gas collection system was installed within the landfill. The passive gas collection system includes a network of interconnected horizontal perforated pipes installed below the cap connected to 12 vertical gas venting pipes.

2.2.7 Post Remediation Monitoring

From 1996 to 2001, semi-annual groundwater monitoring with annual monitoring of private water supply wells was conducted. In October 2001, routine sampling detected a low concentration of vinyl chloride in a residential water supply well (Altnau, N8798 S. Koro Rd.). Follow-up sampling detected vinyl chloride in the water supply well of a recently built home (Ehster, W14271 Charles St.). Subsequent groundwater sampling events have confirmed that no detectable VOCs are present in any other private water supply wells located immediately down gradient of the landfill.

2.2.8 Private Water Supply Response Actions

The FF/NN Landfill PRP Group cooperated fully with the WDNR in responding to the 2001 vinyl chloride detections in the two residential wells. Initially, bottled water was provided to the two residences. Subsequently, air strippers with granular activated carbon treatment systems were installed at the two residences as an interim measure until the homes were hooked up to the municipal water supply.

In November 2002, a municipal water supply pipeline was extended from the City of Ripon along South Koro Road up to and along Charles Street by Alliant Energy (former owner/operator of Ripon water utility). The two homes with impacted wells (Altnau and Ehster) were connected to this municipal water supply, as well as a third home with a non-impacted water supply well

(Miller, N8756 S. Koro Rd.). Municipal water was also offered to the other residents on Charles Street. In 2004, the Hadel (W14292 Charles St) and Wiese (N8778 S. Koro Rd) homes were voluntarily connected to municipal water supply and their private wells were converted to piezometers for further monitoring purposes.

2.2.9 Supplemental Groundwater Investigation and Monitoring

A supplemental groundwater investigation was conducted to better define the horizontal and vertical extent of vinyl chloride impacts. Three deep piezometers were installed in 2002 at two locations downgradient of the landfill. P-111D was installed approximately 900 feet downgradient of the landfill to a depth of 148 feet and P-113A/P-113B were installed approximately 2,300 feet downgradient of the landfill to depths of 322 and 195 feet, respectively. In December 2003, a fourth deep piezometer (P-103D) was installed to a depth of 190 feet directly downgradient of the landfill and adjacent to the existing 103 well nest.

2.2.10 Landfill Gas Evaluation

In 2003, the WDNR requested that gas probes be installed outside the limits of waste to better observe any off-site migration of landfill gas. In 2004, 11 gas probes were installed around the landfill. Methane measurements at the probes and monitoring wells indicated concentrations that exceeded 25% of the lower explosive limit (LEL) at several locations outside the limits of the landfill. In addition, analysis of landfill gas samples indicated that vinyl chloride was present in several landfill gas samples, which was believed to serve as the source of vinyl chloride detected in groundwater.

2.2.11 Active Landfill Gas Extraction Interim Action

The presence of methane at concentrations greater than 25% of the LEL in gas probes located outside of the limits of filling within 200 feet of the landfill property boundary or beyond the landfill property boundary exceeds an ARAR for the site, section NR504.04(4)(e) of the Wisconsin Administrative Code (WAC). In response to the elevated methane levels, pilot testing of active gas extraction was performed in June of 2005. The pilot test demonstrated that conversion of the passive gas control system into an active gas extraction system was feasible. Based upon the results of the pilot test the FF/NN Landfill PRP Group performed an Interim Action by installing an active gas removal system which utilizes the existing passive gas collection system in the landfill. The design for this remedial system was submitted to the WDNR for review and was conditionally approved in October, 2005.

The interim active gas extraction system was installed and started up at the site in March, 2006 using temporary above ground piping to connect the existing gas vents and leachate head wells to a blower. In January, 2007 the piping was buried to prevent condensate freezing and facilitate year-round operation. A performance evaluation report was submitted in July, 2007 indicating that the system was performing well and achieving the following desired affects:

- System operation had reduced the landfill methane gas concentrations outside the limits of fill to below 25% of the LEL,
- Methane concentrations measured within the landfill had been reduced from an average of approximately 52% methane in 2006 down to 11.4% in June 2007,
- Vinyl chloride concentrations within the landfill gas had been reduced to non-detectable levels in nearly all gas extraction vents and leachate wells, and

- Vinyl chloride concentrations in groundwater indicated decreasing or stable trends in nearly all of the groundwater monitoring wells.

Based on the results of the performance evaluation it was recommended by the FF/NN Landfill PRP Group that the interim gas extraction system be selected as the final remedy for source control for the FF/NN Landfill (Alternative C1 of the Focused Feasibility Study modified to include the leachate head wells as part of the gas extraction system). The WDNR corresponded in October, 2007 that the landfill gases have been contained within the landfill boundary and are no longer escaping from the sides of the landfill in compliance with NR507. Regarding the groundwater, the WDNR recommended that additional groundwater sampling be collected through the April 2008 sampling event. An updated performance evaluation was submitted in July, 2008 demonstrating that since the start-up of the interim gas extraction system, vinyl chloride concentrations in groundwater had decreased in all wells where it was detected except for only one well.

2.2.12 Institutional Control Plan

An Institutional Control Plan (February 24, 2011) was prepared for the site and conditionally approved by WDNR on April 13, 2011. The plan provides a comprehensive approach to limiting human exposure to contaminants from the FF/NN Landfill NPL Site through implementation of institutional controls (ICs) until the potential for exposure has been eliminated. The monitoring of ICs is designed to determine: 1) whether the IC mechanism remains in place and 2) whether the ICs are providing the protection required by the remedy. The components of monitoring include site groundwater monitoring, landfill gas monitoring, O&M monitoring and ICs monitoring.

2.3 Applicable or Relevant and Appropriate Requirements

A comprehensive listing of Potential Applicable or Relevant and Appropriate Requirements (ARARs) for the FF/NN Landfill site was identified in the 1994 FS. That listing was updated as part of the 2011 FFS, and is provided as Table 2-1.

2.4 Report Organization

The remainder of the Revised Focused FS consists of four sections. Section 3 summarizes existing conditions, including the geology, hydrogeology and contaminant characterization. Section 4 includes general response actions and technologies to meet the Remedial Action Objectives (RAOs). A screening evaluation of remedial technologies based on their applicability to the FF/NN Landfill is performed in Section 4 to identify the technologies retained for further evaluation. In Section 5, the appropriate remedial technologies are combined to form remedial alternatives, and these alternatives are evaluated further using the nine criteria in the NCP. Section 6 provides a comparison of the alternatives based on the NCP criteria.

3.0 EXISTING CONDITIONS

3.1 Topography

The Site is located in south central Wisconsin (Figure 3-1). The landscape slopes gently eastward. The landfill rises to the approximate elevation of County Trunk Highway (CTH) NN on the west [872 ft above mean sea level (msl)] and slopes downward to the east where it is approximately 20 feet lower (850 ft msl).

3.2 Geology

The Site is located in a glaciated area of south central Wisconsin. The area near the Site consists of poorly sorted ground and end moraine deposits. Outwash deposits of sand and gravel are evident in the Washkovick quarry located just west of the Site and the Northeast Asphalt quarry east of the site.

The geology in the vicinity of the site consists of approximately 150 to 220 feet of unconsolidated glacial deposits underlain by sandstone bedrock to a depth of 330 feet.. Geologic cross-sections are provided in Figures 3-2, 3-3 and 3-4. Site monitoring wells have been grouped into stratigraphic layers as follows: Layer 1 includes water table wells completed in the unconsolidated deposits and approximately 25 to 65 feet deep (821-812 ft msl); Layer 2 includes piezometers completed in the unconsolidated deposits and approximately 60 to 95 feet deep (791-774 ft msl); Layer 3 includes piezometers completed mostly in the upper sandstone bedrock and approximately 150 to 200 feet deep (704-681 ft msl); and Layer 4 includes piezometers completed in the sandstone bedrock and approximately 280 to 330 feet deep (570-508 ft msl).

The geology beneath the landfill is primarily sand with some silty and clayey lenses and gravel overlying bedrock. To the south of the landfill is a relatively thick clay deposit beginning near the P-103D well nest and increasing to a thickness of 100 to 130 feet to the south. The clay unit appears to restrict downgradient plume migration in the upper two layers but force plume migration deeper into Layer 3.

The bedrock is Cambrian-age sandstones of the Lone Rock and Wonewoc Formations (medium-grained sandstones approximately 150 feet thick at the site). The bedrock surface beneath the landfill occurs at an elevation of approximately 690 feet msl (175 feet deep). Approximately 1000 feet south of the landfill, the bedrock surface slopes to the south-southwest as part of a regional northeast-southwest trending bedrock valley. Beneath the sandstone is Precambrian-age granite and quartzite at a depth of 330 feet.

The glacial unconsolidated deposits and the Cambrian sandstone are the two principal aquifers present in the area surrounding the FF/NN Landfill area. The municipal wells and most private water supply wells use the sandstone as their water source. The lower limit of the Cambrian sandstone aquifer is delineated by the granite Precambrian basement at a depth of approximately 330 feet.

3.3 Hydrogeology

Depth to ground water is variable and dependent on topography and precipitation. Groundwater is present at depths ranging from approximately 5 to 50 feet below ground surface. The water table is located approximately 20 feet below the base of the landfill.

3.3.1 Groundwater Flow Direction

Site monitoring wells have been organized into four stratigraphic units based on well screen elevation and are labeled Layers 1 through 4. Table 3-1 provides the groupings for all wells. Figures 3-5, 3-6, 3-7 and 3-8 show the groundwater flow direction determined from groundwater elevations measured in July 2011. In Layers 1 and 2, the flow is generally to the southwest with average horizontal hydraulic gradients of 0.004 ft/ft and 0.005 ft/ft, respectively. In Layer 3, there is a southwesterly flow that turns westerly based on the potentiometric surfaces measured in P-113B and P-116. The average horizontal hydraulic gradient in Layer 3 is 0.002 ft/ft. Green Lake lies to the southwest and the lake may influence groundwater flow even at these depths. In Layer 4, flow was historically to the southeast when City of Ripon municipal water supply Well #9 was operating. When pumping at Well # 9 was terminated in May 2007, the flow direction reverted back to the west. The City brought Well # 9 back on line with a treatment system in April 2010 and as a result the groundwater flow direction has shifted to the south-southeast. The average horizontal hydraulic gradient in Layer 4 is 0.0006 ft/ft.

3.3.2 Vertical Hydraulic Gradient

There are 13 pairs of wells at ten locations that can provide vertical gradient information across the site. Of these 13 pairs, eight include a water table well. The average vertical gradients for each well pair are noted below based on measurements collected over the past five years. Near the landfill, there is generally an upward gradient in the shallow unconsolidated materials and a downward gradient in the deeper unconsolidated deposits and bedrock formations. Vertical gradients in deeper bedrock wells have become more downward in response to pumping at Municipal Well #9 that started back up in April 2010.

	Well Pairs	Five Year Average	Direction
Layer 1 to Layer 2	MW-101, P-101	0.001	Downward
	MW-102, P-102	-0.002	Upward
	MW-103, P-103	-0.056	Upward
	MW-104, P-104	-0.005	Upward
	MW-106, P-106	0.002	Downward
	MW-107, P-107	0.001	Downward
	MW-108, P-108	-0.097	Upward
	MW-111, P-111	0.012	Downward
Layer 2 to Layer 3	P-103, P-103D	0.006	Downward
	P-111, P-111D	-0.035	Upward
Layer 2 to Layer 4	P-107, P-107D	-0.002	Upward
Layer 3 to layer 4	P-113B, P-113A	-0.002	Upward
	MW-3B, MW-3A	0.004	Downward

3.3.3 Hydraulic Conductivity and Groundwater Velocity Calculations

Slug test data from the 1994 investigation indicated an average hydraulic conductivity of 2.5 x 10^{-2} ft/min (1.3 x 10^{-2} cm/sec) for sand and gravel deposits, and 2.9 x 10^{-3} ft/min (1.5 x 10^{-3} cm/sec) for sand and silt deposits.

In 2003 and 2004, slug testing was conducted in nine Layer 3 and 4 wells (four new wells, three converted private wells and two existing wells). Hydraulic conductivity values for Layers 3 and 4 ranged from 2.6 x 10^{-2} ft/min to 9.4 x 10^{-4} ft/min (1.3 x 10^{-2} cm/sec to 4.8 x 10^{-4} cm/sec) with a geometric mean of 3.7 x 10^{-3} ft/min (1.9 x 10^{-3} cm/sec).

The linear groundwater flow velocity was calculated for each layer using the range and geometric mean value for hydraulic conductivity and horizontal gradient. An average porosity of 20% and 10% was assumed for the unconsolidated deposits and sandstone bedrock, respectively. The resulting velocities are summarized below:

	Groundwater Flow Velocity (feet/year)		
	Low	High	Arithmetic Mean
Layer 1 Wells	0.02	708	99
Layer 2 Wells	0.24	1639	113
Layer 3 Wells	2.47	211	37
Layer 4 Wells	41.6	276	117
Arithmetic Mean			91
Arithmetic Mean without Layer 4			83

Note that the private water supply wells are located in Layer 3. The distance from the southern edge of the landfill to the impacted wells on Charles Street is approximately 1,500 feet. Dividing this distance by the arithmetic mean groundwater velocity of Layers 1 through 3 (83 feet per year), results in an estimated travel time of 18 years. This would place the contaminant release in about 1983, which is prior to the capping of the landfill. The travel time estimated from the groundwater velocities suggests that the release which impacted the private wells in 2001 occurred prior to capping of the landfill in 1985.

3.4 Groundwater Contamination

The contaminants of concern (COC) at the site have been primarily chlorinated volatile organic compounds (VOCs) including tetrachloroethene (PCE) and trichloroethene (TCE) and their reductive dechlorination byproducts 1,2-dichloroethene (1,2-DCE) and vinyl chloride (VC). Benzene has also been detected historically at concentrations exceeding the NR140 Preventive Action Limit (PAL); but never above the NR140 Enforcement Standard (ES) of 5 ug/L.

Historical groundwater monitoring results date back to 1993. The highest contaminant concentrations have been detected in Layer 1 water tables wells adjacent to the downgradient edge of the landfill (MW-103, MW-104 and MW-112). The maximum concentrations of COCs ever detected in these wells were 11 ug/L TCE, 1100 ug/L 1,2-DCE and 440 ug/L VC. The NR140 ESs for TCE and 1,2-DCE have never been exceeded in any well other than these three water table wells. Historically, VC has been detected in 13 site monitoring wells at concentrations above the NR140 ES including four Layer 1 wells (MW-103, MW-104, MW-108 and MW-112); three Layer 2 wells (P-102, P-103 and P-106); five Layer 3 wells (P-103D, P-111D, P-114, P-115 and MW-3B) and one Layer 4 well (P-107D). The downgradient extent of the VC plume is approximately 1500 feet south-southwest of the landfill in Layer 3.

With the implementation of source control measures including the composite cap in 1996 and the interim action active gas extraction system in 2006, concentrations of COCs have shown a steady decline in concentration. The most recent monitoring data (Oct 2011) is presented on Figures 3-5, 3-6, 3-7 and 3-8 and indicates the following:

	TCE	1,2-DCE	VC
Layer 1	**MW-103; 3.0 ug/L**	MW-103; 4.3 ug/L	
		MW-112; 1.4 ug/L	
Layer 2			
		P-111D; 1.4 ug/L	**P-111D; 4.5 ug/L**
		P-114; 1.2 ug/L	**P-114; 5.6 ug/L**
Layer 3			**P-115; 1.0 ug/L**
Layer 4			**P-107D; 1.8 ug/L**

Bold indicates PAL exceedances
Bold and shaded indicates ES exceedance

The vertical and horizontal extent of the vinyl chloride plume has been delineated with the existing monitoring well network. Vinyl chloride has been detected 1500 feet downgradient of the landfill (well P-114). There are two monitoring locations downgradient of this well (P-116 and P-113 nest) and neither location has ever had a detection of vinyl chloride in groundwater samples. In addition, there are two private wells downgradient of P-116 (Baneck and Gaastra) and one private well sidegradient (Rhode) and routine sampling since 2001 has never detected VC in any of these wells.

The quantity of contaminated groundwater is estimated to be about 27 million gallons (600 feet wide by 1500 feet long by 40 feet thick, with matrix porosity of 0.10). The total mass of vinyl chloride in the deep aquifer dissolved phase plume is estimated to be approximately one pound, assuming an average concentration of less than 5.0 ug/l.

3.5 Landfill Leachate

In the 1994 Feasibility Study, it was noted that leachate generation at the site was minimal and that attempts in 1994 to perform a pump test on the leachate wells were not successful. This lack of leachate generation continues at the site. Wells LC-1 and LC-3 routinely have no leachate in them. In July 2005, well LC-2 bailed dry after 1.5 gallons were removed. Historical sampling of LC-2 has never contained detectable concentrations of VC. In 2009, 2010 and 2011 leachate samples were able to be obtained from LC-3 which contained VC concentrations of 11.3 ug/L, 14.5 ug/L and 25.8 ug/L, respectively. Given these low concentrations and low leachate volumes, management of leachate as a source control alternative is not warranted.

3.6 Landfill Gas

Section NR 506.07(4), WAC requires that methane concentrations greater than the lower explosive limit (LEL), or 5%, should not occur outside the limits of the wastes. MW-101, MW-102 and MW-103 are the three monitoring points located outside of the limits of the wastes that have historically been used to sample for landfill gas at this site. MW-112, also outside the waste limits, was added to the monitoring program in 2002. For these four locations, the only one where the concentration of methane has ever exceeded the LEL is at MW-103 (Figure 3-9).

In 2004, 11 gas probes (GP-1 through GP-8 and GP-10 through GP-12) were installed within 150 feet of the perimeter of the waste on all four sides of the landfill (Figure 3-9). In 2004 and 2005 the LEL for methane was exceeded in four of these 11 probes (GP-1, GP-2, GP-3 and GP-7). GP-1 is located east of the landfill, GP-2 is located west of the landfill and GP-3 and GP-7 are located south of the landfill.

In May 2005, a pilot study was conducted to determine the effectiveness of using the existing passive gas vent piping as the collection system for an active landfill gas extraction system. The purpose of this system was to address the off-site migration of landfill gas and the transport of vinyl chloride. The pilot study demonstrated that off-site concentrations of methane could be controlled by converting the passive gas vents to an active gas extraction system. As an interim action the existing passive gas vents and leachate wells were connected to an air blower to create an active landfill gas extraction system that has been operating effectively since March, 2006.

Prior to active gas extraction beginning in 2006, the landfill gas composition as measured in the three leachate wells was approximately 62% methane and 36% carbon dioxide. Subsequent to active gas extraction the methane concentrations have decreased to a level ranging between 5-25% for LC-1 and LC-3 and 20-50% for LC-2. Annual increases in methane at the leachate wells are seen in the late summer to early fall months. The operation of the gas extraction system is seasonally adjusted to maximize landfill methane gas extraction while minimizing the introduction of atmospheric oxygen in order to maintain O_2 levels <5%.

Further monitoring of the gas probes and wells outside the limits of fill indicates that the gas extraction system has controlled methane gas migration from the fill area since startup in March 2006. Gas concentrations in all exterior wells and gas probes have been consistently below the methane LEL (5%), except at GP-1 (typically late summer to early fall). The methane concentration in GP-1 has been lowered below the LEL with increased operation of the gas extraction system. The WDNR corresponded in October, 2007 that the landfill gases have been contained within the landfill boundary and are no longer escaping from the sides of the landfill meaning the landfill is in compliance with NR507.

3.7 Continuing Source of Groundwater Contamination

Assuming the FF/NN Landfill is the continuing source of vinyl chloride in groundwater, then one or more of these pathways must be operating:

1. Direct contact of wastes with groundwater (i.e., the depth of wastes extends below the water table).
2. Leachate migration from the landfill to groundwater,
3. Transfer of VOCs contained in landfill gas to groundwater,

Each of these pathways is discussed in more detail below.

3.7.1 Groundwater Contact with Waste Pathway

The base of the landfill is located approximately 20 feet above the water table. As a result, there is not now, nor has there ever been in the past, direct contact between the contents of the landfill and groundwater at the site. Therefore, the first pathway does not appear to be the cause of continued contamination from this site.

3.7.2 Leachate Pathway

During the years 1967 to 1983, when the landfill was accepting waste materials, there was no cap over the existing wastes, therefore leachate generation was at its greatest and the potential for leachate entering groundwater was also at its highest. In 1985 the landfill was capped with clay material. A composite cap was constructed over the landfill in 1996 and the levels of leachate in the leachate wells have fallen by 3 to 8 feet since then. This is consistent with the fact that the composite cap allows a negligible quantity of precipitation to enter the top of the landfill to produce leachate. LC-1 and LC-3 in the thickest portion of the landfill have generally been dry or have only had a few inches of water. LC-2 has had a few feet of water but was found to bail dry after removing 1.5 gallons. The construction logs for these wells indicate that they actually extend beneath the bottom of the wastes in the landfill, which indicates that there is negligible leachate in the landfill at these locations.

Grab samples of water in LC-2 and LC-3 were collected in April 2011. At LC-2, the only site COC detected was benzene at 17 ug/L. At LC-3, the site COCs detected included TCE at 19.6 ug/L, 1,2-DCE at 373 ug/L and VC at 25.8 ug/L, but the amount of water in LC-3 was evacuated dry during grab sampling. The low quantity and COC concentrations of the leachate indicate that leachate is not significant contributor of contaminants to the groundwater. This is supported by groundwater monitoring results from MW-103, MW-104 and MW-112 at the perimeter of the landfill and downgradient of LC-2 and LC-3 that show site COCs have decreased to concentrations below NR140 ES. While leachate generation may have been a source of groundwater contaminants in the past it does not appear to be an ongoing transport mechanism.

3.7.3 Landfill Gas Pathway

Gas samples collected from gas probe GP-3 located adjacent to groundwater monitoring well MW-112 at the southwest corner of the landfill showed very high levels of VC in samples collected in September, 2004 (25,400 ppbv) and January, 2005 (12,600 ppbv). Because there were high levels of VC in landfill gas being generated by the landfill, the transfer of VOCs from the landfill gas to groundwater appeared to be the most likely ongoing transport mechanism of groundwater contamination. The transfer of VOCs from landfill gas to groundwater can occur through direct contact of the gas with groundwater and/or through VOCs in gas condensing out and leaching to groundwater.

Subsequent to implementation of the interim action active gas extraction system in March, 2006, additional gas sampling has been conducted. Landfill gas VC concentrations have dropped as follows:

- from 25,400 ppbv to non-detectable levels in GP-3
- from 3,590 ppbv to 4.2 ppbv in gas vent GV-6
- from 130 ppbv to non-detectable levels in LC-1
- from 166 ppbv to non-detectable levels in LC-2

- from 172,000 ppbv to 11,000 ppbv in LC-3

Coincident with the extraction and reduction of VC in the landfill gas, VC concentrations in groundwater monitoring wells near the source have been reduced to non-detectable levels indicating that VC in landfill gas was the source of continuing groundwater contamination after the landfill cap was upgraded in 1996. These results confirm that the interim action active gas extraction system is performing as an effective groundwater source control and remedial measure for the site.

4.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

4.1 Overview

The purpose of this section is to identify site-specific Remedial Action Objectives (RAOs), General Response Actions (GRAs), and specific technologies which may be appropriate for the identified RAOs and GRAs for the site. After development of the RAOs and GRAs, the identified remedial technologies are screened to eliminate those which are inappropriate for inclusion in specific integrated alternatives. CERCLA guidelines emphasize the use of treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of waste. The technologies identified which satisfy the criteria and appear acceptable as components of final remedial actions will be retained for further evaluation and potential inclusion in remedial alternatives developed for the site.

4.2 Remedial Action Objectives

Based upon the conditions at the time of the 2011 FFS preparation, RAOs were developed for two operable units at the site. The two operable units include source control and groundwater.

4.2.1 Source Control RAOs

The existing composite landfill cap addresses and satisfies many of the RAOs associated with source control including preventing direct contact with the waste, minimizing infiltration and resulting contaminant leaching to groundwater, and controlling surface water run-off and erosion. While collecting and treating leachate is a presumptive remedy for landfills, historic and current conditions at the site indicate the lack of leachate makes this RAO inapplicable. The RAO of controlling landfill methane and vinyl chloride gas was not being achieved with the passive gas control system but with the implementation of interim active gas extraction beginning in 2006, landfill gas is now being actively controlled at the site. The interim system has achieved both a reduction of landfill methane gas inside and outside the limits of fill bringing the landfill into compliance with NR 507 and the removal of landfill gas containing VC which has resulted in a subsequent reduction of VC concentrations in groundwater adjacent to and downgradient of the landfill. Because active gas extraction is operating as an interim action and has not yet been selected as a final remedy, maintaining active gas control was established as an RAO for the site in the 2011 FFS.

4.2.2 Groundwater RAOs

Groundwater RAOs are driven by NR 140 groundwater quality requirements and standards. The NR 140 standards are, by definition, protective of human health and the environment. Therefore the RAO for groundwater is to restore contaminated groundwater to below NR 140 Preventive Action Limits within a reasonable period of time.

4.3 General Response Actions

GRAs have been developed for each operable unit in order to satisfy the RAOs.

4.3.1 Source Control GRAs

In order to meet the RAOs for the source control operable unit the following is the proposed GRA:

- Landfill Methane and VOC Gas Recovery

4.3.2 Groundwater GRAs

In order to meet the RAOs for the groundwater operable unit the following are the proposed GRAs:

- Groundwater Extraction, Treatment and Discharge
- In-Situ Treatment of Groundwater

4.4 Identification and Screening of Process Types and Options

Process types and options for each of these general response actions are described briefly below. Table 4-1 lists the general response actions and provides an initial screening of the technologies that should be considered further for this site.

4.4.1 No Action

The No Further Action alternative provides a baseline against which other alternatives are compared. Under this alternative, no action would be taken to alter current conditions at the FF/NN which entails no cost. No construction, operation, maintenance or monitoring of remedial measures would be required. Under the No Further Action alternative, groundwater contamination and landfill gas at the FF/NN Landfill is assumed to remain in its current condition.

4.4.2 Landfill Gas Recovery

Passive Landfill Gas Venting

Landfill gas control was evaluated under the 1994 FS and passive gas control without treatment was selected as part of the remedy. However, landfill gas at levels greater than 25% of the LEL were present more than 135 feet outside the limits of fill, indicating that the passive gas collection system was not sufficient to control the migration of landfill gas. Therefore, passive landfill gas control will not be carried forward.

Active Landfill Gas Extraction

This general response action is used to control the movement of landfill gas and prevent its migration beyond the boundaries of the waste in excess of standards. Because the landfill gas contains vinyl chloride which is a source of groundwater contamination, a gas control system also serves as a VOC source control remedy by reducing the flux of vinyl chloride into the groundwater. Active landfill gas recovery was implemented as an interim action in 2006 because the passive gas venting system was not preventing the migration of methane beyond the boundaries of waste. Active landfill gas recovery provides gas control but it also serves as a remedy for groundwater because of its demonstrated ability to reduce the source of vinyl chloride groundwater contamination. Therefore, active landfill gas recovery will be carried forward.

Landfill Gas Treatment

Section NR 419.07 WAC requires air emission controls for a landfill gas extraction system if VOC emissions exceed 216 pounds per day or if a source emits more than 300 pounds per year of vinyl chloride (see ch. NR 445, Table 3, Hazardous Air Contaminants without Acceptable Ambient Concentrations Requiring Application of LAER or BACT). During the active gas extraction pilot study, off gases from the extraction system were analyzed for VOCs, including vinyl chloride. Total VOCs (total hydrocarbons as gas) were approximately 11.5 ppmv, and vinyl chloride was found to be between 1.0 and 3.0 ppmv. Based on the pilot test results, at an extraction rate of about 170 cubic feet per minute and an average VOC emission rate of 11.5 ppmv, the estimated average emission rate for VOCs is 0.025 lb/hr, 0.61 lb/day, or 223 lb/year (well below the 216 lb/day limit). For vinyl chloride at a worst case maximum concentration of 3.0 ppmv, the estimated average emission rate would be 0.0045 lb/hr, 0.11 lb/day or 40 lb/year (well below the 300 lb/year limit). During the past five years of interim gas extraction system operation an average of approximately 28 pounds of vinyl chloride have been removed per year. At this rate air emission controls for VOCs or vinyl chloride are not required for long-term operation of an active gas extraction system. Therefore, landfill gas treatment is not carried forward.

4.4.3 Groundwater Extraction, Treatment and Discharge

This general response action is used to reduce contaminant mass and the migration of impacted groundwater by hydraulic control. This general response action combines groundwater extraction with ex-situ treatment and discharge of the treated groundwater, but does not address the source of vinyl chloride within the landfill.

<u>Groundwater Extraction</u>

Groundwater extraction process options include extraction wells and horizontal trenches or drains. Groundwater extraction uses one or more pumps to draw contaminated groundwater to the surface for subsequent treatment. The extraction of groundwater forms a cone of depression in the water table or potentiometric surface providing hydraulic control of the contaminant plume. Because of the depth of vinyl chloride contamination (150 to 300 feet deep), horizontal interceptor trenches and drains are impractical to construct and not cost effective, and were therefore not carried forward.

<u>Groundwater Treatment</u>

The types of processes for treatment of groundwater containing VOCs include physical/chemical and biological treatment. Physical/chemical treatment options include air stripping and carbon adsorption. Air stripping involves blowing a stream of ambient air through impacted groundwater which volatilizes the organic compounds, transferring the VOCs from the dissolved phase to the vapor phase. Carbon adsorption involves pumping extracted groundwater through a series of canisters containing granular activated carbon which adsorbs the dissolved organic contaminants. The primary contaminant of concern at the Site is vinyl chloride which is more effectively treated with air stripping than absorption, therefore carbon adsorption will not be carried forward.

Biological treatment includes both aerobic and anaerobic processes. In *ex-situ* biological treatment processes, impacted groundwater is put into contact with microorganisms in biological reactors in which the microorganisms are either suspended or are attached to the reactor. In suspended systems, such as activated sludge, the groundwater is circulated in an aeration basin. In attached systems, such as trickling filters, microorganisms are established on an inert support matrix. This is a well-developed technology that has been used for many decades in the treatment of municipal wastewater. However, only in the last decade have bioreactors been used to clean up sites impacted with VOCs, typically only those that can be destroyed by aerobic processes. This technology would be relatively difficult to implement at this Site because of the low concentration of VOCs that would not support an adequate microbial population density. In addition, the large quantity of impacted groundwater at this Site would require the construction of large bioreactors that would not be cost effective to construct or operate. Therefore, ex-situ biological treatment will not be carried forward.

Treated Groundwater Discharge
The process options for discharge of treated groundwater include direct discharge to surface waters, indirect discharge to surface water through the City of Ripon POTW, or discharge to groundwater through an infiltration gallery. The City of Ripon POTW is not able to handle the increased volume; therefore this option is not carried forward. Discharge to an infiltration gallery allows treated water to percolate through the soil and recharge to the underlying aquifer. Due to potential problems with clogging, cold weather maintenance, permitting and unsuitable surficial soils, this option will not be carried forward. Options for direct surface water discharge include the wetlands (300 feet southwest of the landfill) or Silver Creek (1500 feet southwest of the landfill). These options are carried forward for further consideration, but are feasible only if access to those off-site properties can be obtained to install and maintain discharge lines.

4.4.4 *In-Situ* Groundwater Treatment

The types of processes for in-situ treatment of groundwater containing VOCs include physical/chemical, biological and natural attenuation.

Physical/Chemical Treatment
Physical/chemical in-situ treatment options include in-well air stripping, permeable reactive barriers and chemical oxidation.

In-well vapor stripping, also known as in situ vapor or in situ air stripping, is a technology for the in situ remediation of ground-water contaminated by VOCs. The in-well stripping process, an extension of air sparging technology, involves the creation of a ground-water circulation cell around a well through which contaminated ground-water is cycled. The air stripping well is a double-cased well ("well-within-a-well") with hydraulically separated upper and lower screened intervals within the same saturated zone (aquifer). The lower screen, through which ground-water enters, is placed at or near the bottom of the contaminated aquifer and the upper screen, through which ground-water is discharged, is installed across or above the water table. A related technology is ART in-well air stripping that combines in-situ air stripping, air sparging, soil vapor extraction and enhanced bioremediation/oxidation plus subsurface circulation. Cooper has had success with the ART in-well systems at other sites and therefore this technology will be carried forward.

A permeable reactive barrier (PRB) is a wall built below the surface to allow impacted groundwater to flow through it. Reactive materials are built into the wall to trap VOCs or to convert VOCs to harmless chemicals. Treated groundwater then flows through to the other side of the wall. Reactive treatment walls work best at sites with loose, sandy soil and a steady flow of groundwater. This is a proven technology and has the benefits of no above ground equipment to maintain. Reactive treatment walls need to span the width and depth of the plume unless a funnel and gate is installed: an impermeable wall funnels water to the PRB through a narrow opening). This technology would be very difficult and expensive to implement at the Site due to the depth of the plume and geologic conditions, therefore it is not carried forward.

Chemical oxidation involves the injection into the subsurface of chemicals which have a high oxidizing potential to degrade the organic contamination to carbon dioxide, chlorine and water. The technology has been used to treat chlorinated solvent constituents. The technology is typically applied for the treatment of a source area, and has only been applied to large-scale sites on a limited basis. Chemical oxidants include hydrogen peroxide, Fenton's reagent and permanganate. These oxidants are injected in a tight grid pattern throughout the area requiring treatment. Because of the very dilute concentrations of vinyl chloride, and the depth and size of the contaminant plume, chemical oxidation is not appropriate for this Site and is therefore not carried forward.

Biological Treatment

In-situ biological treatment options include enhanced bioremediation or bioaugmentation. Bioremediation is a process in which indigenous or inoculated microorganisms (i.e., fungi, bacteria, and other microbes) transform organic materials in groundwater. Enhanced bioremediation is a process that attempts to accelerate the natural biodegradation process by providing nutrients and electron donors (such as lactate, molasses or vegetable oil) whose absence or limited availability may otherwise be limiting the rate of conversion of organics to non-toxic end products. Bioaugmentation goes a step further and adds microorganisms that will degrade site contaminants to augment the indigenous bacteria. Enhanced/augmented bioremediation would be difficult and expensive to implement for the contaminants in the sandstone aquifer because of the depth and width of the plume, therefore this alternative will not be carried forward.

Natural Attenuation

Under the monitored natural attenuation (MNA) treatment option, natural subsurface processes such as dilution, volatilization, biodegradation, absorption, adsorption, and other chemical reactions with subsurface materials, degrade contaminants or limit their movement in the subsurface. Natural attenuation is not the same as "no action," although some perceive it as such. MNA requires an adequate, long-term monitoring program that confirms the natural attenuation processes are protecting public health, welfare and the environment until cleanup standards are ultimately met.

The primary line of evidence that natural attenuation of an organic contaminant is occurring is indicated by a significant decrease in contaminant concentrations over time, or by a significant decrease in chemical concentrations along a groundwater flow path down-gradient from a source area. As demonstrated by routine quarterly groundwater monitoring at the Site, there has been a significant decrease in contaminant concentrations in groundwater over time.

The current condition at the Site is that the parent product trichloroethene has totally degraded to non-detectable levels in 5 of 7 wells and in the 2 wells where it is still present (MW-103 and MW-112) it is at a concentration below the ES. The trichloroethene daughter product cis-1,2-dichloroethene has totally degraded to non-detectable levels in 6 of 11 wells and in the 5 wells where it is still present it is at a concentration below the PAL. The remaining daughter product vinyl chloride has totally degraded to non-detectable levels in 6 of 13 wells and in the 7 wells that it is still present the highest concentration is 5.8 ug/L (P-114).

Indirect (i.e., secondary) lines of evidence that support MNA typically include trends in geochemical or redox indicators which demonstrate biodegradation is occurring down-gradient from a source area, or an increase in daughter product concentrations down-gradient from a source area. Under anaerobic conditions, chlorinated VOC's can be biodegraded by reductive dechlorination which entails the sequential replacement of chlorine atoms by hydrogen to produce more reduced, less-chlorinated products. Rates of reduction are highest for the more chlorinated compounds like trichloroethene and decrease with the degree of chlorination to a point when oxidation rates become faster. While the reductive dechlorination of trichloroethene and cis-1,2-dichloroethene are dominated by anaerobic processes, the reduction of vinyl chloride is typically an aerobic process, although anaerobic microbial vinyl chloride oxidation can occur under iron-reducing conditions.

At the Site the parent and first-order daughter product, trichloroethene and cis-1,2-dichloroethene, respectively, have been nearly totally degraded and the only daughter product remaining above the ES is vinyl chloride. The vinyl chloride is only present in the deepest (Layers 3 and 4) and furthest wells from the Site. Sequential anaerobic/aerobic biodegradation of trichloroethene can take place as reductive dechlorination proceeds under anaerobic conditions and then the dechlorination by-product (vinyl chloride) flows out of the anaerobic zone (possibly created by the landfill plume) and into a more aerobic background environment. In the Layer 3 and 4 groundwater units the dissolved oxygen has historically been >0.5 mg/L but <2.0 mg/L. Dissolved oxygen greater than 0.5 mg/L is considered an aerobic state (EPA, 1998), which would not promote reductive dechlorination but could oxidize vinyl chloride aerobically.

Showing that MNA will adequately address the remaining vinyl chloride requires that conditions for attenuation of vinyl chloride are present, and that the vinyl chloride plume is either stable or receding. The fact that vinyl chloride migrated to the location of the private homes on Charles Street in 2001 indicates that natural attenuation was not sufficient by itself to prevent the migration of vinyl chloride from the Site. However, with the implementation of active gas extraction, the source of vinyl chloride has been significantly reduced and/or eliminated and groundwater quality has substantially improved making it appropriate to consider MNA as a viable remedy for the site. Therefore MNA will be carried forward for further consideration.

4.4.5 Alternative Water Supply

Process options for alternative water supply include municipal water, residential point-of-entry (POE) treatment systems, bottled water and relocating/deepening wells. In November 2002, a municipal water supply pipeline was extended from the City of Ripon along South Koro Road up to and along Charles Street by Alliant Energy (former owner/operator of Ripon water utility). The two homes with impacted wells (Altnau and Ehster) were connected to this municipal water supply, as well as a third home with a non-impacted water supply (Miller, N8756 S. Koro Rd.). Municipal water was also offered to the other residents on Charles Street. In 2004, the Hadel (W14292 Charles St) and Wiese (N8778 S. Koro Rd) homes were voluntarily connected to municipal water supply. The responsible parties paid for the initial capital costs of the extension and hook-up and the home owners are responsible for any ongoing operation and maintenance costs. Additional homes could be readily connected to the municipal water supply system if their wells became impacted. If a currently used private well becomes contaminated, municipal water will be offered and an attempt will be made to connect the user to the municipal water supply voluntarily. If the well owner refuses, then the next option would be to offer to replace the well if that option could provide safe, reliable water. If that option is refused or not viable then the next option would be to offer a home POE treatment unit that the responsible parties would maintain. Bottled water would also be viable as a short-term immediate measure for a residence until a permanent alternative water supply is provided. Therefore, municipal water supply, well replacement, POE treatment systems and bottled water are carried forward.

5.0 DEVELOPMENT AND ANALYSIS OF REMEDIAL TECHNOLOGIES

5.1 Introduction

This section presents a more detailed description and analysis of the remedial options selected for further evaluation as part of the initial screening presented in Section 4.0 of this FFS. The analysis assesses each remedial alternative against a set of evaluation criteria outlined in the National Contingency Plan (NCP). This approach provides information to the WDNR and U.S. EPA sufficient to compare the alternatives and select an appropriate remedy for the Site. Criteria for evaluating remedial alternatives and the description and screening of the alternatives are discussed below.

5.2 Evaluation Criteria

In accordance with Section 121 of CERCLA, nine criteria are used as the basis for analysis and evaluation of each of the remedial alternatives during the FFS. The first two criteria are threshold criteria:

- Compliance with ARARs
- Overall protection of human health and environment

A potential remedy must meet these criteria in order to undergo further consideration.

The next five criteria are primary balancing criteria and include the following:

- Short-term effectiveness
- Long-term effectiveness and performance
- Reduction of toxicity, mobility, and volume of materials
- Implementability
- Cost

These are the primary criteria used to analyze and compare the alternatives.

The remaining two criteria are modifying considerations and include the following:

- State (support agency) acceptance
- Community acceptance

The following describe the nine evaluation criteria used in the analysis of alternatives.

5.2.1 Compliance with ARARs

This criterion is used to determine how each alternative complies with applicable regulations. Potential ARARs for the FF/NN Landfill are listed on Table 2-1.

5.2.2 Overall Protection of Human Health and Environment

This evaluation criterion provides a final check to assess whether each alternative provides adequate protection of human health and the environment. The overall assessment of protection draws on the assessments conducted under other criteria, especially the primary criteria of long-term effectiveness and permanence and short-term effects, and compliance with ARARs.

Evaluation of the overall effectiveness of an alternative will focus on whether a specific alternative achieves adequate protection and will describe how site risks posed through each pathway addressed by the FFS are eliminated, reduced, or controlled through treatment, engineering or institutional controls.

5.2.3 Short-Term Effectiveness

This evaluation criterion involves assessment of the effects of the alternative during construction and implementation. Items of concern are the protection of the community and the workers during implementation of remedial measures, potential adverse environmental impacts, and the time required to achieve RAOs.

5.2.4 Long-Term Effectiveness and Permanence

This evaluation criterion involves consideration of the risks that remain after the Site has been cleaned up to acceptable levels as indicated in the RAOs. Items of concern are the presence of any receptors near the Site, magnitude of the remaining risk from untreated waste or treatment residuals, adequacy of controls that are used to manage treatment residuals or untreated waste, and reliability of these controls.

5.2.5 Reduction of Toxicity, Mobility, and Volume of Material

Consideration of this evaluation criterion is a result of statutory preference for selecting remedial actions that permanently and significantly reduce the toxicity, mobility, and volume of the materials and associated media.

The following factors are considered in this evaluation:

- The treatment process and materials they will treat.
- The amount of materials that will be treated.
- The degree of reduction in toxicity, mobility, or volume expected.
- The degree to which treatment will be irreversible.
- The type and quantity of materials that remain after remediation.

5.2.6 Implementability

This criterion considers the technical and administrative feasibility of implementing an alternative. Technical aspects evaluated for each alternative include construction and operation activities, reliability of the technologies involved, ease of undertaking additional remedial action, and monitoring after completion of activities. Administrative concerns include the need to obtain approvals from appropriate agencies to implement remedial actions (e.g., obtaining permits for construction and operation of a treatment unit). Other factors that must be considered when evaluating implementability of an alternative include availability of materials and equipment needed.

5.2.7 Cost

A remedial cleanup program must be implemented and operated in a cost-effective manner. In considering the cost-effectiveness of the various alternatives, the following categories are evaluated:

- *Capital Costs.* These costs include direct (construction) and indirect (non-construction and overhead) costs. Direct costs include expenditures for equipment, labor, and materials necessary to install remedial actions. Indirect costs are those that may be incurred for engineering, permitting, financial, or other services and that are necessary for completion of the activity but are not directly the result of the installation of remedial systems.

- *Operations and Maintenance (O&M) Costs.* These are post-construction costs incurred to ensure effective implementation of the alternative. Such costs may include, but are not limited to charges for maintenance materials, labor for operating and maintenance, energy, disposal of residues, administration, insurance, and licensing. The O&M costs include system and groundwater monitoring associated with measuring the effectiveness of remedial activities. Cost items may include sampling labor, laboratory analyses, and report preparation.

The capital and O&M costs for each alternative are prepared to provide an accuracy of -50 to +30%. The present-worth value method (2011 dollars basis) is utilized to evaluate the total cost of implementing a remedial alternative. The present-worth was calculated based on a project life of 30 years and a 5 percent discount rate.

5.2.8 State (Support Agency) Acceptance

This assessment evaluates the technical and administrative issues and concerns the state (or support agency in the case of State-lead sites) may have regarding each of the alternatives. If the support agency comments on the FFS are available by the time of the proposed plan they may be addressed in the Proposed Plan and will be addressed in the ROD amendment.

5.2.9 Community Acceptance

This assessment evaluates the issues and concerns the public may have regarding each of the alternatives. As with state acceptance, this criterion will be addressed in the ROD amendment once comments on the FFS report and proposed plan have been received.

5.3 Description and Evaluation of Remedial Alternatives

Based on the retained process options, nine remedial alternatives have been selected as appropriate for the Site:

- Alternative A – No Further Action
- Alternative B1 – Existing Gas Control with MNA
- Alternative B2 – Existing Gas Control with MNA and Municipal Water Contingency
- Alternative B3 – Existing Gas Control with Groundwater Pump & Treatment
- Alternative B4 – Existing Gas Control with In-Situ Groundwater Treatment and MNA
- Alternative C1 – Expanded Gas Control with MNA
- Alternative C2 – Expanded Gas Control with MNA and Municipal Water Contingency
- Alternative C3 – Expanded Gas Control with Groundwater Pump & Treatment
- Alternative C4 – Expanded Gas Control with In-Situ Groundwater Treatment and MNA

5.3.1 Alternative A - No Further Action

5.3.1.1 Description

Alternative A consists of No Further Action. The No Further Action alternative is required by the NCP. The No Further Action alternative provides a baseline against which other alternatives are compared. Under this alternative, no action would be taken to alter current conditions at the FF/NN. No construction, operation, maintenance or monitoring of remedial measures would be required. Under the No Further Action alternative, groundwater contamination and landfill gas at the FF/NN Landfill is assumed to remain in its current condition.

5.3.1.2 Detailed Evaluation

Compliance with ARARs: Chemical-specific ARARs have been identified for groundwater and landfill gas. Under the No Further Action alternative, these chemical-specific ARARs would continue to be exceeded in many areas of the site, including areas considered for groundwater and landfill gas remediation. No location- or action-specific ARARs exist for the No Further Action alternative because, as part of the alternative, no actions would be taken to address the contamination at the site.

Overall Protection of Human Health and the Environment: The No Further Action alternative does not eliminate, reduce, or control exposure to contaminated groundwater and landfill gas. The No Further Action alternative does not attain the RAOs and is not protective of human health.

Short-Term Effectiveness: The No Further Action alternative would not result in additional short-term risks to the community, remediation workers, or environment above baseline conditions because no actions would be conducted. However, RAOs would not be met at the source, landfill gas or groundwater under this alternative.

Long-Term Effectiveness and Permanence: Existing residual groundwater contamination at the site poses potential human health risks under current and likely future land use scenarios. Under the No Further Action alternative, these potential risks would remain over the long term for expected land uses. Additional risks would occur if incompatible land uses and unanticipated groundwater use as a drinking water supply were allowed.

Reduction of Toxicity, Mobility, or Volume: The No Further Action alternative would not result in a reduction in toxicity, mobility, or volume of contaminants through the use of treatment options. No contaminant treatment is proposed as part of the alternative.

Implementability: The No Further Action alternative is readily implemented because no actions would need to be taken.

Cost: There are no costs associated with the No Further Action alternative.

5.3.2 Alternative B1 – Existing Gas Control with MNA

5.3.2.1 Description

Alternative B1 includes the existing interim action active landfill gas recovery system for source control and MNA for the remaining VOCs above groundwater standards throughout the entire plume area. The existing interim action system uses existing vents and leachate wells to prevent the migration of explosive gases generated by the waste fill and to serve as a VOC source control remedy by reducing the flux of vinyl chloride from landfill gas into the groundwater. The existing active gas extraction system includes a trailer-mounted blower unit which is connected to the former passive gas venting system and the three existing leachate wells. The passive gas venting system includes a series of vertical gas vents connected to a network of horizontal collection lines installed in a gas venting layer beneath the geomembrane cap (Figure 3-9). The leachate wells extend through the entire thickness of the waste and are completed as 4-inch diameter wells installed within 10-inch diameter boreholes. The layout for the interim action gas control system is provided on Figure 5-1.

This alternative would also include the current monitoring program for the FF/NN Landfill that has been modified over the years and required under the existing ROD. The required monitoring includes inspection of the landfill cap and sampling and analysis of groundwater monitoring wells, private water supply wells and leachate wells. Landfill gas monitoring was not part of the ROD but was incorporated into the monitoring plan with implementation of the interim action gas extraction system. In addition, monitoring of institutional controls was added as part of the February, 2011 ICP. Continuation of these monitoring tasks is included as a component of all of the alternatives except the No Action alternative.

5.3.2.2 Detailed Evaluation

Compliance with ARARs: The interim action active gas recovery system component of Alternative B1, meets the landfill methane gas control requirements of ch. NR506. This alternative has also already demonstrated a reduction in the transport of vinyl chloride into the groundwater. With the source of vinyl chloride reduced, the remaining groundwater that has already been impacted with vinyl chloride has also begun to show a reduction due to natural attenuation. Continued monitoring will show whether the vinyl chloride plume will continue to contract or remain stable. Under this alternative, contaminant concentrations in the sandstone aquifer may remain above the NR140 PAL for vinyl chloride for some period of time (15 to 30 years).

Overall Protection of Human Health and the Environment: An active gas extraction system is expected to be protective of human health and the environment over the long term as it will reduce or eliminate the source of vinyl chloride impacts in the groundwater. Because it apparently took 18 to 30 years for the vinyl chloride plume in the sandstone aquifer to reach its current extent, the NR140 PAL for vinyl chloride is not expected to be met for at least 15 years.

Short Term Effectiveness: There would be no significant exposure of construction workers or the public to contaminants because the system has already been constructed and operated since 2006.

Long Term Effectiveness and Permanence: The long term effectiveness of an active gas extraction system is that it prevents the migration of methane beyond the boundaries of the landfill and reduces the potential for groundwater to be impacted with VOCs, especially vinyl chloride. Active gas extraction will be required until the landfill is no longer generating an amount of methane that could potentially migrate beyond the property boundary and vinyl chloride gas that could potentially impact groundwater.

Reduction of Toxicity, Mobility or Volume through Treatment: The active landfill gas extraction system would remove landfill methane gas from the landfill and reduce the introduction of VOCs, particularly vinyl chloride in groundwater. Treatment of the extracted gases is not required because the emissions are below the NR445 threshold for vinyl chloride. As indicated in section 4.4.2, a landfill gas extraction system will remove about 28 pounds of vinyl chloride annually from the subsurface, well below the 300 pounds per year emission limit. The methane concentrations in the extracted gas are too low to support flaring.

Implementability: This alternative has already been implemented.

Cost: Because Alternative B1 has already been implemented there are no additional capital costs, just ongoing operation and maintenance costs which are shown on Table 5-3. The present worth of the project (2011 dollars basis) was calculated based on a project life of 30 years and a 5 percent discount rate. In summary, capital costs were estimated to be $0 and annual operation, maintenance and monitoring (OM&M) costs were estimated to be $67,000 per year, for a total net present value (NPV) of $1,029,924.

5.3.3 Alternative B2 – Existing Gas Control with MNA and Municipal Water Contingency

5.3.3.1 Description

Alternative B2 is the same as Alternative B1 (Existing Gas Control with MNA for the entire groundwater plume) with the added component of expanding the connection of municipal water to downgradient private water supply wells as a contingency in the event private water supply wells become impacted.

Extension of the municipal water supply for affected private wells was completed in November 2002. The FF/NN Landfill PRP Group paid for the extension of the Alliant public water service from the intersection of Highway 23 and South Koro Road to the western end of Charles Street. The PRP Group has since connected five residences (Altnau, Ehster, Hadel, Miller and Wiese) to the public water supply. The cost of these activities, borne entirely by the PRP group, was approximately $250,000. At that time, the water utility was owned by Alliant Energy Company; subsequently the water utility was purchased by the City of Ripon in July 2005. This alternative would include a contingency for an additional extension and/or connections to residences if private wells became impacted by site contaminants.

The municipal water supply elements of this alternative include:

- Connection of all remaining homes on Charles Street (Banek and Gaastra) to the existing water main;

- Extending the water main 800 feet along the east-west portion of South Koro Road (old Highway 23) for six residential wells;
- Connection of all remaining homes on South Koro Road to the new water main; and
- Abandonment of existing private drinking water wells, or conversion of a select number of wells into monitoring wells.

The layout of the municipal water supply extension and connections of homes is shown on Figure 5-2.

5.3.3.2 Detailed Evaluation

Compliance with ARARs: The interim action active gas recovery system component of Alternative B2, meets the landfill gas control requirements of ch. NR506. The active gas recovery has also already demonstrated a reduction in the transport of vinyl chloride into the groundwater. With the source of vinyl chloride reduced, the remaining groundwater that has already been impacted with vinyl chloride has also begun to show a reduction due to natural attenuation. Continued MNA monitoring will show whether the vinyl chloride plume will continue to contract or remain stable. Under this alternative, contaminant concentrations in the sandstone aquifer may remain above the NR140 PAL for vinyl chloride for some period of time (15 to 30 years).

Overall Protection of Human Health and the Environment: An active gas extraction system is expected to be protective of human health and the environment over the long term as it will reduce or eliminate the source of vinyl chloride impacts in the groundwater. The extension of the public water supply to all residents on Charles Street and South Koro Road provides overall protection of human health and the environment by preventing the use of impacted groundwater. Because it apparently took 18 to 30 years for the vinyl chloride plume in the sandstone aquifer to reach its current extent, the NR140 PAL for vinyl chloride is not expected to be met for at least 15 years. Groundwater monitoring would continue in order to demonstrate that vinyl chloride is not continuing to migrate in groundwater.

Short Term Effectiveness: There would be no significant exposure of construction workers or the public to contaminants related to the gas extraction system because the system has already been constructed and operated since 2006. The extension of municipal water can be completed quickly by the City of Ripon, as evidenced by the extension of the water main that was completed in November 2002. Because vinyl chloride impacts are located at least 150 feet below the depth of any public water system, construction would not expose workers during construction activities.

Long Term Effectiveness and Permanence: The long term effectiveness of an active gas extraction system is that it prevents the migration of methane beyond the boundaries of the landfill and reduces the potential for groundwater to be impacted with VOCs, especially vinyl chloride. Active gas extraction will be required until the landfill is no longer generating an amount of methane that could potentially migrate beyond the property boundary and vinyl chloride gas that could potentially impact groundwater. Providing public water is considered a permanent remedy as noted in the March 8, 1990 Federal Register.

Reduction of Toxicity, Mobility or Volume through Treatment: The active landfill gas extraction system would remove landfill methane gas from the landfill and reduce the introduction of VOCs, particularly vinyl chloride in groundwater. Treatment of the extracted gases is not required because the emissions will be below the NR445 threshold for vinyl chloride. As indicated in section 4.4.2, a landfill gas extraction system will remove about 28 pounds of vinyl chloride annually from the subsurface, well below the 300 pounds per year emission limit. The methane concentrations in the extracted gas are too low to support flaring. Extension of the public water supply provides no active treatment process for groundwater.

Implementability: This gas extraction component of this alternative has already been implemented. The contingent municipal water supply extension component involves standard construction and plumbing activities, and is readily implementable by the City of Ripon.

Cost: Table 5-2 presents a detailed cost analysis for Alternative B2. The present worth of the project (2011 dollars basis) was calculated based on a project life of 30 years and a 5 percent discount rate. In summary, capital costs were estimated to be $178,480 and annual OM&M costs were estimated to be $67,000 per year, for a total NPV of $1,208,404.

5.3.4 Alternative B3 – Existing Gas Control with Groundwater Pump & Treat

5.3.4.1 Description

Alternative B3 includes the same existing gas control as Alternative B1 with the added component of groundwater extraction and treatment for the deep aquifer. Groundwater extraction wells would be installed in the contaminant plume, upgradient of the homes on Charles Street and near the downgradient extent of the deep aquifer plume. The purpose of these wells would be to remove contaminants from the deep aquifer and to prevent continued migration of the plume front.

Two groundwater extraction wells would be installed in the vicinity of Charles Street as shown on Figures 5-3 and 5-4, and screened in Layer 3, which is the layer in which the vinyl chloride is primarily traveling and in which private drinking water wells are screened. In the proposed pumping location near Charles Street, Layer 3 is a confined aquifer that is overlain by a wedge of clay that thickens to the south. In order to withdraw water from the portion of the aquifer used for drinking water supply, the extraction wells would be screened from approximately 160 feet to 200 feet bgs. The extraction rate would be 20 gpm for each well. Because of the high discharge rate of 40 gpm, it is unlikely that the water could be discharged to the nearby wetland. Therefore, for the purposes of evaluating this alternative it is assumed that the pumped groundwater would be treated by air stripping and discharged to Silver Creek under a WPDES permit.

A two-dimensional groundwater modeling program, WinFlow™, was used to determine the pumping rate, radius of influence and depth and spacing of well(s) required to capture the plume at this location. This program assumes that groundwater flow is horizontal and occurs in an infinite aquifer, and hydraulic conductivity is isotropic and homogeneous. Further discussion of the model and its assumptions is found in Appendix A. The input variables of hydraulic conductivity and horizontal gradient for Layer 3 wells were used for this model. Appendix A contains the input variables and an output map showing the extraction wells and radius of influence. The results of the modeling indicate that the extraction wells are capable of creating a capture zone sufficient to capture the entire plume, remove contaminant mass from the deep aquifer and prevent contaminant plume migration.

5.3.4.2 Detailed Evaluation

Compliance with ARARs: The interim action active gas recovery system component of Alternative B3, meets the landfill gas control requirements of ch. NR506. The active gas recovery has also already demonstrated a reduction in the transport of vinyl chloride into the groundwater.

Pumping and treating groundwater will hydraulically control the plume in the deep aquifer and prevent any further contaminant migration and eventually meet the RAO of complying with the groundwater standards of NR 140 through contaminant mass reduction. This alternative will require at least 15 years for groundwater in the sandstone aquifer that is already impacted to achieve NR140 PALS. Additional time beyond that will depend on the amount of contaminant mass diffused into and residing in the lower permeability rock matrix blocks between fractures.

Overall Protection of Human Health and the Environment: An active gas extraction system is expected to be protective of human health and the environment over the long term as it will reduce or eliminate the source of vinyl chloride impacts in the groundwater. The groundwater extraction and treatment component provides overall protection of human health and the environment by preventing the migration of vinyl chloride past the extraction well network that might otherwise impact private drinking water wells.

The extraction of groundwater at a rate of up to 40 gpm is expected to have no negative impact on the groundwater quantity or quality in nearby private and municipal wells. The private and municipal water supply wells in the area are completed in the deep Cambrian sandstone. The saturated thickness of the aquifer is greater than 125 feet and the maximum drawdown in the vicinity of the extraction wells is on the order of 10 feet which would have little effect on the nearest private wells (500 feet away) and no effect on the nearest municipal well (more than a mile away). There is also no adverse water quality effect expected due to drawing in or releasing natural and/or anthropogenic inorganic contaminants. Site water quality sampling and findings of a Fond du Lac County groundwater study (UWSP, July 2010) show this area of Fond du Lac County has very low levels of inorganics such as arsenic, chloride, sulfate, nitrate, iron and manganese.

Short Term Effectiveness: There would be no significant exposure of construction workers or the public to contaminants related to the gas extraction system because the system has already been constructed and operated since 2006. There is a limited potential for exposure of construction workers to VOCs during construction of the groundwater extraction and treatment system. This potential can be adequately addressed through the use of personal protective equipment. The installation of wells and the treatment system would not release a significant amount of vinyl chloride to the environment. Disposal of all wastes will follow proper handling practices and therefore would not have adverse impacts to the environment. Monitoring during start-up and operation of the treatment system will ensure that the remedial activities are effective in meeting all air and water discharge criteria.

Long Term Effectiveness and Permanence: The long term effectiveness of an active gas extraction system is that it prevents the migration of methane beyond the boundaries of the landfill and reduces the potential for groundwater to be impacted with VOCs, especially vinyl chloride. Active gas extraction will be required until the landfill is no longer generating an amount of methane that could potentially migrate beyond the property boundary and vinyl chloride gas that could potentially impact groundwater.

Groundwater extraction and treatment provides a permanent method for treating the contaminants of concern in the groundwater. The plume of groundwater already impacted with vinyl chloride is expected to eventually be remediated to meet the NR140 standards. The duration of the cleanup will depend largely on the "tailing" effect of removing low levels of vinyl chloride that diffuse out of the bedrock matrix into the fractures.

Reduction of Toxicity, Mobility or Volume through Treatment: The active landfill gas extraction system would remove landfill methane gas from the landfill and reduce the introduction of VOCs, particularly vinyl chloride in groundwater. Treatment of the extracted gases is not required because the emissions will be below the NR445 threshold for vinyl chloride. As indicated in section 4.4.2, a landfill gas extraction system will remove about 28 pounds of vinyl chloride annually from the subsurface, well below the 300 pounds per year emission limit. The methane concentrations in the extracted gas are too low to support flaring. The groundwater extraction and treatment component provides a system designed to remove and treat contaminants of concern in groundwater at the Site which reduces the mobility and volume of contaminated groundwater.

Implementability: The gas extraction component of this alternative has already been implemented. The installation of groundwater extraction wells and an air stripper treatment system are relatively routine construction tasks and readily implementable. The discharge of the treated water may be a bigger challenge. At the minimum, further environmental studies would be needed for discharge to the wetland or Silver Creek.

Cost: Table 5-3 presents costs for Alternative B3, assuming discharge to Silver Creek. The present worth was calculated based on a project life of 30 years and a 5 percent discount rate. Capital costs were estimated to be $561,798 and annual OM&M costs were estimated to be $188,800 per year, for a total NPV of $3,464,032.

5.3.5 Alternative B4 – Existing Gas Control with In-Situ Groundwater Treatment and MNA

5.3.5.1 Description

Alternative B4 includes the same existing gas control as Alternative B1 with the added component of in-situ groundwater treatment for the deep aquifer and MNA for groundwater downgradient of the in-situ treatment system.

The active groundwater treatment component of this alternative includes contaminant remediation and migration control through in-situ treatment using the ART in well stripping technology. The ART in well technology combines in situ air stripping, air sparging, soil vapor extraction (SVE), and enhanced bioremediation/oxidation—plus subsurface groundwater circulation. A line of ART wells (Figure 5-6) would act as a permeable reactive wall that treats vinyl chloride as it migrates through the zone of influence. MNA would be applied to existing contaminants already downgradient and beyond the zone of influence of the proposed line of ART wells (i.e., in the vicinity of MW-114 and MW-115).

The air-sparging component of the ART wells results in reduced water density and lifting (mounding) of the water table in the vicinity of the well. This in turn causes a net negative gradient to the well, resulting in water flowing back toward the well. This upwelling force created by the sparging results in an in-well "packer" concept, resulting in pressure and density gradient from the lower screened interval to the upper screened interval that assists in driving the dynamic subsurface circulation forces.

Vacuum pressure (the vapor extraction component) is applied at the top of the well point to extract vapor from the subsurface. The negative pressure from vacuum extraction creates additional water mounding and boosts the net gradient back toward the well; it also removes vapors from the unsaturated zone and well annulus. The SVE and sparging combined in the same well further enlarges the radius of influence and boosts circulation.

A submersible pump is placed at the bottom of the well to recirculate water to the top for downward discharge through a spray head. The water cascades down the interior of the well and system piping, providing multiple wetted surfaces for mass transfer, similar to what occurs in a packed-column air-stripping tower. Enhanced stripping via air sparging near the bottom of the well occurs simultaneously. In essence, the well acts as a subsurface air-stripping tower, in which the pumped and stripped, dissolved-oxygen-rich water flows down the well annulus and over the mounded water back into the aquifer and vadose zone. This action hydraulically enhances the radius of influence and flushes contamination from this zone. When these are combined, the synergistic technology effects create a circulation zone surrounding the well that further enhances cleanup.

In summary, contaminants are stripped from the water as a result of the combined effects of in-well air stripping and in-well air sparging. The "radius of results," or dynamic subsurface circulation cleaning zone, is created by a combination of negative gradient from air sparging, the application of vacuum extraction, and subsurface water circulation induced by a submersible pump. All of these different components are integrated in the ART Technology and can be installed in a six-inch groundwater well.

According to publications of US EPA's Superfund Innovative Technology Program, groundwater circulation wells have shown an effective radius of influence of 30 to 100 feet. ART Technology claims a radius of influence of up to ten times the water column in the ART remediation wells has been achieved at sites where the technology was implemented. For purposes of this evaluation, a conservative radius of influence of 40 feet was assumed. Therefore, eight ART wells, located along the bike path north of Charles Street (approximately

1,250 feet downgradient of the landfill) would be necessary to intercept and treat impacted groundwater across the width of the plume. For estimation purposes, each well will be constructed of 6-inch diameter schedule 80 PVC casing to a depth of 200 feet. The top of the screen will intersect the water table which is located approximately 30 feet below ground surface. A diagram of a typical ART Technology well is shown in Figure 5-5. The air compressor and blower will be housed in an equipment building along the bike path as shown on Figure 5-6. Because of the low levels of vinyl chloride, no treatment will be needed for vapors.

5.3.5.2 Detailed Evaluation

Compliance with ARARs: The interim action active gas recovery system component of Alternative B4, meets the landfill gas control requirements of ch. NR506. The active gas recovery has also already demonstrated a reduction in the transport of vinyl chloride into the groundwater.

With the in-situ treatment component of this alternative, impacted groundwater that passes through the groundwater circulation well network is expected to comply with ARARs and achieve NR140 PALs. This alternative will require at least 15 years for groundwater in the sandstone aquifer that is already impacted to migrate through the treatment zone. Additional time beyond that will depend on the amount of contaminant mass diffused into and residing in the lower permeability rock matrix blocks between fractures.

The line of ART wells would intercept and remediate vinyl chloride migrating to the southwest in the groundwater plume. With the source of vinyl chloride reduced at the landfill and the plume cut off by the ART wells, the existing contaminants already downgradient and beyond the zone of influence of the active remedy would naturally attenuate. The groundwater that has been impacted with vinyl chloride has already begun to show a reduction due to source control and natural attenuation. Continued MNA monitoring will show whether the vinyl chloride plume beyond the influence of the in-situ treatment system will continue to contract or remain stable.

Overall Protection of Human Health and the Environment: An active gas extraction system is expected to be protective of human health and the environment over the long term as it will reduce or eliminate the source of vinyl chloride impacts in the groundwater. The ART in well alternative provides overall protection of human health and the environment by preventing the migration of vinyl chloride past the circulation well network that might otherwise impact private drinking water wells.

Short Term Effectiveness: There would be no significant exposure of construction workers or the public to contaminants related to the gas extraction system because the system has already been constructed and operated since 2006. There is a limited potential for exposure of construction workers to VOCs during construction of the ART system. This potential can be adequately addressed through the use of personal protective equipment. The installation of wells and equipment building should not release a significant amount of vinyl chloride to the environment. Disposal of all wastes will follow proper handling practices and therefore should not have adverse impacts to the environment.

Long Term Effectiveness and Permanence: The long term effectiveness of an active gas extraction system is that it prevents the migration of methane beyond the boundaries of the landfill and reduces the potential for groundwater to be impacted with VOCs, especially vinyl chloride. Active gas extraction will be required until the landfill is no longer generating an amount of methane that could potentially migrate beyond the property boundary and vinyl chloride gas that could potentially impact groundwater.

The ART Technology provides a method for treating the contaminants of concern in the groundwater. The plume of groundwater already impacted with vinyl chloride is expected to eventually be remediated to meet the NR140 PAL. The duration of the cleanup will depend largely on the "tailing" effect of removing low levels of vinyl chloride that diffuse out of the bedrock matrix and into fractures. The effectiveness of this in-situ treatment method may be compromised by the presence of zones of lower permeability within the unconsolidated deposits which could disrupt the effectiveness of the circulation system and hence radius of influence. High dissolved iron and manganese concentrations that are present in the aquifer may cause frequent and costly maintenance of these systems.

Reduction of Toxicity, Mobility or Volume through Treatment: The active landfill gas extraction system would remove landfill gas from the landfill and reduce the introduction of VOCs, particularly vinyl chloride in groundwater. Treatment of the extracted gases is not required because the emissions will be below the NR445 threshold for vinyl chloride. As indicated in section 4.4.2, a landfill gas extraction system will remove about 28 pounds of vinyl chloride annually from the subsurface, well below the 300 pounds per year emission limit. The methane concentrations in the extracted gas are too low to support flaring.

The in-situ treatment system is designed to remove contaminants of concern from groundwater at the Site. The zone of capture created along the line of wells will contain the plume and reduce the mobility of vinyl chloride in the groundwater medium. The total mass of vinyl chloride in the deep aquifer is estimated to be less than one pound (see section 3.4). This alternative would be expected to remove some fraction of this on an annual basis. Treating the groundwater should reduce the concentrations of vinyl chloride in the extracted water (and therefore, its toxicity) to levels that are protective of human health and the environment.

Implementability: The gas extraction component of this alternative has already been implemented. The installation of groundwater circulation wells, ART in well equipment and an air delivery/vacuum extraction system are routine to complicated construction tasks and the equipment could be readily available.

Cost: Table 5-4 presents a detailed cost analysis for Alternative B4. The present worth was calculated based on a project life of 30 years and a 5 percent discount rate. Capital costs were estimated to be $755,544 and annual OM&M costs were estimated to be $195,332 per year, for a total NPV of $3,758,180.

5.3.6 Alternative C1 – Expanded Gas Control with MNA

5.3.6.1 Description

Alternative C1 is the same as Alternative B1 (Existing Gas Control with MNA for the entire groundwater plume) except that rather than just using existing vents and leachate wells for gas extraction, four new gas extraction wells would be installed. Gas extraction would primarily be from the new extraction wells and supplemented as needed by extraction from the existing vents and leachate wells.

Alternative C1, active landfill gas recovery using new gas extraction wells, would be an enhancement over the interim system (Alternative B1) in that the gas extraction system would include gas extraction wells designed and spaced in accordance with NR 508 requirements. Like Alternative B1, this alternative would be used to prevent the migration of explosive gases generated by the waste fill beyond the landfill property boundary and to serve as a VOC source control remedy by reducing the flux of vinyl chloride from landfill gas into the groundwater. For Alternative C1 the present blower capacity would need to be increased, either by adding an additional blower unit or replacement with a larger blower. A new piping header system, upgrading the test vault for the two new piping runs, modifying the treatment trailer, upgrading the single phase power to the trailer, and modifying/upgrading the existing EOS electronic site data manager would be required. The four new gas extraction wells would extend through the thickness of the landfill waste and be completed as 6-inch diameter wells installed within 36-inch diameter boreholes. The layout for Alternative C1 is provided on Figure 5-7.

5.3.6.2 Detailed Evaluation

Compliance with ARARs: The existing active gas recovery system meets the landfill gas control requirements of ch. NR506 and has also already demonstrated a reduction in the transport of vinyl chloride into the groundwater. Adding gas extraction from four new deeper gas extraction wells would only enhance the gas control capability. With the source of vinyl chloride reduced, the remaining groundwater that has already been impacted with vinyl chloride has also begun to show a reduction due to natural attenuation. Continued monitoring will show whether the vinyl chloride plume will continue to contract or remain stable. Under this alternative, contaminant concentrations in the sandstone aquifer may remain above the NR140 PAL for vinyl chloride for some period of time (15 to 30 years).

Overall Protection of Human Health and the Environment: An active gas extraction system is expected to be protective of human health and the environment over the long term as it will reduce or eliminate the source of vinyl chloride impacts in the groundwater. Because it apparently took 18 to 30 years for the vinyl chloride plume in the sandstone aquifer to reach its current extent, NR140 PALs are not expected to be met for at least 15 years.

Short Term Effectiveness: The construction of vertical gas extraction wells for Alternative C1 would have a potential to expose workers to contaminants and the public to odors. This potential exposure would be for a limited period of time (a few days), and workers exposure would be limited by the use of personal protective equipment. The installation of extraction wells should not release a significant amount of vinyl chloride to the environment. Disposal of all generated wastes will follow proper handling practices and therefore should not have adverse impacts to the environment.

Alternative C1 will require that four new gas extraction wells will penetrate the existing composite cap on the landfill. This will require excavating to the membrane liner and cutting a hole in it to drill the well. Precipitation during well construction could enter the landfill, resulting in possible leachate generation if stormwater management controls are not implemented during construction.

Long Term Effectiveness and Permanence: The long term effectiveness of an active gas extraction system is that it prevents the migration of methane beyond the boundaries of the landfill and reduces the potential for groundwater to be impacted with VOCs, especially vinyl chloride. Active gas extraction will be required until the landfill is no longer generating an amount of methane that could potentially migrate beyond the property boundary and vinyl chloride gas that could potentially impact groundwater.

Reduction of Toxicity, Mobility or Volume through Treatment: The active landfill gas extraction system would remove landfill methane gas from the landfill and reduce the introduction of VOCs, particularly vinyl chloride in groundwater. Treatment of the extracted gases is not required because the emissions will be below the NR445 threshold for vinyl chloride. As indicated in section 4.4.2, the existing landfill gas extraction system will remove about 28 pounds of vinyl chloride annually from the subsurface, well below the 300 pounds per year emission limit. With new extraction wells pulling deeper from within the landfill the amount of vinyl chloride removal could possibly be higher than that being achieved by the interim system, but would still be below the 300 pounds per year emission limit. The methane concentrations in the extracted gas are too low to support flaring.

Implementability: A new blower unit would be purchased and installed. The installation of gas extraction wells and associated piping is somewhat challenging having to go through the existing cap and drill through landfill waste. Care would be needed to prevent precipitation from entering the wastes during construction and in repairing the cap. This alternative is implementable.

Cost: Table 5-5 presents a detailed cost analysis for Alternative C1. The present worth was calculated based on a project life of 30 years and a 5 percent discount rate. Capital costs were estimated to be $295,260 and annual OM&M costs were estimated to be $83,000 per year, for a total NPV of $1,571,136.

5.3.7 Alternative C2 – Expanded Gas Control with MNA and Municipal Water Contingency

5.3.7.1 Description

Alternative C2 is the same as Alternative B2 (Existing Gas Control with MNA for the entire groundwater plume and Municipal Water Contingency) except four new gas extraction wells and associated piping and a new blower (as described under Alternative C1) will be installed to replace/supplement using the existing vents and leachate wells for gas recovery.

5.3.7.2 Detailed Evaluation

Compliance with ARARs: The existing active gas recovery system meets the landfill gas control requirements of ch. NR506 and has also already demonstrated a reduction in the transport of vinyl chloride into the groundwater. Adding gas extraction from four new deeper gas extraction wells would only enhance the gas control capability. With the source of vinyl chloride reduced, the remaining groundwater that has already been impacted with vinyl chloride has also begun to show a reduction due to natural attenuation. Continued monitoring will show whether the vinyl chloride plume will continue to contract or remain stable. Under this alternative, contaminant concentrations in the sandstone aquifer may remain above the NR140 PAL for vinyl chloride for some period of time (15 to 30 years).

Overall Protection of Human Health and the Environment: An active gas extraction system is expected to be protective of human health and the environment over the long term as it will reduce or eliminate the source of vinyl chloride impacts in the groundwater. The extension of the public water supply to all residents on Charles Street and South Koro Road provides overall protection of human health and the environment by preventing the use of impacted groundwater. Because it apparently took 18 to 30 years for the vinyl chloride plume in the sandstone aquifer to reach its current extent, NR140 PALs are not expected to be met for at least 15 years. Groundwater monitoring would continue in order to demonstrate that vinyl chloride is not continuing to migrate in groundwater.

Short Term Effectiveness: The construction of vertical gas extraction wells for Alternative C2 would have a potential to expose workers to contaminants and the public to odors. This potential exposure would be for a limited period of time (a few days), and workers exposure would be limited by the use of personal protective equipment. The installation of extraction wells should not release a significant amount of vinyl chloride to the environment. Disposal of all generated wastes will follow proper handling practices and therefore should not have adverse impacts to the environment.

Alternative C2 will require that four new gas extraction wells will penetrate the existing composite cap on the landfill. This will require excavating to the membrane liner and cutting a hole in it to drill the well. Precipitation during well construction could enter the landfill, resulting in possible leachate generation if stormwater management controls are not implemented during construction.

The contingent extension of municipal water can be completed quickly, as evidenced by the extension of the water main that was completed in November 2002. Because vinyl chloride impacts are located at least 150 feet below the depth of any public water system, construction would not expose workers during construction activities.

Long Term Effectiveness and Permanence: The long term effectiveness of an active gas extraction system is that it prevents the migration of methane beyond the boundaries of the landfill and reduces the potential for groundwater to be impacted with VOCs, especially vinyl chloride. Active gas extraction will be required until the landfill is no longer generating an amount of methane that could potentially migrate beyond the property boundary and vinyl chloride gas that could potentially impact groundwater. Providing public water is considered a permanent remedy as noted in the March 8, 1990 Federal Register.

Reduction of Toxicity, Mobility or Volume through Treatment: The active landfill gas extraction system would remove landfill methane gas from the landfill and reduce the introduction of VOCs, particularly vinyl chloride in groundwater. Treatment of the extracted gases is not required because the emissions will be below the NR445 threshold for vinyl chloride. As indicated in section 4.4.2, the existing landfill gas extraction system will remove about 28 pounds of vinyl chloride annually from the subsurface, well below the 300 pounds per year emission limit. With new extraction wells pulling deeper from within the landfill the amount of vinyl chloride removal could possibly be higher than that being achieved by the interim system, but would still be below the 300 pounds per year emission limit. The methane concentrations in the extracted gas are too low to support flaring. Extension of the public water supply provides no active treatment process for groundwater.

Implementability: A new blower unit would be purchased and installed. The installation of gas extraction wells and associated piping is somewhat challenging having to go through the existing cap and drill through landfill waste. Care would be needed to prevent precipitation from entering the wastes during construction and in repairing the cap, but the gas control component of this alternative is implementable. The municipal water supply extension component involves standard construction and plumbing activities, and is readily implementable.

Cost: Table 5-6 presents a detailed cost analysis for Alternative C2. The present worth of the project (2011 dollars basis) was calculated based on a project life of 30 years and a 5 percent discount rate. In summary, capital costs were estimated to be $295,260 for the expanded gas control system and $178,480 for extension of municipal water. Annual OM&M costs were estimated to be $83,000 per year, for a total NPV of $1,749,616.

5.3.8 Alternative C3 – Expanded Gas Control with Groundwater Pump & Treat

5.3.8.1 Description

Alternative C3 is the same as Alternative B3 (Existing Gas Control with Groundwater Extraction & Treatment) except four new gas extraction wells and associated piping and a new blower (as described under Alternative C1) will be installed to replace/supplement using the existing vents and leachate wells for gas recovery.

5.3.8.2 Detailed Evaluation

Compliance with ARARs: The existing active gas recovery system meets the landfill gas control requirements of ch. NR506 and has also already demonstrated a reduction in the transport of vinyl chloride into the groundwater. Adding gas extraction from four new deeper gas extraction wells would only enhance the gas control capability.

Pumping and treating groundwater will hydraulically control the plume in the deep aquifer and prevent any further contaminant migration and eventually meet the remedial action objective of complying with the groundwater standards of NR 140 through contaminant mass reduction. This alternative will require at least 15 years for groundwater in the sandstone aquifer that is already impacted to achieve NR140 PALS. Additional time beyond that will depend on the amount of contaminant mass diffused into and residing in the lower permeability bedrock matrix blocks between fractures.

Overall Protection of Human Health and the Environment: An active gas extraction system is expected to be protective of human health and the environment over the long term as it will reduce or eliminate the source of vinyl chloride impacts in the groundwater. The groundwater extraction and treatment component provides overall protection of human health and the environment by preventing the migration of vinyl chloride past the extraction well network that might otherwise impact private drinking water wells.

The extraction of groundwater at a rate of up to 40 gpm is expected to have no negative impact on the groundwater quantity or quality in nearby private and municipal wells. The private and municipal water supply wells in the area are completed in the deep Cambrian sandstone. The saturated thickness of the aquifer is greater than 125 feet and the maximum drawdown in the vicinity of the extraction wells is on the order of 10 feet which would have little effect on the nearest private wells (500 feet away) and no effect on the nearest municipal well (more than a mile away). There is also no adverse water quality effect expected due to drawing in or releasing natural and/or anthropogenic inorganic contaminants. Site water quality sampling and findings of a Fond du Lac County groundwater study (UWSP, July 2010) show this area of Fond du Lac County has very low levels of inorganics such as arsenic, chloride, sulfate, nitrate, iron and manganese.

Short Term Effectiveness: The construction of vertical gas extraction wells for Alternative C3 would have a potential to expose workers to contaminants and the public to odors. This potential exposure would be for a limited period of time (a few days), and workers exposure would be limited by the use of personal protective equipment. The installation of extraction wells should not release a significant amount of vinyl chloride to the environment. Disposal of all generated wastes will follow proper handling practices and therefore should not have adverse impacts to the environment.

Alternative C3 will require that four new gas extraction wells will penetrate the existing composite cap on the landfill. This will require excavating to the membrane liner and cutting a hole in it to drill the well. Precipitation during well construction could enter the landfill, resulting in possible leachate generation if stormwater management controls are not implemented during construction.

There is a limited potential for exposure of construction workers to VOCs during construction of the groundwater extraction and treatment system. This potential can be adequately addressed through the use of personal protective equipment. The installation of wells and the treatment system would not release a significant amount of vinyl chloride to the environment. Disposal of all wastes will follow proper handling practices and therefore would not have adverse impacts to the environment. Monitoring during start-up and operation of the treatment system will ensure that the remedial activities are effective in meeting all discharge criteria.

Long Term Effectiveness and Permanence: The long term effectiveness of an active gas extraction system is that it prevents the migration of methane beyond the boundaries of the landfill and reduces the potential for groundwater to be impacted with VOCs, especially vinyl chloride. Active gas extraction will be required until the landfill is no longer generating an amount of methane that could potentially migrate beyond the property boundary and vinyl chloride gas that could potentially impact groundwater.

Groundwater extraction and treatment provides a permanent method for treating the contaminants of concern in the groundwater. The plume of groundwater already impacted with vinyl chloride is expected to eventually be remediated to meet the NR140 PAL for vinyl chloride. The duration of the cleanup will depend largely on the "tailing" effect of removing low levels of vinyl chloride that diffuse out of the bedrock matrix and into fractures.

Reduction of Toxicity, Mobility or Volume through Treatment: The active landfill gas extraction system would remove landfill methane gas from the landfill and reduce the introduction of VOCs, particularly vinyl chloride in groundwater. Treatment of the extracted gases is not required because the emissions will be below the NR445 threshold for vinyl chloride. As indicated in section 4.4.2, the existing landfill gas extraction system will remove about 28 pounds of vinyl chloride annually from the subsurface, well below the 300 pounds per year emission limit. With new extraction wells pulling deeper from within the landfill the amount of vinyl chloride removal could possibly be higher than that being achieved by the interim system, but would still be below the 300 pounds per year emission limit. The methane concentrations in the extracted gas are too low to support flaring.

The groundwater extraction and treatment component provides a system designed to remove and treat contaminants of concern in groundwater at the Site which reduces the mobility and volume of contaminated groundwater.

Implementability: A new blower unit would be purchased and installed. The installation of gas extraction wells and associated piping is somewhat challenging having to go through the existing cap and drill through landfill waste. Care would be needed to prevent precipitation from entering the wastes during construction and in repairing the cap, but the gas control component of this alternative is implementable.

The installation of groundwater extraction wells and an air stripper treatment system are relatively routine construction tasks and readily implementable. The discharge of the treated water may be a bigger challenge. At the minimum, further environmental studies would be needed for discharge to the wetland or Silver Creek.

Cost: Table 5-7 presents a detailed cost analysis for Alternative C3, assuming discharge to Silver Creek. The present worth of the project (2011 dollars basis) was calculated based on a project life of 30 years and a 5 percent discount rate. In summary, capital costs were estimated to be $295,260 for the expanded gas control system and $561,798 for the groundwater extraction and treatment system. Annual OM&M costs were estimated to be $204,800 per year, for a total NPV of $4,005,244.

5.3.9 Alternative C4 – Expanded Gas Control with In-Situ Groundwater Treatment and MNA

5.3.9.1 Description

Alternative C4 is the same as Alternative B4 (Existing Gas Control with In-Situ Groundwater Treatment and MNA for the plume downgradient of in-situ treatment) except four new gas extraction wells and associated piping and a new blower (as described under Alternative C1) will be installed to replace/supplement using the existing vents and leachate wells for gas recovery.

5.3.9.2 Detailed Evaluation

Compliance with ARARs: The existing active gas recovery system meets the landfill gas control requirements of ch. NR506 and has also already demonstrated a reduction in the transport of vinyl chloride into the groundwater. Adding gas extraction from four new deeper gas extraction wells would only enhance the gas control capability.

With the in-situ treatment component of this alternative, impacted groundwater that passes through the groundwater circulation well network is expected to comply with ARARs and achieve NR140 PALs. This alternative will require at least 15 years for groundwater in the sandstone aquifer that is already impacted to migrate through the treatment zone. Additional time beyond that will depend on the amount of contaminant mass diffused into and residing in the lower permeability rock matrix blocks between fractures.

The line of ART wells would intercept and remediate vinyl chloride migrating to the southwest in the groundwater plume. With the source of vinyl chloride reduced at the landfill and the plume cut off by the ART wells, the existing contaminants already downgradient and beyond the zone of influence of the active remedy would naturally attenuate. The groundwater that has been impacted with vinyl chloride has already begun to show a reduction due to source control and natural attenuation. Continued MNA monitoring will show whether the vinyl chloride plume beyond the influence of the in-situ treatment system will continue to contract or remain stable.

Overall Protection of Human Health and the Environment: An active gas extraction system is expected to be protective of human health and the environment over the long term as it will reduce or eliminate the source of vinyl chloride impacts in the groundwater. The ART in well alternative provides overall protection of human health and the environment by preventing the migration of vinyl chloride past the circulation well network that might otherwise impact private drinking water wells.

Short Term Effectiveness: The construction of vertical gas extraction wells for Alternative C4 would have a potential to expose workers to contaminants and the public to odors. This potential exposure would be for a limited period of time (a few days), and workers exposure would be limited by the use of personal protective equipment. The installation of extraction wells should not release a significant amount of vinyl chloride to the environment. Disposal of all generated wastes will follow proper handling practices and therefore should not have adverse impacts to the environment.

Alternative C4 will require that four new gas extraction wells will penetrate the existing composite cap on the landfill. This will require excavating to the membrane liner and cutting a hole in it to drill the well. Precipitation during well construction could enter the landfill, resulting in possible leachate generation if stormwater management controls are not implemented during construction.

There is a limited potential for exposure of construction workers to VOCs during construction of the ART system. This potential can be adequately addressed through the use of personal protective equipment. The installation of wells and equipment building should not release a significant amount of vinyl chloride to the environment. Disposal of all wastes will follow proper handling practices and therefore should not have adverse impacts to the environment.

Long Term Effectiveness and Permanence: The long term effectiveness of an active gas extraction system is that it prevents the migration of methane beyond the boundaries of the landfill and reduces the potential for groundwater to be impacted with VOCs, especially vinyl chloride. Active gas extraction will be required until the landfill is no longer generating an amount of methane that could potentially migrate beyond the property boundary and vinyl chloride gas that could potentially impact groundwater.

The ART Technology provides a permanent method for treating the contaminants of concern in the groundwater. The plume of groundwater already impacted with vinyl chloride is expected to eventually be remediated to meet the NR140 PAL. The duration of the cleanup will depend largely on the "tailing" effect of removing low levels of vinyl chloride that diffuse out of the rock matrix. The effectiveness of this in-situ treatment method may be compromised by the presence of zones of lower permeability within the unconsolidated deposits which could disrupt the effectiveness of the circulation system and hence radius of influence. High dissolved iron and manganese concentrations that are present in the aquifer may cause frequent and costly maintenance of these systems.

Reduction of Toxicity, Mobility or Volume through Treatment: The active landfill gas extraction system would remove landfill methane gas from the landfill and reduce the introduction of VOCs, particularly vinyl chloride in groundwater. Treatment of the extracted gases is not required because the emissions will be below the NR445 threshold for vinyl chloride. As indicated in section 4.4.2, the existing landfill gas extraction system will remove about 28 pounds of vinyl chloride annually from the subsurface, well below the 300 pounds per year emission limit. With new extraction wells pulling deeper from within the landfill the amount of vinyl chloride removal could possibly be higher than that being achieved by the interim system, but would still be below the 300 pounds per year emission limit. The methane concentrations in the extracted gas are too low to support flaring.

The in-situ treatment system is designed to remove contaminants of concern from groundwater at the Site. The zone of capture created along the line of wells will contain the plume and reduce the mobility of vinyl chloride in the groundwater medium. The total mass of vinyl chloride in the deep aquifer is estimated to be less than one pound (see section 3.4). This alternative would be expected to remove some fraction of this on an annual basis. Treating the groundwater should reduce the concentrations of vinyl chloride in the extracted water (and therefore, its toxicity) to levels that are protective of human health and the environment.

Implementability: A new blower unit would be purchased and installed. The installation of gas extraction wells and associated piping is somewhat challenging having to go through the existing cap and drill through landfill waste. Care would be needed to prevent precipitation from entering the wastes during construction and in repairing the cap, but the gas control component of this alternative is implementable.

The installation of groundwater circulation wells, ART in well equipment and an air delivery/vacuum extraction system are routine to complicated construction tasks and the equipment could be readily available.

Cost: Table 5-8 presents a detailed cost analysis for Alternative C4. The present worth of the project (2011 dollars basis) was calculated based on a project life of 30 years and a 5 percent discount rate. In summary, capital costs were estimated to be $295,260 for the expanded gas control system and $755,544 for the in-situ ART technology system. Annual OM&M costs were estimated to be $211,332 per year, for a total NPV of $4,299,392.

6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

Table 6-1 provides a comparative analysis of the nine remedial alternatives evaluated against seven CERCLA criteria. As noted previously, the final two criteria (dealing with state and public comments) will be evaluated after this FFS has been reviewed by these parties. A brief comparison of these alternatives is provided below.

Compliance with ARARs:
All alternatives are expected to meet all location-specific and action-specific ARARs. Alternative A would not achieve chemical-specific ARARs since uncontrolled methane gas could exceed the LEL outside the limits of filling and with 200 feet of the property boundary and vinyl chloride in groundwater exceeds regulatory standards. All the other alternatives are expected to eventually meet all chemical-specific ARARs.

Overall Protection of Human Health and the Environment: Alternative A (No Further Action) is not protective of human health and the environment. Source control with the existing active gas recovery system (Alternatives B1-B4) has demonstrated the ability to control landfill methane gas migration, remove vinyl chloride mass from the subsurface and reduce vinyl chloride in groundwater under the landfill and is therefore protective of human health and the environment. Replacing or supplementing the gas recovery vents and leachate wells with new gas extraction wells and blower unit (Alternatives C1-C4) would be capable of increasing the amount of gas removed from the deeper portion of the landfill compared to the B alternatives, but it is not certain that would result in being any more protective of human health and the environment. The alternatives that include active groundwater remediation (Alternatives B3, B4, C3 and C4) are protective of human health and the environment in that they provide further contaminant migration control and mass reduction in the deep aquifer. The alternatives that include extension of municipal water (Alternatives B2 and C2) are the most protective of human health compared to the other alternatives that don't because they eliminate a potential exposure pathway, but less protective of the environment compared to those that include an active groundwater remedy.

Short Term Effectiveness: Alternative A creates no short-term impacts to human health or the environment because no action is performed. All alternatives except Alternative A implement risk mitigation measures and monitoring that will have minimal impacts to the community, remediation workers, and the environment. Alternatives with new gas extraction wells and piping (Alternatives C1-C4), groundwater remediation wells (Alternatives B3, B4, C3 and C4) and municipal water extension (Alternatives B2 and C2) have short-term impacts to remediation workers, the public, and the environment during implementation. Alternatives with new gas extraction wells and piping (Alternatives C1-C4) have short-term impacts to the cap integrity. All alternatives except Alternative A have aboveground and underground remediation components that may create minor visual and auditory nuisances during and after construction. Environmental drilling to install gas wells and groundwater extraction/recirculation wells would occur under all alternatives except Alternatives A, B1 and B2. Environmental drilling may produce contaminated soil cuttings, wastes and liquids that present some risk to remediation workers at the site. Groundwater monitoring will have minimal impact on workers responsible for periodic sampling as currently performed.

Long Term Effectiveness and Permanence:
Alternative A provides no reduction in contaminant levels or risk. Institutional controls and risk mitigation measures under the remaining alternatives could provide adequate protection of human health if properly implemented and maintained. However, they rely upon continuous management to maintain their effectiveness. Monitored natural attenuation under all alternatives is considered a method that can reduce low level contaminant concentrations in groundwater in all portions of the site.

Active gas control under all alternatives except Alternative A is considered an adequate and reliable source control method for landfill gas and for reducing contaminant concentrations entering into the groundwater. The alternatives that include the addition of new gas extractions wells and upgraded blower unit (Alternatives C1-C4) are considered more adequate and reliable than those using existing vents and leachate wells alone (Alternatives B1-B4). However, based on the performance of the existing gas control system it would not appear that the cost of an upgraded gas control system is justified.

Alternatives with active groundwater remediation (Alternatives B3, B4, C3 and C4) are considered an adequate and reliable method for controlling plume migration; however, they would be very expensive alternatives regarding contaminant mass reduction considering there is only approximately one pound of vinyl chloride in the deep groundwater. Alternatives with groundwater extraction and treatment (Alternatives B3 and C3) are considered more adequate and reliable for controlling the plume and reducing contaminant concentrations in the deep groundwater than alternatives using the ART technology (Alternatives B4 and C4). The ART wells may not be able to achieve the full radius of influence anticipated due to geologic heterogeneities and the thickness of the treatment zone.

Some residual risk above levels of concern remains in contaminated groundwater under all of the alternatives as they rely upon institutional controls over the long term for protection. Residual risk under Alternatives B2 and C2 is substantially reduced by providing potentially affected receptors with clean drinking water.

Reduction of Toxicity, Mobility or Volume through Treatment: No reduction in toxicity, mobility, or volume of contaminants occurs under Alternative A. Under the remaining alternatives it is estimated that up to 28 pounds of vinyl chloride or more will be removed annually using active gas recovery for source control; those alternatives supplemented with new gas extraction wells and upgraded blower unit (Alternatives C1-C4) would likely remove more vinyl chloride and methane gas but at a significantly higher cost. The alternatives with an active groundwater remediation component (Alternatives B3, B4, C3 and C4) would reduce the mobility of contaminant migration and remove an additional pound of vinyl chloride from the deep aquifer, although at a significant cost.

Implementability: Alternative A, No Further Action, is the easiest alternative to implement. Alternative B1 is also easy to implement as it would involve continued OM&M of the current interim action system. The alternatives with new gas extraction wells and upgraded blower unit (Alternatives C1-C4) would be more difficult to implement than those that use existing vents and leachate wells (Alternatives B1-B4). The alternatives with active groundwater remediation

(Alternatives B3, B4, C3 and C4) would be more difficult to implement than those that don't (Alternatives B1, B2, Cl and C2). Municipal water extension (Alternatives B2 and C2) could be difficult to implement if home owners refused hook-up.

Cost: There is no cost for the No Further Action alternative. Detailed costs are provided in Tables 5-1 through 5-8 for all other alternatives. Table 6-1 provides a summary of costs. The lowest cost alternative (exclusive of Alternative A) is Alternative B1 which is continued OM&M of the current gas extraction system. The most expensive alternative is C4 followed by C3, B4, B3, C2, C1 and B2.

7.0 REFERENCES

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TABLES

[redacted]

Table 2-1 Potential ARARs for Remedial Actions
FF/NN Landfill, Ripon, Wisconsin
Focused Feasibility Study, 2012

		Remedial Alternatives								
		A	B1	B2	B3	B4	C1	C2	C3	C4
Regulation, Policy or Law	**Description**	**No Action**	**Existing Gas Control with MNA**	**Existing Gas Control with MNA and Municipal Water Contingency**	**Existing Gas Control with Groundwater Pump & Tretment**	**Existing Gas Control with In-Situ Groundwater Treatment and MNA**	**Expanded Gas Control with MNA**	**Expanded Gas Control with MNA and Municipal Water Contingency**	**Expanded Gas Control with Groundwater Pump & Tretment**	**Expanded Gas Control with In-Situ Groundwater Treatment and MNA**
	FEDERAL REGULATIONS									
Clean Air Act (CAA) and National Ambient Air Quality Standards (NAAQS)	Regulates site air emissions	*	*	*	*	*	*	*	*	*
40 CFR 52	Regional air quality plan for remedial activities. Federal Prevention of Significant Deterioration Program		*	*	*	*	*	*	*	*
40 CFR 50	Air quality standards for remedial activities		*	*	*	*	*	*	*	*
40 CFR257	Criteria for classification of solid waste disposal facilities and practices	*	*	*	*	*	*	*	*	*
40 CFR 261	Identification of hazardous waste	*	*	*	*	*	*	*	*	*
40 CFR 262	Regulations for hazardous waste generators	*	*	*	*	*	*	*	*	*
40 CFR 263	Regulations for transport of hazardous waste	*	*	*	*	*	*	*	*	*
Department of Transportation Hazardous Materials Transportation Act	Off-site transport of hazardous waste		*	*	*	*	*	*	*	*
Occupational Safety and Health Administration (OSHA)	Regulates worker safety	*	*	*	*	*	*	*	*	*
Fish and Wildlife Coordination Act	Regulates flow modification of Silver Creek				*				*	
Endangered Species Act	Protects endangered species and habitats. No endangered species are known to exist at the site.	*	*	*	*	*	*	*	*	*
OSWER Directive 9355.0-28	Control of air emissions from Superfund air strippers at Superfund groundwater sites (emissions threshold for air strippers is set at 3 lbs/hr or 15 lbs/day or a potential rate of 10 tons/yr of total VOCs)				*	*			*	*
40 CFR Part 264, AA	Requires total organic emissions from air strippers be reduced below 1.4 kg/hr and 2.8 megagrams/yrs or by 95% by weight				*	*			*	*
Executive Order 11988 and 11990: 40 CFR 6, Subpart A	Requirements for remedial actions impacting floodplains or wetlands				*				*	
RCRA, Subtitle C	Regulates hazardous waste. Water treatment residuals may be hazardous waste		*	*	*	*	*	*	*	*
Clean Water Act (CWA)	Regulates surface water quality				*				*	
40 CFR 264.18(b) (RCRA)	Requirements for design, construction, operation and maintenance of remedial actions at RCRA hazardous waste sites located in floodplain				*				*	
National Pollutant Discharge Elimination System (NPDES)	Regulates discharge into Silver Creek				*				*	
Pretreatment Requirements 40 CFR, Part 403.5	Pretreatment standards for discharge to POTW				*				*	
Fresh Water Quality Criteria (FWQC)	Surface water quality standards				*				*	

Table 2-1 Potential ARARs for Remedial Actions
FF/NN Landfill, Ripon, Wisconsin
Focused Feasibility Study, 2012

Regulation, Policy or Law	Description	Remedial Alternatives A No Action	B1 Existing Gas Control with MNA	B2 Existing Gas Control with MNA and Municipal Water Contingency	B3 Existing Gas Control with Groundwater Pump & Tretment	B4 Existing Gas Control with In-Situ Groundwater Treatment and MNA	C1 Expanded Gas Control with MNA	C2 Expanded Gas Control with MNA and Municipal Water Contingency	C3 Expanded Gas Control with Groundwater Pump & Tretment	C4 Expanded Gas Control with In-Situ Groundwater Treatment and MNA
Executive Order for Wetlands and Floodplains	Regulates actions in wetlands or floodplains				*				*	
Response in a Floodplain or Wetlands; 40 CFR Part 6, Append. A	Construction in flood hazard areas				*				*	
STATE OF WISCONSIN REGULATIONS										
NR 102 - Water Quality Standards for Wisconsin Surface Waters	Specifies water quality standards for use classifications. Dissolved oxygen must not be lowered below 5 mg/L and pH must be maintained within 6 to 9 units. See NR 102 for additional standards				*				*	
NR 103 - Water Quality Standards for Wetlands	Regulates water discharges to wetlands				*				*	
NR 104 - Intrastate Water Uses and Designated Standards	Designates use classifications for surface waters.				*				*	
NR 105 - Surface Water Quality Criteria for Toxic and Organoleptic Substances	Specifies water quality criteria for toxic and organoleptic substances for protection of human health and welfare and aquatic life.				*				*	
NR 106 - Procedures for Calculating Water Quality-based Effluent Limitations for Toxic and Organoleptic Substances Discharged to Surface Waters	Specifies procedures for how effluent limitations are to be calculated for toxic and organoleptic substances.				*				*	
NR 108 - Requirement for Plans and Specifications - Submittal for Reviewable Projects and Operations of Community Water Systems, Sewerage Systems, and Industrial Waste Facilities	Sets guidelines for plans and specifications for actions which propose a discharge to ground water or community sewerage systems				*				*	
NR 112 - Well Construction and Pump Installation	Specifies construction standards for well and pump installations and abandonment of wells		*	*	*	*	*	*	*	*
NR 116 - Wisconsin's Flood Plain Management Program	Requires and establishes standards for municipal flood plain zoning ordinances. Relevant and appropriate to construction of remediation facilities				*				*	
NR140 - Groundwater Quality	Specifies groundwater quality preventive action limits and enforcement standards. Notification requirements and potential response actions when standards are exceeded are listed.	*	*	*	*	*	*	*	*	*
NR 149 Lab Certification	Sets analytical standards for lab certification	*	*	*	*	*	*	*	*	*
NR 200 - Application for Discharge Permit	Discharge permit is required for discharges to surface waters and to land areas where water may percolate to ground water				*				*	
NR 207 - Water Quality Antidegradation	Sets procedures for proposed new or increased discharge to ORWs or ERWs				*				*	

Table 2-1 Potential ARA[redacted]Remedial Actions [redacted]
FF/NN Landfill, Ripon, Wisconsin
Focused Feasibility Study, 2012

		Remedial Alternatives								
		A	B1	B2	B3	B4	C1	C2	C3	C4
Regulation, Policy or Law	Description	No Action	Existing Gas Control with MNA	Existing Gas Control with MNA and Municipal Water Contingency	Existing Gas Control with Groundwater Pump & Tretment	Existing Gas Control with In-Situ Groundwater Treatment and MNA	Expanded Gas Control with MNA	Expanded Gas Control with MNA and Municipal Water Contingency	Expanded Gas Control with Groundwater Pump & Tretment	Expanded Gas Control with In-Situ Groundwater Treatment and MNA
NR 211 - General Pretreatment Requirements	Prohibits discharges to POTWs which pass through or interfere with the operation or performance of the POTW and thereby cause a POTW to violate its WPDES permit				*				*	
NR 214 - Land Application and Disposal of Liquid Industrial Wastes and Byproducts	Requires land disposal systems to meet design and construction criteria and requires plans and specification to be approved by WDNR. Effluent limitations and ground-water monitoring requirements are also specified.				*				*	
NR 218 - Sampling	Establishes sampling methods for WPDES				*				*	
NR 219 - Analytical Test Methods and Procedures	Sets procedures applicable to effluent limitations for discharges from point sources				*				*	
NR 220 - Categories and Classes of Point Sources and Effluent Limitations	Requires WDNR to establish effluent limits for uncategorized point sources and to base those limits on best practicable control technology currently available or best available control technology economically achievable.				*				*	
Ch 147.Stats - Pollution Discharge Elimination	Requires point source discharges to obtain a permit from WDNR				*				*	
NR 445 - Control of Hazardous Pollutants	Specifies emission limits and control requirements for air contaminant sources emitting hazardous pollutants		*	*	*	*	*	*	*	*
NR 504 - Landfill location, performance, design and construction criteria	Specifies minimum design and construction criteria for landfill gas extraction systems.		*	*	*	*	*	*	*	*
NR 507 - Monitoring for Landfills	Specifies monitoring requirements for ground water, leachate and gas.	*	*	*	*	*	*	*	*	*
NR 508 - Responses when a groundwater standard is exceeded	Specifies procedures for responding to groundwater exceeding a standard.	*	*	*	*	*	*	*	*	*
NR 600-620 - Hazardous Waste Management	Establishes requirements for the identification of hazardous waste and standards for the storage, transport, and disposal of hazardous waste. Generally parallels RCRA part 264 requirements (see Federal ARARs table)	*	*	*	*	*	*	*	*	*
NR 700-754 - Investigation and Remediation of Environmental Contamination	Specifies standards and procedures pertaining to the identification, investigation and remediation of sites.	*	*	*	*	*	*	*	*	*
NR 809 Safe Drinking Water	Establishes minimum standards for safe drinking water	*	*	*	*	*	*	*	*	*
NR 811 Requirements for the Operation and Design of Community Water Systems	Establishes design and operation standards for community water systems			*				*		
NR 812 Well Construction and Pump Installation	Establishes standards for extracting groundwater			*	*	*		*	*	*

Table 3-1 Stratigraphic Groupings of Monitoring Wells
FF/NN Landfill, Ripon, WI

Layer	Well ID	Well Screen Elevation (ft msl)	Lithology at Well Screen
Layer 1 Wells	MW-106	821.0	sand
Layer 1 Wells	MW-101	820.4	sand
Layer 1 Wells	MW-104	819.3	sand & gravel
Layer 1 Wells	MW-102	818.9	sand & gravel
Layer 1 Wells	MW-103	818.7	sand
Layer 1 Wells	MW-107	816.5	sand
Layer 1 Wells	MW-108	814.9	sand
Layer 1 Wells	MW-112	814.1	sand
Layer 1 Wells	MW-111	812.3	sand
Layer 2 Wells	P-106	791.7	sand
Layer 2 Wells	P-101	790.0	sand
Layer 2 Wells	P-103	789.9	silt
Layer 2 Wells	P-107	785.6	sand
Layer 2 Wells	P-108	783.5	sand
Layer 2 Wells	P-104	782.0	sand
Layer 2 Wells	P-102	781.3	sand
Layer 2 Wells	P-111	774.2	sand
Layer 3 Wells	P-111D	704.0	sand and gravel
Layer 3 Wells	P-103D	682.08	sandstone
Layer 3 Wells	MW-3B	665.0	sandstone
Layer 3 Wells	P-113B	634.2	sandstone
Layer 3 Wells	P-114	654.4	sandstone
Layer 3 Wells	P-115	662.7	sandstone
Layer 3 Wells	P-116	681.3	sandstone
Layer 4 wells	MW-3A	570.0	sandstone
Layer 4 wells	P-107D	544.0	granite
Layer 4 wells	P-113A	507.8	sandstone

Table 4-1 Screening of General Response Actions and Technologies

General Response Action	Potential Remedial Technology	Process Options	Description	Initial Screening
No Action	None	Not Applicable	No additional action. Groundwater would be subject to on-going, uncontrolled hydrologic processes.	Required for consideration by NCP
Landfill Gas Control	Landfill Gas Extraction	Active Landfill Gas Extraction	Vacuum blower applied to vents and/or wells in the landfill to actively remove landfill gas.	Potentially applicable. Interim system installed and operating
		Passive Landfill Gas Extraction	Gases are passively vented from extraction vents and/or wells	Not appropriate because gases are not controlled.
	Landfill Gas Treatment	Flaring	Gases are combusted using thermal flare	Not appropriate because gases can be vented without treatment
Groundwater Extraction	Extraction	Extraction Wells	Series of wells to extract contaminated water	Potentially applicable.
	Subsurface Drains	Trench or Horizontal Drains	Trenches or horizontal boreholes with perforated pipes, and backfill with porous media to collect groundwater.	Not feasible because of depth of aquifer
Groundwater Treatment (Ex-situ)	Physical/Chemical Treatment	Air Stripping	Mixing large volumes of air with water in it in a packed column or trays to promote transfer of VOCs to air	Potentially applicable.
		Carbon Adsorption	Adsorption of VOCs onto activated carbon by passing water through carbon column	Not effective in removal of vinyl chloride.
	Biological Treatment	Aerobic	Degradation of VOCs using microorganisms in an aerobic environment	Not feasible due to insufficient contaminant mass to support an adequate microbial population density.
		Anerobic	Degradation of VOCs using microorganisms in an anaerobic environment	Not feasible due to insufficient contaminant mass to support an adequate microbial population density.
Groundwater Discharge	Discharge	POTW	Discharge to Ripon POTW via sanitary sewer approximately 1 mile away.	Not feasible due to distance and inability of POTW to handle volume of water
		Surface Waters	Discharge to Silver Creek or wetland.	Potentially applicable.
		Infiltration Gallery	Discharge to infiltration gallery upgradient of extraction wells.	Not feasible due to potential problems with clogging, cold weather maintenance, and unsuitable soils.
Groundwater Treatment (In-situ)	Physical/ Chemical treatment	ART In Well Technology	In-well technology that combines in-situ air stripping, air sparging, soil vapor extraction and enhanced bioremediation/oxidation plus subsurface circulation	Potentially applicable.
		Permeable Reactive Barrier	Barriers constructed of reactive materials, such as iron filings, that serve to reductively dechlorinate VOCs as they pass through the permeable wall. Reactive materials can be implaced via trenches or injection wells.	Not feasible because of depth and thickness of aquifer
		Chemical Oxidation	System of injection wells to inject oxidizer such as hydrogen peroxide or potassium permanganate to oxidize VOCs	Not feasible because of depth and thickness of aquifer and areal extent of VOC plume
	Biological treatment	Bioaugmentation	System of injection wells to introduce and/or recirculate halorespiring bacteria and electron donor, such as lactate or emulsified oil, to produce anaerobic environment that results in reductive dechlorination of VOCs.	Not feasible because of depth and thickness of aquifer and areal extent of VOC plume
	Natural Attenuation	Monitored Natural Attenuation	Monitoring groundwater parameters to determine if natural subsurface processes, such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials, are naturally reducing VOC concentrations such that the plume is stable or shrinking.	Potentially applicable.
Alternative Water Supply	Alternative Water Supply	Municpal Water Supply	Extension of existing municipal well system to serve residents in the area of influence.	Potentially applicable. Already implemented for some residences and available for others potentially at risk.
		Residential Point-of-Entry Treatment System	Install POE treatment at residences with impacted water. It is considered a temporary measure.	Potentially applicable if contingency municipal water supply is refused
		Bottled water	Provide bottled water for residents with impacted private well. It is considered a temporary measure.	Potentially applicable as temporary measure only
		Relocate wells	Install new wells to serve residents within potentially contaminated area.	Potentially applicable if contingency municipal water supply is refused

Note: Shaded areas indicate response actions that are not carried forward for further consideration.

Table 5-1 Cost Estimate for Alternative B1- Existing Gas Control with MNA

Capital Costs	
Total	$0

Annual Costs	
Gas Control System Maintenance and Repair	$8,000
Gas Control System Off Site Data Evaluation for Blower Run time	$6,000
Gas Control Syetem Piping Bi Annual Leak Testing and Repairs	$5,000
Gas Control System Operation (electricity, condensate disposal)	$8,000
Groundwater Monitoring [1]	$40,000
Total Annual Costs	$67,000
Present Worth of Annual Costs (30 yrs for extraction system, 30 yrs for monitoring) *	$1,029,924

Present Worth of Alternative B1	$1,029,924

Notes

[1] Groundwater sampling: 13 wells quarterly, 16 wells semiannually, 27 wells annually;
Gas sampling: 6 points quarterly; Leachate sampling: 3 well annually;
Private well sampling: 3 wells annually

* Present worth calculated for 30 years at 5% (pwf = 15.372)

Table 5-2 Cost Estimate for Alternative B2- Existing Gas Control with MNA and Municipal Water Contingency

Capital Costs				
Item	Unit Cost	Unit	Quantity	Total
Extend Water Main on South Koro Rd.	$ 110	linear ft	800	$88,000
Private Well Abandonments	$ 1,000	well	12	$12,000
Connection Fees	$ 600	home	12	$7,200
Plumbing, etc. to connect to homes	$ 4,000	home	12	$48,000
Subtotal				$155,200
Contingency (15%)				$23,280
Total				$178,480

Annual Costs	
Gas Control System Maintenance and Repair	$8,000
Gas Control System Off Site Data Evaluation for Blower Run time	$6,000
Gas Control Syetem Piping Bi Annual Leak Testing and Repairs	$5,000
Gas Control System Operation (electricity, condensate disposal)	$8,000
Groundwater Monitoring [1]	$40,000
Total Annual Costs	$67,000
Present Worth of Annual Costs (30 yrs for extraction system, 30 yrs for monitoring) *	$1,029,924

Present Worth of Alternative B2	$1,208,404

Notes

[1] Groundwater sampling: 13 wells quarterly, 16 wells semiannually, 27 wells annually;
Gas sampling: 6 points quarterly; Leachate sampling: 3 well annually;
Private well sampling: 3 wells annually

* Present worth calculated for 30 years at 5% (pwf= 15.372)

Table 5-3 Cost Estimate for Alternative B3- Existing Gas Control with Groundwater Extraction & Treatment

Capital Costs				
Item	Unit Cost	Unit	Quantity	Total
Permitting, Design, and Regulatory Requirements	$30,000	each	1	$30,000
Well Installation, 6" DIA SCH 80 PVC, per foot	$150	LF	400	$60,000
Header Pipe Install., Power Supply, Groundwater Re	$80	LF	700	$56,000
Groundwater Pumps 20 GPM per well	$4,000	each	2	$8,000
Power Drop	$20,000	each	1	$20,000
Building to house groundwater treatment system	$30,000	each	1	$30,000
Air stripper skid and control panel	$70,000	each	1	$70,000
Subsurface Pipeline to Silver Creek	$40	linear ft	1,500	$60,000
Property Access - 2 wells plus 1 treatment building	$20,000	each	3	$60,000
NPDES Permit/ Hydrologic Evaluation	$20,000	each	1	$20,000
Subtotal				$414,000
Permitting and Design (10%)				$41,400
Construction Oversight (8%)				$33,120
Contingency (15%)				$73,278
Total				$561,798

Annual Costs			
Groundwater Extraction and Treatment System Operation: 3 HP blower motor, 2 HP water disharge pump, two 1 HP well pumps, filters, 3 manhours per week at $60	$60,000	1	$60,000
Monthly Water Discharge Sampling and Analysis	$1,400	12	$16,800
Groundwater Extraction & Treatment System Maintenance and Repair			$45,000
Gas Control System Maintenance and Repair			$8,000
Gas Control System Off Site Data Evaluation for Blower Run time			$6,000
Gas Control Syetem Piping Bi Annual Leak Testing and Repairs			$5,000
Gas Control System Operation (electricity, condensate disposal)			$8,000
Groundwater Monitoring [1]			$40,000
Total Annual Costs			$188,800
Present Worth of Annual Costs (30 yrs for extraction system, 30 yrs for monitoring) *			$2,902,234

Present Worth of Alternative B3	$3,464,032

Notes

[1] Groundwater sampling: 13 wells quarterly, 16 wells semiannually, 27 wells annually;
Gas sampling: 6 points quarterly; Leachate sampling: 3 well annually;
Private well sampling: 3 wells annually

* Present worth calculated for 30 years at 5% (pwf= 15.372)

Table 5-4 Cost Estimate for Alternative B4- Existing Gas Control with In-Situ Groundwater Treatment and MNA

Capital Costs				
Item	Unit Cost	Unit	Quantity	Total
Permitting, Design, and Regulatory Requirements	$50,000	each	1	$50,000
Well Installation, 6" DIA SCH 80 PVC, per foot	$150	LF	1600	$240,000
Header Pipe Install., Air and Power Supply, Vapor R	$80	LF	700	$56,000
Power Drop	$20,000	each	1	$20,000
ART Technology well head units	$9,281	each	8	$74,248
ART Technology mobilization and start up	$2,945	each	1	$2,945
ART Technology Technical Assistance + Consulting	$145	per hour	24	$3,480
ART Technology Electrical Water Pumps and Wire I	$1,106	each	8	$8,848
ART Technology in well piping and fittings	$1,182	each	8	$9,456
ART Technology Traveling costs	$598	each	2	$1,196
ART Technology Shipping	$725	each	1	$725
ART Technology Per Diem	$295	each	4	$1,180
Building with Air Compressor and Vacuum Blower	$80,000	each	1	$80,000
System Startup	$20,000	each	1	$20,000
Subtotal				$568,078
Permitting and Design (10%)				$56,808
Construction Oversight (8%)				$45,446
Contingency (15%)				$85,212
Total				$755,544

Annual Costs	
ART System Maintenance and Repair (15% of Capital Costs)	$113,332
ART System Operation (electricity, condensate disposal)	$15,000
Gas Control System Maintenance and Repair	$8,000
Gas Control System Off Site Data Evaluation for Blower Run time	$6,000
Gas Control Syetem Piping Bi Annual Leak Testing and Repairs	$5,000
Gas Control System Operation (electricity, condensate disposal)	$8,000
Groundwater Monitoring [1]	$40,000
Total Annual Costs	$195,332
Present Worth of Annual Costs (30 yrs for extraction system, 30 yrs for monitoring) *	$3,002,637

Present Worth of Alternative B4	$3,758,180

Notes

[1] Groundwater sampling: 13 wells quarterly, 16 wells semiannually, 27 wells annually;
Gas sampling: 6 points quarterly; Leachate sampling: 3 well annually;
Private well sampling: 3 wells annually

* Present worth calculated for 30 years at 5% (pwf= 15.372)

Table 5-5 Cost Estimate for Alternative C1- Expanded Gas Control with MNA

Capital Costs				
Item	Unit Cost	Unit	Quantity	Total
Install Active Gas Extraction Wells 36" DIA Boreho	$ 500	linear ft	120	$ 60,000
Repair Landfill Cap at Borehole Locations	$ 4,000	each	4	$ 16,000
Install Horizontal Header System - 3" SCH 40 PVC	$ 50	linear ft	1,500	$ 75,000
Upgrade Test Vault and Manifold	$ 15,000	each	1	$ 15,000
Upgrade Blower System	$ 25,000	each	1	$ 25,000
Modify Trailer	$ 10,000	each	1	$ 10,000
Upgrade EOS electronic monitoring system	$ 15,000	each	1	$ 15,000
Increase 1-Phase Power	$ 6,000	each	1	$ 6,000
Subtotal				$ 222,000
Design (10% of Costs)				$ 22,200
Construction Oversight and Reporting (8% of costs)				$ 17,760
Contingency (15%)				$ 33,300
Total				$ 295,260

Annual Costs	
Gas Control System Maintenance and Repair	$20,000
Gas Control System Off Site Data Evaluation for Blower Run time	$6,000
Gas Control Syetem Piping Bi Annual Leak Testing and Repairs	$5,000
Gas Control System Operation (electricity, condensate disposal)	$12,000
Groundwater Monitoring [1]	$40,000
Total Annual Costs	$83,000
Present Worth of Annual Costs (30 yrs for extraction system, 30 yrs for monitoring) *	$1,275,876

Present Worth of Alternative C1	$1,571,136

Notes

[1] Groundwater sampling: 13 wells quarterly, 16 wells semiannually, 27 wells annually;
Gas sampling: 6 points quarterly; Leachate sampling: 3 well annually;
Private well sampling: 3 wells annually

* Present worth calculated for 30 years at 5% (pwf = 15.372)

Table 5-6 Cost Estimate for Alternative C2- Expanded Gas Control with MNA and Municipal Water Contingency

Expanded Gas Control System Capital Costs				
Item	Unit Cost	Unit	Quantity	Total
Install Active Gas Extraction Wells 36" DIA Boreho	$ 500	linear ft	120	$ 60,000
Repair Landfill Cap at Borehole Locations	$ 4,000	each	4	$ 16,000
Install Horizontal Header System - 3" SCH 40 PVC	$ 50	linear ft	1,500	$ 75,000
Upgrade Test Vault and Manifold	$ 15,000	each	1	$ 15,000
Upgrade Blower System	$ 25,000	each	1	$ 25,000
Modify Trailer	$ 10,000	each	1	$ 10,000
Upgrade EOS electronic monitoring system	$ 15,000	each	1	$ 15,000
Increase 1-Phase Power	$ 6,000	each	1	$ 6,000
Subtotal				$ 222,000
Design (10% of Costs)				$ 22,200
Construction Oversight and Reporting (8% of costs)				$ 17,760
Contingency (15%)				$ 33,300
Total				$ 295,260

Municpal Water Extension Capital Costs				
Item	Unit Cost	Unit	Quantity	Total
Extend Water Main on South Koro Rd.	$ 110	linear ft	800	$88,000
Private Well Abandonments	$ 1,000	well	12	$12,000
Connection Fees	$ 600	home	12	$7,200
Plumbing, etc. to connect to homes	$ 4,000	home	12	$48,000
Subtotal				$155,200
Contingency (15%)				$23,280
Total				$178,480

Annual Costs	
Gas Control System Maintenance and Repair	$20,000
Gas Control System Off Site Data Evaluation for Blower Run time	$6,000
Gas Control Syetem Piping Bi Annual Leak Testing and Repairs	$5,000
Gas Control System Operation (electricity, condensate disposal)	$12,000
Groundwater Monitoring [1]	$40,000
Total Annual Costs	$83,000
Present Worth of Annual Costs (30 yrs for extraction system, 30 yrs for monitoring) *	$1,275,876

Present Worth of Alternative C2	$1,749,616

Notes

[1] Groundwater sampling: 13 wells quarterly, 16 wells semiannually, 27 wells annually;
Gas sampling: 6 points quarterly; Leachate sampling: 3 well annually;
Private well sampling: 3 wells annually

* Present worth calculated for 30 years at 5% (pwf= 15.372)

Table 5-7 Cost Estimate for Alternative C3- Expanded Gas Control with Groundwater Extraction & Treatment

Expanded Gas Control System Capital Costs				
Item	Unit Cost	Unit	Quantity	Total
Install Active Gas Extraction Wells 36" DIA Boreho	$ 500	linear ft	120	$ 60,000
Repair Landfill Cap at Borehole Locations	$ 4,000	each	4	$ 16,000
Install Horizontal Header System - 3" SCH 40 PVC	$ 50	linear ft	1,500	$ 75,000
Upgrade Test Vault and Manifold	$ 15,000	each	1	$ 15,000
Upgrade Blower System	$ 25,000	each	1	$ 25,000
Modify Trailer	$ 10,000	each	1	$ 10,000
Upgrade EOS electronic monitoring system	$ 15,000	each	1	$ 15,000
Increase 1-Phase Power	$ 6,000	each	1	$ 6,000
Subtotal				$ 222,000
Design (10% of Costs)				$ 22,200
Construction Oversight and Reporting (8% of costs)				$ 17,760
Contingency (15%)				$ 33,300
Total				$ 295,260

Groundwater Extraction & Treatment Capital Costs				
Item	Unit Cost	Unit	Quantity	Total
Permitting, Design, and Regulatory Requirements	$30,000	each	1	$30,000
Well Installation, 6" DIA SCH 80 PVC, per foot	$150	LF	400	$60,000
Header Pipe Install., Power Supply, Groundwater Re	$80	LF	700	$56,000
Groundwater Pumps 20 GPM per well	$4,000	each	2	$8,000
Power Drop	$20,000	each	1	$20,000
Building to house groundwater treatment system	$30,000	each	1	$30,000
Air stripper skid and control panel	$70,000	each	1	$70,000
Subsurface Pipeline to Silver Creek	$40	linear ft	1,500	$60,000
Property Access - 2 wells plus 1 treatment building	$20,000	each	3	$60,000
NPDES Permit/ Hydrologic Evaluation	$20,000	each	1	$20,000
Subtotal				$414,000
Permitting and Design (10%)				$41,400
Construction Oversight (8%)				$33,120
Contingency (15%)				$73,278
Total				$561,798

Annual Costs			
Groundwater Extraction and Treatment System Operation: 3 HP blower motor, 2 HP water disharge pump, two 1 HP well pumps, filters, 3 manhours per week at $60	$60,000	1	$60,000
Monthly Water Discharge Sampling and Analysis	$1,400	12	$16,800

Table 5-7 Cost Estimate for Alternative C3- Expanded Gas Control with Groundwater Extraction & Treatment

Groundwater Extraction & Treatment System Maintenance and Repair	$45,000
Gas Control System Maintenance and Repair	$20,000
Gas Control System Off Site Data Evaluation for Blower Run time	$6,000
Gas Control Syetem Piping Bi Annual Leak Testing and Repairs	$5,000
Gas Control System Operation (electricity, condensate disposal)	$12,000
Groundwater Monitoring [1]	$40,000
Total Annual Costs	$204,800
Present Worth of Annual Costs (30 yrs for extraction system, 30 yrs for monitoring) *	$3,148,186

Present Worth of Alternative C3	$4,005,244

Notes

[1] Groundwater sampling: 13 wells quarterly, 16 wells semiannually, 27 wells annually;
Gas sampling: 6 points quarterly; Leachate sampling: 3 well annually;
Private well sampling: 3 wells annually

* Present worth calculated for 30 years at 5% (pwf = 15.372)

Table 5-8 Cost Estimate for Alternative C4- Expanded Gas Control with In-Situ Groundwater Treatment and MNA

Expanded Gas Control System Capital Costs				
Item	Unit Cost	Unit	Quantity	Total
Install Active Gas Extraction Wells 36" DIA Boreho	$ 500	linear ft	120	$ 60,000
Repair Landfill Cap at Borehole Locations	$ 4,000	each	4	$ 16,000
Install Horizontal Header System - 3" SCH 40 PVC	$ 50	linear ft	1,500	$ 75,000
Upgrade Test Vault and Manifold	$ 15,000	each	1	$ 15,000
Upgrade Blower System	$ 25,000	each	1	$ 25,000
Modify Trailer	$ 10,000	each	1	$ 10,000
Upgrade EOS electronic monitoring system	$ 15,000	each	1	$ 15,000
Increase 1-Phase Power	$ 6,000	each	1	$ 6,000
Subtotal				$ 222,000
Design (10% of Costs)				$ 22,200
Construction Oversight and Reporting (8% of costs)				$ 17,760
Contingency (15%)				$ 33,300
Total				$ 295,260

In-Situ Groundwater Treatment Capital Costs				
Item	Unit Cost	Unit	Quantity	Total
Permitting, Design, and Regulatory Requirements	$50,000	each	1	$50,000
Well Installation, 6" DIA SCH 80 PVC, per foot	$150	LF	1600	$240,000
Header Pipe Install., Air and Power Supply, Vapor R	$80	LF	700	$56,000
Power Drop	$20,000	each	1	$20,000
ART Technology well head units	$9,281	each	8	$74,248
ART Technology mobilization and start up	$2,945	each	1	$2,945
ART Technology Technical Assistance + Consulting	$145	per hour	24	$3,480
ART Technology Electrical Water Pumps and Wire I	$1,106	each	8	$8,848
ART Technology in well piping and fittings	$1,182	each	8	$9,456
ART Technology Traveling costs	$598	each	2	$1,196
ART Technology Shipping	$725	each	1	$725
ART Technology Per Diem	$295	each	4	$1,180
Building with Air Compressor and Vacuum Blower	$80,000	each	1	$80,000
System Startup	$20,000	each	1	$20,000
Subtotal				$568,078
Permitting and Design (10%)				$56,808
Construction Oversight (8%)				$45,446
Contingency (15%)				$85,212
Total				$755,544

Annual Costs	
ART System Maintenance and Repair (15% of Capital Costs)	$113,332

Table 5-8 Cost Estimate for Alternative C4- Expanded Gas Control with In-Situ Groundwater Treatment and MNA

ART System Operation (electricity, condensate disposal)	$15,000
Gas Control System Maintenance and Repair	$20,000
Gas Control System Off Site Data Evaluation for Blower Run time	$6,000
Gas Control Syetem Piping Bi Annual Leak Testing and Repairs	$5,000
Gas Control System Operation (electricity, condensate disposal)	$12,000
Groundwater Monitoring [1]	$40,000
Total Annual Costs	$211,332
Present Worth of Annual Costs (30 yrs for extraction system, 30 yrs for monitoring) *	$3,248,589

Present Worth of Alternative C4	$4,299,392

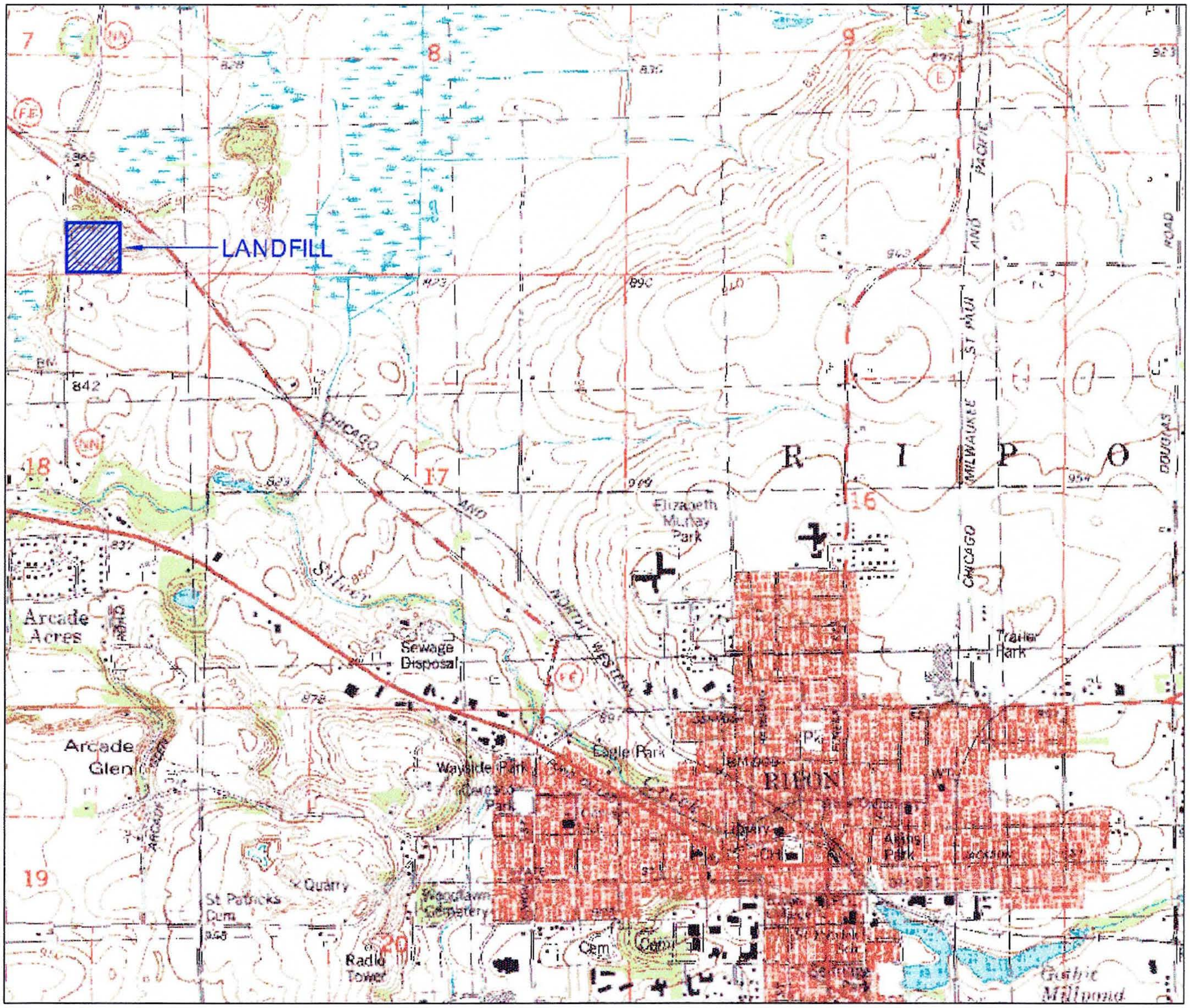
Notes

[1] Groundwater sampling: 13 wells quarterly, 16 wells semiannually, 27 wells annually;
Gas sampling: 6 points quarterly; Leachate sampling: 3 well annually;
Private well sampling: 3 wells annually

* Present worth calculated for 30 years at 5% (pwf = 15.372)

Table 6-1. Summary Comparison of Remedial Alternatives

Alternative	Description	Compliance with ARARs	Overall Protection of Human Health and the Environment	Short Term Effectiveness	Long Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume	Implementability	Capital Cost	Annual OM&M	Net Present Value
A	No Further Action	No	No	High	Low	Low	High	$0	$0	$0
B1	Existing Gas Control with MNA	Yes	Yes	High	Medium	Medium	High	$0	$67,000	$1,029,924
B2	Existing Gas Control with MNA and Municipal Water Contingency	Yes	Yes	Medium	High	Medium	Medium	$178,480	$67,000	$1,208,404
B3	Existing Gas Control with Groundwater Pump & Treatment	Yes	Yes	Low	High	High	Low	$561,798	$188,800	$3,464,032
B4	Existing Gas Control with In-Situ Groundwater Treatment and MNA	Yes	Yes	Low	High	High	Low	$755,544	$195,332	$3,758,180
C1	Expanded Gas Control with MNA	Yes	Yes	Medium	Medium	Medium	Medium	$295,260	$83,000	$1,571,136
C2	Expanded Gas Control with MNA and Municipal Water Contingency	Yes	Yes	Medium	High	Medium	Medium	$473,740	$83,000	$1,749,616
C3	Expanded Gas Control with Groundwater Pump & Treatment	Yes	Yes	Low	High	High	Low	$857,058	$204,800	$4,005,244
C4	Expanded Gas Control with In-Situ Groundwater Treatment and MNA	Yes	Yes	Low	High	High	Low	$1,050,804	$211,332	$4,299,392



QUADRANGLE LOCATION

SCALE

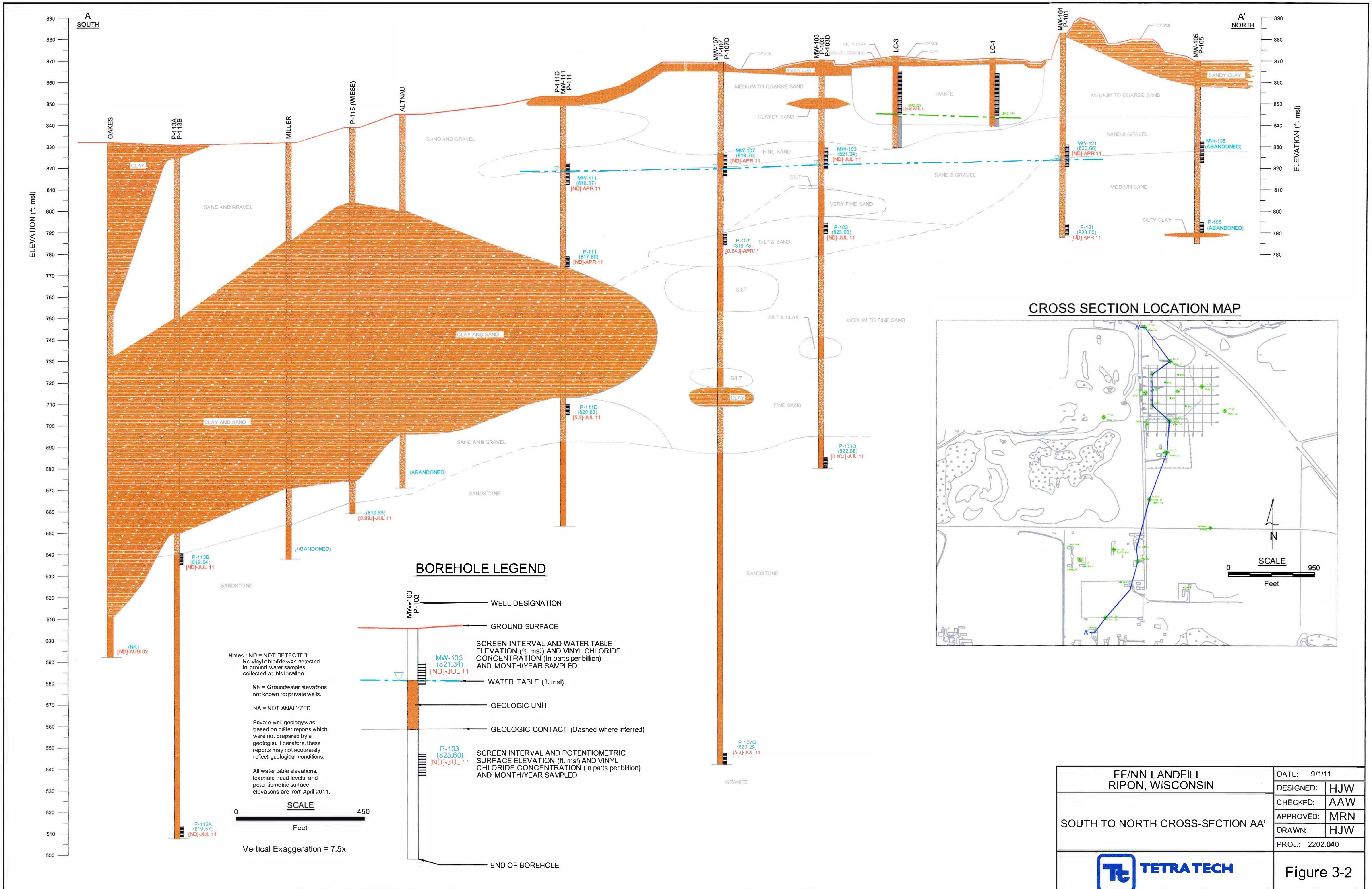
0 — 6000

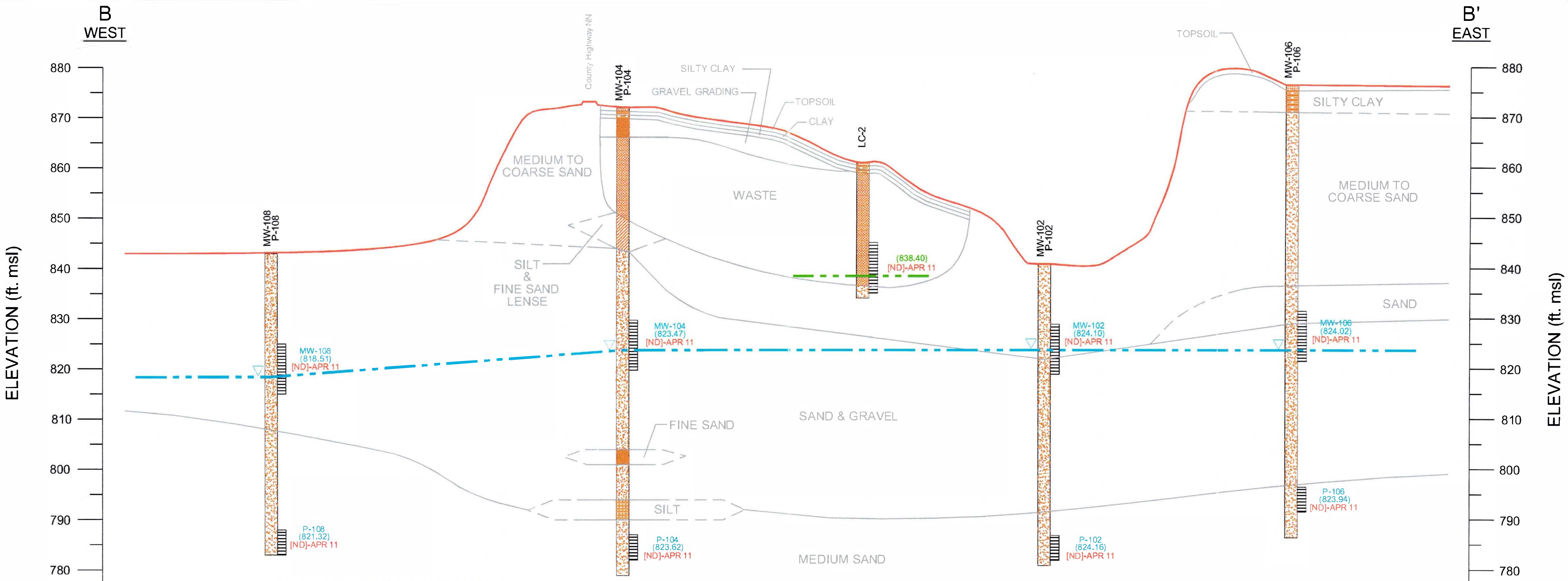
Feet

N

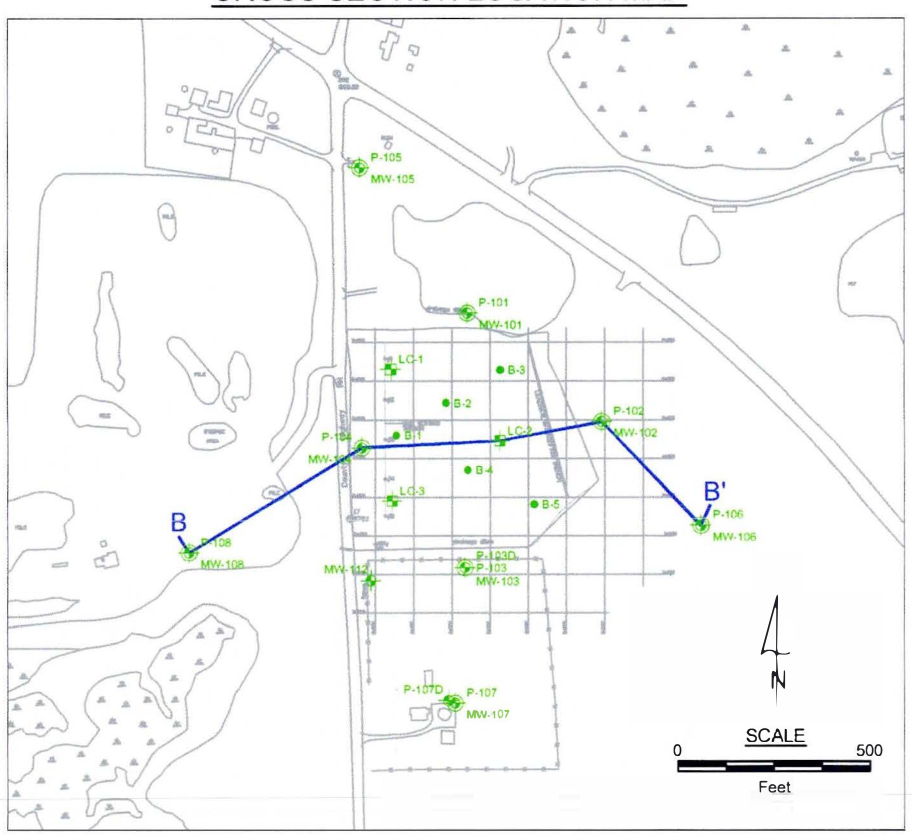
TITLE:	FF/NN LANDFILL SITE LOCATION MAP		
LOCATION:	RIPON, WISCONSIN		
TETRA TECH	CHECKED	MRN	FIGURE:
	DRAFTED	HJW	3-1
	PROJECT	117-2202040	
	DATE	11/18/10	

S:\CAD\Ripon\FS Report\2202040Fig3-1.dwg

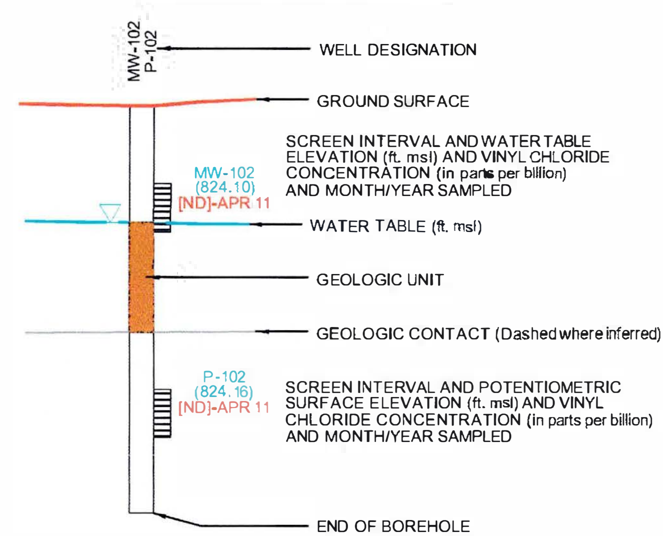

A
SOUTH
A'
NORTH
ELEVATION (ft. msl)
OAKES
P-113A
P-113B
MILLER
P-115 (WIESE)
ALTNAU
P-111D
MW-111
P-111
MW-107
P-107
P-107D
MW-103
P-103
P-103D
LC-3
LC-1
MW-101
P-101
MW-105
P-105
CLAY
SAND AND GRAVEL
CLAY AND SAND
SANDSTONE
GRANITE
MEDIUM TO COARSE SAND
CLAYEY SAND
FINE SAND
WASTE
SAND & GRAVEL
MEDIUM SAND
SILTY CLAY
SANDY CLAY
VERY FINE SAND
SILT & SAND
SILT
SILT & CLAY
MEDIUM TO FINE SAND
FINE SAND
MW-111
(818.37)
[ND]-APR 11
P-111
(817.89)
[ND]-APR 11
P-111D
(820.83)
[5.3]-JUL 11
MW-107
(819.76)
[ND]-APR 11
P-107
(819.73)
[0.84J]-APR11
P-107D
(820.29)
[5.3]-JUL 11
MW-103
(821.34)
[ND]-JUL 11
P-103
(823.60)
[ND]-JUL 11
P-103D
(822.88)
[0.78J]-JUL 11
MW-101
(823.66)
[ND]-APR 11
P-101
(823.60)
[ND]-APR 11
MW-105
(ABANDONED)
P-105
(ABANDONED)
P-113B
(819.64)
[ND]-JUL 11
P-113A
(819.67)
[ND]-JUL 11
(819.85)
[0.99J]-JUL 11
(ABANDONED)
(NK)
[ND]-AUG 02
CROSS SECTION LOCATION MAP
N
SCALE
0
950
Feet
BOREHOLE LEGEND
WELL DESIGNATION
GROUND SURFACE
SCREEN INTERVAL AND WATER TABLE ELEVATION (ft. msl) AND VINYL CHLORIDE CONCENTRATION (in parts per billion) AND MONTH/YEAR SAMPLED
WATER TABLE (ft. msl)
GEOLOGIC UNIT
GEOLOGIC CONTACT (Dashed where inferred)
SCREEN INTERVAL AND POTENTIOMETRIC SURFACE ELEVATION (ft. msl) AND VINYL CHLORIDE CONCENTRATION (in parts per billion) AND MONTH/YEAR SAMPLED
END OF BOREHOLE
Notes : ND = NOT DETECTED: No vinyl chloride was detected in ground water samples collected at this location.
NK = Groundwater elevations not known for private wells.
NA = NOT ANALYZED
Private well geology was based on driller reports which were not prepared by a geologist. Therefore, these reports may not accurately reflect geological conditions.
All water table elevations, leachate head levels, and potentiometric surface elevations are from April 2011.
SCALE
0
450
Feet
Vertical Exaggeration = 7.5x
FF/NN LANDFILL
RIPON, WISCONSIN
SOUTH TO NORTH CROSS-SECTION AA'
DATE: 9/1/11
DESIGNED: HJW
CHECKED: AAW
APPROVED: MRN
DRAWN: HJW
PROJ.: 2202.040
TETRA TECH
Figure 3-2



CROSS SECTION LOCATION MAP



BOREHOLE LEGEND



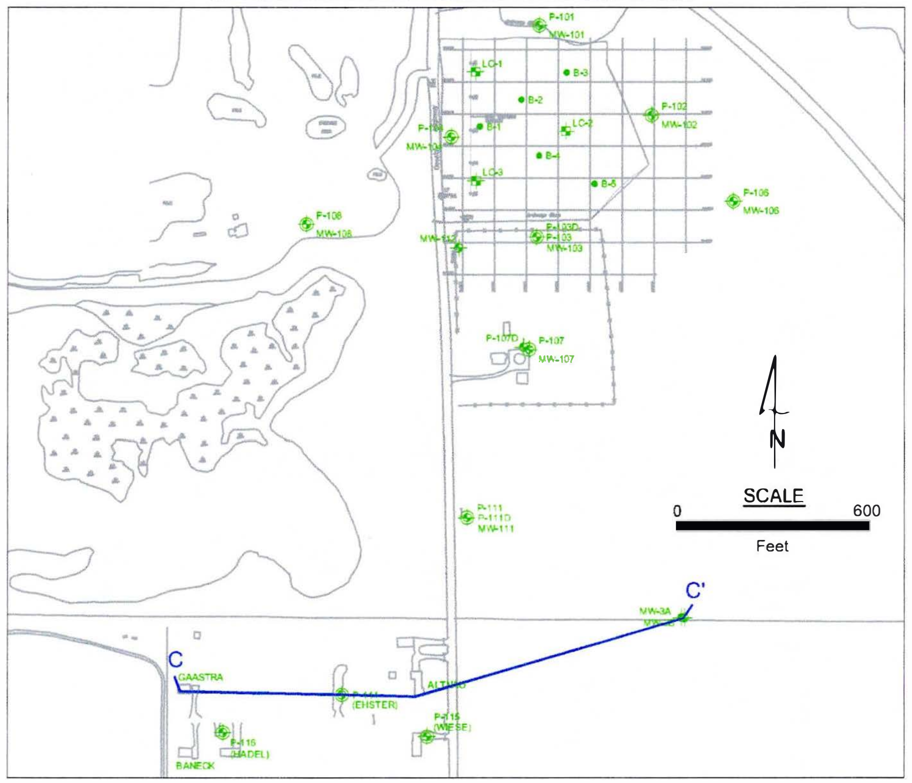
Notes : ND = NOT DETECTED:
No vinyl chloride was detected in ground water samples collected at this location.

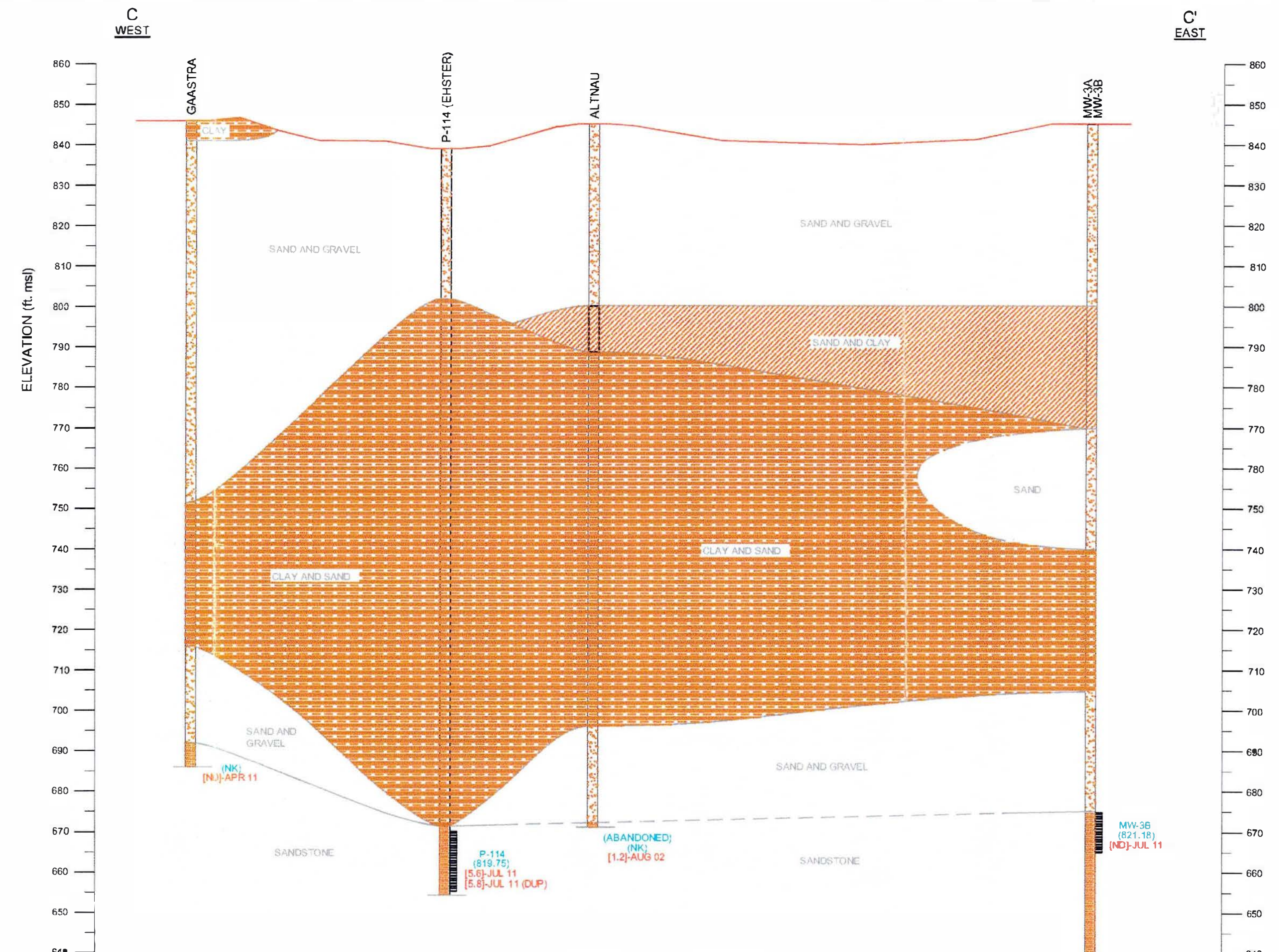
NA = NOT ANALYZED

All water table elevations, leachate head levels, and potentiometric surface elevations are from April 2011.

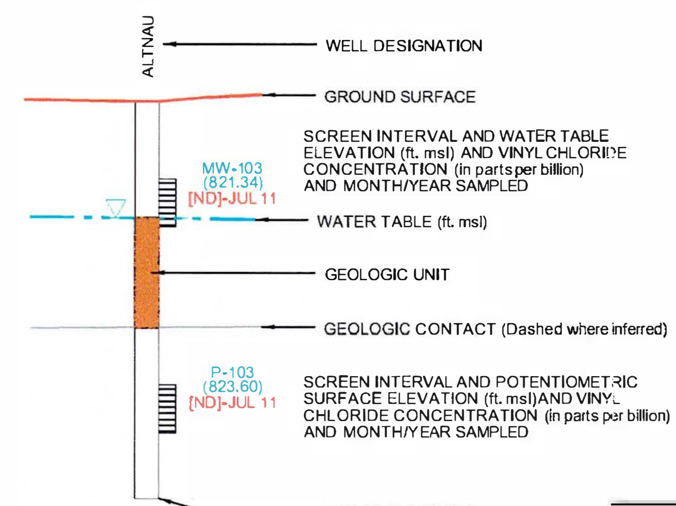
FF/NN LANDFILL RIPON, WISCONSIN		DATE:	9/1/11
		DESIGNED:	HJW
WEST TO EAST CROSS-SECTION BB'		CHECKED:	AAW
		APPROVED:	MRN
		DRAWN:	HJW
		PROJ.:	2202.040
TETRA TECH		Figure 3-3	

CROSS SECTION LOCATION MAP





BOREHOLE LEGEND



SCALE
0 450
Feet

Vertical Exaggeration = 7.5x

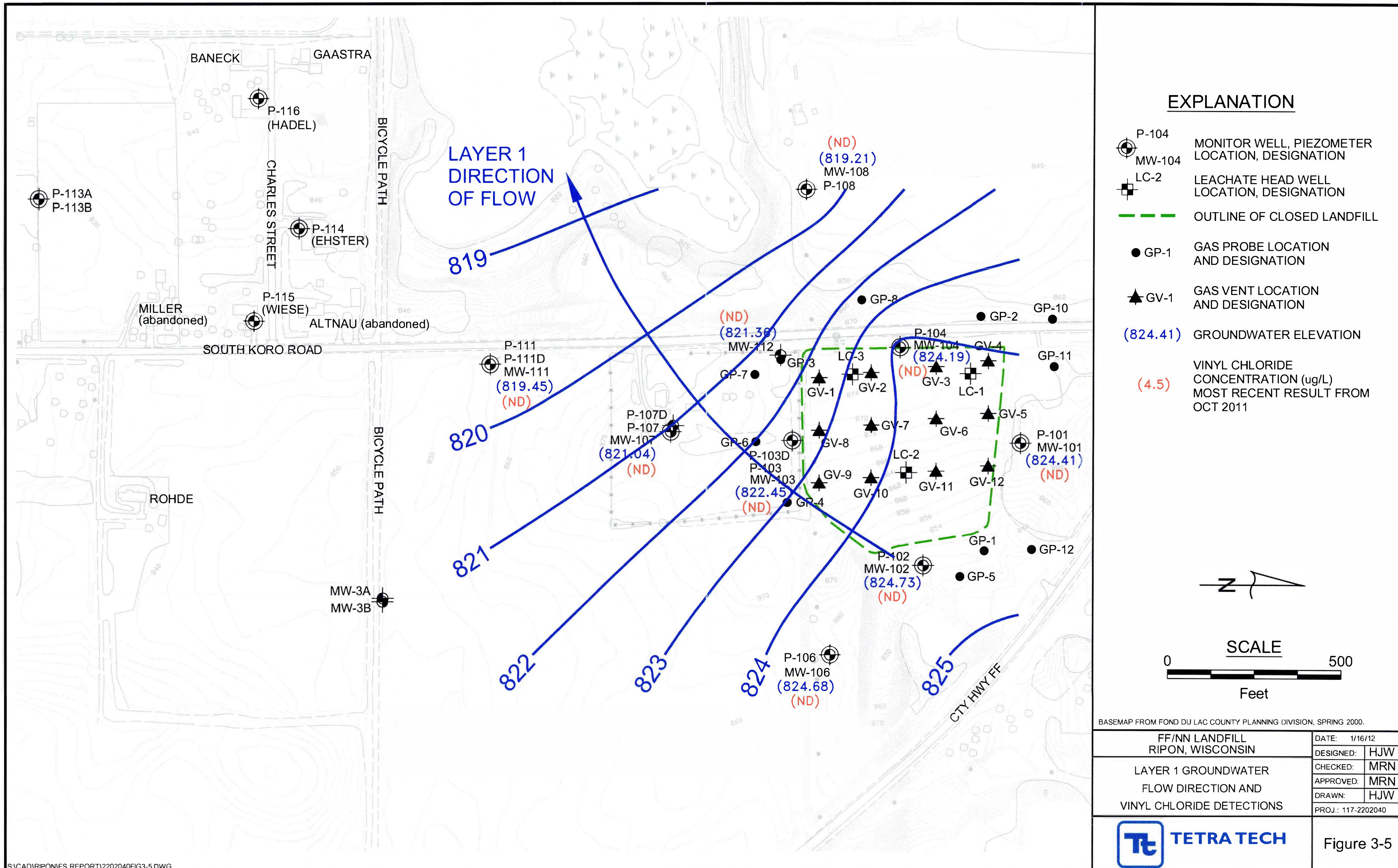
Notes : ND = NOT DETECTED: No vinyl chloride was detected in ground water samples collected at this location.

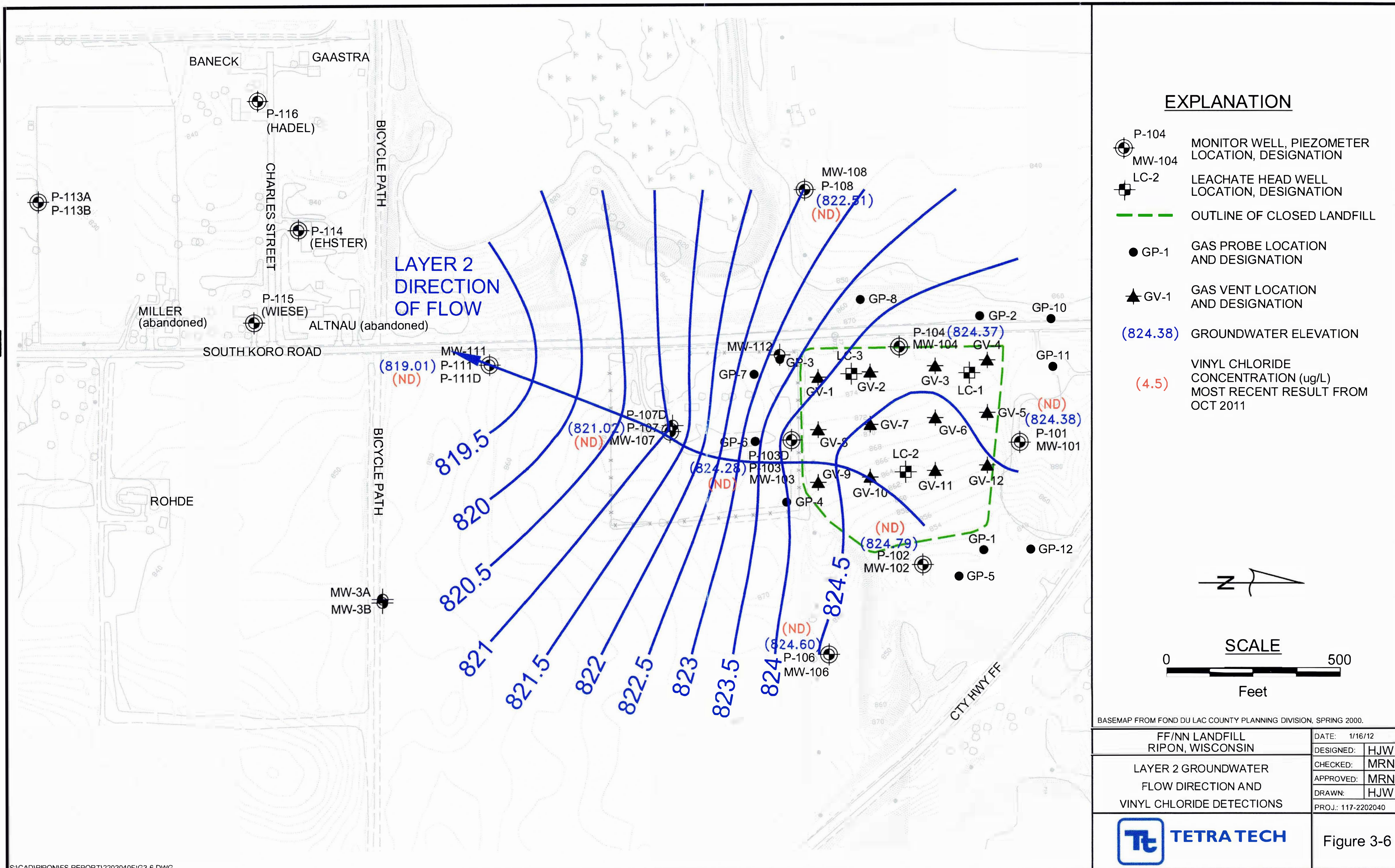
NK = Groundwater elevations not known for private wells.

NA = NOT ANALYZED

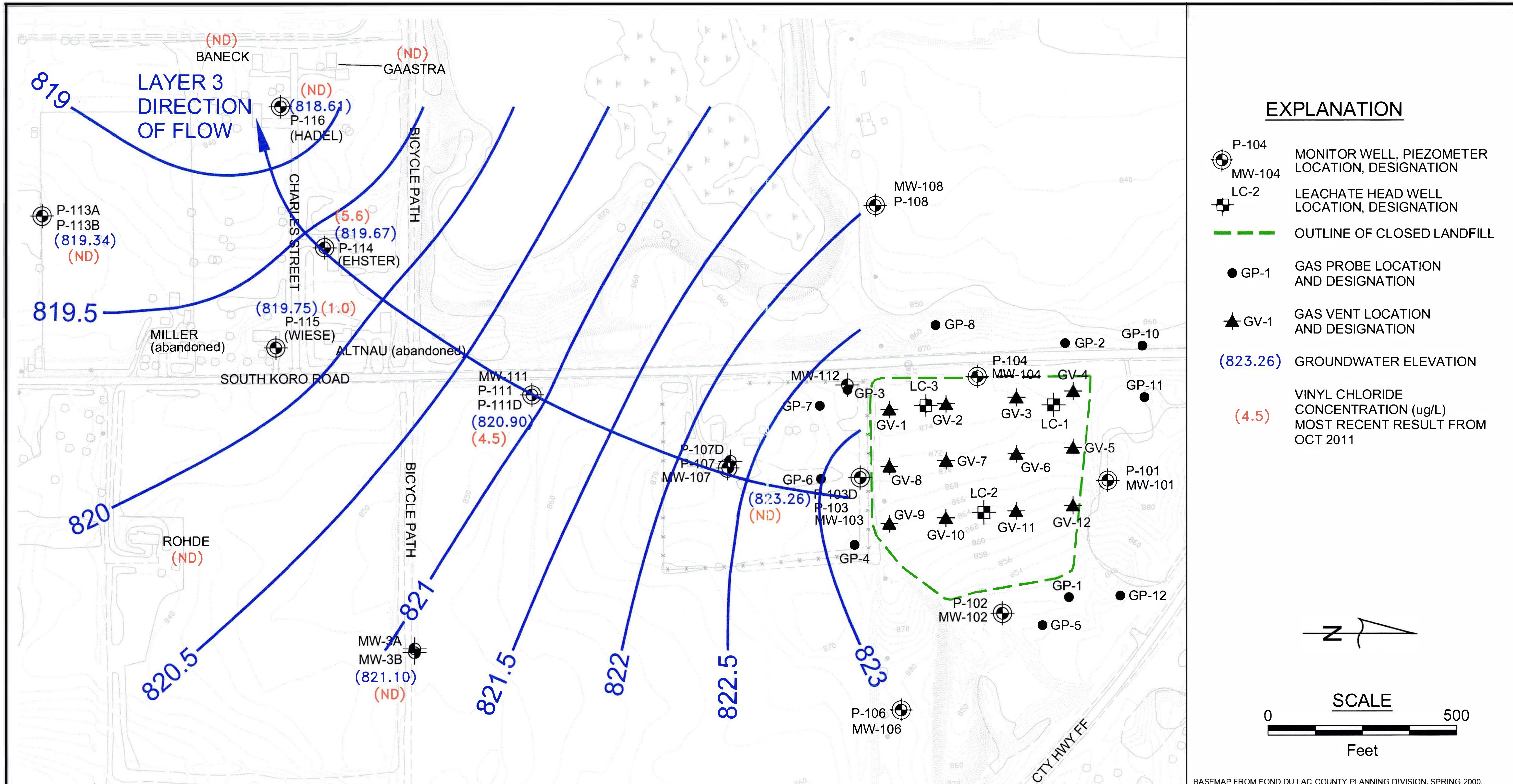
All water table and potentiometric surface elevations are from April 2011.

FF/NN LANDFILL RIPON, WISCONSIN	DATE: 9/1/11
	DESIGNED: HJW
	CHECKED: AAW
WEST TO EAST CROSS-SECTION CC'	APPROVED: MRN
	DRAWN: HJW
	PROJ.: 2202.040
TETRA TECH	Figure 3-4


BANECK
GAASTRA
P-116
(HADEL)
BICYCLE PATH
CHARLES STREET
LAYER 1
DIRECTION
OF FLOW
P-113A
P-113B
P-114
(EHSTER)
819
(ND)
(819.21)
MW-108
P-108
MILLER
(abandoned)
P-115
(WIESE)
ALTNAU (abandoned)
SOUTH KORO ROAD
P-111
P-111D
MW-111
(819.45)
(ND)
820
(ND)
(821.36)
MW-112
GP-3
GP-7
GP-8
GP-2
GP-10
P-104
MW-104
(824.19)
(ND)
GV-4
GP-11
LC-3
GV-1
GV-2
GV-3
LC-1
GV-5
P-107D
P-107
MW-107
(821.04)
(ND)
GP-6
P-103D
P-103
MW-103
(822.45)
(ND)
GP-4
GV-7
GV-6
GV-8
LC-2
GV-9
GV-10
GV-11
GV-12
P-101
MW-101
(824.41)
(ND)
ROHDE
821
GP-1
GP-12
P-102
MW-102
(824.73)
(ND)
GP-5
MW-3A
MW-3B
822
823
824
P-106
MW-106
(824.68)
(ND)
825
CTY HWY FF
S:\CAD\RIPON\FS REPORT\2202040FIG3-5.DWG
EXPLANATION
P-104
MW-104
MONITOR WELL, PIEZOMETER LOCATION, DESIGNATION
LC-2
LEACHATE HEAD WELL LOCATION, DESIGNATION
OUTLINE OF CLOSED LANDFILL
GP-1
GAS PROBE LOCATION AND DESIGNATION
GV-1
GAS VENT LOCATION AND DESIGNATION
(824.41)
GROUNDWATER ELEVATION
(4.5)
VINYL CHLORIDE CONCENTRATION (ug/L) MOST RECENT RESULT FROM OCT 2011
N
SCALE
0
500
Feet
BASEMAP FROM FOND DU LAC COUNTY PLANNING DIVISION, SPRING 2000.
FF/NN LANDFILL
RIPON, WISCONSIN
LAYER 1 GROUNDWATER FLOW DIRECTION AND VINYL CHLORIDE DETECTIONS
DATE: 1/16/12
DESIGNED: HJW
CHECKED: MRN
APPROVED: MRN
DRAWN: HJW
PROJ.: 117-2202040
TETRA TECH
Figure 3-5



BANECK
GAASTRA
P-116
(HADEL)
P-113A
P-113B
P-114
(EHSTER)
CHARLES STREET
BICYCLE PATH
LAYER 2
DIRECTION
OF FLOW
P-115
(WIESE)
MILLER
(abandoned)
ALTNAU (abandoned)
SOUTH KORO ROAD
MW-111
(819.01) P-111
(ND) P-111D
ROHDE
MW-3A
MW-3B
BICYCLE PATH
819.5
820
820.5
821
821.5
822
822.5
823
823.5
824
824.5
MW-108
P-108
(822.51)
(ND)
P-107D
(821.02) P-107
(ND) MW-107
MW-112
GP-3
GP-7
GP-6
P-103D
(824.28) P-103
(ND) MW-103
GP-4
GP-8
GP-2
GP-10
P-104 (824.37)
MW-104
GV-4
LC-3
GV-1
GV-2
GV-3
LC-1
GP-11
GV-5
(ND)
(824.38)
P-101
MW-101
GV-7
GV-6
GV-8
LC-2
GV-9
GV-10
GV-11
GV-12
(ND)
(824.79)
P-102
MW-102
GP-1
GP-12
GP-5
(ND)
(824.60)
P-106
MW-106
CTY HWY FF
EXPLANATION
P-104
MW-104
MONITOR WELL, PIEZOMETER LOCATION, DESIGNATION
LC-2
LEACHATE HEAD WELL LOCATION, DESIGNATION
OUTLINE OF CLOSED LANDFILL
GP-1
GAS PROBE LOCATION AND DESIGNATION
GV-1
GAS VENT LOCATION AND DESIGNATION
(824.38) GROUNDWATER ELEVATION
(4.5) VINYL CHLORIDE CONCENTRATION (ug/L) MOST RECENT RESULT FROM OCT 2011
N
SCALE
0
500
Feet
BASEMAP FROM FOND DU LAC COUNTY PLANNING DIVISION, SPRING 2000.
FF/NN LANDFILL
RIPON, WISCONSIN
LAYER 2 GROUNDWATER
FLOW DIRECTION AND
VINYL CHLORIDE DETECTIONS
DATE: 1/16/12
DESIGNED: HJW
CHECKED: MRN
APPROVED: MRN
DRAWN: HJW
PROJ.: 117-2202040
TETRA TECH
Figure 3-6
S:\CAD\RIPON\FS REPORT\2202040FIG3-6.DWG



BASEMAP FROM FOND DU LAC COUNTY PLANNING DIVISION, SPRING 2000.

FF/NN LANDFILL
RIPON, WISCONSIN

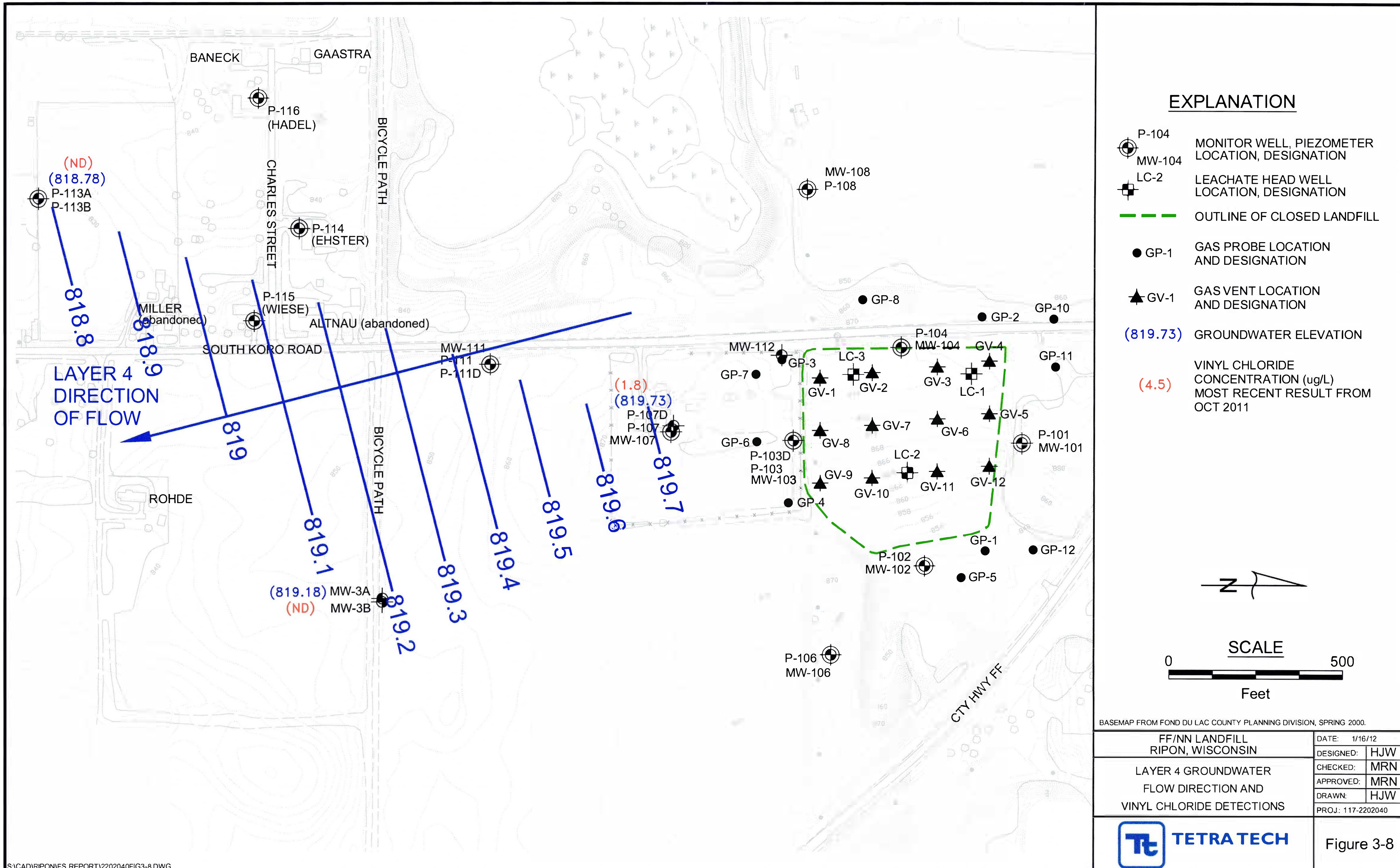
LAYER 3 GROUNDWATER FLOW DIRECTION AND VINYL CHLORIDE CETECTIONS

DATE:	1/16/12
DESIGNED:	HJW
CHECKED:	MRN
APPROVED:	MRN
DRAWN:	HJW
PROJ.: 117-2202040	

TETRA TECH

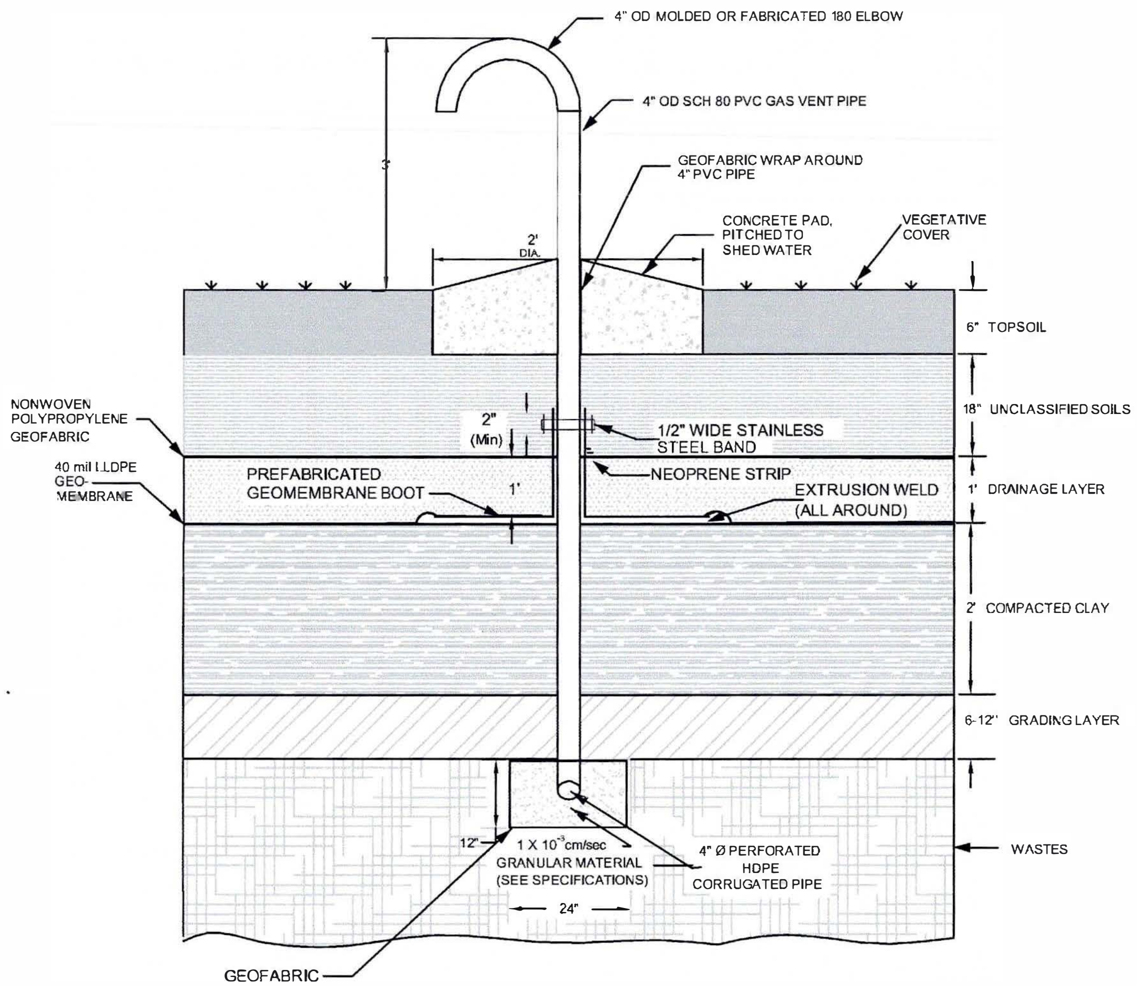
Figure 3-7

S:\CAD\RIPON\FS REPORT\2202040FIG3-7.DWG

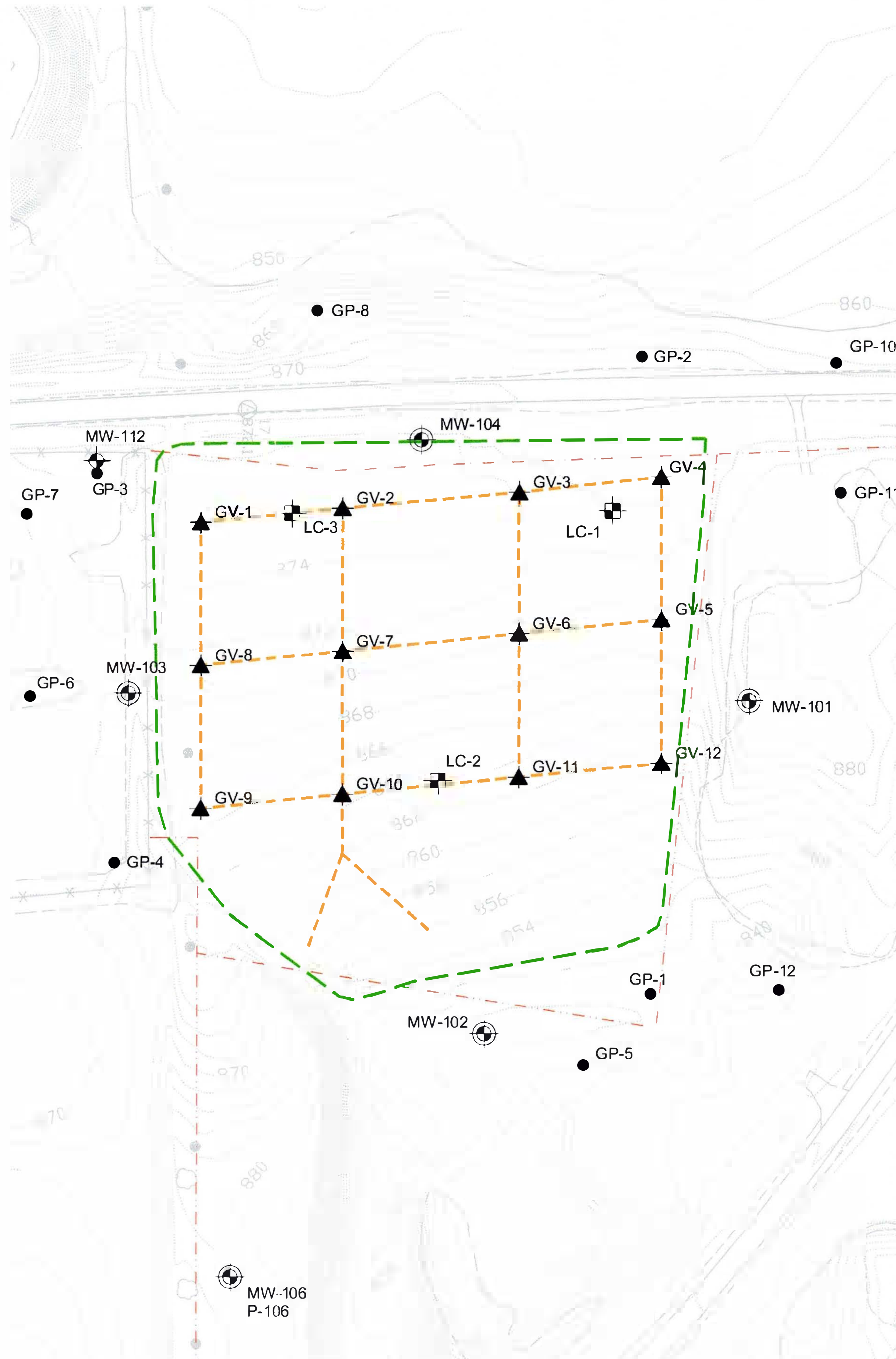


BANECK
GAASTRA
P-116 (HADEL)
BICYCLE PATH
CHARLES STREET
(ND)
(818.78)
P-113A
P-113B
P-114 (EHSTER)
P-115 (WIESE)
MILLER (abandoned)
ALTNAU (abandoned)
SOUTH KORO ROAD
MW-108
P-108
818.8
818.9
819
819.1
819.2
819.3
819.4
819.5
819.6
819.7
LAYER 4 DIRECTION OF FLOW
MW-111
P-111
P-111D
(1.8)
(819.73)
P-107D
P-107
MW-107
ROHDE
(819.18) MW-3A
(ND) MW-3B
MW-112
GP-3
GP-7
GP-6
GP-8
GP-2
GP-10
GP-11
P-104
MW-104
LC-3
LC-2
LC-1
GV-1
GV-2
GV-3
GV-4
GV-5
GV-6
GV-7
GV-8
GV-9
GV-10
GV-11
GV-12
P-103D
P-103
MW-103
GP-4
P-101
MW-101
GP-1
GP-12
P-102
MW-102
GP-5
P-106
MW-106
CTY HWY FF
EXPLANATION
P-104 MW-104 MONITOR WELL, PIEZOMETER LOCATION, DESIGNATION
LC-2 LEACHATE HEAD WELL LOCATION, DESIGNATION
OUTLINE OF CLOSED LANDFILL
GP-1 GAS PROBE LOCATION AND DESIGNATION
GV-1 GAS VENT LOCATION AND DESIGNATION
(819.73) GROUNDWATER ELEVATION
(4.5) VINYL CHLORIDE CONCENTRATION (ug/L) MOST RECENT RESULT FROM OCT 2011
N
SCALE
0 500
Feet
BASEMAP FROM FOND DU LAC COUNTY PLANNING DIVISION, SPRING 2000.
FF/NN LANDFILL
RIPON, WISCONSIN
LAYER 4 GROUNDWATER FLOW DIRECTION AND VINYL CHLORIDE DETECTIONS
DATE: 1/16/12
DESIGNED: HJW
CHECKED: MRN
APPROVED: MRN
DRAWN: HJW
PROJ.: 117-2202040
TETRA TECH
S:\CAD\RIPON\FS REPORT\2202040FIG3-8.DWG

Figure 3-8



A Passive Vent Detail
NTS



EXPLANATION

- MW-104 — MONITOR WELL LOCATION, DESIGNATION
- LC-2 — LEACHATE HEAD WELL LOCATION, DESIGNATION
- GP-1 — GAS PROBE LOCATION AND DESIGNATION
- GV-9 — GAS VENT LOCATION AND DESIGNATION
- 4" DIAMETER BURIED PASSIVE GAS COLLECTION SYSTEM PIPING
- PROPERTY LINE
- OUTLINE OF CLOSED LANDFILL

N

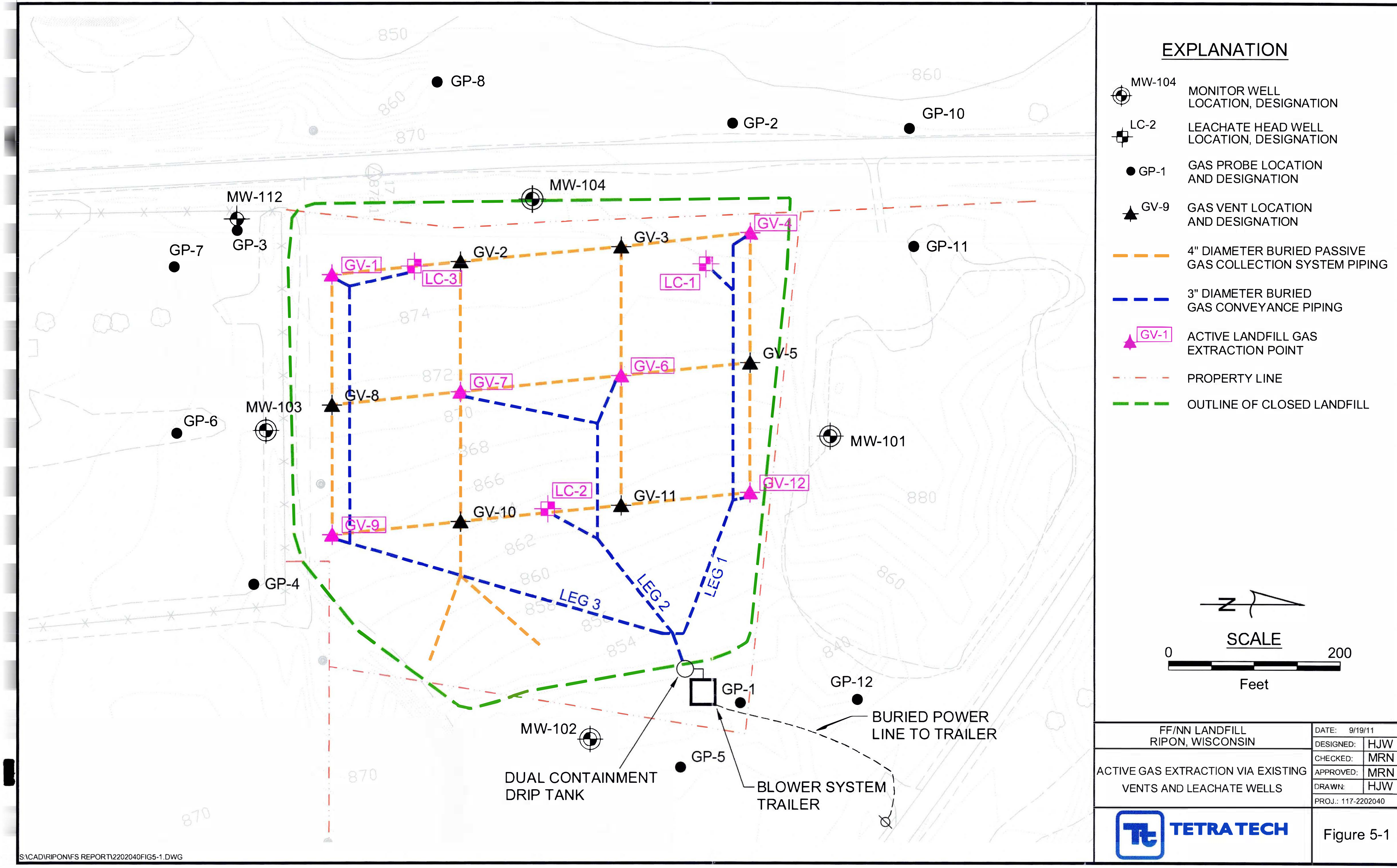
SCALE

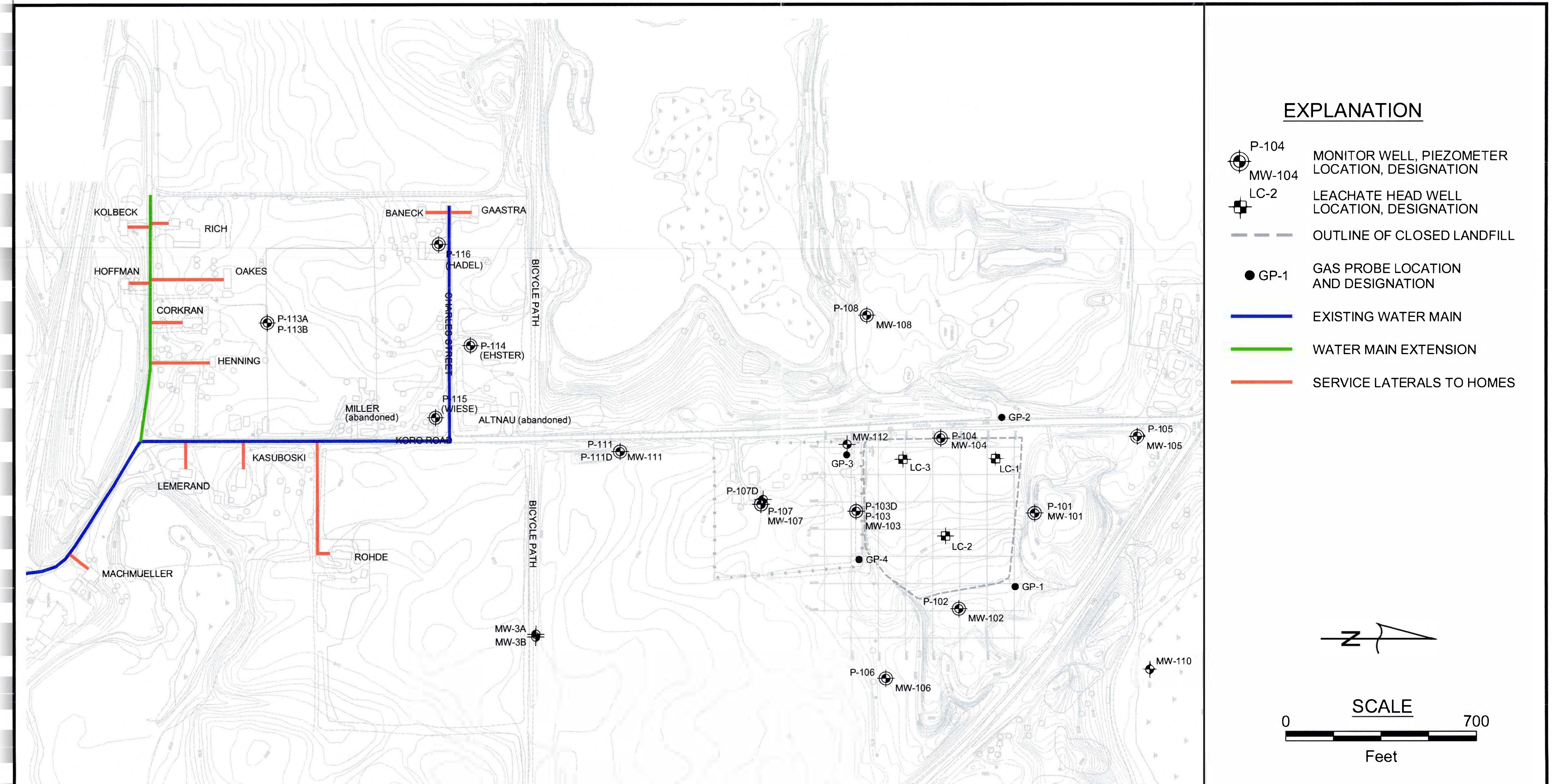
0 300

Feet

FF/NN LANDFILL RIPON, WISCONSIN	DATE: 10/12/11
	DESIGNED: HJW
FORMER PASSIVE GAS VENTING SYSTEM	CHECKED: MRN
	APPROVED: MRN
	DRAWN: HJW
	PROJ.: 117-2202040
TETRA TECH	Figure 3-9

S:\CAD\RIPON\FS REPORT\2202040FIG3-9.DWG


EXPLANATION
MW-104
MONITOR WELL LOCATION, DESIGNATION
LC-2
LEACHATE HEAD WELL LOCATION, DESIGNATION
GP-1
GAS PROBE LOCATION AND DESIGNATION
GV-9
GAS VENT LOCATION AND DESIGNATION
4" DIAMETER BURIED PASSIVE GAS COLLECTION SYSTEM PIPING
3" DIAMETER BURIED GAS CONVEYANCE PIPING
GV-1
ACTIVE LANDFILL GAS EXTRACTION POINT
PROPERTY LINE
OUTLINE OF CLOSED LANDFILL
N
SCALE
0
200
Feet
GP-8
GP-2
GP-10
MW-104
MW-112
GP-3
GP-7
GP-11
GV-1
LC-3
GV-2
GV-3
GV-4
LC-1
GV-5
GV-6
GV-7
GV-8
MW-103
GP-6
MW-101
LC-2
GV-11
GV-12
GV-10
GV-9
GP-4
LEG 3
LEG 2
LEG 1
GP-1
GP-12
BURIED POWER LINE TO TRAILER
MW-102
GP-5
DUAL CONTAINMENT DRIP TANK
BLOWER SYSTEM TRAILER
850
860
870
874
872
870
868
866
862
860
858
854
880
860
840
870
870
S:\CAD\RIPON\FS REPORT\2202040FIG5-1.DWG
FF/NN LANDFILL
RIPON, WISCONSIN
ACTIVE GAS EXTRACTION VIA EXISTING VENTS AND LEACHATE WELLS
DATE: 9/19/11
DESIGNED: HJW
CHECKED: MRN
APPROVED: MRN
DRAWN: HJW
PROJ.: 117-2202040
TETRATECH
Figure 5-1



BASEMAP FROM FOND DU LAC COUNTY PLANNING DIVISION, SPRING 2000.

FF/NN LANDFILL RIPON, WISCONSIN	DATE: 9/19/11
	DESIGNED: HJW
EXPANDED CONNECTION TO MUNICIPAL WATER	CHECKED: MRN
	APPROVED: MRN
	DRAWN: HJW
	PROJ.: 117-2202040
TETRA TECH	Figure 5-2

S:\CAD\RIPON\FS REPORT\2202040FIG5-2.DWG

EXPLANATION

- EW — GROUNDWATER EXTRACTION WELL LOCATION ALONG EAST-WEST CENTERLINE OF NORTH HALF OF NORTHWESTERN TRAIL RIGHT OF WAY
- 4" SDR 17 HDPE DISCHARGE PIPING AT 4.5 FEET BELOW SURFACE GRADE - INSTALL BY TRENCHING OR DIRECTIONAL DRILLING IN SOUTH KORO ROAD RIGHT OF WAY
- GROUNDWATER TREATMENT SYSTEM DISCHARGE POINT ON SILVER CREEK - 40 GPM DISCHARGE STRUCTURE REQUIRED TO DISSIPATE FLOW

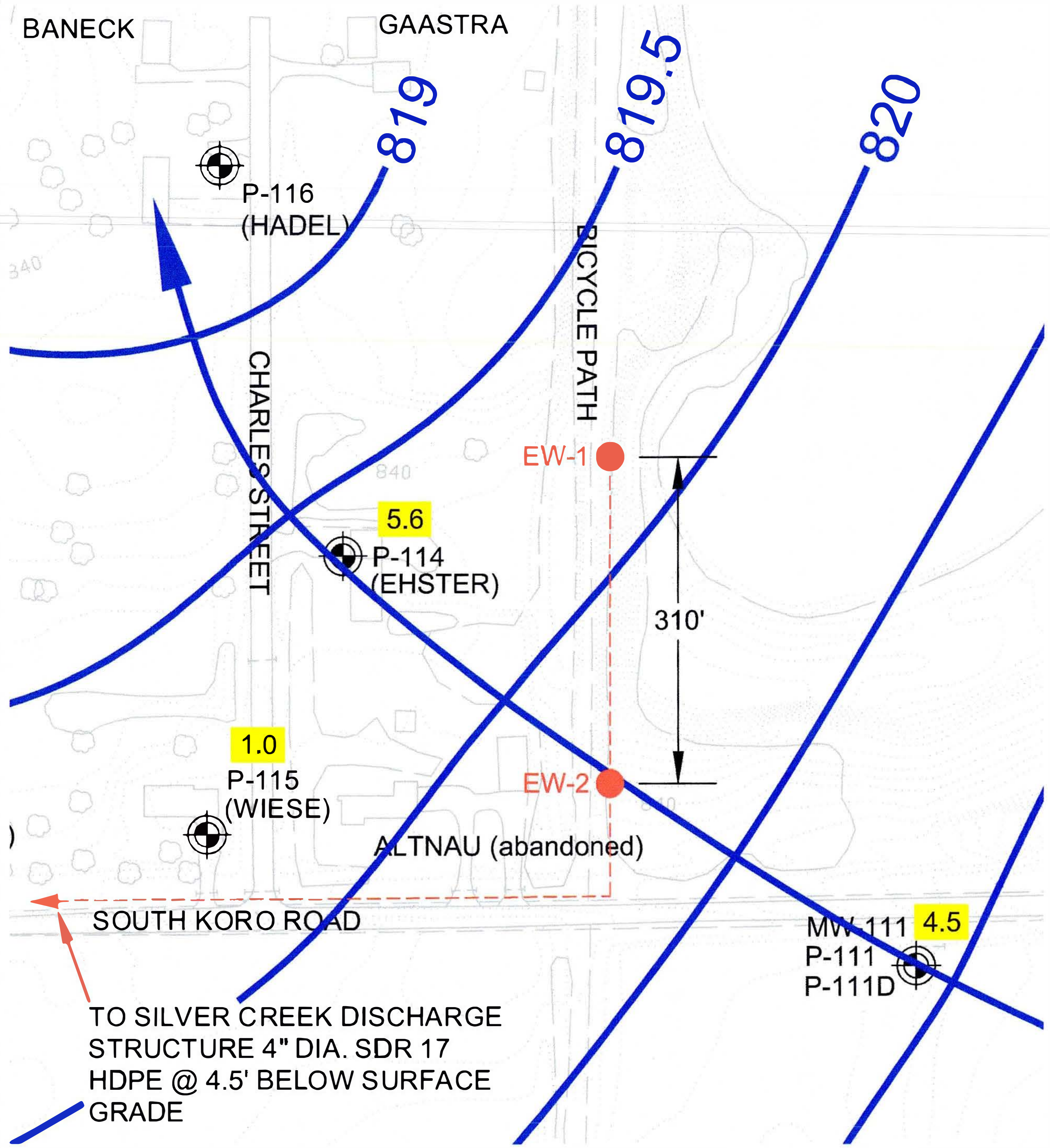
N

SCALE

0 400

Feet

FF/NN LANDFILL RIPON, WISCONSIN	DATE: 1/12/12
GROUNDWATER PUMP AND TREAT PIPING LOCATION PLAN	DESIGNED: HJW CHECKED: MRN APPROVED: MRN DRAWN: HJW PROJ.: 117-2202040
TETRA TECH	Figure 5-3



EXPLANATION

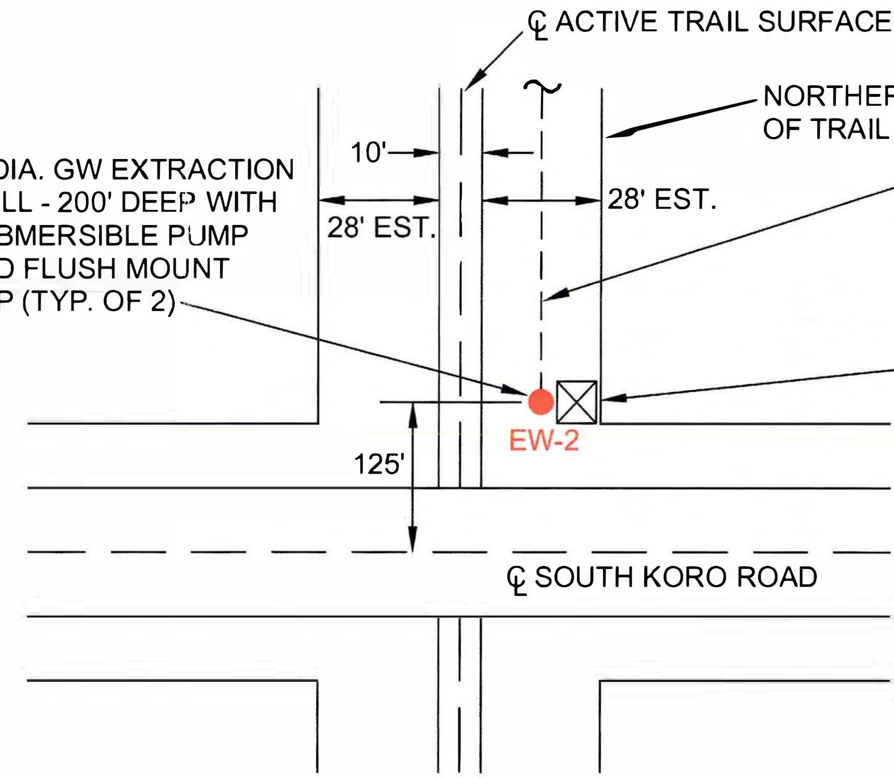
P-104 / MW-104 — MONITOR WELL, PIEZOMETER LOCATION, DESIGNATION

5.6 — OCTOBER 2011 VINYL CHLORIDE IN GROUNDWATER (ug/L)

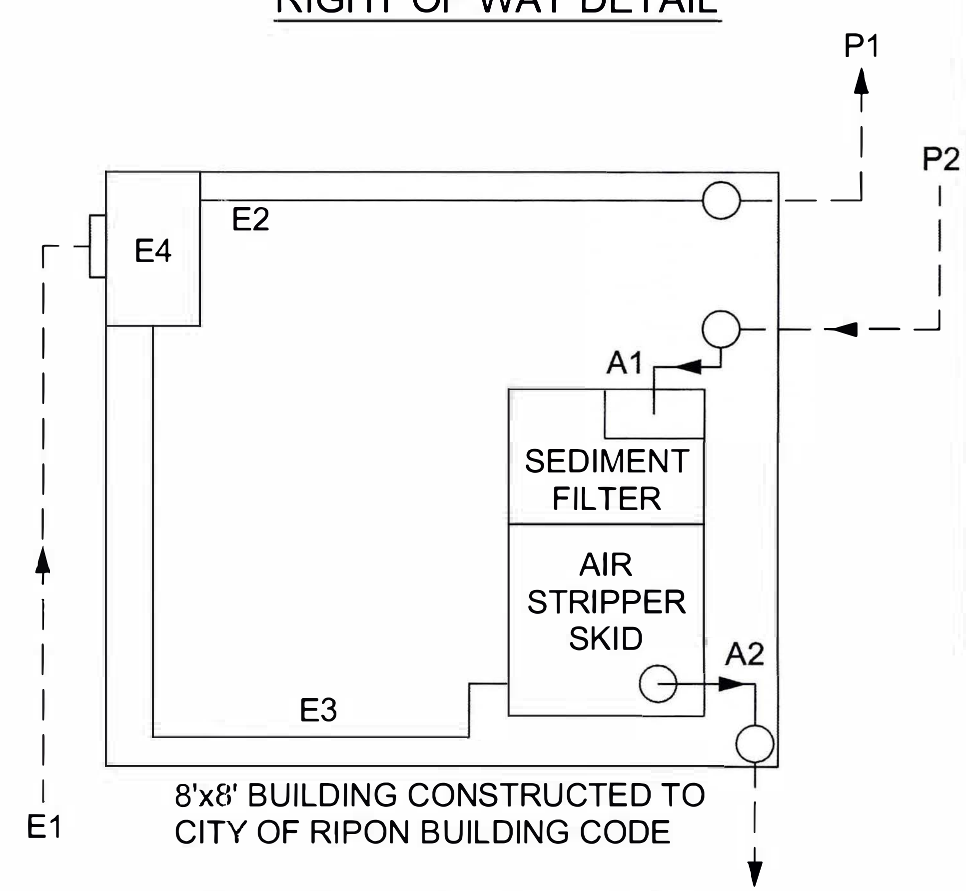
SCALE

0 — 300

Feet



RIGHT OF WAY DETAIL



TREATMENT EQUIPMENT BUILDING PLAN

E1: ELETRICAL SERVICE - BELOW GRADE FROM SOUTH KORO ROAD.

E2: ELETRICAL POWER TO EXTRACTION WELL PUMPS.

E3: ELETRICAL POWER TO AIR STRIPPER SKID.

E4: POWER / CONTROL PANEL WITH EXTERIOR METER / SOCKET.

A1: GROUNDWATER RETURN HEADER FROM GROUNDWATER WELL PUMPS.

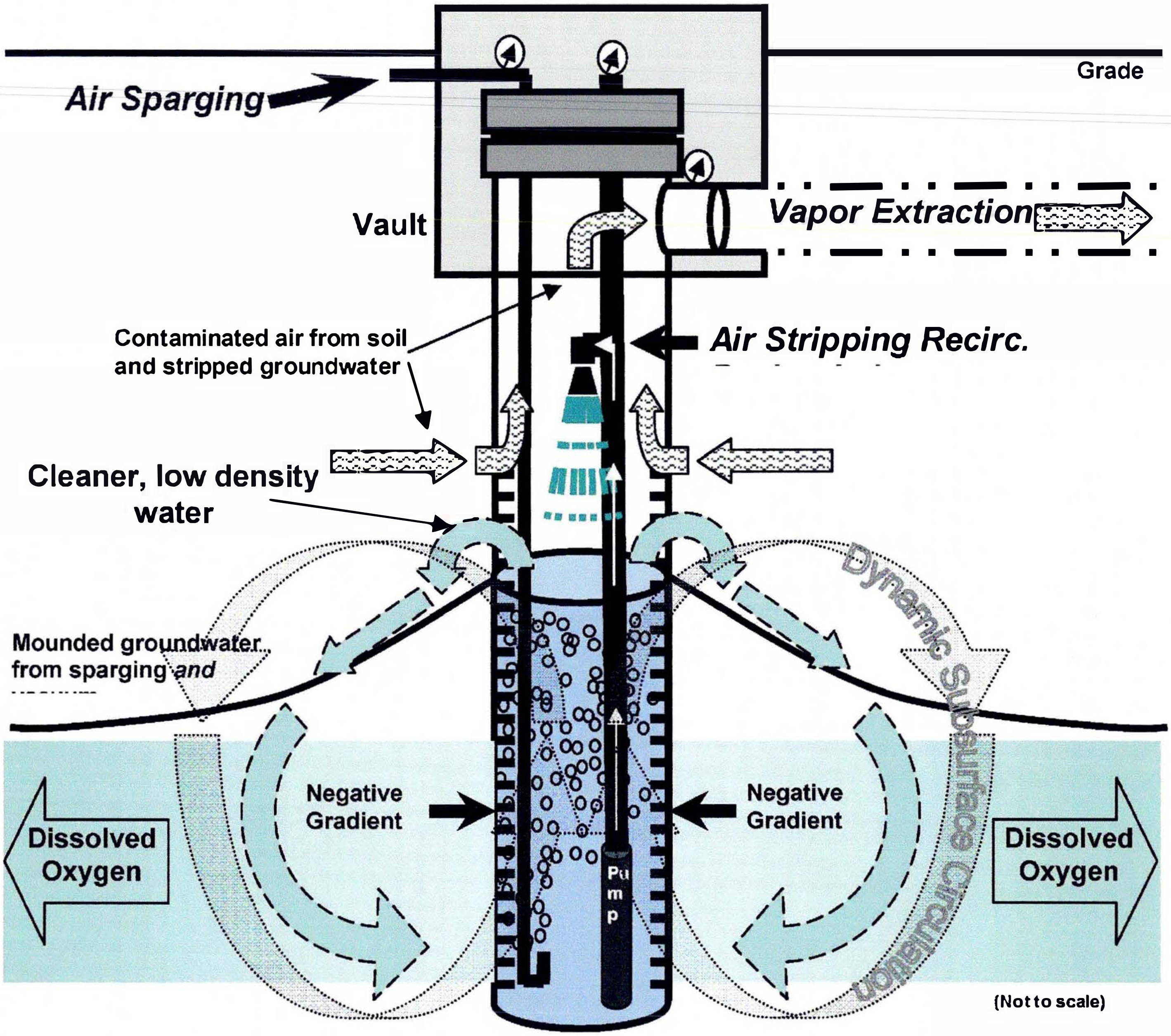
A2: GROUNDWATER DISCHARGE LINE TO SILVER CREEK.

P1: ELECTRICAL POWER SUPPLY TO WELLS: INSIDE 2" DIA. SCH. 40 PVC IN COMMON TRENCH WITH P2.

P2: GROUNDWATER RETURN FROM WELLS: 3" DIA. SDR11 HDPE IN COMMON TRENCH WITH P1.

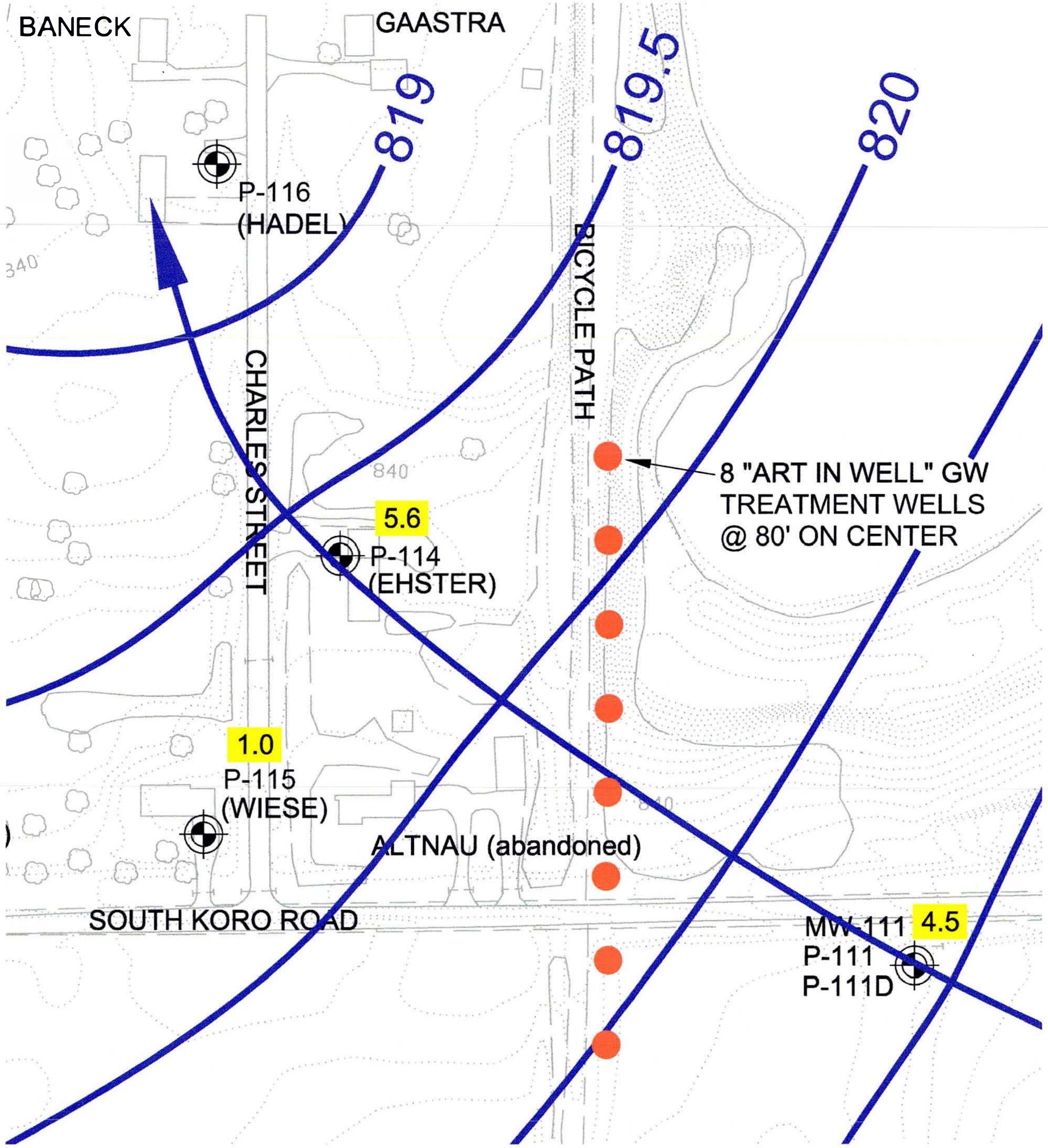
FF/NN LANDFILL RIPON, WISCONSIN	DATE: 1/16/12
GROUNDWATER PUMP AND TREAT SYSTEM LOCATION PLAN AND DETAILS	DESIGNED: HJW
	CHECKED: MRN
	APPROVED: MRN
	DRAWN: HJW
	PROJ.: 117-2202040
TETRA TECH	Figure 5-4

S:\CAD\RIPON\FS REPORT\2202040FIG5-4.DWG



FF/NN LANDFILL RIPON, WISCONSIN	DATE: 9/19/11
	DESIGNED: HJW
ART IN WELL TECHNOLOGY DIAGRAM	CHECKED: MRN
	APPROVED: MRN
	DRAWN: HJW
	PROJ.: 117-2202040
TETRA TECH	Figure 5-5

S:\CAD\RIPON\FS REPORT\2202040FIG5-5.DWG



EXPLANATION

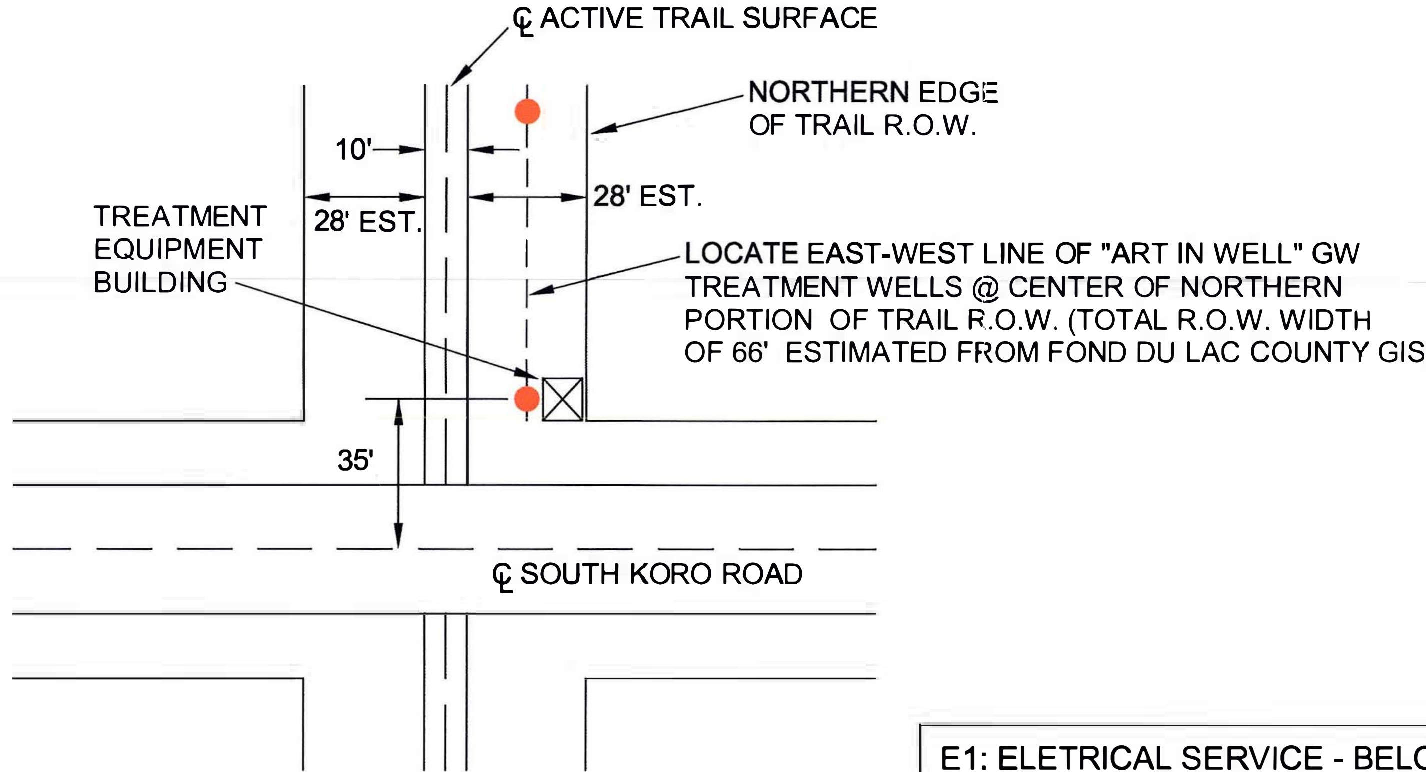
P-104 / MW-104 — MONITOR WELL, PIEZOMETER LOCATION, DESIGNATION

5.6 — OCTOBER 2011 VINYL CHLORIDE IN GROUNDWATER (ug/L)

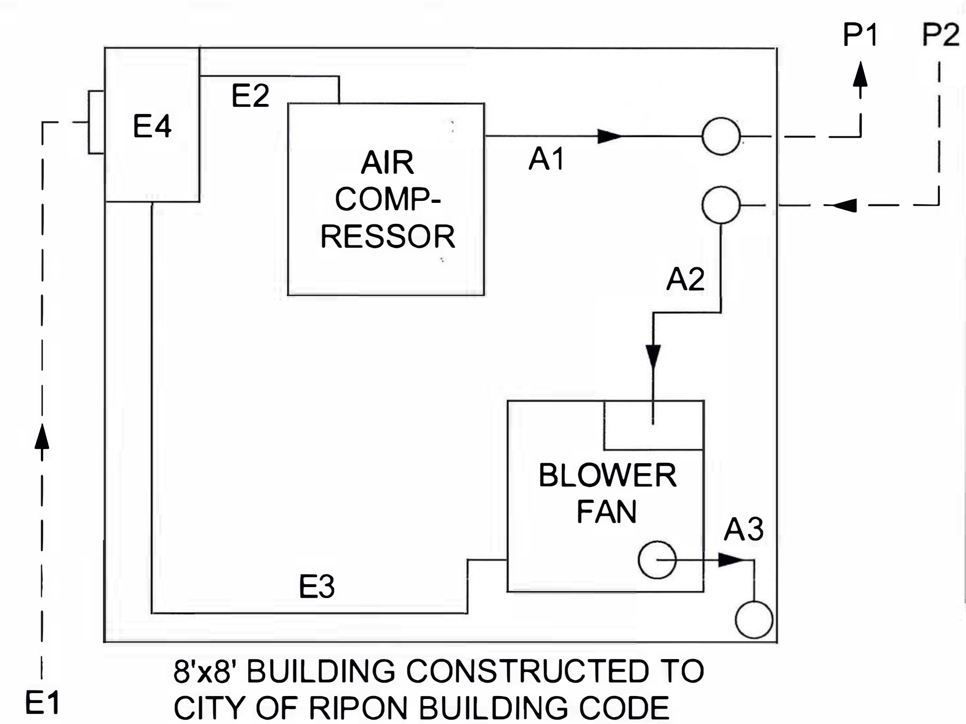
SCALE

0 — 300

Feet



RIGHT OF WAY DETAIL



8'x8' BUILDING CONSTRUCTED TO CITY OF RIPON BUILDING CODE

TREATMENT EQUIPMENT BUILDING PLAN

E1: ELETRICAL SERVICE - BELOW GRADE FROM SOUTH KORO ROAD.

E2: ELETRICAL POWER TO AIR COMPRESSOR.

E3: ELETRICAL POWER TO FAN / BLOWER.

E4: POWER / CONTROL PANEL WITH EXTERIOR METER / SOCKET.

A1: SUPPLY AIR HEADER TO GROUNDWATER WELL PUMPS / SPARGE FITTINGS.

A2: VAPOR RETURN HEADER FROM GROUNDWATER WELL PUMPS.

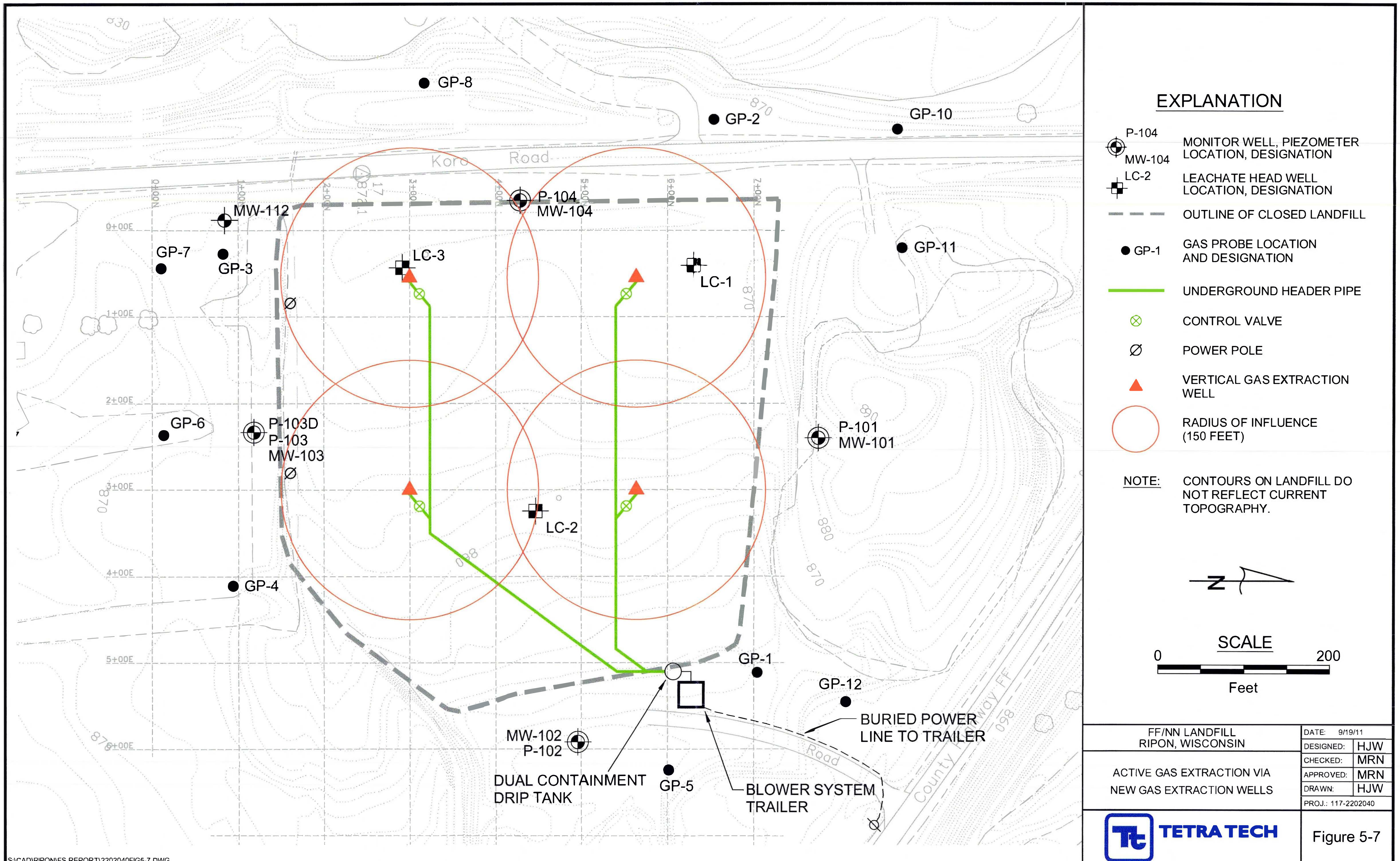
A3: VAPOR DISCHARGE LINE TO ATMOSPHERE - TERMINATE TWO FEET ABOVE ROOF LINE WITH GOOSE NECK.

P1: AIR SUPPLY TO WELLS: 125 PSI AIR HOSE INSIDE 2" DIA. SCH. 40 PVC IN COMMON TRENCH WITH P2.

P2: VAPOR RETURN FROM WELLS: 4" DIA. SCH. 40 PVC IN COMMON TRENCH WITH P1.

FF/NN LANDFILL RIPON, WISCONSIN	DATE: 1/16/12
ART IN WELL LOCATION PLAN AND DETAILS	DESIGNED: HJW
	CHECKED: MRN
	APPROVED: MRN
	DRAWN: HJW
	PROJ.: 117-2202040
TETRA TECH	Figure 5-6

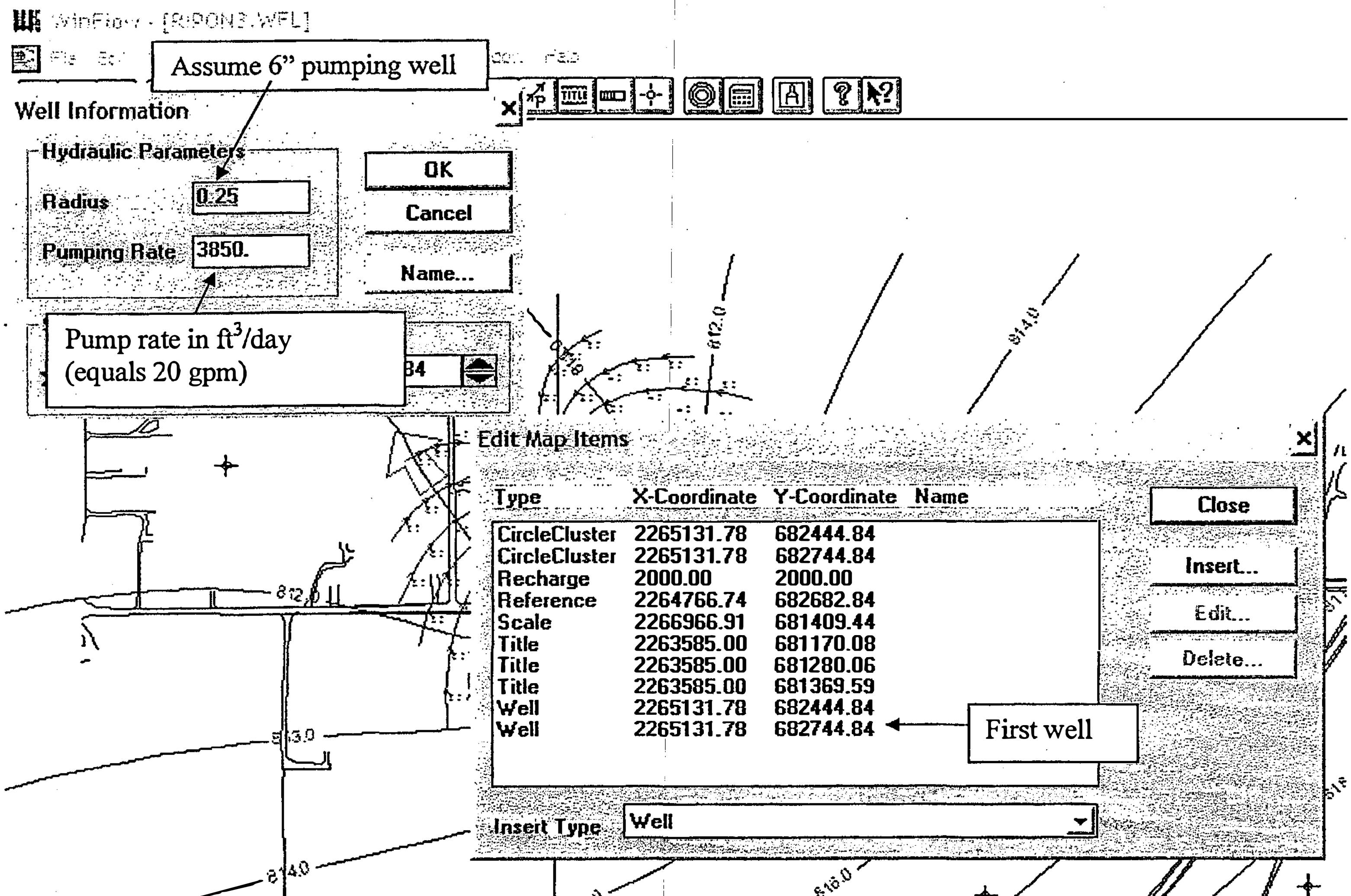
S:\CAD\RIPON\FS REPORT\2202040FIG5-6.DWG


GP-8
GP-2
GP-10
Koro Road
P-104
MW-104
MW-112
GP-7
GP-3
LC-3
LC-1
GP-11
GP-6
P-103D
P-103
MW-103
P-101
MW-101
LC-2
GP-4
GP-1
GP-12
BURIED POWER LINE TO TRAILER
MW-102
P-102
DUAL CONTAINMENT DRIP TANK
GP-5
BLOWER SYSTEM TRAILER
County Highway FF
Road
0+00E
1+00E
2+00E
3+00E
4+00E
5+00E
6+00E
0+00N
1+00N
2+00N
3+00N
4+00N
5+00N
6+00N
7+00N
870
880
890
EXPLANATION
P-104 MW-104 MONITOR WELL, PIEZOMETER LOCATION, DESIGNATION
LC-2 LEACHATE HEAD WELL LOCATION, DESIGNATION
OUTLINE OF CLOSED LANDFILL
GP-1 GAS PROBE LOCATION AND DESIGNATION
UNDERGROUND HEADER PIPE
CONTROL VALVE
POWER POLE
VERTICAL GAS EXTRACTION WELL
RADIUS OF INFLUENCE (150 FEET)
NOTE: CONTOURS ON LANDFILL DO NOT REFLECT CURRENT TOPOGRAPHY.
N
SCALE
0
200
Feet
FF/NN LANDFILL
RIPON, WISCONSIN
ACTIVE GAS EXTRACTION VIA NEW GAS EXTRACTION WELLS
DATE: 9/19/11
DESIGNED: HJW
CHECKED: MRN
APPROVED: MRN
DRAWN: HJW
PROJ.: 117-2202040
TETRA TECH
Figure 5-7
S:\CAD\RIPON\FS REPORT\2202040FIG5-7.DWG

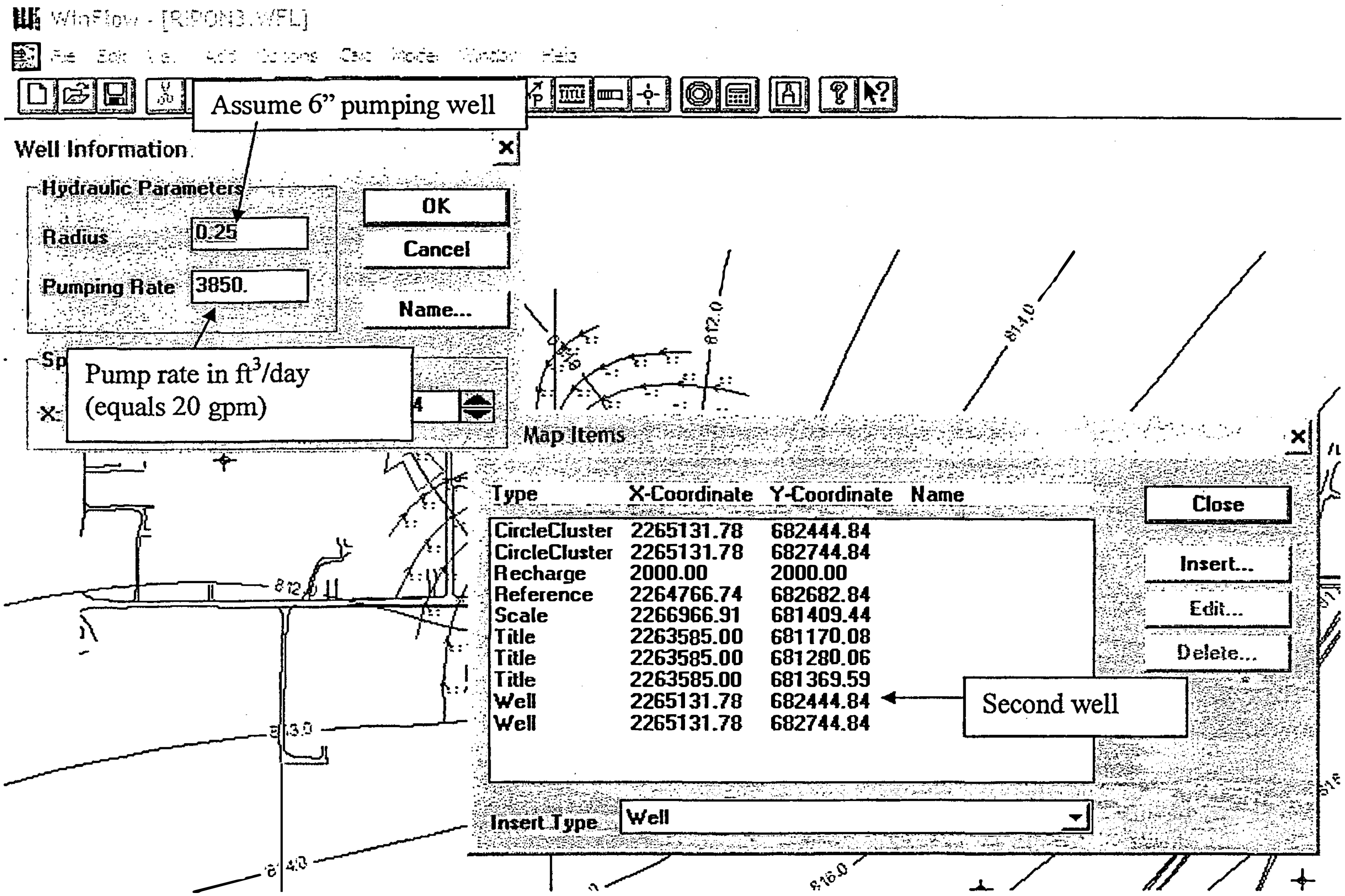
APPENDICES

[redacted]

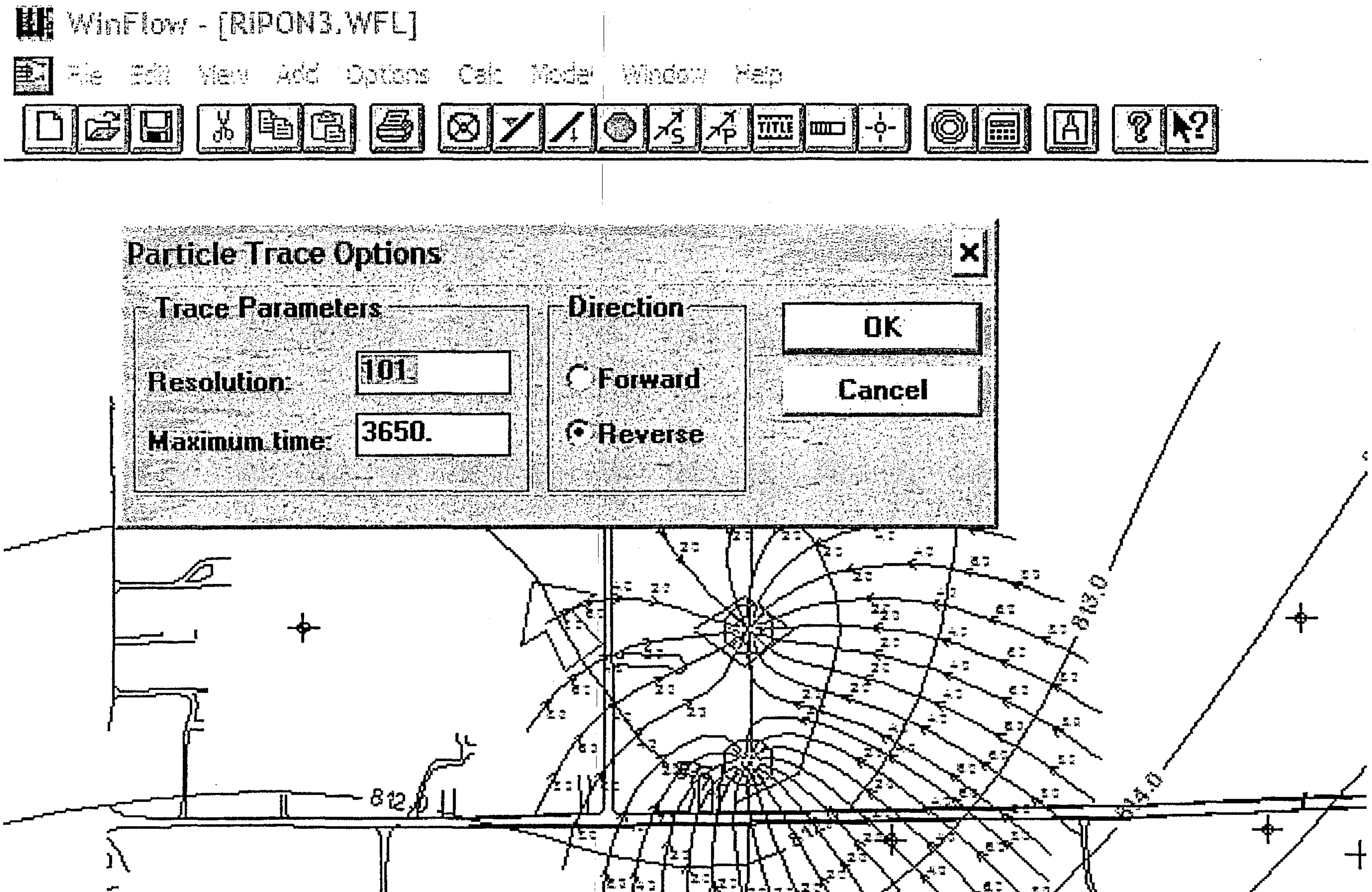
Well pumping parameters for WinFlow™ model



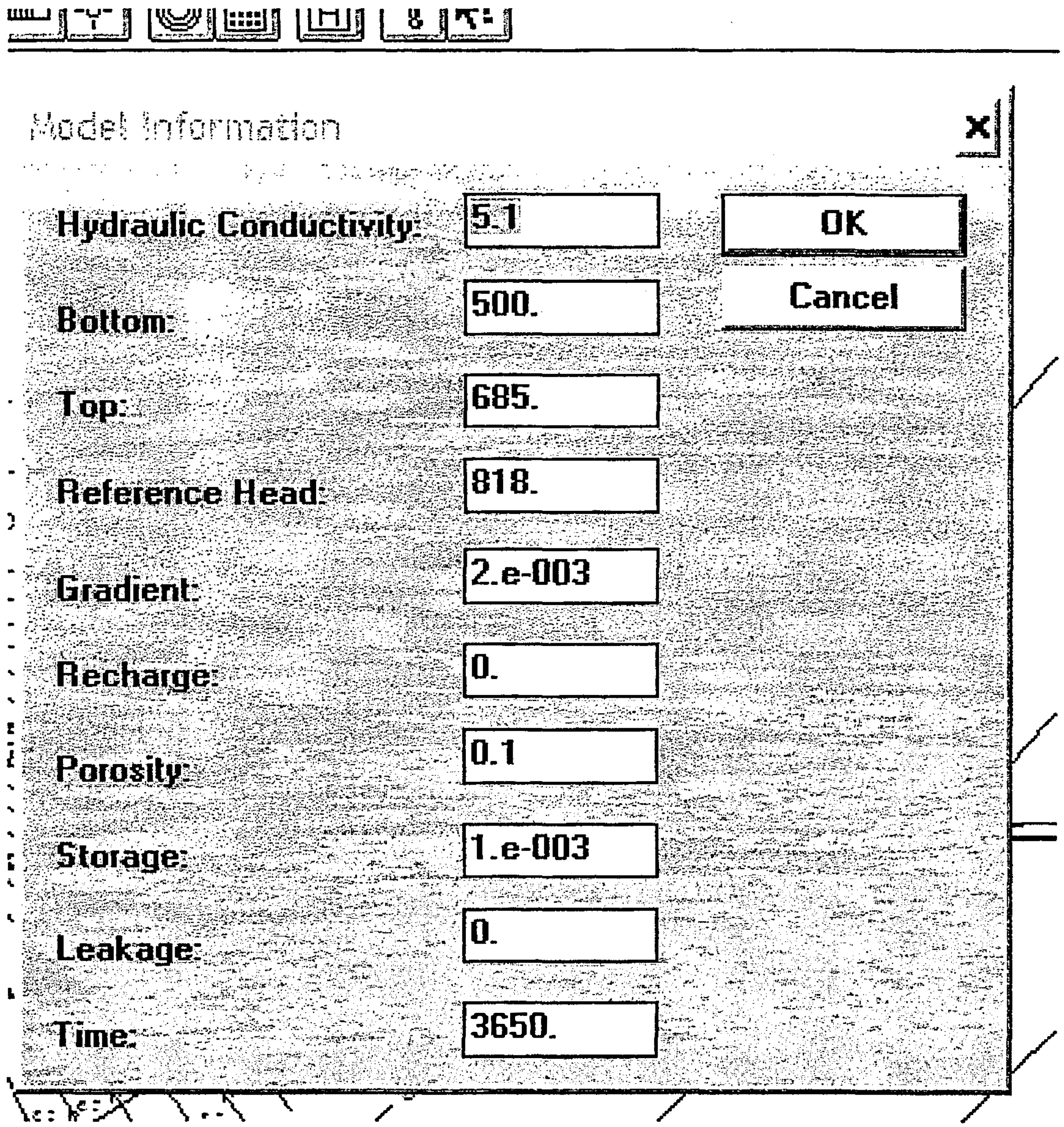
Well pumping parameters for WinFlow™ model



Particle tracking parameters for WinFlow™ model



Hydrogeologic Parameters for WinFlow™ model



WinFlow Assumptions

It is important to understand the many simplifying assumptions inherent in an analytical model before the model can be applied to a real-world problem. Chapter 5 described the equations that are solved in WinFlow. Chapter 6 verified that these equations are properly implemented in the WinFlow software. This chapter presents potential applications of WinFlow to the solution of ground-water problems. First, however, some important assumptions are discussed as they apply to practical application of WinFlow. For easy identification, the primary assumptions are underlined.

WinFlow is designed to solve two-dimensional ground-water flow problems in a horizontal plane. It is not designed for two-dimensional cross-sections (2D vertical plane). The two primary assumptions are that ground-water flow is horizontal and occurs in an infinite aquifer. WinFlow should not be applied to aquifers exhibiting strong vertical gradients unless the scale of the problem is such that horizontal flow can still be considered dominant. WinFlow can be used even in cases where there are significant vertical gradients if the horizontal scale of the model is much larger than the vertical scale, such as in regional studies.

Another assumption is that the aquifer hydraulic conductivity is assumed to be isotropic and homogeneous. The base of the aquifer is horizontal and fixed at a given elevation. In the steady-state and transient models, the top of the aquifer is also horizontal and fixed at a given elevation. In the steady-state model, however, unconfined conditions are simulated when the hydraulic head is below the top of the aquifer. In the transient model, the aquifer is always confined, even when the head falls below the top of the aquifer.

The reference head in the steady-state model is constant throughout all calculations. The reference head is analogous to a constant head boundary condition in a numerical model. It is therefore very important to keep the reference head far from the area of interest so that model predictions are not impacted.

The reference head in the transient model is only used in combination with the uniform gradient to compute an initial planar potentiometric surface. Drawdowns computed by either the Theis (1935) or the Hantush and Jacob (1955) methods are then subtracted from the planar potentiometric surface to obtain the resulting flow field. Drawdowns are also subtracted from the reference head in the transient model; however, there is an option that allows the user to keep the reference head constant in the transient model. This option should only be used when trying to compare the transient model to the steady-state model.

All pumping rates, linesink fluxes, pond recharge, and elliptical recharge rates are constant through time. In the transient model, all wells start pumping or injecting water at time zero.

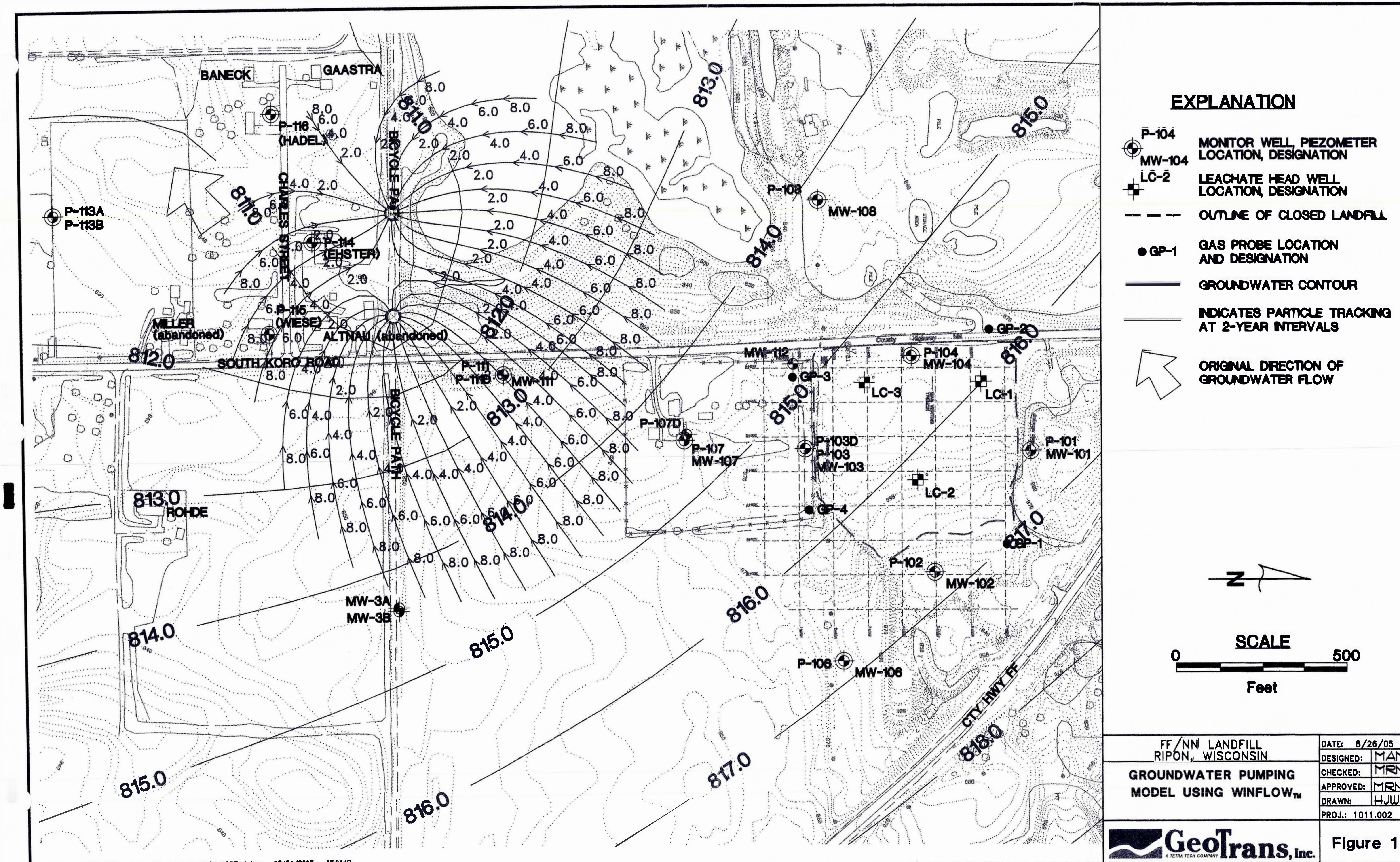
All wells are assumed to fully penetrate the aquifer. Wells are assumed to be perfectly efficient and linesinks are in perfect hydraulic communication with the aquifer. Both assumptions are rarely encountered in practice. There is often head loss around the well screen or stream bottom caused by clogging of the pore-space by fine-grained material (clay). There are two important consequences of imperfect hydraulic communication.

(1) Pumping rates predicted by WinFlow to achieve a desired response may not be attainable because more drawdown will be encountered in the actual well. The increased

drawdown encountered in the field is caused by inefficiency around the well screen. The same effect will happen using linesinks to simulate trenches or drains.

(2) The amount of water produced or injected by a linesink to maintain a specified head in the linesink will be overestimated if the actual drain has less than 100 percent efficiency.

Particle traces and streamlines are two-dimensional. In cases where the aquifer receives recharge, the capture zone of a pumping well will be large enough to capture the amount of recharge equaling the pumping rate of the well (Larson et al. 1987). In two-dimensional analyses, such as in WinFlow, the capture zone extends upgradient until encountering a ground-water divide or infinity. This is an important consideration in designing a containment system.



FF/NN LANDFILL
RIPON, WISCONSIN

GROUNDWATER PUMPING MODEL USING WINFLOW™

DATE:	8/26/05
DESIGNED:	MAM
CHECKED:	MRN
APPROVED:	MRN
DRAWN:	HJW
PROJ.:	1011.002

GeoTrans, Inc. A TETRA TECH COMPANY

Figure 1

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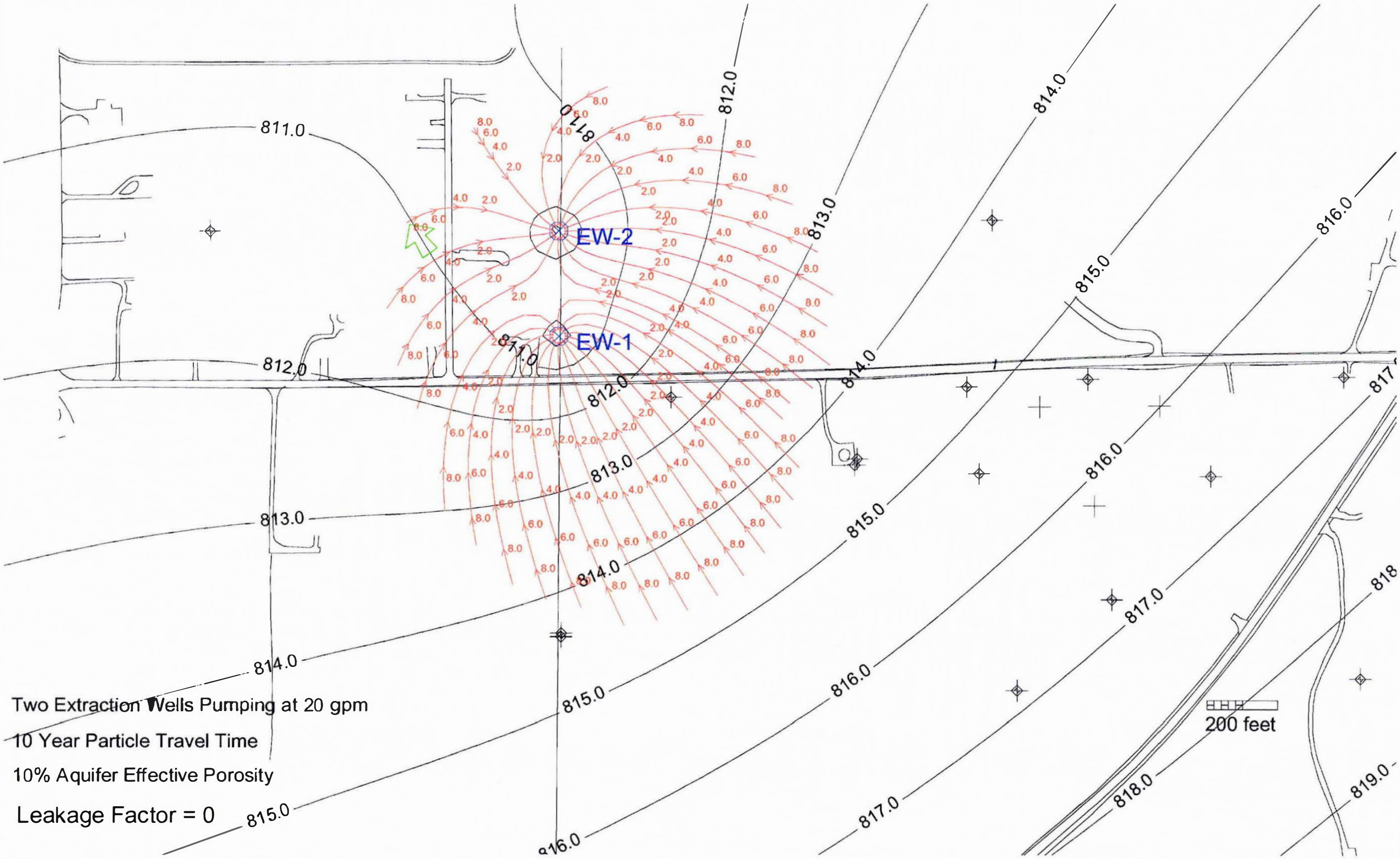
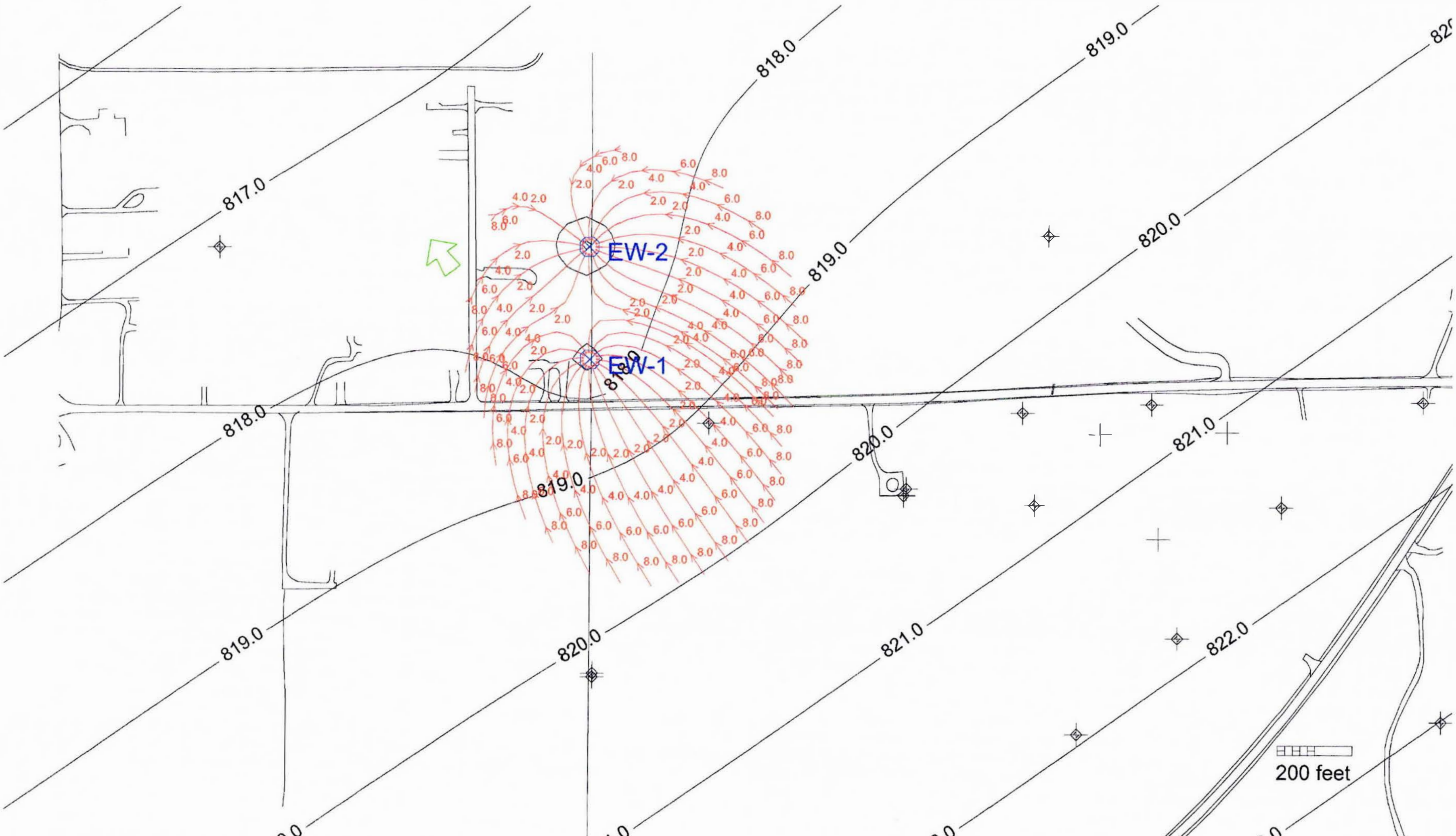


EW-2
EW-1
811.0
812.0
813.0
814.0
815.0
816.0
817.0
818.0
819.0
200 feet
Two Extraction Wells Pumping at 20 gpm
10 Year Particle Travel Time
10% Aquifer Effective Porosity
Leakage Factor = 0

[redacted]

Two Extraction Wells Pumping at 20 gpm
10 Year Particle Travel Time
10% Aquifer Effective Porosity
Leakage Factor = 307.2



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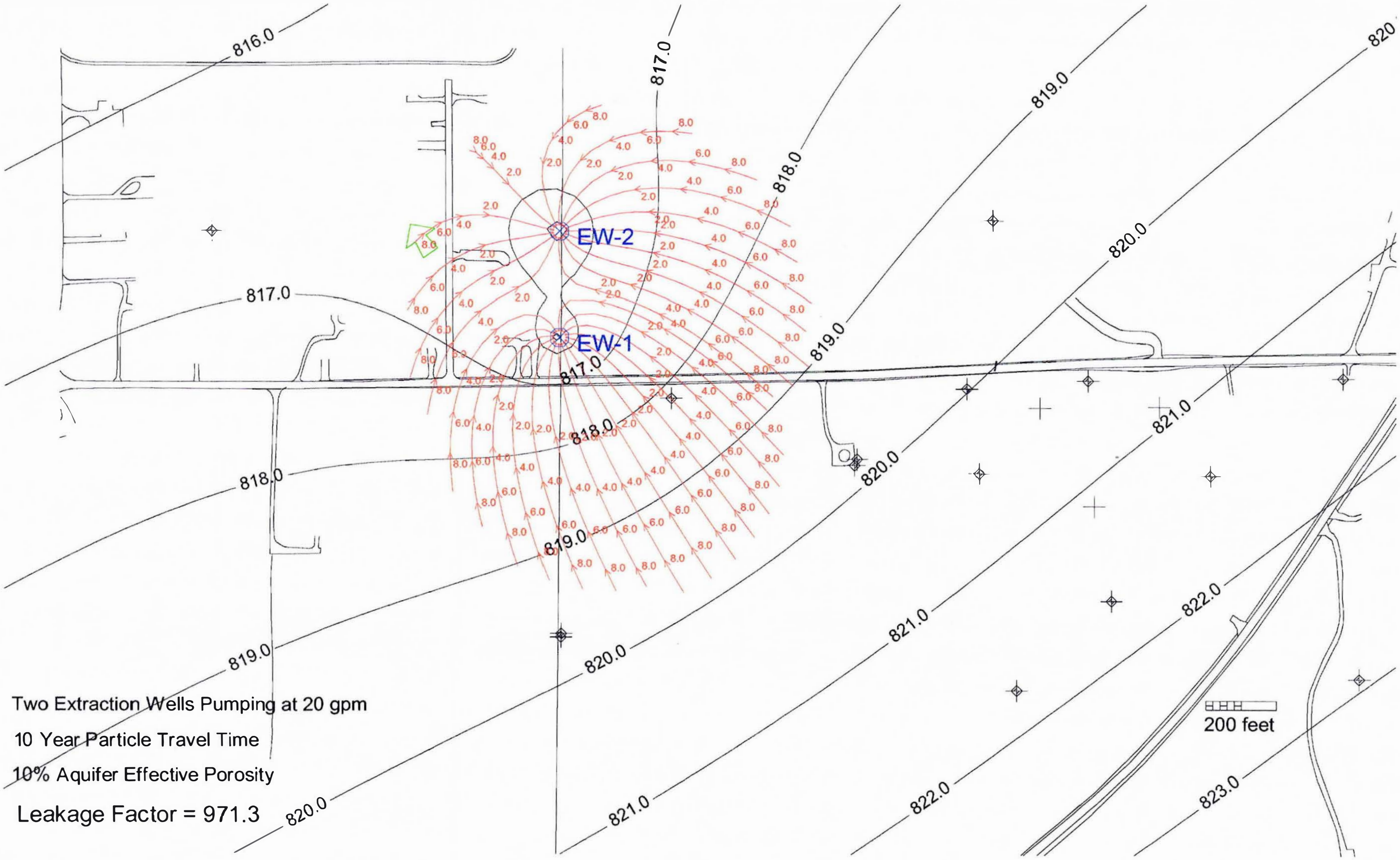
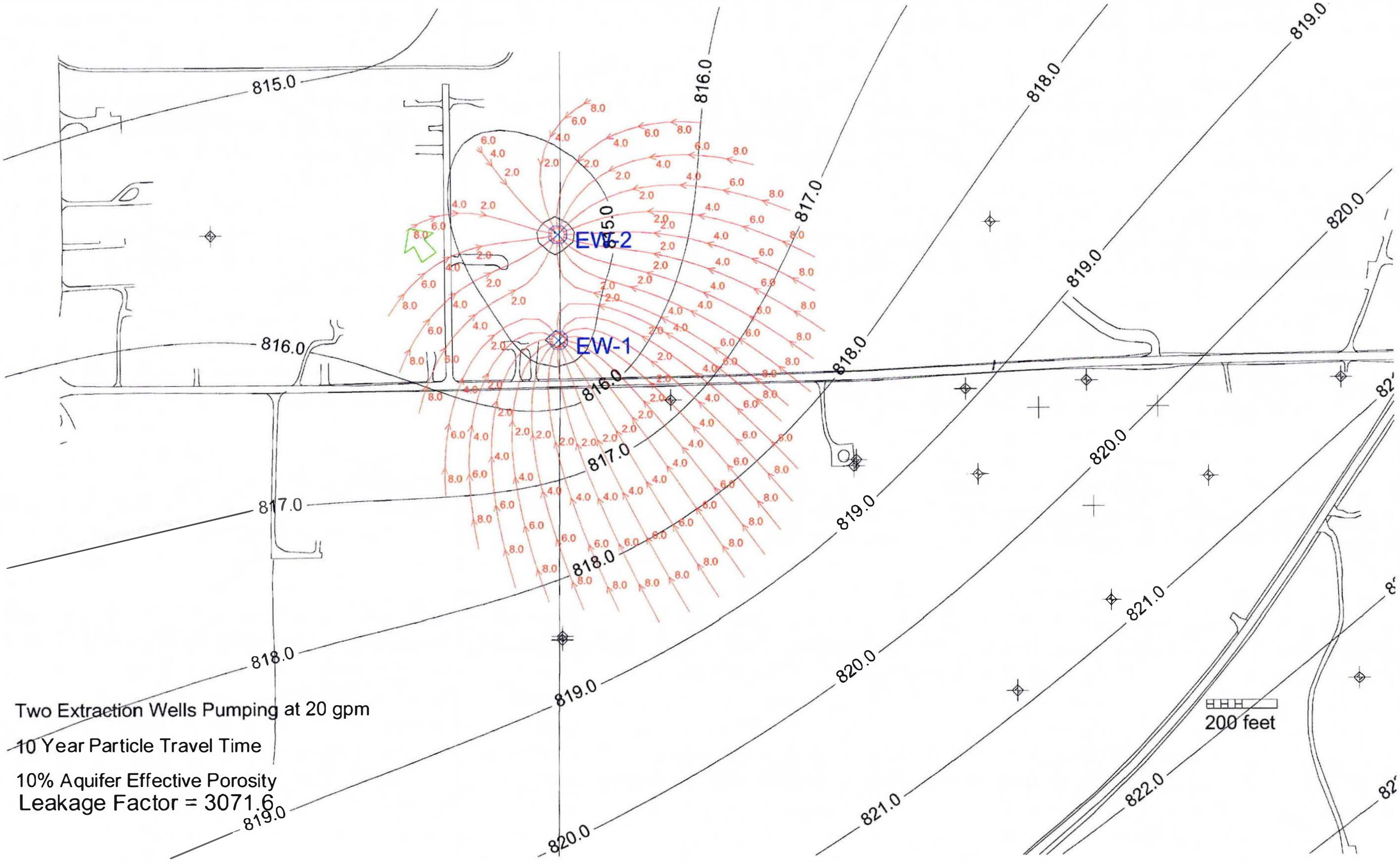
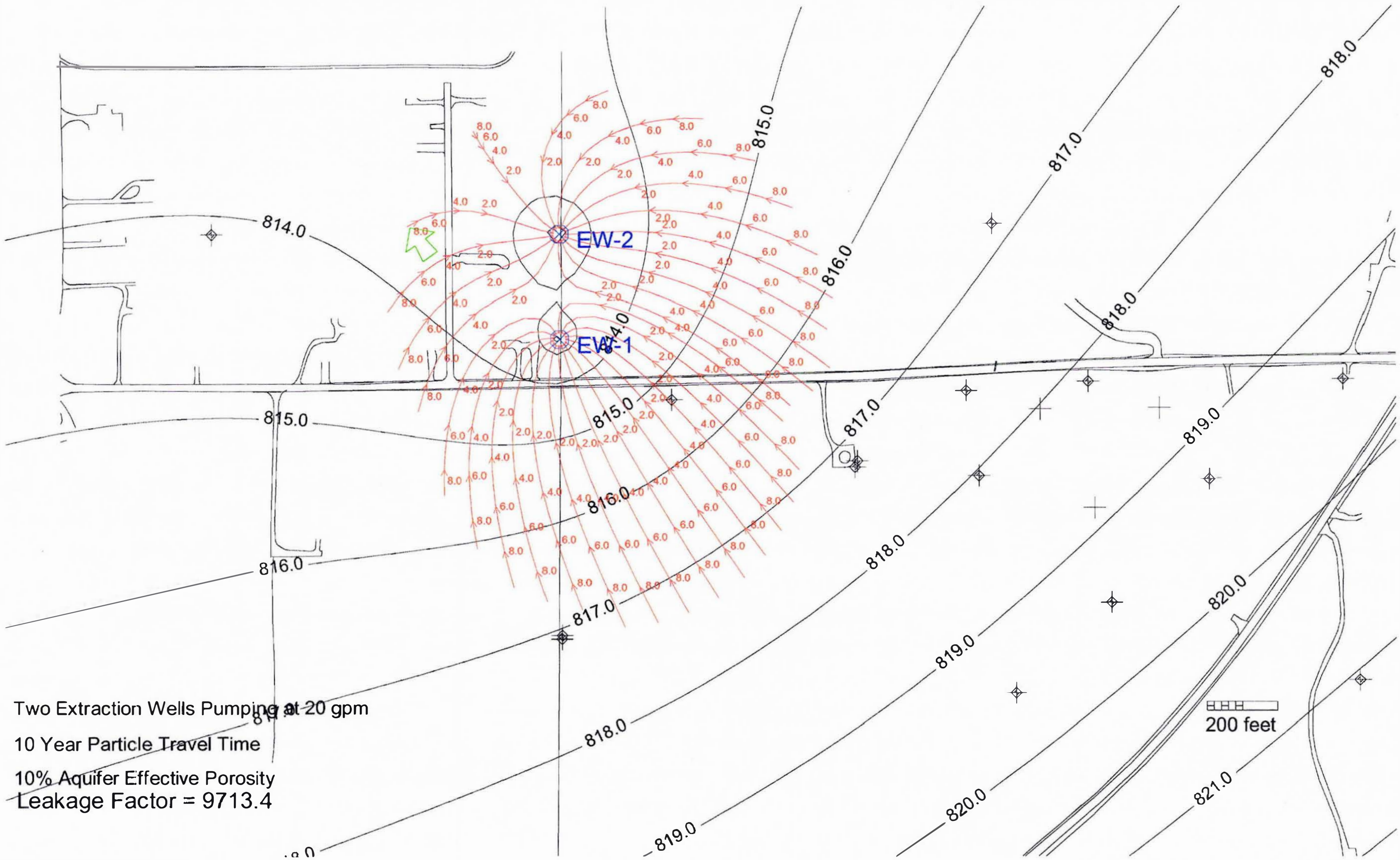


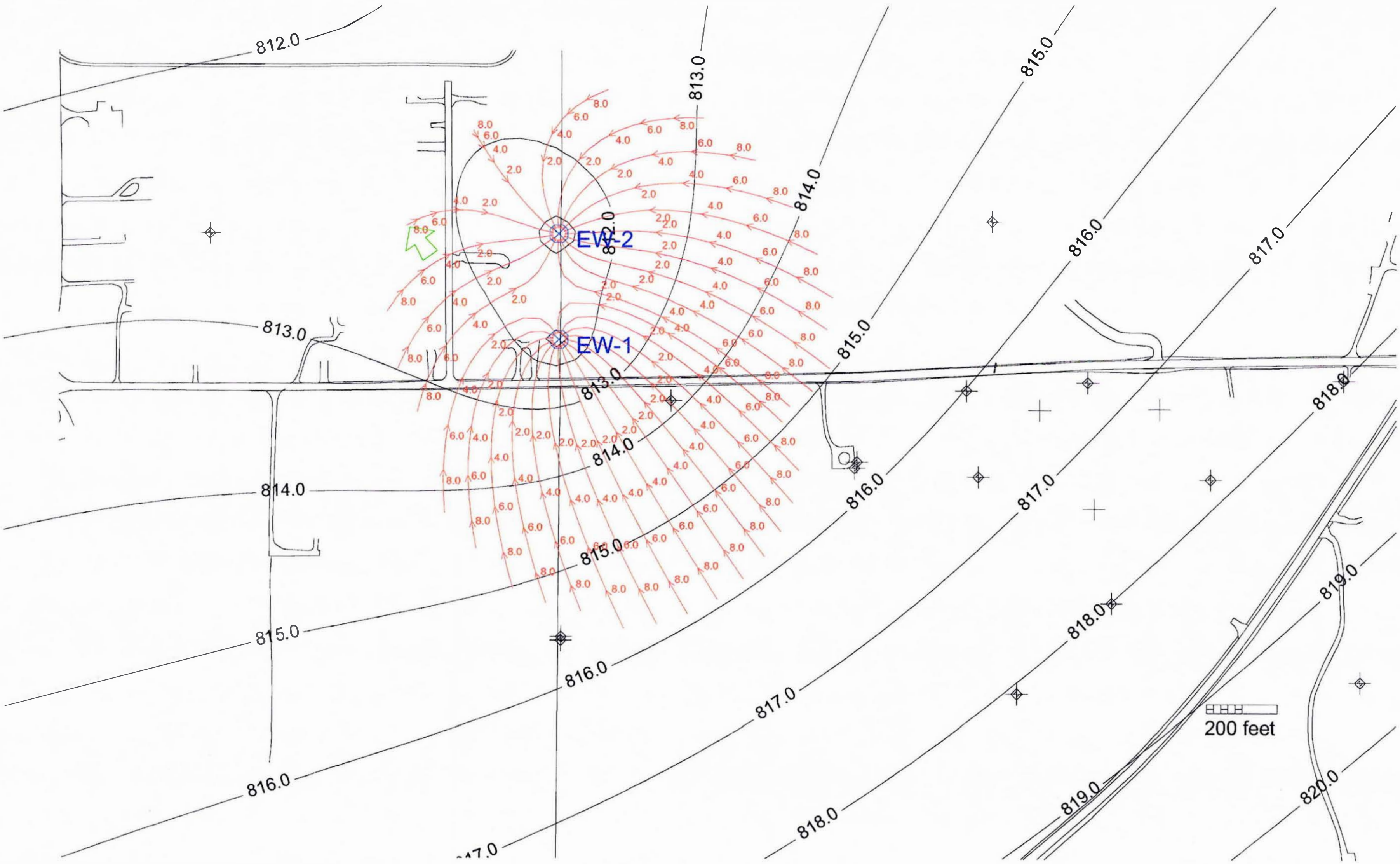
EW-2
EW-1
816.0
817.0
818.0
819.0
820.0
821.0
822.0
823.0
200 feet
Two Extraction Wells Pumping at 20 gpm
10 Year Particle Travel Time
10% Aquifer Effective Porosity
Leakage Factor = 971.3



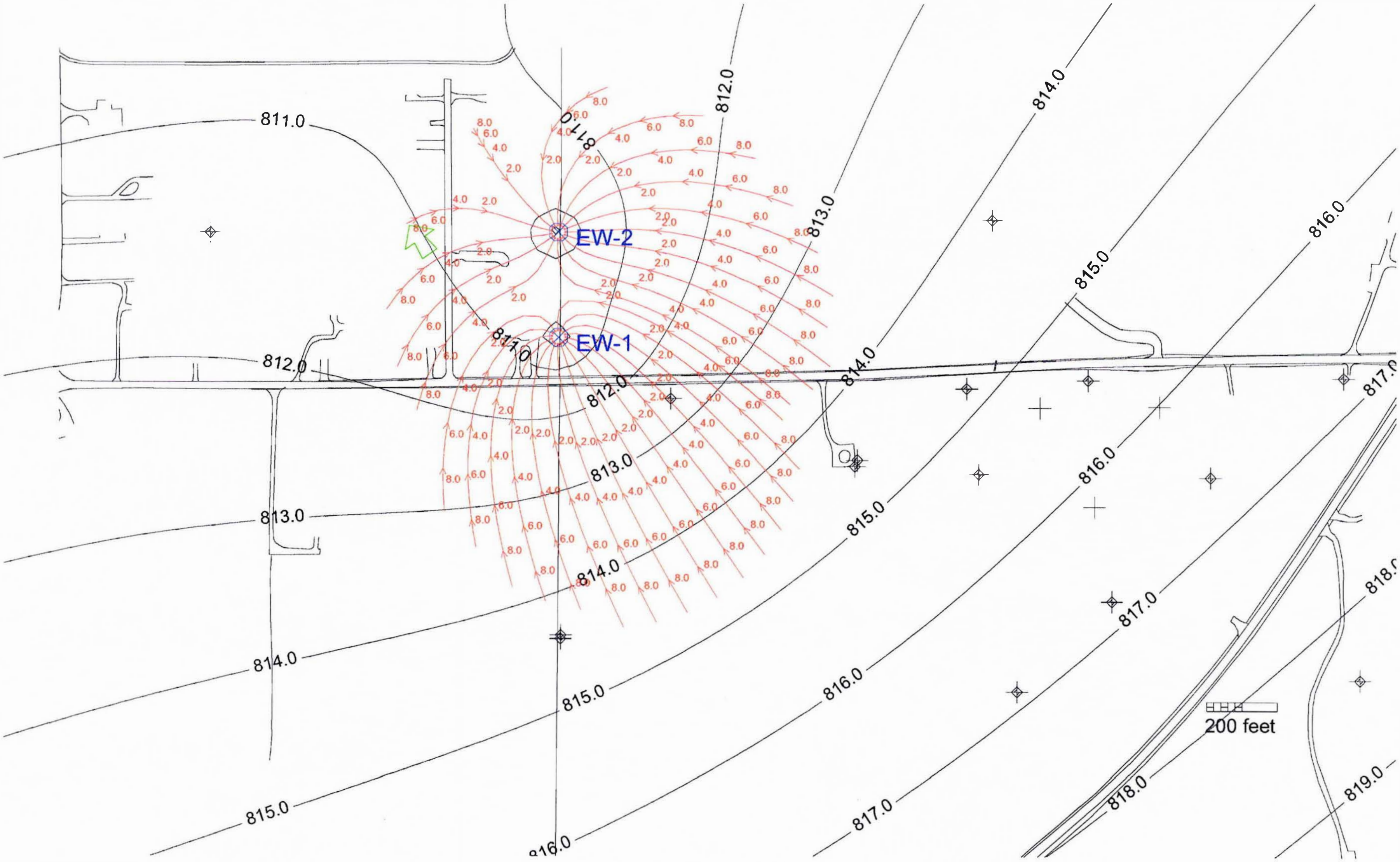
EW-2
EW-1
815.0
816.0
817.0
818.0
819.0
820.0
821.0
822.0
200 feet
Two Extraction Wells Pumping at 20 gpm
10 Year Particle Travel Time
10% Aquifer Effective Porosity
Leakage Factor = 3071.6


EW-2
EW-1
814.0
815.0
816.0
817.0
818.0
819.0
820.0
821.0
200 feet
Two Extraction Wells Pumping at 20 gpm
10 Year Particle Travel Time
10% Aquifer Effective Porosity
Leakage Factor = 9713.4

Two Extraction Wells Pumping at 20 gpm
10 Year Particle Travel Time
10% Aquifer Effective Porosity
Leakage Factor = 30716.4



Two Extraction Wells Pumping at 20 gpm
10 Year Particle Travel Time
10% Aquifer Effective Porosity
Leakage Factor = 307164.5



Aquitard Thickness (b'):	100	100	100	100	100	100	100
Aquitard Vertical Hydraulic conductivity (K') ft/day:	1.00E+00	1.00E-01	1.00E-02	1.00E-03	1.00E-04	1.00E-05	1.00E-06
Aquitard Vertical Hydraulic conductivity (K') cm/sec:	3.53E-04	3.53E-05	3.53E-06	3.53E-07	3.53E-08	3.53E-09	3.53E-10
Aquifer Transmissivity (T):	943.5	943.5	943.5	943.5	943.5	943.5	943.5
Leakage Factor (B):	307.2	971.3	3071.6	9713.4	30716.4	97133.9	307164.5

Notes:

Aquifer K = 5.1 ft/day

Aquifer Thickness = 185 feet

Leakage Factor (B) = Square Root((Txb')/K')

Calculation of Vinyl Chloride Mass in Deep Aquifer

Groundwater Volume	=	l*w*t*n*(Gal/ft3)	
	=	1500*600*40*.1*7.4805	
	=	26,929,800	gal
	=	101,929,293	liters

Length (l)	1500
Width (w)	600
Thick (t)	40
Porosity (n)	0.1
gal/ft3	7.4805
L/gal	3.785

VC Mass	=	GW volume (L)*concentration (ug)	
	=	509,646,465	ug
	=	509.65	g
	=	1.12	lbs

VC Concentration (ug/L)	5
g/lbs	453.5923