Office of Solid Waste and
Emergency Response
(5102G)

EPA-540-R-11-019
February 2011
www.epa.gov/tio
www.clu-in.org/optimization

Streamlined Remediation System Evaluation
Wash King Laundry Superfund Site

Pleasant Plains Township, Michigan

STREAMLINED REMEDIATION SYSTEM EVALUATION

WASH KING LAUNDRY SITE
PLEASANT PLAINS TOWNSHIP, LAKE COUNTY, MICHIGAN

Report of the Streamlined Remediation System Evaluation
Conference Call Conducted for the Wash King Laundry Site
July 26, 2010

Revised Report
February 18, 2011

NOTICE

Work described herein was performed by GeoTrans, Inc. (GeoTrans) for the U.S. Environmental Protection Agency (U.S. E.P.A). Work conducted by GeoTrans, including preparation of this report, was performed under Work Assignment #48 of EPA contract EP-W-07-078 with Tetra Tech EM, Inc., Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This report was prepared as part of a project conducted by the United States Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (U.S. EPA OSRTI) in support of the "Action Plan for Ground Water Remedy Optimization" (OSWER 9283.1-25, August 25, 2004). The objective of this project is to conduct Remediation System Evaluations (RSEs) at selected pump and treat (P&T) systems that are jointly funded by EPA and the associated State agency. The project contacts are as follows:

Organization	Key Contact	Contact Information
U.S. EPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Jennifer Hovis	USEPA Headquarters – Potomac Yard 2777 Crystal Drive Arlington, VA 22202 phone: 703-603-8888 hovis.jennifer@epa.gov
Tetra Tech EM, Inc. (Contractor to EPA)	Therese Gioia	Tetra Tech EM Inc. 1881 Campus Commons Drive, Suite 200 Reston, VA 20191 phone: 815-923-2368 Therese.Gioia@tetratech.com
GeoTrans, Inc. (Contractor to Tetra Tech EM, Inc.)	Doug Sutton	GeoTrans, Inc. 2 Paragon Way Freehold, NJ 07728 phone: 732-409-0344 dsutton@geotransinc.com

TABLE OF CONTENTS

Tables

Attachments

1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001 independent reviews called Remediation System Evaluations (RSEs) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (i.e., those sites with P&T systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, EPA OSRTI has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies as documented in *OSWER Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. A strong interest in sustainability has also developed in the private sector and within Federal, State, and Municipal governments. Consistent with this interest, OSRTI has developed a Green Remediation Primer (http://cluin.org/greenremediation/) and now as a pilot effort considers green remediation during independent evaluations.

The RSE process involves a team of expert hydrogeologists and engineers that are independent of the site, conducting a third-party evaluation of the operating remedy. It is a broad evaluation that considers the goals of the remedy, site conceptual model, available site data, performance considerations, protectiveness, cost-effectiveness, closure strategy, and sustainability. The evaluation includes reviewing site documents, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Green remediation

The streamlined RSE process or RSE-lite is similar to the RSE process but does not include a site visit.

The recommendations are intended to help the site team identify opportunities for improvements. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation, and represent the opinions of the evaluation team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the Region and other site stakeholders.

Wash King Laundry Site was selected by EPA OSRTI based on a nomination from EPA Region 5 and the State of Michigan due to the upcoming transition of the site from a long-term remedial action (LTRA) to operations and maintenance (O&M).

1.2 TEAM COMPOSITION

The RSE team consists of the following individuals:

Name	Affiliation	Phone	Email
Doug Sutton	GeoTrans, Inc.	732-409-0344	dsutton@geotransinc.com
Sarah Farron	GeoTrans, Inc.	732-409-0344	sarah.farron@geotransinc.com

In addition, Jennifer Hovis from EPA Headquarters participated in the RSE-lite conference call.

1.3 DOCUMENTS REVIEWED

The following documents were reviewed. The reader is directed to these documents for additional site information that is not provided in this report.

- EPA Superfund Record of Decision – March 1993
- Technical Memorandum Predesign Field Investigations – June 1995
- EPA Explanation of Significant Differences – July 1996
- EPA Five-Year Review Report – September 2006
- Long-Term Monitoring Network Optimization Evaluation, June 2006
- Great Lakes March 2006 Weekly Report – April 2006
- Operation and Maintenance Manual, Carbonair
- In-Situ Bioremediation Work Plan and Proposal – July 2009
- Quarterly Report and Remedial Systems Summary – July 2006
- Quarterly Report and Remedial Systems Summary – October 2006
- Quarterly Report and Remedial Systems Summary – January 2007
- Quarterly Report and Remedial Systems Summary – April 2007
- Quarterly Report and Remedial Systems Summary – July 2007
- Quarterly Report and Remedial Systems Summary – October 2007
- Quarterly Report and Remedial Systems Summary – January 2008
- Quarterly Report and Remedial Systems Summary – April 2008
- Quarterly Report and Remedial Systems Summary – July 2008
- Quarterly Report and Remedial Systems Summary – October 2008
- Quarterly Report and Remedial Systems Summary – January 2009
- Quarterly Report and Remedial Systems Summary – April 2009
- Quarterly Report and Remedial Systems Summary – July 2009
- Quarterly Report and Remedial Systems Summary – October 2009
- Quarterly Report and Remedial Systems Summary – January 2010
- Electronic Data

1.4 Persons Contacted

The following individuals associated with the site participated in the conference call:

Name	Affiliation	Phone	Email
Shari Kolak	U.S. EPA Region 5 (RPM)	312-886-6151	kolak.shari@epa.gov
Keith Krawczyk	Michigan DNRE	517-335-4103	KRAWCZYKK@michigan.gov
Bill Bolio	Michigan DNRE		
James Wilson	Lakeshore Env.		

DNRE= "Department of Natural Resources and Environment"

1.5 Basic Site Information and Scope of Review

1.5.1 Location

According to the 2006 Five Year Review and other site documents, the Wash King Laundry Site ("the site") is located south of the city of Baldwin in Pleasant Plains Township, Lake County, Michigan, in the Pere Marquette River Basin. It is bordered on the east by a north-south trending line approximately 300 feet east of M-37, Star Lake Road (76th Street) to the south, the C & O Railroad to the west, and the Middle Branch Pere Marquette River to the north. The Pere Marquette Subdivision Plat which comprises the site, includes 123 residential lots, most of which are not used on a year-round basis. Housing in the area consists primarily of mobile homes, trailers, and cottages. Numerous commercially developed lots exist along Highway M-37. The site is generally flat except for a steep embankment leading down to the Middle Branch Pere Marquette River.

1.5.2 Site History, Potential Sources, and RSE Scope

According to the site documents, the Wash King Laundry facility was a small, privately-owned laundromat that operated between 1962 and 1978 as Wash King Laundry and continued until 1991 under different ownership until the latter owner filed for bankruptcy. Beginning in 1962, the facility discharged laundry wastes (detergent and bleach) to four nearby seepage lagoons located about 500 feet west of the laundry facility. As part of the laundry operations/services, dry cleaning was conducted, which included the use of the solvent perchloroethene or tetrachloroethylene (PCE). Consequently, PCE was also discharged to the unlined wastewater lagoons until late 1978. Laundry detergent wastes and PCE were first detected in the groundwater by state personnel in August 1973, when the contamination was detected in residential wells located in the vicinity of the lagoons.

In 1976, further contamination (PCE) of groundwater was discovered, and the State of Michigan issued a Notice of Noncompliance and Order to Comply to the Wash King Laundry owner. In

1977, concentrations of PCE up to 6,000 ug/L were recorded in the Wash King Laundry well, and up to 20,000 ug/L in an adjacent restaurant well, located directly down-gradient of the former laundry building. In 1978, Wash King Laundry agreed to cease all dry cleaning operations.

In 1979, a preliminary hydrogeologic investigation was initiated to obtain information related to groundwater contamination and flow and soil types at the site. Subsequent investigations and analysis indicate that a groundwater contaminant plume(s) is migrating toward the Middle Branch of the Pere Marquette River.

While high levels of organic contaminants were generally not present in soil samples collected from the lagoons, high levels of PCE contamination in soil were detected near the Wash King Laundry building. Breakdown products of PCE, such as Trichloroethene (TCE) and cis-1,2-Dichloroethylene (cis-1,2-DCE) have also been detected.

In 1983, the state negotiated a settlement with the site owner, specifying that he construct a public water supply system to serve residences and businesses in the area of contamination. Two wells were subsequently developed into a deeper uncontaminated aquifer to supply water for the public water system. The main well is located on Wash King Laundry property and is 259 feet deep. The standby well is located on the Windjammer Restaurant property adjacent to Wash King Laundry, and is 240 feet deep. Local residents were offered the opportunity to connect to this water supply in 1984. Those that did not connect are now participating in a residential well sampling program. The residential wells are sampled on an annual basis.

The Wash King Laundry site was placed on the National Priorities List of Superfund sites in 1983. The Remedial Investigation/Feasibility Study (RI/FS) process, lead by the MDNR, began in September 1988 with an emphasis on data collection and site characterization. The Record of Decision was signed in March 1993, followed by an Explanation of Significant Differences in June 1996, and a remedy design thereafter. Remedy implementation began in June 1999 and included building demolition, tank removal, installation of a pump and treat (P&T) system, and installation of a soil vapor extraction (SVE) system. The P&T system and SVE system were fully operational in April 2001. In July 2009, the site contractor provided a work plan for implementing in-situ bioremediation of the groundwater and saturated soils in the vicinity of the former Wash King Laundry facility. In-situ bioremediation began in January 2010.

This RSE-lite focuses on all aspects of site remediation including the P&T system, SVE system, in-situ bioremediation, and site-wide monitoring program.

1.5.3 HYDROGEOLOGIC SETTING

Information in this section is primarily from site documents and does not include interpretation by the RSE-lite team.

The site is in the Pere Marquette River basin, which provides drainage for a 681.6 square mile area. The river flows generally westward, discharging into Lake Michigan. The Pere Marquette River and its tributaries are classified by the State of Michigan as "top quality main streams" and "trout streams".

A series of end moraines and ground moraines were deposited in this region by the Lake Michigan Lobe of the Wisconsin glaciation. Most of the boundaries of the basin are comprised of end moraines. Glacial outwash between moraines covers more than half of the drainage basin. The outwash plains are relatively level, but are dissected in places by streams and pitted with kettle holes formed by melting blocks of glacial ice. The Middle Branch of the Pere Marquette River, which forms the northern boundary of the Site, is one of these dissecting streams.

Glacial deposits in this region range from approximately 400 to 600 feet thick. The bedrock underlying the glacial deposits is the Mississippian Age Michigan Formation, which is not utilized as an aquifer in this region.

Site soils are generally composed of fine- to medium-grained sands to a depth of approximately 75 to 100 feet below ground surface (bgs), with some interbedded clay, sand and clay, and gravel lenses, ranging in thickness from one to several feet. These deposits are underlain by a thicker clay layer that begins at about 85 feet below ground surface and subdivides the shallow sandy aquifer from a deeper, predominantly sandy aquifer that extends to a depth of approximately 350 feet bgs. Figures 15B, 16B, and 17B (see Attachment A) provide north-south cross-sections of the geology to the top of the clay layer.

Aquifers in the region are predominantly outwash sands and gravels. Groundwater recharge occurs on uplands with sandy soils. Groundwater in the upper aquifer generally flows to the north-northeast, discharging into the Middle Branch Pere Marquette River. It is uncertain if deeper groundwater in the upper aquifer also discharges to the river. The overall horizontal hydraulic gradient is about 0.0055 feet per foot. A pumping test conducted as part of the 1995 predesign investigation yields a hydraulic conductivity of approximately 1×10^{-3} cm/s (approximately 2.8 feet per day) to 1×10^{-2} cm/s (approximately 28 feet per day). Horizontal hydraulic conductivities from slug tests conducted in many monitoring wells varies from 0.9 feet per day to 340 feet per day. Vertical hydraulic gradients are downward near the source area and are upward near the river.

1.5.4 POTENTIAL RECEPTORS

Contaminant exposure pathways considered to be most significant at the site at the time of the ROD are summarized as follows:

- Exposure of children to contaminated lagoon sediment through incidental ingestion and dermal absorption while playing in the lagoons.

- Exposure of residents to contaminated groundwater resulting from use of a well within the contaminated groundwater plume or by migration of groundwater contaminants to existing wells. Exposure may occur through ingestion or dermal contact with contaminated water. It would also be possible for exposure to occur through inhalation during household water usage.

- Exposure of individuals to contaminated soils at a future residence(s) developed at the site (e.g., on top of the lagoons). Exposure may occur through incidental ingestion of soil and dermal contact. It is assumed that contaminants in either lagoon sediments or subsurface soils at current concentrations would be available for exposure as a result of site development.

- Exposure of recreational users of the Middle Branch of the Pere Marquette River to contaminated surface water. Exposures may occur through incidental ingestion and dermal contact with surface water while swimming. (Even though this exposure route is more unlikely than the ones noted above, it was still considered in the risk analysis.)

Subsequent to the ROD, the lagoon sediments/soils were found to not pose a risk to human health but soils near the former Wash King Laundry building did pose a risk to human health and continued groundwater contamination. These findings, the decision to not excavate lagoon sediments/soils, and the decision to install the SVE system near the former building are documented in the ESD. Backfilling and grading of the lagoons has subsequently occurred and operation of the SVE system continues as needed.

The ROD documented that contamination levels in the surface water and river sediments do not pose an unacceptable risk. Therefore, the only remaining potential receptors are associated with potential use of contaminated groundwater and potential exposure to soil contamination or soil vapors near the former Wash King Laundry building.

1.5.5 DESCRIPTION OF GROUND WATER PLUME

The predominant contaminants of concern that remain in ground water are PCE, TCE, and cis-1,2-DCE. At most locations, PCE is typically found in higher concentrations than the other two compounds. Figures 14, 23, and 23B (see Attachment A) show the horizontal extent and concentrations of the contaminant plume in this area based on analytical results from March 2008, October 2008, and October 2009, respectively.

These figures show that the highest concentrations (which range from 1,400 ug/L to 25,000 ug/L for PCE at MW-101S) are located in the shallow zone (~30 to 50 ft) in the immediate vicinity of the former Wash King Laundry facility. This area of high concentration extends approximately 120 feet north of the building to EW-2. A larger area of moderate to high concentrations exists to the north of the building in the intermediate to deep zones (~50 to 100feet). This deeper contamination extends to the area near the MW-306 well cluster, where the highest concentrations are detected in the intermediate well, MW-306I. Concentrations downgradient of the source area in 2009 were as high as 3,000 ug/L in deep MW-303, which is screened from approximately 90 to 100 feet bgs.

A smaller area of groundwater contamination at depths between 50 and 80 feet near the MW-307 cluster is shown on the figures for March and October 2008. PCE concentrations in March 2008 at this location were highest (520 ug/L) at the intermediate well MW-307I.

The vertical distribution of contamination is also presented in the north-south cross-sections presented in Figures 15B, 16B, and 17B.

2.0 SYSTEM DESCRIPTION

The operational remedies include a P&T system, SVE system, and in-situ bioremediation. The P&T and SVE systems began operation in April 2001, and in-situ bioremediation began in January 2010. Each of these remedies is discussed in more detail below.

2.1 P&T SYSTEM

The original P&T system consisted of five extraction wells; however, a sixth (EW-3) and seventh (EW-7) extraction well were added in October 2008 and July 2010, respectively. These wells significantly improve control of source area contamination. The extraction well locations are depicted in Figure 21 (see Attachment A). Extraction well EW-3 was installed in the area of the former Wash King Laundry building and is fully screened through the upper till (source area) and deep portion of the main aquifer. EW-7, also fully screened, was installed approximately 25 feet east of EW-2, which contains only a five-foot screen set near the water table. EW-2 has been shut down indefinitely.

Extracted groundwater is treated by two Carbonair STAT 180 low-profile air strippers arranged in parallel. Four 4,000-pound vapor granular activated carbon (GAC) units are provided for treating the air stripper off-gas but are not used because air permit requirements are met without using the units. Treated water is discharged to the subsurface via a lagoon located north and west of the former laundry facility lagoons. The following table provides key information regarding the extraction network based on information provided by the site team.

Well Name	Screen Interval Elevation (ft AMSL)	Extraction Rate (gpm)	July 2010 PCE+TCE Concentration (ug/L)
EW-1	792.8 - 737.8	35	18.8
EW-2	780.0 - 775.0	0	420
EW-3	782.7 - 722.7	25	2,100
EW-4	750.3 - 725.3	25	3.1
EW-5	757.0 - 737.0	20	67.2
EW-6	741.2 - 721.2	60	157.9
EW-7	786.5 – 726.5*	60	190

* *Approximated based on provided depth interval and elevation of nearby EW-2*

The total flow rate is approximately 225 gpm, and the average influent concentration varies from approximately 200 ug/L to 500 ug/L (approximately 335 ug/L based on a weighted average of the values in the above table). The P&T system is co-located in a small building with the SVE and in-situ bioremediation systems. The building is heated with natural gas during the winter.

2.2 SVE SYSTEM

The SVE system consists of SVE wells at five locations, with two locations having two screens set at different depths in the vadose zone for a total of seven SVE wells.

There are two 1,500-pound vapor phase granular activated carbon tanks in series located in the treatment building that are no longer used. The system meets air discharge requirements without treatment. A blower extracts soil vapors at approximately 350 to 400 cubic feet per minute. A silencer is used in conjunction with the blower so that remedial operations are not a noise nuisance to the community.

SVE wells are controlled by butterfly valves and solenoid valves with control relays to allow programmed operation of the wells. The SVE vapors pass through an air/water separator tank to separate liquid water present in SVE vapors. Water separated by the air/water separator is combined with the untreated water in the groundwater treatment system.

The SVE system began operating on a cyclic basis in late October 2007. According to the January 4, 2008 Quarterly Report of Groundwater and SVE System Sampling, the decision to reduce system operating time was based on the predominance of non-detectable levels of VOCs in the majority of combined influent air samples from the previous two years. This measure was also intended to conserve electricity and reduce energy costs. Currently, the SVE system runs for 1 week and is then shut off for 2 or more weeks. The site team believes the SVE is reasonably successful in the upper 25 feet of soil.

The following table summarizes recent soil vapor concentrations at each of the SVE locations.

Well Name	June 2010 PCE Concentration (ug/L or mg/m^3)
SVE-1	0.400
SVE-2	0.590
SVE-3	0.097
SVE-4S	1.4
SVE-4D	61
SVE-5S	0.42
SVE-5D	0.58

TCE concentrations are less than PCE concentrations by a factor of approximately 100.

2.3 IN-SITU BIO-REMEDIATION

The in-situ bioremediation system was implemented after additional investigation (completed in 2009) identified a remaining, significant source area at the location of the former Wash King Laundry building. The bioremediation system includes 67 two-inch injection wells with screen intervals from 32 feet bgs to 57 feet bgs, arranged in six injection arrays containing between 10 and 12 wells per array. The screened interval of these injection wells corresponds to the general thickness of the upper till layer source material in the vicinity of the former Wash King Laundry building. PCE concentrations in saturated soil ranged up to approximately 40,000 ug/Kg at locations sampled. A distribution wheel located in a concrete vault controls which array receives the reagents. The system is depicted in Figures 26c, 27, and 28 (see

Attachment A). The system uses the Oppenheimer Formula CL product, which involves injection of microorganisms, a biocatalyst, and nutrients. Each of the six injection arrays received 250 pounds of product mixed with 2,000 gallons of water in January 2010, followed by the same process in September 2010. Addition of nutrients is an on-going process. Another similar bioremediation event will be implemented in 2011.

2.4 MONITORING PROGRAM

Process Monitoring

Volatile organic compounds (VOCs) are sampled quarterly at each of the extraction wells, the combined extracted groundwater (influent), and the effluent from each of the air strippers. Vapors from each of the SVE wells, the combined SVE vapors, and the air stripper off-gas vapors are also sampled quarterly for VOCs.

Groundwater Monitoring

Groundwater has been monitored for VOCs at many of the 64 monitoring wells on a semi-annually basis to develop a robust dataset needed to evaluate remedial progress, using low-flow sampling methods and disposable polyethylene tubing. Metals are monitored on an annual basis at monitoring well locations within the contaminant plume, at the P&T effluent area, and at background locations Water levels are monitored once per year under pumping and non-pumping conditions.

Bioremediation Performance Monitoring

Nine source area monitoring wells and three extraction well locations are monitored quarterly for VOCs, select inorganic indicator parameters associated with bioremedial activity.

3.0 SYSTEM OBJECTIVES, PERFORMANCE, AND CLOSURE CRITERIA

3.1 CURRENT SYSTEM OBJECTIVES AND CLOSURE CRITERIA

The ROD for the Wash King Laundry Site identifies the following Remedial Action Objectives (RAOs):

- Prevent ingestion and dermal contact with lagoon sediments
- Prevent ingestion and dermal contact with contaminated groundwater by a hypothetical future resident

The 1993 ROD specified the use of Michigan Type A and Type B cleanup criteria for the lagoons and groundwater, based on the Environmental Response Act, 1982 PA 307, as amended. However, at the time of the ESD in 1996, the Type A and Type B cleanup criteria were no longer supported by the current State regulations, and therefore, the ESD prescribed use of the Part 201 residential cleanup criteria as RAO's.

The residential cleanup criteria generated under Part 201, Environmental Remediation, of Act 451of the NREPA and applied for this site include the treatment standards in the following table for the primary contaminants of concern identified during the Remedial Investigation and Feasibility Study:

Contaminant of Concern	Cleanup Criteria (µg/L)
PCE	5
TCE	5
cis 1,2-DCE	70

State standards and Federal maximum contaminant levels also apply to other contaminants, including lead.

3.2 TREATMENT PLANT OPERATION STANDARDS

There is no formal permit or permit equivalency for regulating the discharge of the treated water. The site team maintains undetectable VOC concentrations in the effluent. The SVE and P&T systems have separate permits for air discharge. Both systems must discharge less than 0.03 pounds of VOCs per hour.

4.0 FINDINGS

4.1 GENERAL FINDINGS

The observations provided below are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions in the best interest of the EPA and the public. These observations have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of ground water remediation have changed over time.

4.2 SUBSURFACE PERFORMANCE AND RESPONSE

4.2.1 GROUNDWATER FLOW AND PLUME CAPTURE

Groundwater flow under non-pumping and pumping conditions in 2008 (prior to the installation of EW-7) are presented in Figures 11 and 13 (see Attachment A). Figure 11 illustrates that groundwater flows to the north, north-east toward the river, and the slight curvature of the contours in the vicinity of EW-6 may result from incomplete aquifer recovery prior to collecting the non-pumping round of water levels. Figure 13 provides the site team's depiction of the horizontal capture zone. The RSE-lite team evaluated the water levels and potentiometric surface map and generally agrees with the interpreted potentiometric surface map and extent of the capture zone in the vicinity of EW-4, EW-5, and EW-6. In general, when evaluating capture in the area of these wells, the intermediate and deep wells should generally be used because that is the interval where most of the contamination is present. There are a few instances where water levels from individual wells do not appear accurate based on water level measurements from surrounding wells or other wells in the well cluster. MW-202D and MW-206D are a few examples. The inconsistencies appear to occur during each water level event, suggesting that a survey error may be the cause.

Comparing the extraction rate from EW-5 and EW-6 to the groundwater flow rate, saturated thickness, and approximate plume width yields a similar interpretation of plume capture to that from the potentiometric surface maps.

$$Q = \text{Saturated Thickness} \times \text{Width} \times \text{Hydraulic Gradient} \times \text{Hydraulic Conductivity}$$

$$5{,}775\ ft^3/day = 70ft \times 500ft \times 0.0055\ ft/ft \times 30\ ft/day$$

$$5{,}775\ ft^3/day = 30\ gpm$$

In the above calculations, the hydraulic conductivity of 30 feet per day is the approximate upper range of the hydraulic conductivity calculated from the pumping test during the 1995 predesign investigation. It is unclear if this is a reasonable average hydraulic conductivity to apply in the area of EW-5 and EW-6. The actual pumping rate from these two wells is approximately 65 gpm. Therefore, based on these assumptions and pumping rates, there is a factor of safety of more than 2.0 to account for heterogeneity, potential erroneous assumptions regarding the hydraulic conductivity, and other factors.

The capture zones in the vicinities of EW-1 and EW-2 is based on limited data. The extent of capture from EW-2 may be overestimated in Figure 13. Use of water level data from the new 400 series monitoring wells will provide more information to interpret capture and extraction from EW-7, which is now occurring, will greatly improve capture in this area. Based on the observed drawdown and the background water hydraulic gradient, the interpreted capture zone near EW-1 is likely a reasonable approximation.

4.2.2 GROUND WATER CONTAMINANT CONCENTRATIONS

VOCs

This section evaluates groundwater contaminant trends along potential migration pathways under non-pumping conditions that were then influenced by pumping starting in 2001. The three pathways can be observed by review of the Figures 8 and 11 (see Attachment A) in which groundwater under non-pumping conditions flows north and north-northeast. It is noted that although the three pathways are discussed separately, the pathways may overlap making it difficult to attribute all contamination at a particular sampling location to only one pathway or source

- East Pathway – This pathway has the highest contaminant concentrations by a significant margin, and has resulted PCE in the upper till layer near the former Wash King Laundry building, likely from the former leaking storage tank, and perhaps poor housekeeping practices. This pathway extends north-northeast through EW-2 and EW-7 toward the MW-309 cluster, then east of State Road M-37 at the north-south location of EW-6, and then northeast toward the MW-306 cluster. Since pumping began in 2001, groundwater in this pathway near EW-6 flows more directly toward EW-6, some contamination past EW-6 is pulled back toward EW6, and contamination on the eastern fringe of the pathway is pulled west.

- Mid Pathway – This potential pathway initiates at some point between the former Wash King Laundry building and the original discharge lagoons or at the southern most reach of the original discharge lagoons. The area immediately east of the current remediation building would be a reasonable approximation of this location. Contamination would flow from this location north-northeast toward the MW-308 cluster, to the MW-206 cluster, to the MW-205 cluster, and onward toward the Middle Branch of the Pere Marquette River. It is also possible, that the contamination observed at these specified locations result completely or partially from dispersed East or West Pathway contamination. However, if the contamination does result from a third contamination source between the former Wash King Laundry building and the original discharge lagoons, this third source area would not be addressed by the existing remedy or other more aggressive efforts to address the other two source areas.

- West Pathway – This pathway originates from or near the former discharge lagoons and migrates north and north-northeast near MW-215, toward the MW-212 cluster and on to the MW-307 cluster.

It is the RSE-lite team’s experience that contaminant plumes are often narrower than conceptually depicted, and that adhering to such narrowly defined pathways is not unreasonable. The following observations are made with respect to each of these pathways. The RSE-lite team also, however, notes that there may be reasonable competing conceptual models for contaminant sources and migration.

East Pathway

- Contamination at MW-309D has remained as high as 1,000 ug/L despite source area pumping, suggesting that the EW-2 has not provided sufficient containment. The RSE-lite team believes that the core of this contaminant plume migrates toward MW-303 and is then captured by EW-6

- Under pumping conditions, the eastern fringe of this pathway is directed through the MW-306 cluster such that concentrations of approximately 50 ug/L continue. This contamination may or may not be fully captured by the extraction network.

- PCE concentration decreases at MW-3 cluster are consistent with the plume being pulled west toward EW-6.

- The bioremediation remedy and the new extraction well (EW-7) should address this pathway at its source.

Mid Pathway

The existence of this pathway suggests that there is a source of PCE somewhere between the former building and the former lagoons, perhaps a leak in the former discharge pipe. The area immediately east of the current remediation building would be a reasonable approximation of this location. It is also possible that source area contamination in the former lagoon area extends sufficiently south to fall in line with the same migration pathway.

- Contamination along this pathway may have been pulled east by pumping from EW-2 such that a slight increase was noted at the MW-207 cluster after pumping began.

- The MW-308 cluster was only recently installed, so 10 years of results are not available at this location. However, PCE concentrations at the MW-308 cluster are in the 50 ug/L range despite 10 years of pumping, suggesting that the source of this contamination (regardless of its exact location) is not fully captured.

- PCE concentrations at the MW-206 cluster have also remained relatively consistent, suggesting the source is not fully contained. However, under pumping conditions, contamination at the MW-206 cluster may also be diffuse contamination from the above-discussed East Pathway because pumping appears to cause a more northerly rather than north-northeasterly flow groundwater direction between the former Wash King Laundry building and the MW-206 cluster.

- PCE concentrations at MW-205 have been influenced by pumping at EW-5 and EW-6, which has modified groundwater flow direction. PCE concentrations at the MW-205 cluster increased from an initial concentration of 50 ug/L to over 1,000 ug/L between 2002 and 2003, and have since decreased back to approximately 100 ug/L. The concentrations at the MW-205 cluster may now represent a blend of contamination from the original East and Mid Pathways.

- If the conceptual model described here is true, the source of this pathway has not and will not be captured by existing P&T system or remediated by the recently implemented bioremediation efforts in the vicinity of the former Wash King Laundry building.

West Pathway

- PCE concentrations at MW-215, MW-103, and MW-104 have all declined to at or below cleanup standards, suggesting that EW-1 and EW-4 have been successful at containing the plume along this pathway. Note that a PCE concentration of 21 ug/L in 2008 was detected at D-1A (approximately 60 feet below ground surface and adjacent to EW-1) in 2008, suggesting that contamination persists in this source area that continues to be captured by EW-1. The contamination in this area likely results from use of the original discharge lagoons by the laundry facility. The discharge lagoons were constructed in fine sand, which is present to a depth of approximately 20 feet. A 20 to 30-foot thick dense, very fine sand till underlies this fine sand, and D-1A is screened in the gravelly sand beneath the till. It is possible that PCE contamination in the till is slowly leaching into the underlying gravelly sand, causing a long-term dilute source of contamination to the more transmissive gravelly sand. Operation of EW-1 will likely need to continue for a many years unless the source can be identified and removed.

- The location of well cluster MW-307 may be located along the core of this plume. PCE concentrations have decreased from over 500 ug/L in 2008 to approximately 300 ug/L in 2010. It is unclear what the initial concentrations were at this location prior to pumping. The RSE-lite team believes that concentrations at this location will likely continue to decrease and may have lingered as a result of a stagnation point in groundwater flow created by the pumping from EW-4, EW-5, and EW-6.

It should be noted that PCE concentrations at the MW-306 and MW-307 cluster exceed the groundwater-surface water interface (GSI) criteria.

Metals

The site team analyzes samples annually for 12 metals, including lead. Zinc, iron, manganese, and occasionally aluminum have concentrations that exceed criteria. The historic concentrations were substantially higher for total metals than for dissolved metals, and recent samples collected with low-flow sampling are substantially lower than historic values. The RSE-lite team therefore believes that some contribution of the detected metals resulted from turbidity in the well during sampling.

Historic groundwater monitoring indicates a history of lead contamination in groundwater with concentration decreases in some locations correlated with the onset of the P&T system. Recent sampling indicates substantially improved groundwater quality with respect to lead. The RSE-lite team counts 10 monitoring points that had exceedances of the lead criteria in either 2009 or 2010. One of these was MW-105, which is located far east of the site and may be impacted by lead from a historic localized gasoline release (unassociated with the Wash King site). The other exceedances are typically within a factor of 2 of the cleanup standard. Based on the historic distribution of lead in groundwater, the former lagoon area appears to have been the primary source of groundwater contamination from lead. For example, MW-215, which is located downgradient of the lagoons had concentrations as high as 97 ug/L when the P&T system started operating. Concentrations have since declined to be consistently below the cleanup standard of 4 ug/L. This decrease in the lead concentration likely results from capture provided by EW-1. Similarly, lead contamination at MW-212S and MW-212D were above 100 ug/L when the P&T began operation and have subsequently decreased by an order of magnitude, presumably due to plume capture and/or redirection of the lead contaminated groundwater.

The P&T system is not designed to treat lead, but the effluent is occasionally sampled for lead, and lead is not detected in the effluent.

4.3 COMPONENT PERFORMANCE

4.3.1 GROUNDWATER EXTRACTION SYSTEM

EW-1, EW-3, EW-4, and EW-7 have 3 HP submersible electric pumps and EW-5 and EW-6 have 5 HP pumps. The site team did not report the pump sizes for EW-2. For the purpose of this evaluation, it is assumed that EW-2 has a 1 HP pump. The site team reports some limited well and pump fouling from iron. The site team recently cleaned the pumps and risers and rehabilitated EW-3, EW-5, and EW-6. The rehabilitation exercise involved removing the riser and pump, steam cleaning the pump, cleaning the pump in acid-water solution, and surging/scraping the well-screens. Well maintenance chemicals were added to maintain a pH of 1.5 for 24 to 72 hours prior to replacing the pumps. The flow rate from EW-5 still appears to be low, and the site team is considering jetting the well for further cleaning. The RSE-lite team has observed success from jetting wells at other sites and suggests proceeding with well jetting as an option for rehabilitating EW-5.)

4.3.2 AIR STRIPPERS

According to the O&M manual, the STAT 180 air strippers each have seven trays and are fitted with a 25 HP pressure blower rated for 900 cfm at a pressure of 66 inches of water. This sizing assumed use of the vapor GAC units, which are no longer used. The vendor software output in the O&M manual suggests that each of the air strippers were sized to treat approximately 130 gpm of water (total capacity of 260 gpm) with a PCE concentration of 2,200 ug/L. With all wells pumping, the actual flow rate is approximately 225 gpm with an average influent concentration between 200 ug/L and 500 ug/L. Based on these findings, it appears that the system is likely overdesigned for the current conditions. The treated water from both air strippers has routinely been non-detect for VOCs, and there is likely room to decrease the air flow rate to the air strippers without sacrificing treatment effectiveness. To decrease the air flow rate and saving the associated electricity would require installation of variable frequency drives, replacing the existing blowers with smaller units, or discontinuing operation of one of the existing air strippers.

4.3.3 VAPOR GAC

The vapor GAC units are not longer used.

4.3.4 SVE SYSTEM

The SVE system now runs for one week and is then off for three weeks. SVE-4D has the highest vapor concentrations (as high as 61 ug/L or 61 mg/m3) when extraction is reinitiated. The vapors extracted by SVE-4D and the other wells may be the result of VOC volatilization from groundwater (not contaminated vadose zone soil) or from the upper till source area in the vicinity of the former building.

4.3.5 BIOREMEDIATION SYSTEM

The as-built schematics for the bioremediation system are show in Figures 26C, 27, and 28 (see Attachment A). The RSE-lite team has little additional information on system operation and performance and therefore cannot comment on system performance or effectiveness.

4.4 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

The project team has not provided specific cost information for this remedy, with the exception of the costs associated with the bioremediation remedy. The RSE-lite team estimates that annual costs for P&T operation, SVE operation, and groundwater monitoring are approximately $220,000 as described in the following table. The values in the table for these remedy components are estimates by the RSE-lite team based on experience and professional judgment.

Item Description	Approximate Annual Cost
Project Management	$18,000
Reporting (quarterly reports)	$18,000
Routine system O&M labor	$31,200
Electricity	$45,000
Natural gas	Unknown
Materials	Negligible
Disposal	Negligible
Groundwater monitoring labor	$64,000
Laboratory analysis – process water and vapor	$4,300
Laboratory analysis – groundwater	$20,400
Non-routine maintenance	$20,000
Total	**$220,900**

In addition to the above costs, the bioremediation system requires approximately $85,000 for materials per year. Oversight and system checks are conducted as part of the routine visits for the P&T and SVE systems

4.4.1 UTILITIES

Electricity costs are based on estimated electricity usage by the following motors:

- Submersible pumps: four 3HP, two 5HP, and one 1HP
- Air stripper blowers: two 25 HP
- SVE blower: 10 HP

All motors with the exception of the SVE blower are assumed to operate continuously at 75% efficiency and at 75% load. The SVE blower is assumed to operate 33% of the time. Based on these assumptions, the total electricity usage is approximately 500,000 kWh per year. Assuming the average state electricity rate from www.eia.gov of $0.09 per kWh, this translates to a cost of approximately $45,000 per year.

Natural gas is used to heat the building and, as required, to have a tempered water supply available for emergency purposes; however, insufficient information is available to the RSE-lite team to estimate usage.

4.4.2 NON-UTILITY CONSUMABLES AND DISPOSAL COSTS

The bioremediation materials include the microorganisms, biocatalyst, and nutrients required for one year of operation. GAC is no longer used at the site.

4.4.3 LABOR

Labor costs for project management assume 15 hours per month at $100 per hour. Routine O&M costs assume 8-hour visits per week at $75 per hour. Groundwater sampling assumes four wells are sampled per day by a two-person team that costs $2,000 for labor, materials, and sampling equipment.

4.4.4 CHEMICAL ANALYSIS

Chemical analysis assumes a cost of $60 per sample for VOCs and $50 per sample for analysis of 12 metals. Trip blanks, duplicate samples, and various other quality assurance samples are included.

4.5 APPROXIMATE ENVIRONMENTAL FOOTPRINTS ASSOCIATED WITH REMEDY

4.5.1 ENERGY, AIR EMISSIONS, AND GREENHOUSE GASES

The primary use of energy and associated emissions of greenhouse gases and criteria air pollutants is associated with site electricity usage. Contributions from operator and sampling technician travel are negligible, as is the operation of sampling generators and pumps. Attachment B provides the electricity generation mix and estimated emissions associated with electricity for the electricity provider, Consumers Energy. The following table summarizes energy usage plus emissions for the estimated 500,000 kWh of electricity used per year at the site.

Gas Emitted	Energy Usage and Emissions per Year
Energy usage	5,745 MMBtu
Carbon dioxide	1,030,900 lbs
Nitrogen dioxide	1,360 lbs
Sulfur dioxide	4,745lbs

- *Energy usage assumes 33% thermal efficiency at power plant and 10% loss due to transmission and distribution*
- *Emissions assume 500,000 kWh per year of electricity usage. Emissions due not account for resource extraction (e.g., coal mining) or transmission losses.*

Energy usage and emissions for analyzing the samples and for the production of the bioremediation materials are unknown. However, based on a document titled *U.S. Carbon Dioxide Emissions and Intensities Over Time: A Detailed Accounting of Industries, Government and Households, April 2010*, approximately 1 lb of CO2 is emitted per dollar of gross domestic product. In the absence of other information, it is assumed that the laboratory and the manufacturer also have emission profiles of approximately 1 lb of CO2 emitted per dollar of sample cost or per dollar of material. Laboratory costs are approximately $25,000 per year and bioremediation materials are approximately $85,000. Based on these values, the carbon dioxide emissions would be approximately 110,000 lbs per year, which is approximately 10% of the emissions associated with the electricity usage. Absent other information, it is reasonable to assume that the energy usage and other gas emissions are similarly small compared to the on-site electricity usage.

Without GAC treatment of the air stripper off-gas, the P&T system emits approximately 330 pounds of PCE, a hazardous air pollutant, to the atmosphere per year. The SVE system is likely emitting approximately 1.3 pounds of PCE to the atmosphere per year.

4.5.2 Water Resources

The primary use of water associated with the site is the extraction and treatment by the P&T system; however, all of this water is treated and reinjected into the same aquifer such that there is no net affect on local water resources.

4.5.3 Land and Ecosystems

The remedy involves use of existing infrastructure; therefore, continued O&M has very little impact on the surrounding land and ecosystems. One nearby resident has complained about noise from the air stripper and rumbling underfoot when the pumps operate to transmit effluent to the discharge lagoons.

4.5.4 Materials Usage and Waste Disposal

With the exception of the bioremediation reagents, materials are not used at the site because GAC is no longer used at the site. No appreciable waste is generated for disposal except for materials (e.g., tubing and personal protection equipment) associated with groundwater sampling.

4.6 Recurring Problems or Issues

No recurring problems or issues were reported by the site team.

4.7 Regulatory Compliance

The treatment systems routinely comply with the air permits. The P&T system routinely achieves undetectable VOC concentrations at the air stripper effluent.

4.8 Safety Record

No health and safety issues were identified during the RSE-lite conference call.

5.0 EFFECTIVENESS OF THE SYSTEM TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT

5.1 GROUND WATER

Some residences located immediately west of Oakland Drive still utilize water supply wells on their property. Local residents west of Oakland Drive were given the option to tie into a water supply system paid for by the former owner (deceased) of the site. Those that did not opt to connect are participating in a well sampling program, and the site team reports that there are no VOCs detected in those wells. PCE is likely discharging to the Middle Branch of the Pere Marquette River. The site team reports evaluating river sediments and water quality during the remedial investigation, and the Five Year Review reports that no VOCs were detected in surface water. However, concentrations at the MW-306 and MW-307 clusters exceed the state groundwater-surface interface (GSI) criteria of 45 ug/L for PCE, and no other monitoring locations are present (or practical to install) between these clusters and the river. The exceedance of the screening criteria suggests the need to revisit a GSI evaluation; however, the remediation of the contamination between MW-306/MW-307 and the river would be difficult given the terrain. Furthermore, the majority of the contamination in this area may migrate and discharge to the river and be flushed with clean water before an appropriate remedy could be conceived, designed, and installed. As a result, the RSE-lite team suggests focusing efforts on containing and remediating plume south of these points so that any future discharges of PCE to surface water can be mitigated or avoided.

5.2 SURFACE WATER

Please refer to Section 5.1.

5.3 AIR

PCE is emitted directly to the air within compliance limits, and preliminary air modeling by the RSE-lite team indicates that this emission rate would not result in an appreciable increased risk to human health. Soil vapor concentrations measured in the SVE wells is sufficiently high to be concerned about vapor intrusion into the neighboring restaurant. The use of the SVE system likely mitigates the potential for the problem, but additional evaluation may be warranted.

5.4 SOIL

Site surface soils have been remediated or the exposure pathway has been eliminated. Subsurface soils may continue to be impacting groundwater.

5.5 WETLANDS AND SEDIMENTS

Please refer to Section 5.1.

6.0 RECOMMENDATIONS

Cost estimates provided herein have levels of certainty comparable to those done for CERCLA Feasibility Studies (-30%/+50%), and these cost estimates have been prepared in a manner generally consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000. The costs presented do not include potential costs associated with community or public relations activities that may be conducted prior to field activities. The costs and sustainability impacts of these recommendations are summarized in Tables 6-1 and 6-2.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 SAMPLE P&T DISCHARGE AND RESIDENTIAL WELLS FOR LEAD

Groundwater containing elevated metals has historically and may continue to be extracted by the P&T system. The site team should sample the extraction wells and P&T system discharge for appropriate metals to determine if impacted water is extracted and is being discharged to the subsurface at concentrations that exceed standards. The RSE-lite team anticipates that lead concentrations from EW-1 and EW-4 are likely higher than those from the other well locations. This sampling should likely continue quarterly for one year and the data evaluated to determine if further monitoring or additional considerations are merited. The site team should also sample residential wells for lead along with VOCs during each sampling event. The cost for implementing this recommendation is relatively small (e.g., under $1,000) because all locations are already sampled for VOCs and laboratory analysis for lead is relatively inexpensive.

6.1.2 COMPLETE INSTITUTIONAL CONTROLS

The site team indicated there are on-going efforts to evaluate institutional controls necessary to prevent human exposure to contaminated groundwater. The RSE-lite team recommends that these efforts continue and that institutional controls be put in place to restrict the use of groundwater that would result in human exposure or spreading the plume.

6.1.3 JET EW-5 AND MEASURE/TRACK EXTRACTION WELL SPECIFIC CAPACITY

The site team has experienced fouling in the extraction wells, particularly EW-5. Rehabilitation efforts improved pumping conditions at the wells, but EW-5 reportedly continues to pump less than intended. The RSE-lite team recommends that the site team pressure jet the EW-5 extraction screen to further rehabilitate the well. In addition, the site team should measure specific capacity of EW-5 on a quarterly basis. This involves dividing the extraction rate by the amount of drawdown caused by pumping. The site team could use a representative static water level measurement (e.g., 789 feet AMSL) and hold it constant on a move forward basis, measure the water level quarterly during pumping, and divide the extraction rate by the difference between the selected static water level and the pumping water level. A consistently decreasing specific capacity indicates well fouling is occurring and that well maintenance measures are appropriate. This proposed method of measuring specific capacity will result in some variation as the regional water level rises and falls with the season, but the approach should still provide an early warning as to when well maintenance is required. The RSE-lite team estimates that pressure jetting might cost on the order of $5,000 for one well, which is significantly smaller than abandoning the well, installing a replacement well, and connecting the replacement well to system piping. Measuring and tracking the specific capacity should not appreciably impact management and reporting costs.

6.1.4 EVALUATE AND MANAGE SOIL VAPORS

The RSE-lite team believes that the SVE system likely addresses the shallow (e.g., less than 30 feet below ground surface) soil contamination. Any persistent soil vapor contamination is likely due to volatilization of VOCs from the contaminated groundwater and/or from the upper till source area. Therefore, the RSE team believes that the only reason to operate the SVE system is to mitigate vapor intrusion to the adjacent restaurant, which is immediately north of the building property, and to the hotel immediately south of the site. The RSE-lite team recommends sampling indoor air at the restaurant and any other building within 100 feet of the source area for VOCs under the current operational program for the SVE system (i.e., 1 week on and two weeks off). If the results indicate indoor air impacts, the site team will need to address them by either increasing the operational frequency of the SVE system or potentially using vapor mitigation systems for the affected buildings. If the results indicate no indoor air impacts, the RSE-lite team suggests discontinuing the SVE system and sampling indoor air again on a monthly basis to determine if indoor air becomes impacted. If indoor air is not impacted over a pre-determined period (e.g., 6 months), then the SVE system can remain off and the sampling could be eliminated or reduced in frequency (e.g., quarterly). The cost for 7 sampling events (including labor, and two summa canister samples per event) would likely be approximately $10,000. If the SVE system remains off for 6 months instead of operating at its current frequency, this cost of $10,000 would be partially offset by approximately $1,000 in savings. Future savings from not operating the SVE system would be approximately $2,000 per year from reduced electricity usage plus additional savings from reduce O&M parts and labor.

6.2 RECOMMENDATIONS TO REDUCE COSTS

6.2.1 CONSIDER DISCONTINUING PUMPING FROM EW-4

EW-1 appears to have successfully captured much of the contamination that would migrate to EW-4, and the VOC concentrations at EW-4 and nearby MW-301S and MW-301D are routinely below standards. The RSE-lite team suggests discontinuing pumping from EW-4 because it is extracting water that already meets standards. Discontinuing pumping from EW-4 may also help ease the stagnation zone that is inhibiting flushing of the contamination in the vicinity of the MW-307 cluster. The RSE-lite team estimates that this will reduce electricity usage by 20,000 kWh per year and may reduce the electricity bill by approximately $1,800 per year. The well can continue to be sampled along with the other extraction wells to confirm concentrations in EW-4 remain below standards.

6.2.2 REDUCE METALS ANALYSIS

The site team analyzes samples annually for 12 metals, but only lead appears to continue to impact water quality. The RSE-lite team suggests eliminating the metals analysis for the other 11 metals if a cost savings can be realized. The RSE-lite team estimates that approximately $2,500 per year might be saved by implementing this recommendation plus potential additional savings resulting from reduced data management requirements.

6.2.3 RECONFIGURE AIR STRIPPERS AND POSSIBLY RESIZE AIR STRIPPER BLOWERS

The air strippers are overdesigned for the current application. Vendor software for the air strippers suggests that one air stripper with 7 trays can treat 200 gpm at 500 ug/L and a factor of safety of 2.0 to non-detect effluent standards. The treatment plant, however, operates two of these air strippers. The RSE-lite team recommends sending all extracted water to one of the air strippers in a phased approach to confirm that one air stripper can provide the necessary level of treatment.

In addition, the current blowers were sized assuming the vapor GAC vessels and associated ducting would be used and are not optimally configured for current operation. The site team should contact Carbonair (the air stripper manufacturer) or New York Blower (the blower manufacturer) to determine the costs and savings of purchasing a new appropriately sized blower with the GAC vessels bypassed and process ducting reduced accordingly.

Assuming the same blower is used, the RSE-lite team estimates that operating one air stripper will reduce electricity usage by approximately 164,000 kWh per year and reduce electricity costs by approximately almost $15,000 per year. Additional savings could be realized if the blower is replaced or a variable frequency drive is used. If the pressure can be reduced to 45 inches of water by removing the GAC vessels and some ducting, electricity usage might be further reduced by 50,000 kWh per year for additional annual savings of $4,500 per year. An initial investment to make the modification will be required. The site team should consider all of the recommendations in this report, including the implications of additional source area investigation and remediation (see Section 6.4), before investing in different equipment for the air strippers.

6.2.4 MODIFY GROUNDWATER MONITORING PROGRAM

During the RSE-lite conference call, the site team stated that it was sampling a robust number of wells semi-annually for VOCs for a few years to obtain a comprehensive data set, and would then reduce the number of sampling locations and/or frequency as appropriate. The RSE-lite team provides for consideration by the site team the following suggested groundwater monitoring program for VOCs and lead.

Evaluate Capture Along East Pathway

Sample the following wells semi-annually to track the progress of remediation downgradient of the source area as a result of source area remediation via bioremediation and/or capture by EW-7. A semi-annual frequency is selected because the RSE-lite team estimates that the seepage velocity may be higher than 200 feet per year and decreases in PCE concentrations in this area downgradient of the source area may occur relatively quickly once the source is remediated or controlled.

- MW-4
- MW-309S
- MW-309D
- MW-3S
- MW-3D

Sample the following wells annually to track progress of aquifer restoration downgradient of EW-5 and EW-6. This frequency is chosen because the wells are relatively far downgradient of the source area. Changes in concentration as a result of source area remediation or control will happen slower, and contaminant flushing of this area may be slowed due to the pumping of EW-5 and EW-6.

- MW-305S

- MW-305I
- MW-305D
- MW-306S
- MW-306I
- MW-306D

Sample the following wells for performance monitoring of the bioremediation system or other source are remediation attempts. Thereafter, sample annually to track progress of aquifer restoration. If concentration declines are slow and restoration is expected to take many years, consider extending the sampling frequency to every two years as long as the contamination is captured by EW-2, EW-3 and/or EW-7.

- MW-101S
- MW-101D
- MW-401S
- MW-401D
- MW-402S
- MW-403S
- MW-403I

Sample the following wells every two years to keep track of remedy progress. The reason for the suggested frequency reduction is provided:

- MW-213S because it is within the capture zone of EW-7
- MW-213D because it is within the capture zone of EW-7
- MW-303 because it is within the capture zone of EW-6

Note that sampling at MW-304S, MW-304I, MW-304D, and MW-105 would no longer occur because they historically were not contaminated and continue to not be contaminated.

Evaluate Capture, Contaminant Migration, and Aquifer Restoration Along Mid Pathway

Sample the following wells semi-annually to evaluate capture of the potential Mid Pathway source and efforts to remediate that source. A semi-annual frequency is selected because the RSE-lite team estimates that the seepage velocity may be higher than 200 feet per year and decreases in PCE concentrations in this area downgradient of the source area may occur relatively quickly once the source is remediated or controlled.

- MW-205S
- MW-205D
- MW-206S
- MW-206D
- MW-207S
- MW-207D
- MW-308S
- MW-308D

Note that sampling at MW-102S, MW-102D, MW-202S, MW-202I, and MW-202D would no longer occur because they historically were not contaminated and continue to not be contaminated.

Evaluate Capture, Contaminant Migration, and Aquifer Restoration Along West Pathway

Sample the following wells semi-annually for the first two years following the shutdown of EW-4 to see how PCE concentrations change at each location. If concentrations increase at some locations, revisit the site conceptual model and consider various alternatives for achieving restoration. If the wells remain clean or cleanup, take steps to demonstrate attainment of aquifer restoration goals for this part of the aquifer.

- MW-103
- MW-104
- MW-212S
- MW-212D
- MW-215
- MW-301S
- MW-301D
- MW-307S
- MW-307I
- MW-307D

Sample MW-2D every two years as long as EW-1 is operating at the same rate because it is within the capture zone of EW-1. If source area remediation is considered for the lagoon area, increase the frequency to semi-annual to monitor the effects of source area remediation.

Note that sampling at MW-204S, MW-204D, MW-211S, MW-211D, and MW-201 would no longer occur because they historically were not contaminated and continue to not be contaminated.

Once the bioremediation performance monitoring has been completed, the above program would involve 23 samples semi-annually, and 6 to 13 samples annually, and 4 to 11 samples every two years. The RSE-lite team estimates that this might reduce sampling costs to between by $26,000 and $31,500 for a cost reduction of approximately $32,500 to $38,000 per year. Laboratory costs for VOCs would be reduced by approximately $6,000.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

6.3.1 PREPARE AN ANNUAL REPORT

The site consultant should prepare an annual report that documents the site conceptual model and evaluates concentration trends and water level measurements against this conceptual model. The effectiveness of plume capture, progress toward aquifer restoration, and changes to the conceptual model should be documented. The report should also include the current and historic groundwater monitoring data along the extraction well and blended influent data for the P&T system. The current quarterly reports are sufficiently detailed. Rather than repeat the findings from these reports, the four quarterly operational reports should be included as an attachment to the annual report. The RSE-lite team estimates that approximately $10,000 is needed each year to prepare this report.

6.4 CONSIDERATIONS FOR GAINING SITE CLOSE OUT

6.4.1 INVESTIGATE SOURCES IN LAGOON AREA AND PIPING TO FORMER LAGOONS

The consistent PCE concentrations at EW-1 suggest that there is a source, perhaps relatively small, that persists in the lagoon area. As long as this source remains, EW-1 will need to continue pumping. Source area investigation and subsequent remediation, if successful, would allow pumping from EW-1 to be discontinued. Additionally, the RSE-lite team believes that continuing contamination at the MW-308 cluster and the increase in concentrations at the MW-207 cluster with the onset of pumping suggests there is a source for the "Mid Pathway". This source would lie between the former Wash King Laundry building and the former lagoons (e.g., near the current remediation building) and may have resulted from a potential leak in the former 500-foot pipe to the lagoons. Alternatively, there may be a source in the southern portion of the lagoons that migrates north-northeast to the east of the EW-1 capture zone. Therefore, even if bioremediation of the source near the former Wash King Laundry building is successful, as long as Mid Pathway source remains and is not controlled, the aquifer upgradient of EW-5 and EW-6 will remain contaminated and EW-5 and EW-6 will need to continue to operate.

The RSE team recommends that the site team review historic documents and data to determine those potential areas and depths that were not investigated and to use the information from this review and the migration pathways discussed in this RSE report to develop a direct-push investigation to identify the sources of the West Pathway and Mid Pathway. Once the source is identified, the site team can evaluate the need for further characterization and remediation options. The RSE-lite team suggests a phased approach to identifying and characterizing these source areas.

The first phase would involve installing three monitoring wells to a depth of approximately 60 to 70 feet below ground surface with soil samples collected every 10 feet. One monitoring well would be immediately north (e.g., 10 feet north) of the location of the former discharge lagoon shown on Figure 2-5 of the 1995 Technical Memorandum Predesign Field Investigations. Another well would be installed near the current treatment building in a direct line between the new monitoring well just described and the MW-308 cluster. The third well would be installed midway between the former Wash King Laundry Facility and MW-2D. These three wells, along with D-1A, D-1B, D-1C, and MW-2D would be sampled once, and all of these wells plus MW-215, MW-207S/D, and MW-401I/D would be gauged twice. One gauging event should be conducted with EW-1 pumping and the other one should be conducted several days after EW-1 has been temporarily shut down to provide water level information under pumping and non-pumping conditions. The PCE results and the water levels would be used to better understand groundwater flow in this part of the site and to try to identify the path of the plume core from this source area.

Based on these results, the site team could use direct-push to collect soil samples at several locations from as deep as the rig will allow. Based on experience, site team suggests this is approximately 25 feet below ground surface, and the RSE-lite team hopes that this corresponds to at least the upper several feet of the till. This phase could involve approximately three days of soil sampling to depths of approximately 25 feet below ground surface, which should translate to approximately 20 locations. These locations should coincide with the areas of the each of the former discharge locations (particularly the southernmost ones) and a several locations along the former discharge pipe near the existing treatment plant building. This phase should help identify where PCE contamination migrated downward into the till.

A third, phase would involve additional borings and discrete soil sampling based on the findings from the earlier phases. The site team will likely need to use hollow stem auger drilling to obtain deeper soil samples and groundwater samples. The locations would be based on the results from the first two phases, but the RSE-lite team estimates that sampling may be taken at up to 5 locations, with samples from several depth intervals from 30 feet to 80 feet. This should provide enough information to identify the source, but additional characterization at a later date may be needed prior to design of a source area remedy.

These three phases of investigation, or a similarly dynamic work plan for characterization, should help the site team identify the source and provide sufficient characterization to consider various, viable remedial options. The RSE-lite team estimates that this investigation may cost of approximately $100,000 to develop the plan, implement the plan, and report the results and conclusions. This cost is based on the following approximate values:

- $15,000 for plan development (including review of historic documents)
- $25,000 for the first three monitoring wells, including one round of sampling and two rounds of gauging
- $15,000 for the direct-push borings
- $30,000 for the deeper borings
- $15,000 to analyze and report results

6.4.2 DEVELOP AN EXIT STRATEGY

The site team has already made important additions to the site remedy, including the installation of EW-3 and EW-7, and the source area bioremediation system. These two components have not been operating for long enough for the RSE-lite team to comment on their performance. Nevertheless, the RSE-lite team believes they are important steps in attempting to reach site closure. The site team should develop an exit strategy that documents a path forward for sequentially ending active remediation, delisting the site, and closing the site.

If EW-7 is successful at controlling the source for the East Pathway or the bioremediation system is successful at remediating that source, then much of the aquifer between that source and EW-5 and EW-6 will begin to cleanup. It may only take a few years to see substantial results. However, the RSE-lite team believes that identification and either control or remediation of the source for the Mid Pathway will also be needed to reach aquifer restoration of the area upgradient of EW-5 and EW-6 and to allow pumping from EW-5 and EW-6 to be discontinued. The RSE-lite team already believes that pumping from EW-4 can be discontinued.

The above-mentioned investigation (if funded and implemented) should identify the source(s) for the West and Mid Pathway(s). Design and implementation of the remedial options for these pathways should be postponed until after the effectiveness of the current bioremediation efforts have been evaluated. If bioremediation has been successful or will be successful at removing the source near the former Wash King Laundry building, then the P&T system will no longer be needed for the East Pathway and a source area remedy should likely be attempted for the lagoon/piping source areas so that P&T can be discontinued altogether. If the bioremediation remedy is not or will not be successful, then the sit team will either need to consider alternative source area remedial approaches or continue with P&T as a containment remedy for all contaminant pathways. If the P&T system will need to continue operating to contain the source near the former Wash King Laundry facility, then using the P&T system to control the West and Mid Pathways would likely be more cost effective than aggressively remediating them.

The exit strategy should be developed after the investigation of the sources for the West and Mid Pathways and after the conclusion of the initially scoped bioremediation system. These additional points of information will allow the site team to make practical decisions regarding source area remediation. The RSE-lite team estimates that development of the exit strategy for this site will cost approximately $10,000 total for a draft and final document.

6.5 Recommendations for Additional Green Practices

6.5.1 Use Dedicated Tubing

The site team currently uses new polyethylene tubing for each sampling event. Although this is relative cost-effective due to the relatively low price of polyethylene tubing, it involves use of materials and disposal of materials that could otherwise be reused. The RSE-lite team suggests that sampling be conducted with dedicated tubing for each well. Once the sampling is completed for a particular well, the tubing could be left in the well for the next sampling event. If dedicated tubing is used, the site team should consider using Teflon-lined tubing. The cost impacts of this recommendation are minor, but it should avoid the use and disposal of over 6,000 feet of polyethylene tubing each year.

6.5.2 Considerations for Renewable Energy at the Site

The current remedy is electricity intensive, and the remedy footprint could be substantially reduced by using renewable energy. However, the site team has invested in a bioremediation remedy, and the RSE-lite team encourages source investigation and remediation to hopefully end or significantly reduce the operation of the P&T system. Given this new direction, the RSE-lite team does not encourage consideration and investment into a renewable energy system for the site. If the site team chooses to reduce the remedy footprint through the use of renewable energy, it could consider green power purchasing through the local utility (if available) or through the purchase of renewable energy certificates. Green power purchasing would increase costs by approximately $0.03 per kWh, but would avoid significant capital costs for renewable energy system design and installation.

Table 6-1. Cost Summary Table

Recommendation	Reason	Additional Capital Costs ($)	Estimated Change in Annual Costs ($/yr)	Estimated Change in Life-Cycle Costs $*	Discounted Estimated Change in Life-Cycle Costs $**
6.1.1 SAMPLE P&T DISCHARGE AND RESIDENTIAL WELLS FOR LEAD	Effectiveness	$200	$0	$200	$200
6.1.2 COMPLETE INSTITUTIONAL CONTROLS	Effectiveness	Not provided	$0	$0	$0
6.1.3 JET EW-5 AND MEASURE/TRACK EXTRACTION WELL SPECIFIC CAPACITY	Effectiveness	$5,000	$0	$5,000	$5,000
6.1.4 EVALUATE AND MANAGE SOIL VAPORS	Effectiveness	$9,000	($2,000)	($51,000)	($30,200)
6.2.1 CONSIDER DISCONTINUING PUMPING FROM EW-4	Cost Reduction	$0	($1,800)	($54,000)	($38,300)
6.2.2 REDUCE METALS ANALYSIS	Cost Reduction	$0	($2,500)	($75,000)	($49,000)
6.2.3 RECONFIGURE AIR STRIPPERS AND POSSIBLY RESIZE AIR STRIPPER BLOWERS	Cost Reduction	$0	($15,000)	($450,000)	($294,000)
6.2.4 MODIFY GROUNDWATER MONITORING PROGRAM	Cost Reduction	$0	($38,500) To ($44,000)	($1,155,000) To ($,320,000)	($754,600) To ($862,400)
6.3.1 PREPARE AN ANNUAL REPORT	Technical Improvement	$0	$10,000	$300,000	$196,000
6.4.1 INVESTIGATE SOURCES IN LAGOON AREA AND PIPING TO FORMER LAGOONS	Site Closeout	$100,000	Not quantified		

Recommendation	Reason	Additional Capital Costs ($)	Estimated Change in Annual Costs ($/yr)	Estimated Change in Life-Cycle Costs $*	Discounted Estimated Change in Life-Cycle Costs $**
6.4.2 DEVELOP AN EXIT STRATEGY	Site Closeout	$10,000	Not quantified		
6.5.1 USE DEDICATED TUBING	Green Practice	Negligible			
6.5.2 CONSIDERATIONS FOR RENEWABLE ENERGY AT THE SITE	Green Practice	Not quantified			

Costs in parentheses imply cost reductions
* assumes 30 years of operation with a discount rate of 0% (i.e., no discounting)
** assumes 30 years of operation with a discount rate of 3%

Table 6-2. Green Remediation Summary Table

Recommendation	Reason	Green Remediation Effects
6.1.1 SAMPLE P&T DISCHARGE AND RESIDENTIAL WELLS FOR LEAD	Effectiveness	Negligible increases or decreases in remedy footprint
6.1.2 COMPLETE INSTITUTIONAL CONTROLS	Effectiveness	Negligible increases or decreases in remedy footprint
6.1.3 JET EW-5 AND MEASURE/TRACK EXTRACTION WELL SPECIFIC CAPACITY	Effectiveness	Negligible increases or decreases in remedy footprint
6.1.4 EVALUATE AND MANAGE SOIL VAPORS	Effectiveness	Potential to reduce electricity usage and associated emissions by approximately 22,000 kWh per year
6.2.1 CONSIDER DISCONTINUING PUMPING FROM EW-4	Cost Reduction	Potential to reduce electricity usage and associated emissions by approximately 20,000 kWh per year
6.2.2 REDUCE METALS ANALYSIS	Cost Reduction	Reduction in energy and materials usage by laboratory associated with sample analysis
6.2.3 RECONFIGURE AIR STRIPPERS AND POSSIBLY RESIZE AIR STRIPPER BLOWERS	Cost Reduction	Potential to reduce electricity usage and associated emissions by approximately 164,000 to 214,000 kWh per year.
6.2.4 MODIFY GROUNDWATER MONITORING PROGRAM	Cost Reduction	Reduction in energy and materials usage by laboratory associated with sample analysis. Small reductions in energy and emissions associated with less technician travel and less small generator use for sampling.
6.3.1 PREPARE AN ANNUAL REPORT	Technical Improvement	Negligible increases or decreases in remedy footprint

Recommendation	Reason	Green Remediation Effects
6.4.1 INVESTIGATE SOURCES IN LAGOON AREA AND PIPING TO FORMER LAGOONS	Site Closeout	Increases in footprint associated with on-site diesel usage for direct-push rig operation plus energy and materials associated with laboratory analysis. Substantial life-cycle remedy footprint decreases associated with decreased P&T operation if source can be found and remediated in a timely manner.
6.4.2 DEVELOP AN EXIT STRATEGY	Site Closeout	Negligible increases or decreases in remedy footprint
6.5.1 USE DEDICATED TUBING	Green Practice	Potential to eliminate use and disposal of 6,400 feet of polyethylene tubing each year.
6.5.2 CONSIDERATIONS FOR RENEWABLE ENERGY AT THE SITE	Green Practice	Use of renewable energy could reduce remedy emissions footprints by approximately 90% due to the electricity intensive nature of the remedy.

ATTACHMENT A
FIGURES FROM EXISTING REPORTS

LAKESHORE ENVIRONMENTAL, INC.

CROSS SECTION OUTLINE MAP

WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	MAY, 2009	FIGURE 4

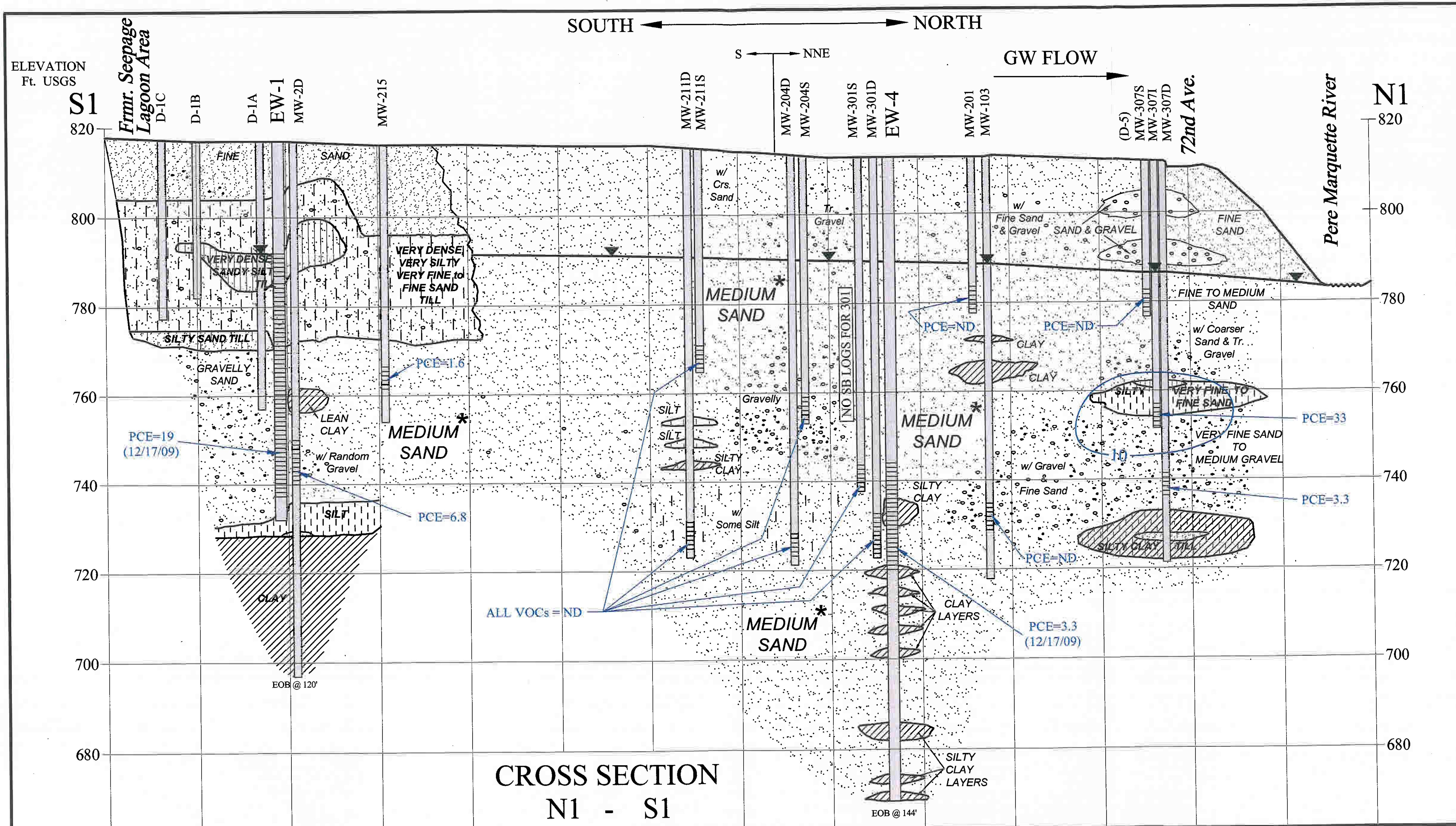
LAKESHORE ENVIRONMENTAL, INC.

SCIENTISTS • ENGINEERS • PLANNERS

GROUNDWATER REMEDIATION SYSTEM UNDERGROUND PIPING MAP

WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	DECEMBER, 2008	FIGURE 21



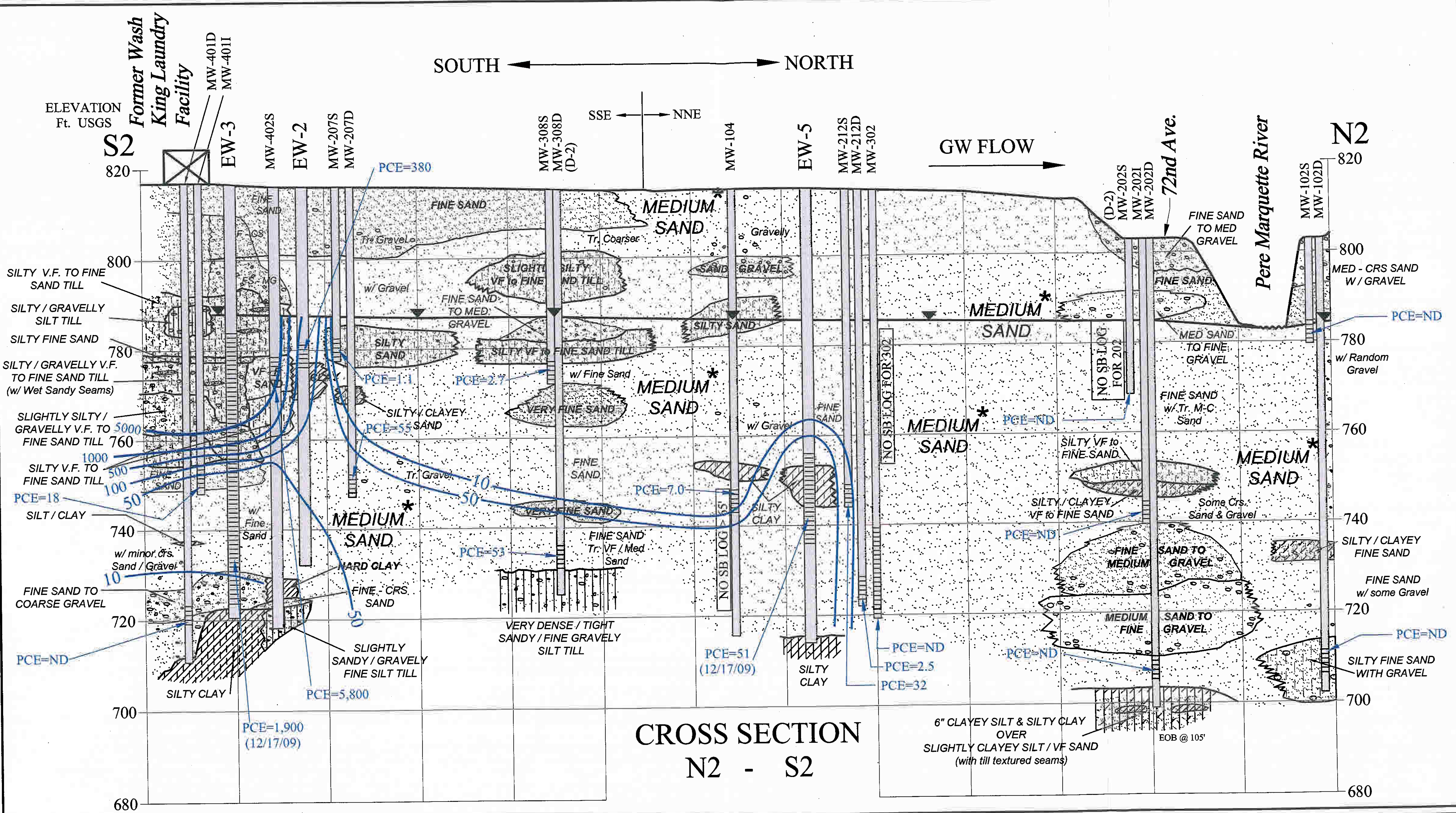
* Based on the cumulative historical soil boring logs, the predominant and/or average grain size description for the fluvial deposits is "Medium Sand". Lesser amounts of Silt, Fine and Coarse Sand, and Gravel were also described as being present at random depths and locations, as clarified in smaller print. Discrete low permeability layers (i.e. Clays, Silts, Very Fine Sands, or poorly sorted mixtures thereof [e.g. Fine-Grained Tills]), layers of Coarse Sand and Gravel, and in some cases Fine Sand, are mapped as distinct units.

SCALES:
HORIZONTAL 1"=120'
VERTICAL 1"=20'

LAKESHORE ENVIRONMENTAL, INC.
SCIENTISTS • ENGINEERS • PLANNERS

PCE ISOCONCENTRATIONS(10/27/09)
CROSS SECTION N1 - S1
WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	FEBRUARY 2010	FIGURE 15 B



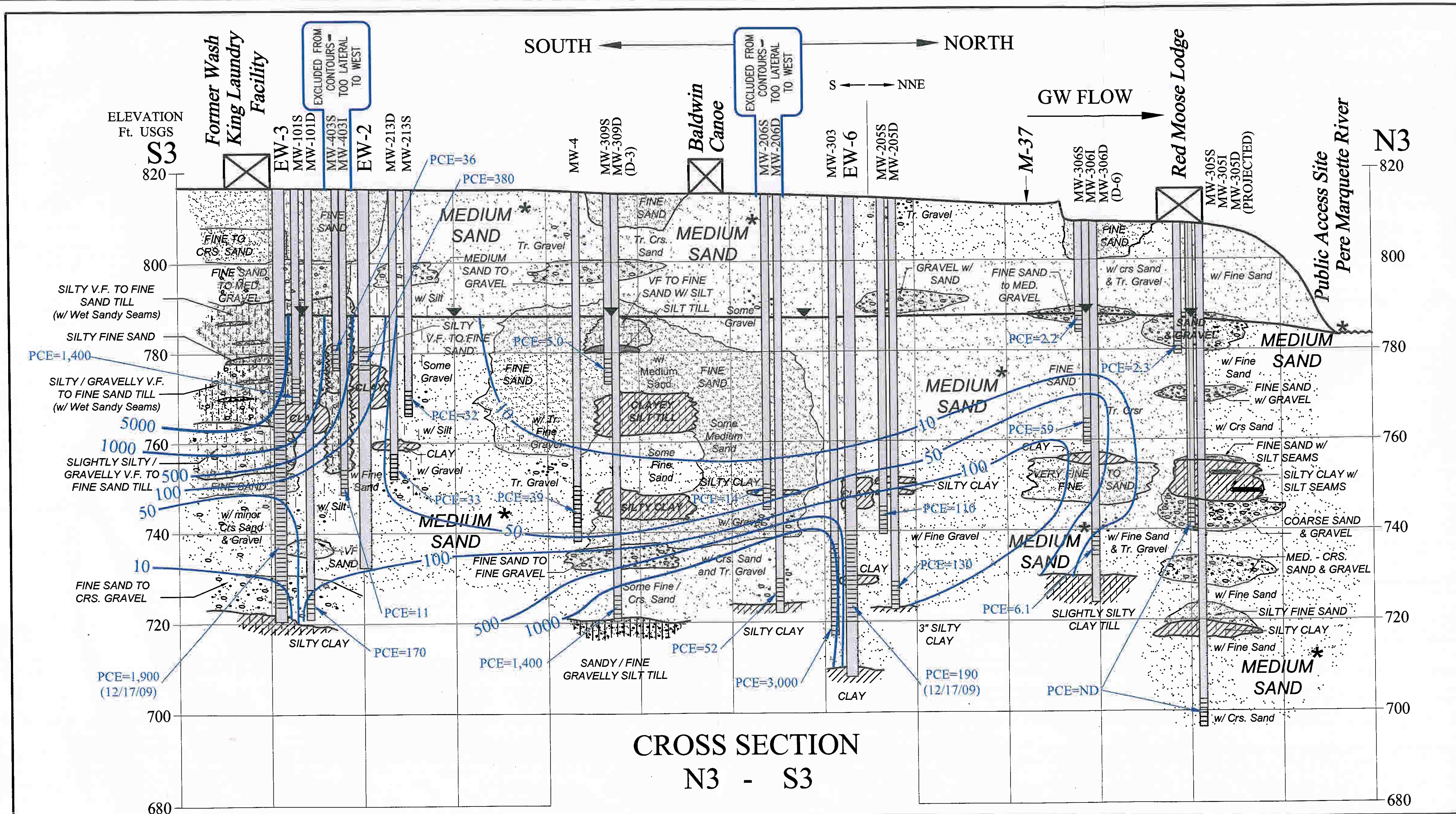
* Based on the cumulative historical soil boring logs, the predominant and/or average grain size description for the fluvial deposits is "Medium Sand". Lesser amounts of Silt, Fine and Coarse Sand, and Gravel were also described as being present at random depths and locations, as clarified in smaller print. Discrete low permeability layers (i.e. Clays, Silts, Very Fine Sands, or poorly sorted mixtures thereof [e.g. Fine-Grained Tills]), layers of Coarse Sand and Gravel, and in some cases Fine Sand, are mapped as distinct units.

SCALES:
HORIZONTAL 1"=120'
VERTICAL 1"=20'

LAKESHORE ENVIRONMENTAL, INC.
SCIENTISTS • ENGINEERS • PLANNERS

PCE ISOCONCENTRATIONS (10-27-09)
CROSS SECTION N2 - S2
WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	FEBRUARY 2010	FIGURE 16 B



* Based on the cumulative historical soil boring logs, the predominant and/or average grain size description for the fluvial deposits is "Medium Sand". Lesser amounts of Silt, Fine and Coarse Sand, and Gravel were also described as being present at random depths and locations, as clarified in smaller print. Discrete low permeability layers (i.e. Clays, Silts, Very Fine Sands, or poorly sorted mixtures thereof [e.g. Fine-Grained Tills]), layers of Coarse Sand and Gravel, and in some cases Fine Sand, are mapped as distinct units.

SCALES:

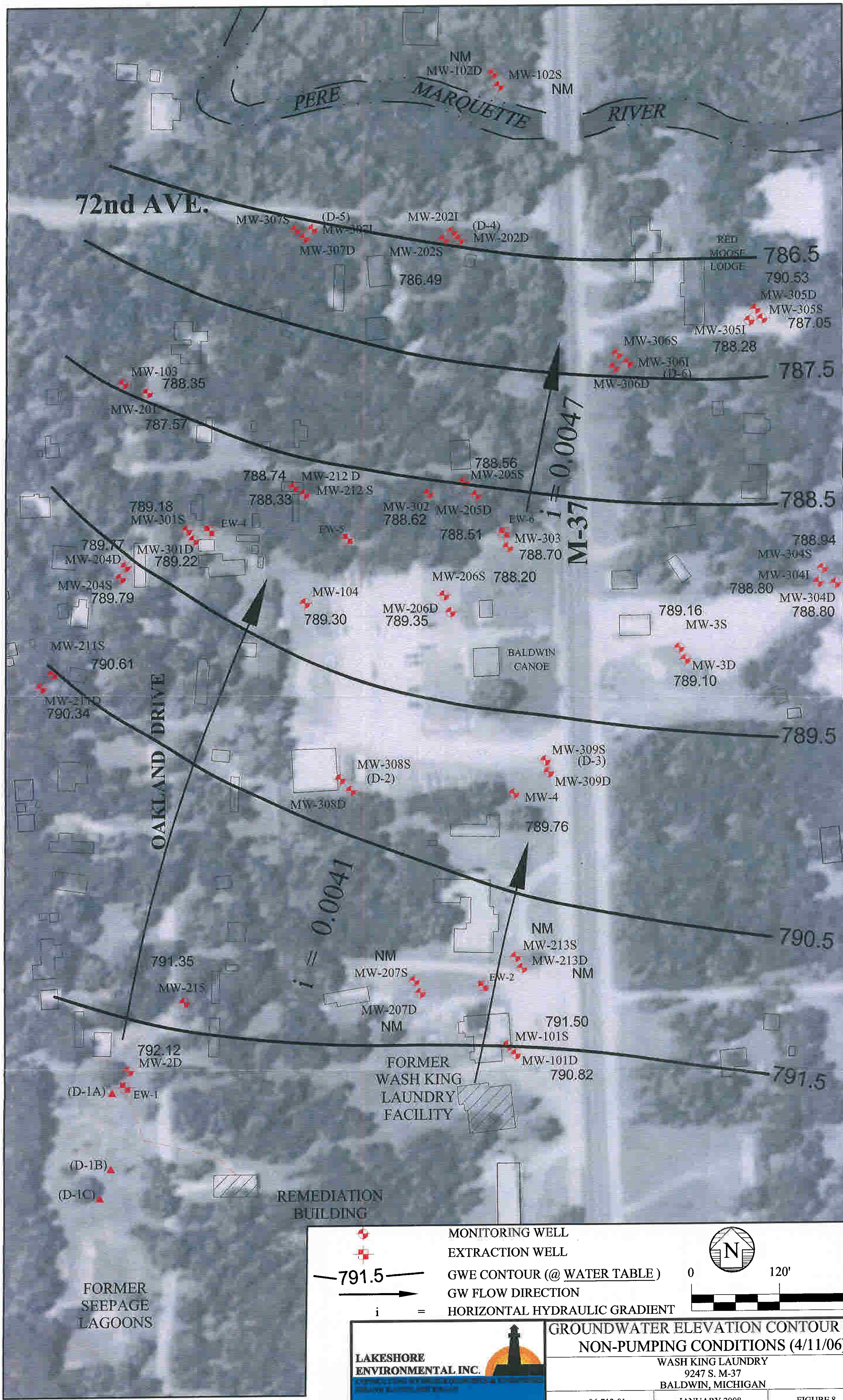
HORIZONTAL	1"=120'
VERTICAL	1"=20'

LAKESHORE ENVIRONMENTAL, INC.

SCIENTISTS · ENGINEERS · PLANNERS

PCE ISOCONCENTRATION (10/27/09)
CROSS SECTION N3 - S3
WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	FEBRUARY 2010	FIGURE 17 B



MONITORING WELL

EXTRACTION WELL

—791.5— GWE CONTOUR (@ WATER TABLE)

→ GW FLOW DIRECTION

i = HORIZONTAL HYDRAULIC GRADIENT

N

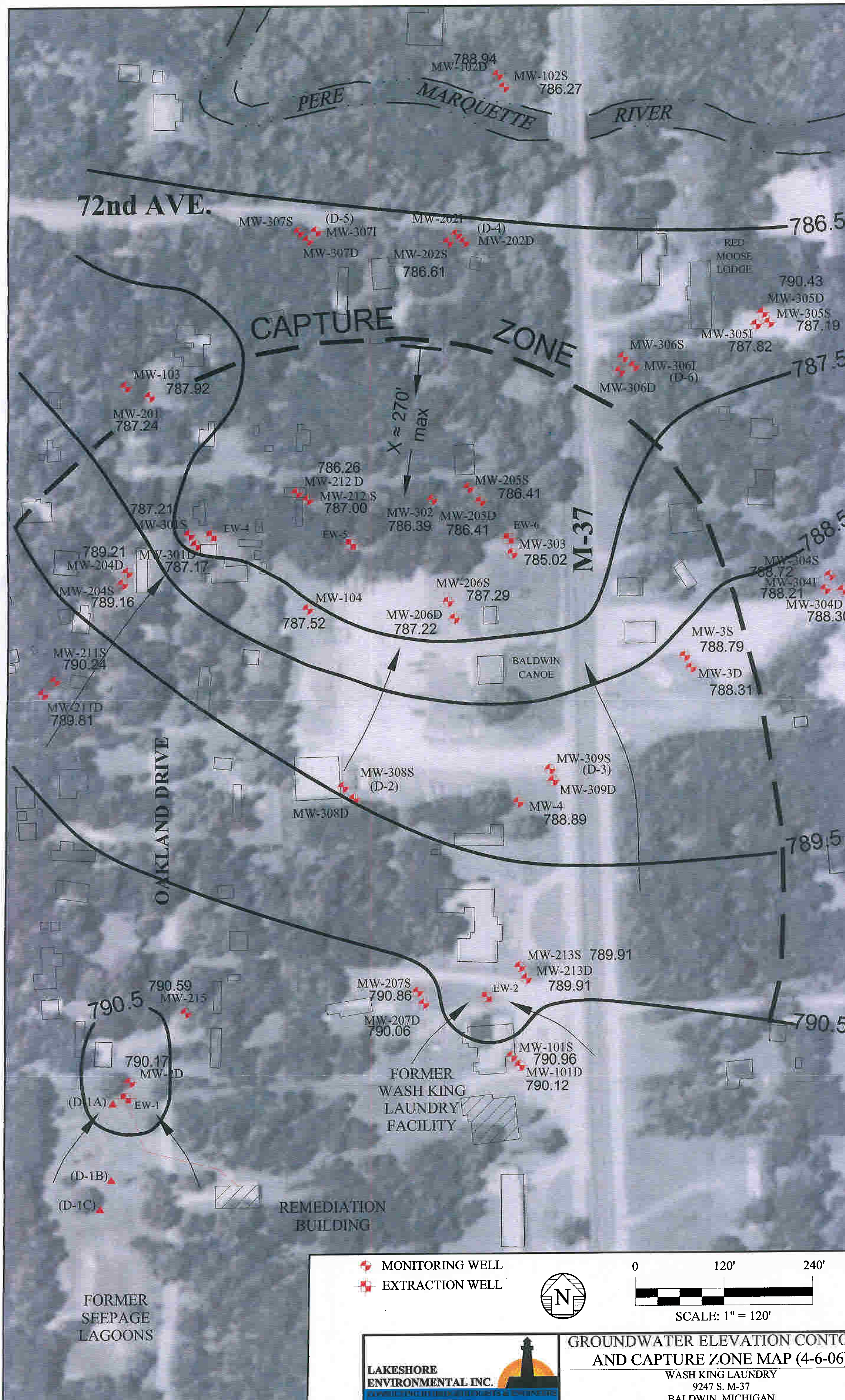
0 120' 240'

LAKESHORE ENVIRONMENTAL INC.

GROUNDWATER ELEVATION CONTOUR MAP
NON-PUMPING CONDITIONS (4/11/06)

WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	JANUARY 2008	FIGURE 8

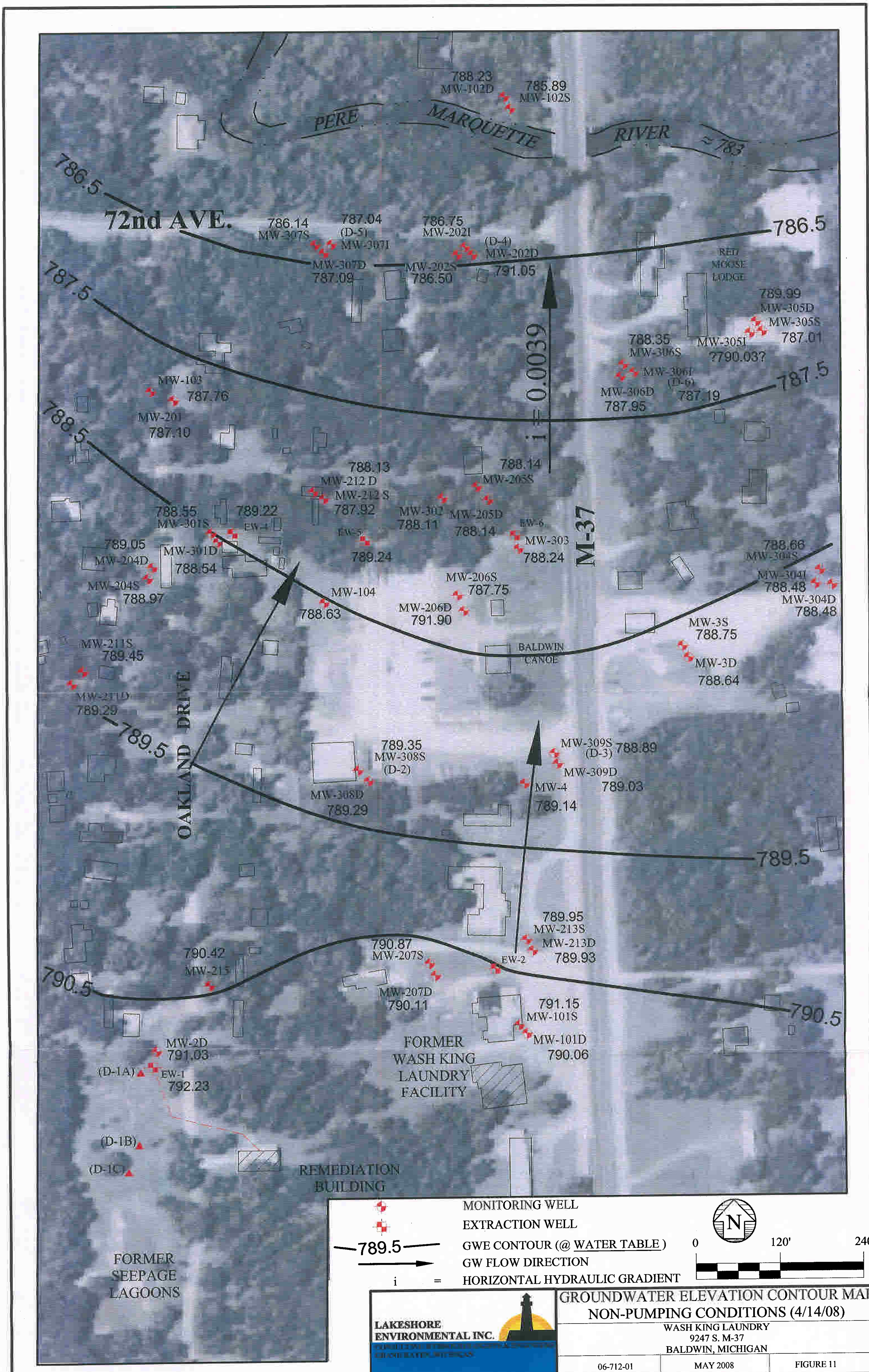


LAKESHORE ENVIRONMENTAL INC.

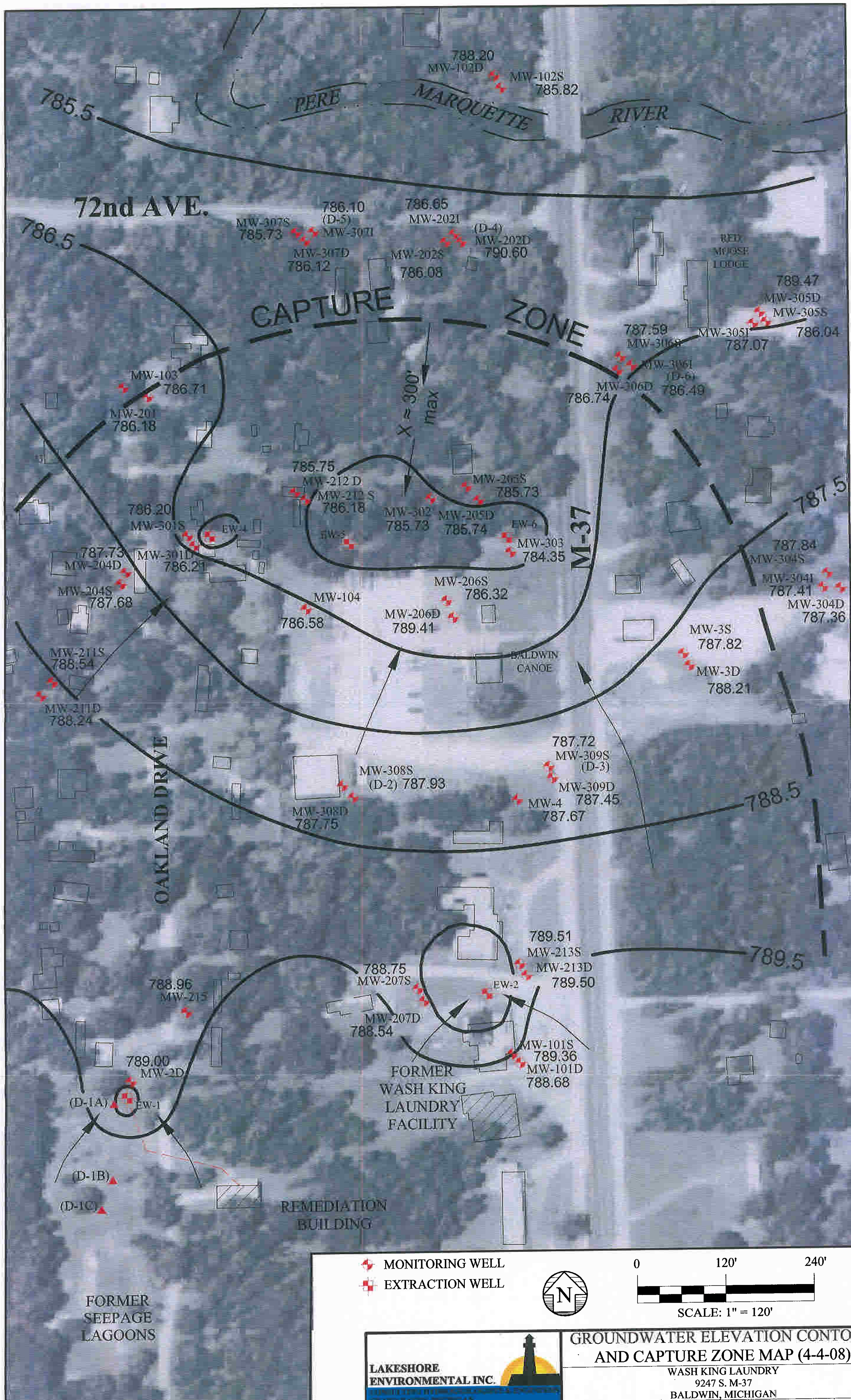
GROUNDWATER ELEVATION CONTOUR AND CAPTURE ZONE MAP (4-6-06)

WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	JANUARY 2008	FIGURE 10



788.23
MW-102D
785.89
MW-102S
PERE MARQUETTE RIVER
≈783
786.5
72nd AVE.
786.14
MW-307S
787.04
(D-5)
MW-307I
MW-307D
787.09
786.75
MW-202I
(D-4)
MW-202D
MW-202S
786.50
791.05
786.5
RED MOOSE LODGE
789.99
MW-305D
MW-305S
787.01
788.35
MW-306S
MW-305I
?790.03?
MW-306I
(D-6)
MW-306D
787.95
787.19
787.5
787.5
i = 0.0039
MW-103
787.76
MW-201
787.10
788.5
788.13
MW-212 D
MW-212 S
787.92
788.14
MW-205S
MW-302
788.11
MW-205D
788.14
EW-6
MW-303
788.24
M-37
788.55
MW-301S
789.22
EW-4
EW-5
789.24
789.05
MW-204D
MW-301D
788.54
MW-204S
788.97
MW-104
788.63
MW-206S
787.75
MW-206D
791.90
788.66
MW-304S
MW-304I
788.48
MW-304D
788.48
MW-3S
788.75
MW-3D
788.64
BALDWIN CANOE
MW-211S
789.45
MW-211D
789.29
789.5
OAKLAND DRIVE
789.35
MW-308S
(D-2)
MW-308D
789.29
MW-309S 788.89
(D-3)
MW-309D
789.03
MW-4
789.14
789.5
789.95
MW-213S
MW-213D
789.93
790.42
MW-215
790.87
MW-207S
EW-2
790.5
MW-207D
790.11
791.15
MW-101S
MW-101D
790.06
790.5
FORMER WASH KING LAUNDRY FACILITY
MW-2D
791.03
(D-1A)
EW-1
792.23
(D-1B)
(D-1C)
REMEDIATION BUILDING
FORMER SEEPAGE LAGOONS
MONITORING WELL
EXTRACTION WELL
789.5 GWE CONTOUR (@ WATER TABLE)
GW FLOW DIRECTION
i = HORIZONTAL HYDRAULIC GRADIENT
N
0
120'
240
LAKESHORE ENVIRONMENTAL INC.
GROUNDWATER ELEVATION CONTOUR MAP
NON-PUMPING CONDITIONS (4/14/08)
WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN
06-712-01
MAY 2008
FIGURE 11

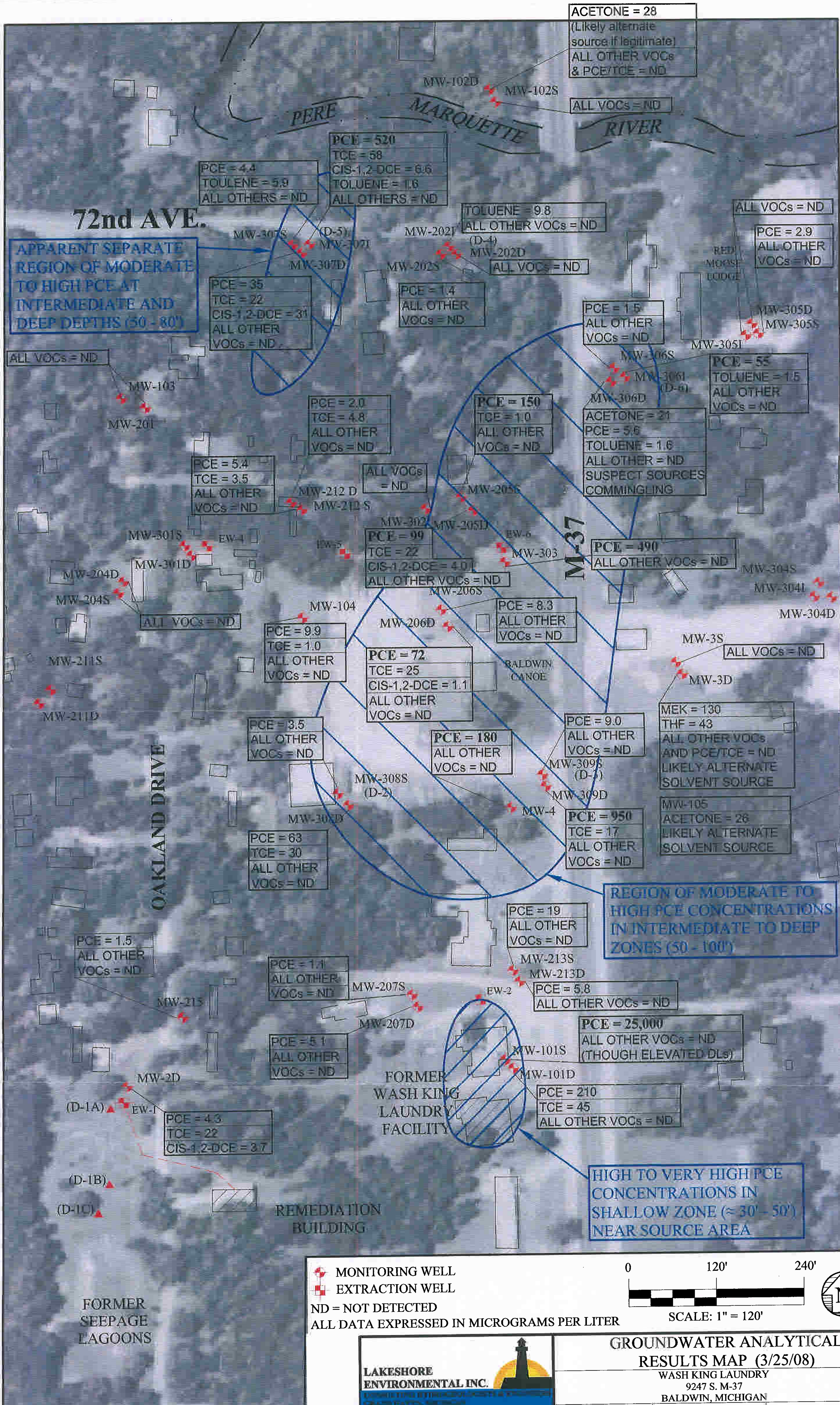


LAKESHORE ENVIRONMENTAL INC.

GROUNDWATER ELEVATION CONTOUR AND CAPTURE ZONE MAP (4-4-08)

WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	MAY 2008	FIGURE 13



MONITORING WELL

EXTRACTION WELL

ND = NOT DETECTED

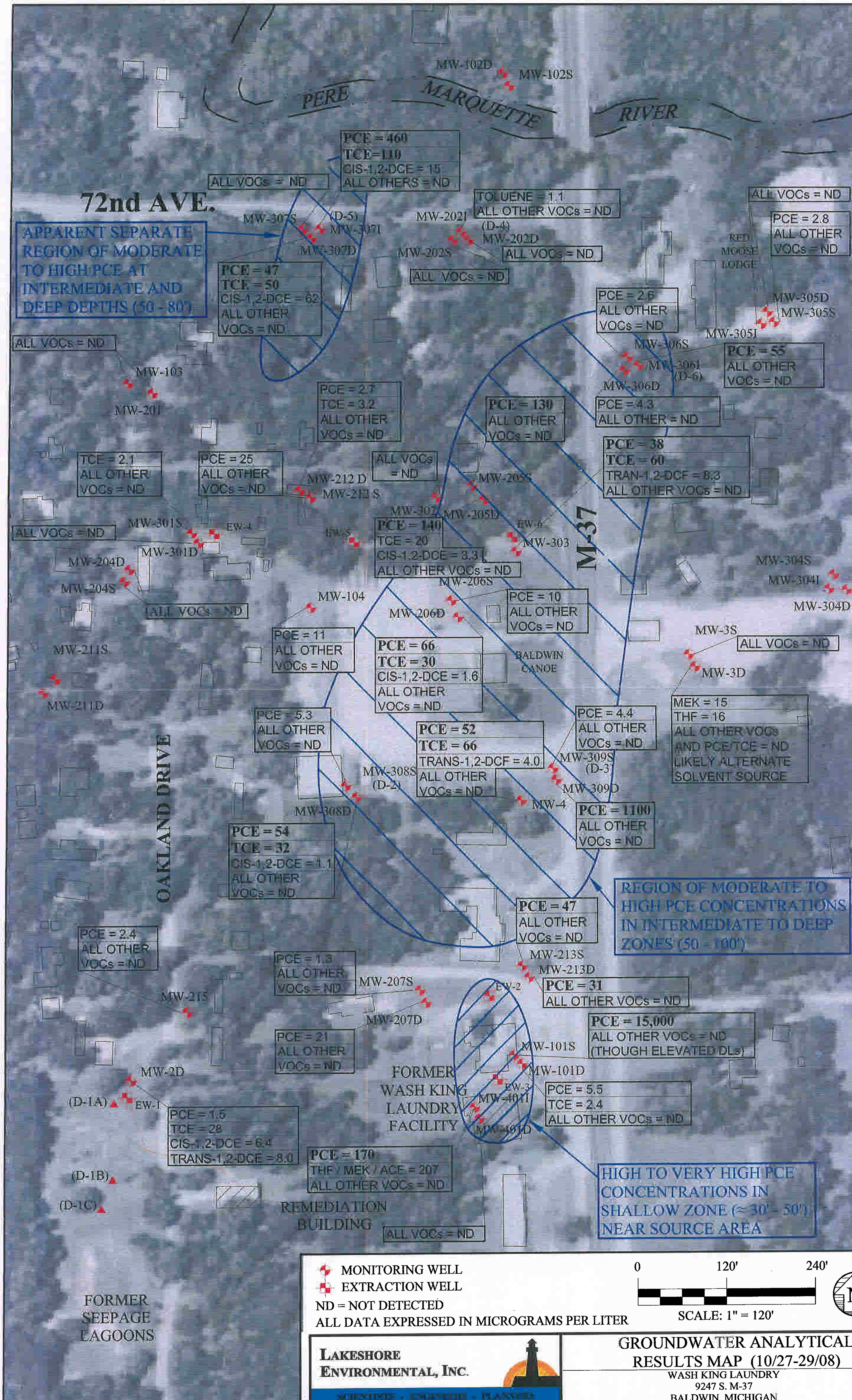
ALL DATA EXPRESSED IN MICROGRAMS PER LITER

LAKESHORE ENVIRONMENTAL INC.

GROUNDWATER ANALYTICAL RESULTS MAP (3/25/08)

WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	MAY 2008	FIGURE 14

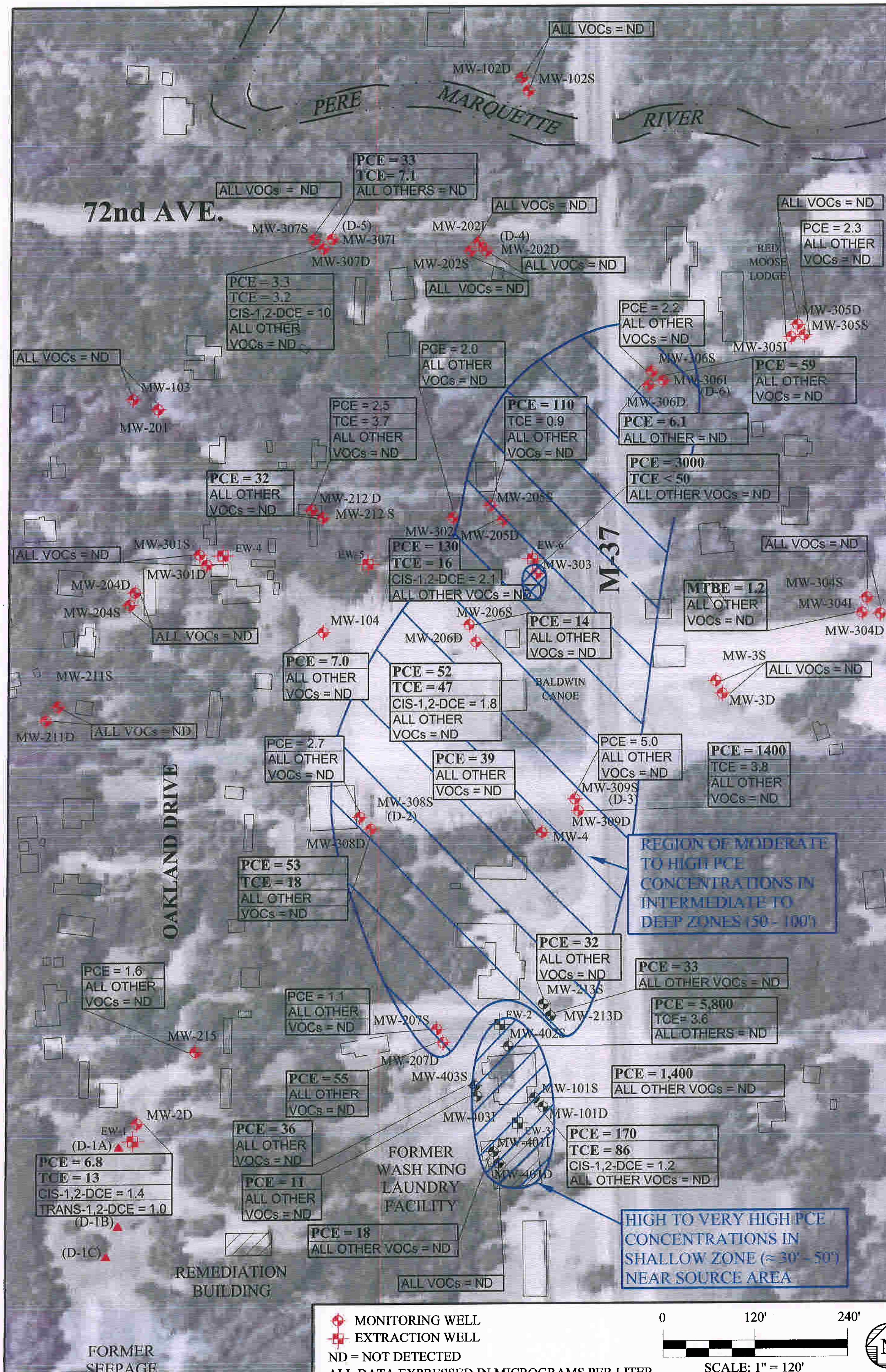


MONITORING WELL
EXTRACTION WELL
ND = NOT DETECTED
ALL DATA EXPRESSED IN MICROGRAMS PER LITER

LAKESHORE ENVIRONMENTAL, INC.
SCIENTISTS • ENGINEERS • PLANNERS

GROUNDWATER ANALYTICAL RESULTS MAP (10/27-29/08)
WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	DECEMBER, 2008	FIGURE 23



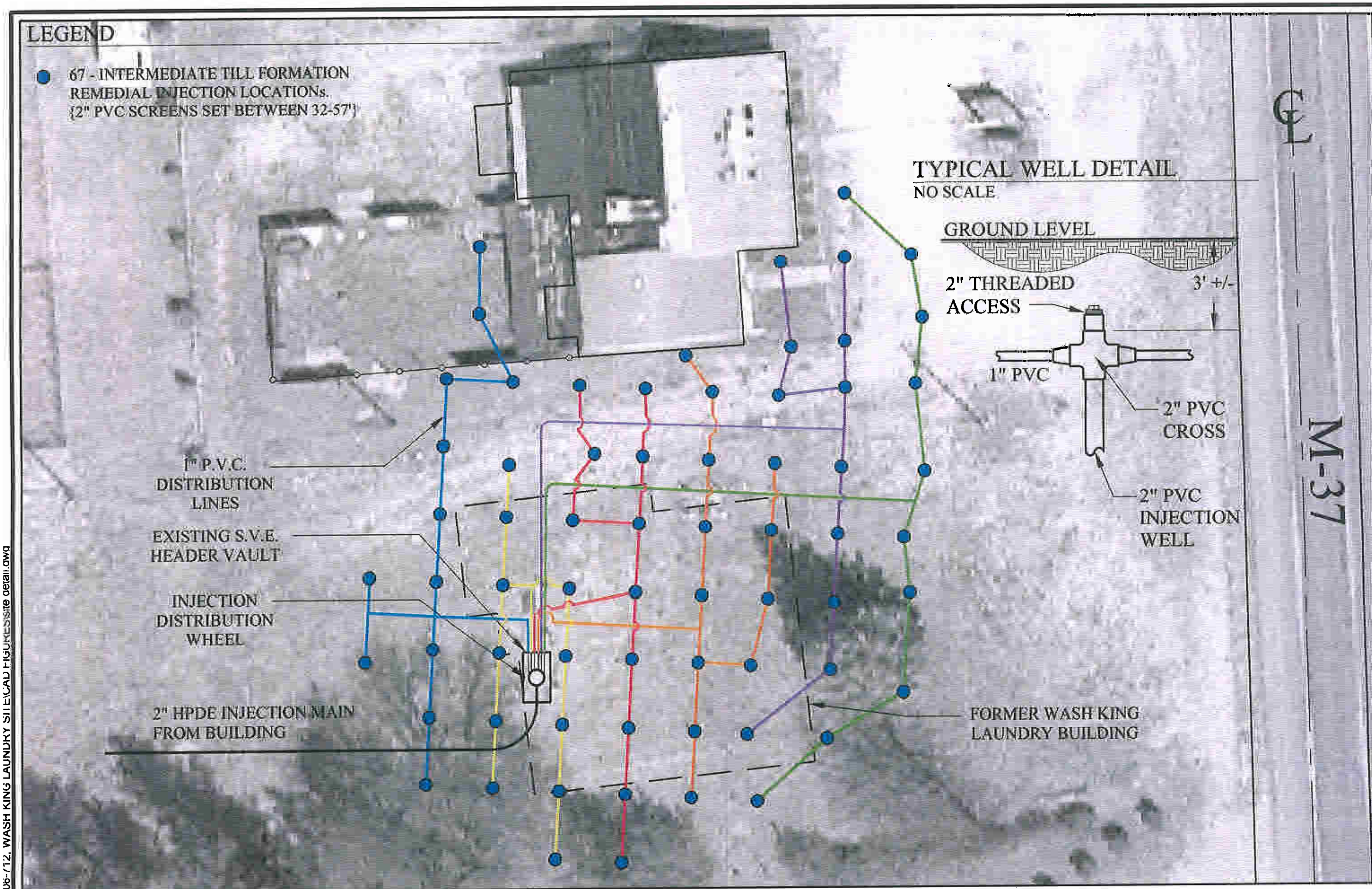
LAKESHORE ENVIRONMENTAL, INC.

SCIENTISTS • ENGINEERS • PLANNERS

GROUNDWATER ANALYTICAL RESULTS MAP (10/27-29/09)

WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

06-712-01	FEBRUARY 2010	FIGURE 23 B



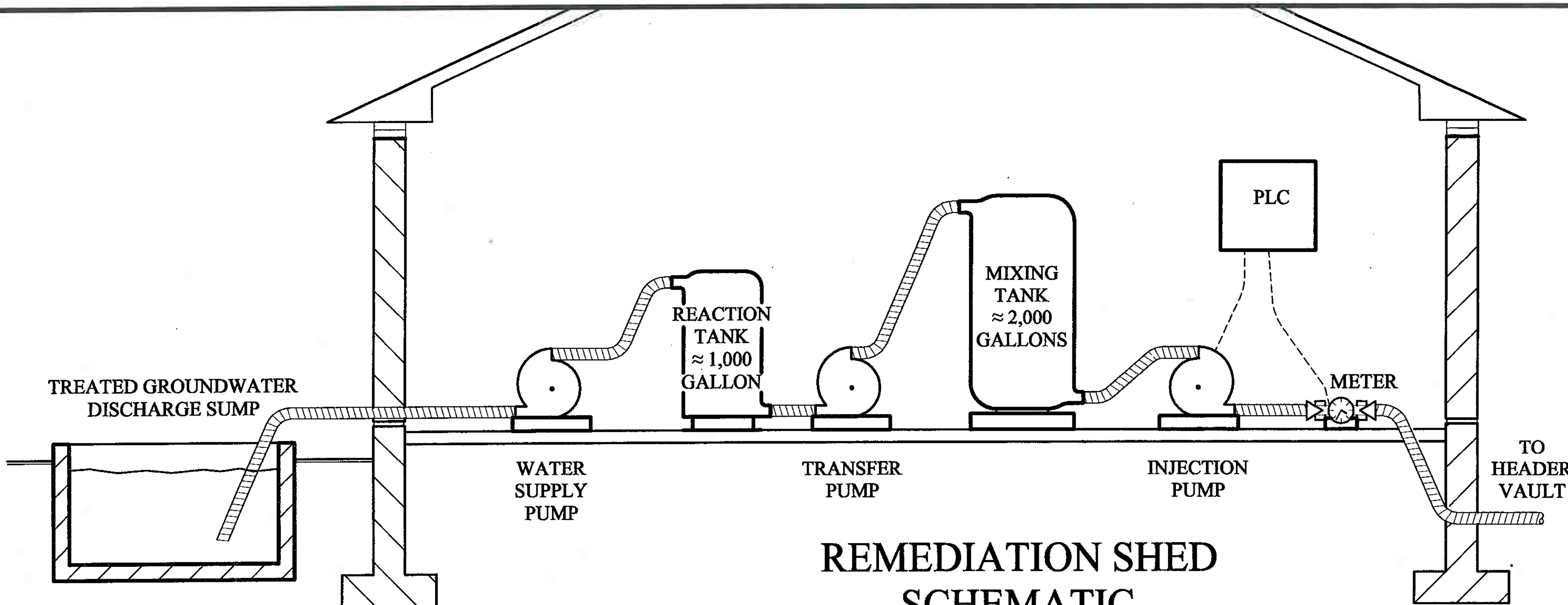
LAKESHORE ENVIRONMENTAL, INC.

SCIENTISTS • ENGINEERS • PLANNERS

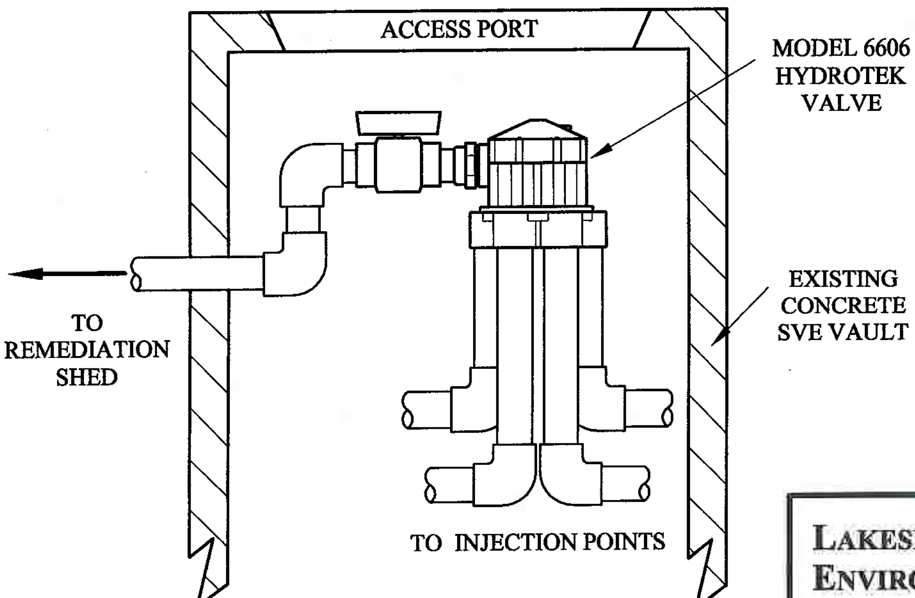
TILL ZONE REMEDIATION GRID AND PIPING LAYOUT - AS BUILT

WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

NOVEMBER, 2009	06-712-01	FIGURE 26 c



REMEDIATION SHED SCHEMATIC



HEADER VAULT SCHEMATIC

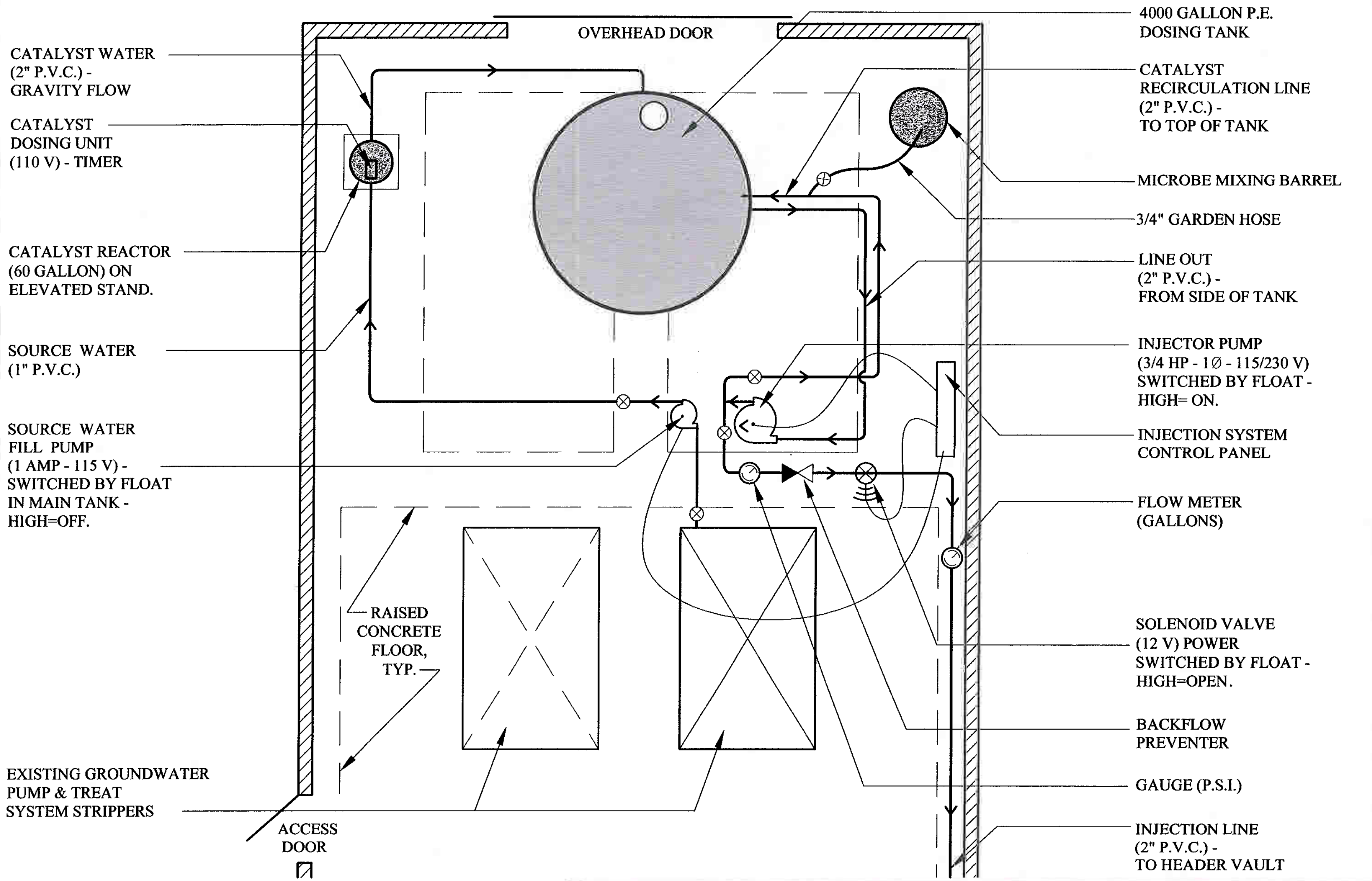
NOT TO SCALE

LAKESHORE ENVIRONMENTAL, INC.

IN-SITU BIO-REMEDIATION SYSTEM SCHEMATIC

WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

JULY, 2009	06-712-01	FIGURE 27



LEGEND

⊗ MANUAL VALVE

⟵ FLOW DIRECTION

N

NOT TO SCALE

LAKESHORE ENVIRONMENTAL, INC.

SCIENTISTS - ENGINEERS - PLANNERS

IN-SITU BIO-REMEDIATION SYSTEM AS-BUILT

WASH KING LAUNDRY
9247 S. M-37
BALDWIN, MICHIGAN

FEBRUARY, 2010	06-712-01	FIGURE 28

N:_PROJECTS\700 PROJECTS\06-712, WASH KING LAUNDRY SITE\CAD FIGURES\site detail.dwg

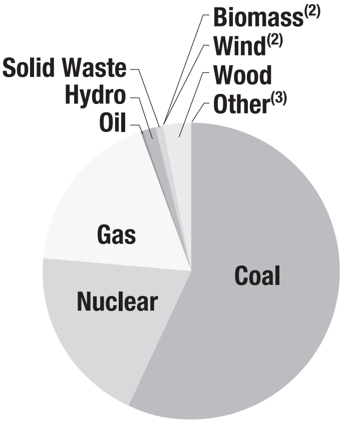
ATTACHMENT B
ELECTRICITY GENERATION MIX AND EMISSIONS

Projected Environmental Characteristics of Consumers Energy Electricity

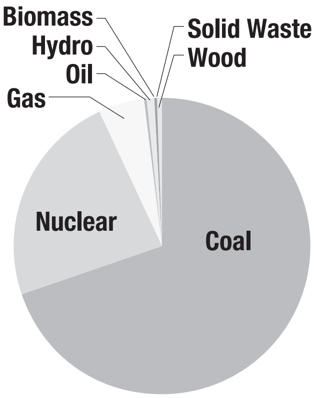
OCTOBER 1, 2006 – SEPTEMBER 30, 2007

Fuel source	Fuel mix used to generate total electricity supplied by Consumers Energy	Regional* average fuel mix used to generate electricity
Coal	57.4%	70.0%
Nuclear	20.5%	23.3%
Gas	16.7%	4.7%
Oil	0.3%	0.4%
Hydroelectric	1.5%	0.7%
Biofuel	0%	0%
Biomass (2)	< 0.1%	< 0.1%
Solar	0%	0%
Solid Waste Incineration	0.9%	0.3%
Wind (2)	< 0.1%	< 0.1%
Wood	2.8%	0.5%
Other (3)	< 0.1%	0%

Emissions/waste in pounds per megawatt-hour	Consumers Energy's emissions/waste for fossil/nuclear generation	Regional* average emissions/waste for fossil/nuclear generation
Sulfur Dioxide	9.49	11.56
Carbon Dioxide	2,061.8	2,132.5
Oxides of Nitrogen	2.72	3.32
High-level Nuclear Waste (1)	0.0069	0.0083



Percentage of fuel type used to produce Consumers Energy's total electricity



Regional* average fuel mix used to generate electricity

During the reporting period, Consumers Energy purchased 24.3 percent of the electricity it supplied from other suppliers. The fuel mix used to generate this purchased electricity could not be discerned; regional average fuel mix data was used in this table to approximate the actual fuel mix of purchased electricity. The method for calculating emissions at the company level has changed. The emissions associated with some of the purchased power is now included.

Please note: Numbers do not add to 100 percent due to rounding.

* Regional average fuel mix data was compiled from Michigan, Illinois, Indiana, Ohio and Wisconsin.

(1) The high-level waste generated by the Palisades Nuclear Plant is not discharged to the environment.

(2) This energy type is provided in part at the request of customers who voluntarily have agreed to pay additional costs to increase the amount of renewable and environmentally friendly energy the company provides.

(3) "Other" fuel source is the Ludington Pumped Storage Plant.