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report, hw 336006. 2008-05-16, Conceptual_Site_Model_Supplemental RAWP. pdf

The Maybrook and Harriman Environmental Trust
Former Nepera Facility
41 Arden House Rd.
Harriman, NY 10926

CONCEPTUAL SITE MODEL AND SUPPLEMENTAL REMEDIAL ACTION WORK PLAN

FORMER NEPERA FACILITY
HARRIMAN, NEW YORK

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Engineers & Scientists P.C.

May 16, 2008
MHET.001.010

HydroQual

Environmental
Engineers & Scientists

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FIGURES

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SECTION 1

INTRODUCTION AND BACKGROUND

The former Nepera Site, which manufactured fine and bulk pharmaceutical products from 1942 to 2005, is located in the Village of Harriman, Orange County, New York (Figure 1). The facility is currently inactive and the tank farms, distilling operations, and other manufacturing areas have been decommissioned. A biosparging system is currently operating at the site, as a component of on-going groundwater remediation activities, along with a semi-annual groundwater monitoring program.

Groundwater contamination, consisting principally of benzene and pyridine, was identified in the mid 1980's and interim remedial measures (IRM) consisting of groundwater extraction and treatment were initiated in 1990. In 1995 a Remedial Investigation and Feasibility Study (RI/FS) was completed followed by a Record of Decision (ROD) in March 1997. A Consent Decree for implementation of the ROD was signed by the Maybrook and Harriman Environmental Trust (The Trust) in May 1998. As one aspect of the ROD requirements, a biosparge system for the remediation of groundwater was brought online in December 2001. This system continues to operate as of the date of this work plan. The IRM system, specifically wells RW-1S and RW-3, operated from 1990 through 2004. As a result of decreased well efficiencies and pumping rates from these wells resulting from siltation and other factors, pumping from both wells was discontinued in September 2004. RW-1R was constructed in 2005 to replace both wells. MW-1S operated from 1990 through 2003. Due to electrical problems and with the plant in shutdown transition, pumping was discontinued in February 2003. The IRM has not been placed back into operation. Rather, the biosparge system has continued to operate and the groundwater plume, based on semi-annual groundwater monitoring data, is contained on-site. The monitoring data document declining groundwater concentrations within the interior portions of the site and that groundwater quality meets the standards, criteria and guidance values (SCG's) established by the ROD at the site perimeter.

In July 2006, ARCADIS U.S. Inc. and The Trust met with representatives of the New York State Department of Environmental Conservation (NYSDEC) as part of a remediation progress update. During this meeting, it was agreed that preparation of an Explanation of Significant Differences (ESD) would be appropriate for the site. The ESD would address the additional data that has been collected since the ROD was issued in 1997 and the applicable changes in the remedial action called for in the ROD, as a result of these data. With this objective, ARCADIS simultaneously submitted the January 2007 report titled "Groundwater Quality Assessment, Groundwater Remediation Progress and Proposed

Updated Remediation Program" and a Preliminary Draft ESD. This was followed by the October 2007 report titled "Groundwater Quality Assessment, Groundwater Remediation Progress and Proposed Updated Remediation Program – Supplemental Report". These two reports present a comprehensive overview of the site investigations, ROD requirements, remedial actions, water quality trends, and biogeochemical processes present underlying the site. This includes historical and current groundwater quality maps (plume maps), analysis of groundwater concentration trends in graphical and tabular format, and the presentation of data describing the biodegradation properties of the site constituents and the geochemical site data that support/promote the ongoing degradation of these constituents in site groundwater.

In January 2008, HydroQual was retained by the Trust to complete a comprehensive review of the existing database of information relative to the Site and to propose a path forward relative to remedial actions, the groundwater monitoring program and the proposed ESD. Following this review, representatives of the Trust, Quantum Management Group and HydroQual, met with NYSDEC to present the results of this review, the refined conceptual site model, and to discuss the proposed recommendations for additional work to fill remaining data gaps and implement a final site remedy. At the conclusion of the meeting, it was agreed that a Work Plan would be submitted documenting the refined conceptual site model and presenting the proposed recommendations in greater detail. This document, prepared in response to this agreement and to meet the objectives enumerated below, supercedes the additionally proposed work included in the Arcadis October 2007 Report. Similarly, it is recommended that further review and decisions related to the January 2007 Preliminary Draft ESD be tabled pending completion and evaluation of the data collection efforts presented in this work plan.

1.1 WORK PLAN OBJECTIVES AND REPORT FORMAT

The objectives of this work plan are to document the refined conceptual site model, developed upon review of the existing database of information, and present a proposed course of action to fill identified data gaps. The site conceptual model forms the basis for understanding groundwater flow and contaminant transport at the site and provides a framework within which future remedial actions may be implemented. The objectives of the work plan may thus be stated as follows:

- Present and document the refined conceptual site model based upon an understanding of the site hydrogeology, contaminant behavior, and contaminant distribution in soils and groundwater,

- Using the conceptual site model as a basis, identify potential data gaps and develop a work plan to fill the identified data gaps,

- Present a Field Sampling and Data Quality Assurance/Quality Control plan that will document how the work will be conducted,

- Present a proposed schedule for implementation pending NYSDEC approval to proceed.

Section 2.0 thus presents a discussion of the site hydrogeology, observed concentration trends, and contaminant spatial distribution in soils and groundwater as it relates to defining and presenting the site conceptual model. Based upon this understanding, Section 3.0 presents a proposed scope of work to address identified data needs, with a field sampling and data quality assurance plan provided in Section 4.0. A proposed schedule for implementation of the work, pending NYSDEC approval to proceed, is then presented in Section 5.0.

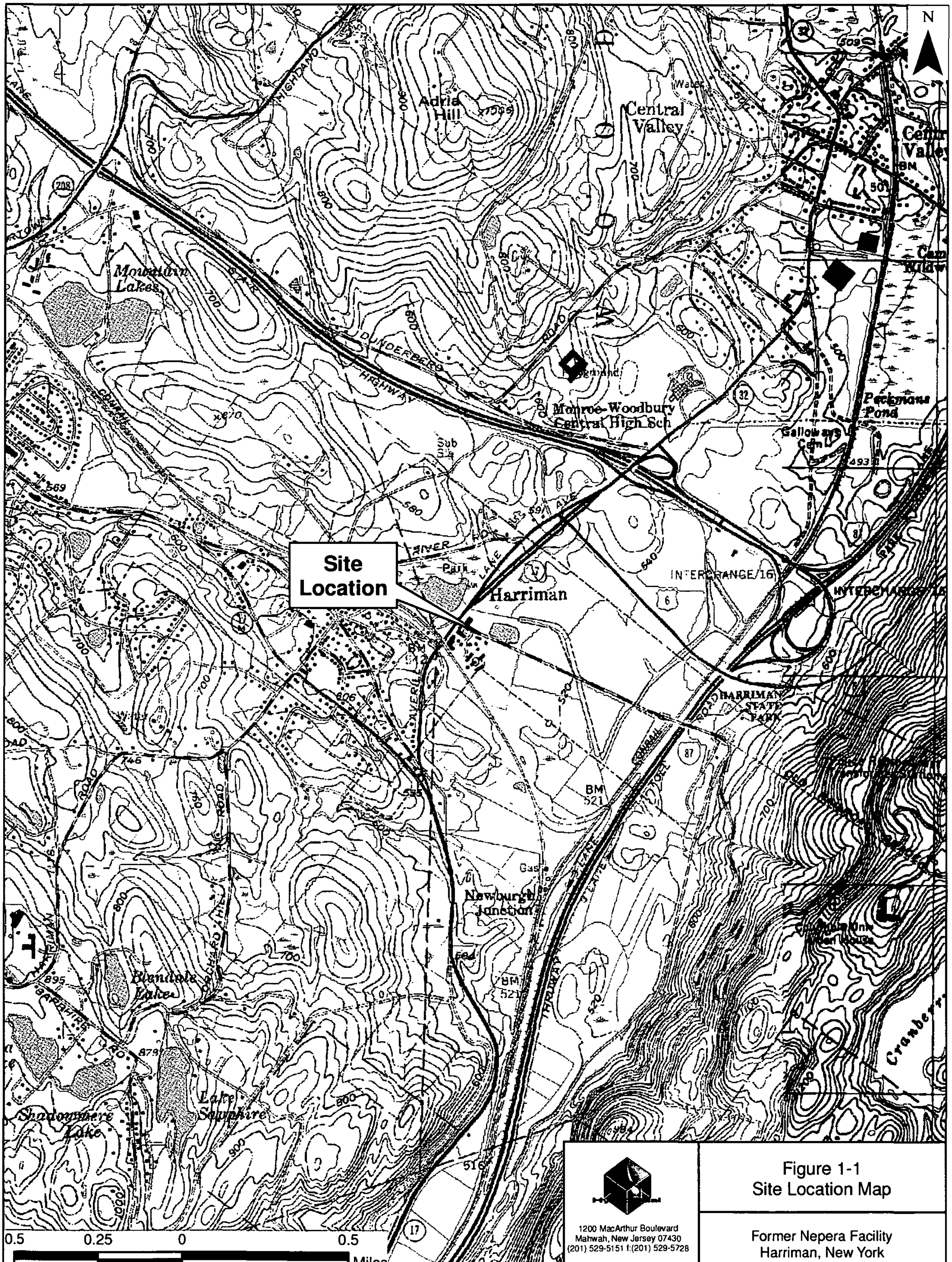

Figure 1-1
Site Location Map

Former Nepera Facility
Harriman, New York

Data Source: USGS Digital Raster Graphics, Monroe and Popolopen Lake

SECTION 2

CONCEPTUAL SITE MODEL

The conceptual site model represents a written description or understanding of the site conditions that dictate contaminant fate and transport. The following sections first describe the site hydrogeology and groundwater flow followed by a discussion of the site analytical data. Based upon these observations, a site conceptual model is then presented.

Site Hydrogeology

The site is underlain by a layer of fill material overlying a complex sequence of glacially derived clay, silt, sand and gravel. Near surface, immediately underlying any fill material, is a fine grained Clay and Silt with interbedded, discontinuous layers of Silt and fine Sand. This fine grained unit represents a glacial lacustrine or lake deposit that is present throughout the entire site with the exception of the area near PZ-1 near the west-central portion of the facility. Underlying the Clay and Silt deposits is a glacial outwash or stream deposit that varies across the site from fine to coarse Sand. Generally speaking, the sand is finer near the southeast end of the facility and coarser and thicker near the central portion. Also within the central portion of the facility, the coarse Sand deposits immediately overlie bedrock. Within the northeast side of the side, the glacial lacustrine and glacial outwash deposits are underlain by a kame or esker deposit which is characterized by a mix of clay, silt, sand and gravel that is weakly cemented. Glacial till, consisting of a dense silt and clay matrix with lesser amounts of sand and gravel, is present intermittently at various locations immediately overlying bedrock. The entire site is underlain by fractured dolomite bedrock.

Figure 2-1 presents a map of the site along with the orientation of three cross sections that are presented in Figures 2-2 through 2-4. The cross sections illustrate the relationship between the various glacially derived deposits described above and visually depict the layer of glacial lacustrine silt and clay overlying the coarser-grained sand and gravel as well as the kame and glacial till deposits. Figure 2-5 presents an isopach map of the thickness of the glacial outwash deposits. This map illustrates a thicker sequence of sand and gravel underlying the central portions of the facility as illustrated by the light blue shading.

Conceptually, the depositional history can be envisioned as glacial ice moving southward across the region while depositing the glacial till. As the glaciers melted, fast moving water carrying sand and gravel eroded channels into the glacial till, with the deepest channels cutting completely through the glacial till to the underlying bedrock. As the melt waters subsided, the coarse sand carried by these melt water streams fell out of suspension and was deposited within these channels. Over the course of multiple thaw and melt cycles, the melt water would overflow the banks of these channels and fine sands and silts suspended in the water were deposited along the banks. The thicker glacial outwash deposits underlying the central portion of the site, as illustrated in Figure 2-5, represents the channel cut into the underlying glacial till by the glacial melt water. Likewise, the observed finer grained sands represent materials deposited to the sides of the channel. The edges of the channel are reflected in cross section C-C' (Figure 2-4) where the coarse sand deposits abruptly intersect the glacial till deposits between wells R-3D and MW-27D.

The kame deposits, illustrated on the northern end of cross section A-A' (Figure 2-2) and comprised of an unsorted mix of silt, sand and gravel, represent localized deposition of materials immediately adjacent to the edge of a glacier. Finally, as the glaciers retreated farther to the north, the area was repeatedly flooded by glacial lakes which deposited the fine grained clay and silt deposits that are present over the majority of the site.

The variations in grain size and the thickness of the glacial deposits described above and illustrated in figures 2-2 through 2-5 represent the controlling factors relative to groundwater flow beneath the facility. Water levels collected on October 15, 2007 are plotted on the cross sections presented in Figures 2-2 through 2-4 and are used as control points for construction of the equipotential lines illustrated in blue. These data consistently indicate principally vertical (downward) flow paths within the near surface, fine grained glacial lacustrine deposits and more horizontal flow paths in the coarser-grained outwash deposits. Collectively, this indicates that the finer grained silt and clay deposits represented by the Glacial lacutrine deposits, glacial till and to a slightly lesser degree the kame deposits, serve as aquitards, limiting the volume of water moving through them and principally demonstrating downward, vertical flow paths. Hydraulic conductivity estimates of the near surface glacial lacustrine deposits, at 10^{-6} cm/sec, further support this interpretation. Conversely, the coarser-grained outwash deposits represent an aquifer with the ability to transfer larger volumes of water in a preferentially horizontal orientation. This is supported by aquifer tests completed within the thicker, more coarse grained portions of the outwash channel, which suggest permeability on the order of 5×10^{-2} cm/sec; and water quality data as discussed further below. Note that this estimated permeability is likely high in that the referenced aquifer test was completed in an area where the outwash is in direct hydraulic communication with the bedrock, and therefore, the resulting hydraulic conductivity represents a combination of both the bedrock and the outwash. In addition, as one moves out of the channel of thicker coarse-grained outwash to where finer-grained sands predominate, the hydraulic conductivity will further decrease.

Hydrogeologically, the data indicate that the glacial lacustrine deposits represent an aquitard while the outwash deposits serve as an aquifer. As illustrated in the cross sections, both units underlie the majority of the site. However, the extent to which the aquifer can transmit significant volumes of water is dictated by grain size and thickness. Accordingly, greater flow volumes are anticipated near the central portion of the site where the outwash is thickest and coarse grained. Conversely, lower flow volumes will be present where the outwash is finer grained and thinner. The extent to which the channeling of the coarser-grained outwash deposits influences groundwater flow is further evident in the southeastern portion of the site where the aquifer is apparently blocked, or a least limited, by the abrupt intersection of the glacial outwash with the glacial till as shown in Section C- C' (Figure 2-4). This observation, coupled with water quality data discussed further below, and the knowledge that thicker, coarse-grained outwash deposits are present to the north of this area underlying the central portions of the site, suggest that groundwater flow is diverted around the low permeability till towards the central portion of the site before again moving eastward.

Monitoring wells completed within the overburden aquifer (i.e., outwash deposits) have been used to construct a potentiometric surface map as illustrated in Figure 2-6. In a homogeneous, isotropic aquifer, groundwater flow paths would be oriented perpendicular to the equipotential lines. As an example, under isotropic conditions, one would anticipate groundwater flow in the southern portion of the site to travel roughly from the MW-25 location towards the MW-12/MW-13 location. As noted above, however, the system is not homogeneous or isotropic, therefore, groundwater flow would not be perpendicular to the equipotential lines. Further, the boring logs indicate that there are thicker, coarser-grained outwash deposits underlying the central portion of the site that have the potential to transmit greater volumes of groundwater. Finally, water quality data indicate elevated concentrations of site contaminants of concern (COCs) at the MW-25S location but non-detectable (ND) to trace level ("J" qualified) concentrations at MW-12S and MW-13S (with the exception of one detection of 18 ppb of benzene). This observation is true as far back as 1985, prior to any remedial actions. These data provide further evidence that groundwater flow is not perpendicular to the equipotential lines but at an angle, consistent with what one would expect in an anisotropic medium.

Collectively, the data suggest that groundwater flow is controlled by the thick channel of coarser-grained outwash underlying the central portion of the site. As a result, groundwater flow is not perpendicular to the equipotential lines but at an angle, with a conceptualized flow path sweeping generally from the MW-25S area towards MW-16S, RW-1R and MW-18S. Similar flow paths would be present at other locations across the site with the predominant flow paths converging towards the coarser-grained, thicker outwash deposits underlying the central portion of the facility.

Contaminant behavior and distribution

As described above, the grain size of the glacially derived deposits underlying the site range from fine-grained silt and clay to coarse-grained sand and some gravel. To better understand how the site COC's behave in response to these variables and to assess changes in concentration with time, benzene concentrations have been plotted for wells MW-8S, MW-11S and MW-16S in Figures 2-7 through 2-9 respectively. As described in greater detail by Arcadis (October 2007), benzene is consistently detected at concentrations above that of other COCs and fluctuations in concentration of other constituents through time are consistent with those observed for benzene. Therefore, plotting of the benzene concentrations provides a good representation of COC concentrations in the aquifer.

Well MW-11S (Figure 2-8) represents a location near the central portion of the facility where the outwash deposits are coarse grained. MW-8S represents a transitional area comprised of interlayered coarse and fine sand. Finally, MW-16S is within principally fine sand. As illustrated in Figures 2-7 through 2-9, all three locations illustrate declining concentrations with time. However, MW-11S started out at lower concentration than the other two locations and responded quickly to the groundwater pumping IRM implemented in September 1990. Benzene concentrations reached non-detectable levels in the mid to late 1990s and have remained at these levels since that time. MW-8S started out at higher concentrations than MW-11S. However, even though this well is closer to the IRM pumping well (RW-1R) than MW-11S, the benzene concentrations respond slowly to the IRM pumping and only reach consistent non-detectable levels in 2006. Finally, MW-16S represents the highest initial starting concentrations of benzene and while it appears that the IRM pumping helped to reduce benzene concentrations (a downward trend is noted prior to the start of pumping) the concentrations reach an asymptotic level in the mid 1990s (fluctuating in the hundreds of parts per billion) and have remained at these levels since that time.

While the starting concentrations are partially a function of where the well is located (i.e., spatial variability, proximity to former releases, etc.), both the starting concentration and how these concentrations behaved with time are strongly related to grain size. At MW-11S, where the aquifer materials consist of coarse sand and some gravel, the groundwater velocities are high (in comparison to other locations on site) and contaminants are quickly flushed through the system. Further, the coarser-grained materials do not lend themselves readily to adsorption and retardation of the COCs, so that the concentrations do not linger. MW-8S represents a transition in the aquifer materials from the coarse-grained deposits at MW-11S to the fine-grained deposits at MW-16S. As a consequence, both the starting concentrations and declining trends with time illustrate an intermediate point between that observed in MW-11S and MW-16S. The portion of the aquifer materials at MW-8S that are finer grained do not transmit groundwater as rapidly as the coarser-grained materials and they also tend to adsorb and retard the COCs more readily. As a result, it takes longer for the concentrations to decline following implementation of the IRM, as the contaminants slowly release from the finer-grained materials. The lower permeability of the finer grained soils also does not allow the oxygenated water provided by the biosparge system to move readily through the aquifer and enhance aerobic biodegradation. These limiting factors are most evident in MW-16S. Consequently, MW-16S demonstrates the highest concentration of these three wells and detectable concentrations still remain after implementation of the IRM pumping and biosparge systems.

As described in detail within the Arcadis, October 2007 Report, the site COCs (specifically benzene, pyridine, and picoline) are all biodegradable, both aerobically and anaerobically, and there is strong evidence that biodegradation is contributing to the observed decline in concentrations. This declining trend is particularly evident when comparing concentrations and plume maps prior to remedial actions, circa 1988, versus those in January 2007 (Arcadis, October 2007). A further assessment of the changing conditions with time has been completed by comparing the soil gas results obtained in 1991 versus recent soils analytical data collected as part of the RCRA Facility Investigation (RFI), Brown and Caldwell April, 2007, and a Geoprobe investigation conducted by Arcadis (October 2007). Comparison of the RFI data to the 1991 soil gas results is presented in Figure 2-10. RFI soils data reporting elevated concentrations of benzene and locations that were completed in the vicinity of elevated soil gas measurements are tabulated and plotted in Figure 2-10. For ease of reference, boring locations with benzene concentrations above 10 mg/kg are plotted in magenta while those with concentrations below 10 mg/kg or not detectable, are plotted in green. As detailed in the table on Figure 2-10, most of the locations plotted in green represent trace to non-detectable benzene concentrations.

Comparison of the RFI soils data to the 1991 soil gas concentrations does not indicate a good correlation. For example, while the RFI samples with the highest benzene concentrations (magenta) are plotted just to the north of an area with elevated soil gas readings, there are other RFI locations to the northwest that are within areas with low soil gas. Further, there are numerous locations (green) with low to non-detectable levels of benzene that are associated with areas identified with elevated soil gas concentrations.

Similarly inconsistent results were found as part of the Geoprobe Investigation conducted by Arcadis (October 2007). Figure 2-11 illustrates the location of the Geoprobe borings in comparison to the soil gas readings, as well as the analytical results from soil and groundwater samples collected from these borings. As illustrated, the Geoprobe borings are adjacent to an area identified as having high soil gas concentrations. However, the soil concentrations are comparable to those reported in RFI samples 50-B-001 and A-B-012, which are located in an area with low soil gas readings. In addition, while the soil and groundwater samples were not collected from the same depth (soil samples were collected from intervals with the highest PID reading and groundwater samples were collected from the most productive water-bearing interval) the soil sample and the groundwater results do not correlate well.

These data provide further evidence of the influence of biodegradation, effects of the remedy components that have been implemented at the site, and declining groundwater concentrations with time and that the 1991 soil gas results are no longer representative of current conditions. This observation is consistent with the data indicating that benzene, as well as other site COCs, are undergoing biodegradation, and that the soil gas data are now 16 years old.

Conceptual Site Model (CSM)

On the basis of the information presented above, the conceptual site model (CSM) may be described as follows:

- Groundwater flow in the near surface glacial lacustrine deposits (aquitard) is principally vertical with discharge into the underlying glacial outwash. Horizontal flow in the aquitard is limited to localized and discontinuous lenses of sand.

- A channel of coarser-grained sand and some gravel outwash, underlying the central portions of the site, is the primary conduit for groundwater flow and contaminant transport. While the outwash aquifer is present underlying most, if not all of the site, these deposits thin and become finer grained to the north and south, thus limiting their ability to transmit groundwater.

- The variable thickness and grain size of the outwash aquifer deposits result in a non-homogeneous, anisotropic aquifer. As a consequence, groundwater flow is not perpendicular to the equipotential lines. Rather, groundwater flow will travel at an angle to the equipotential lines toward the coarser-grained, thicker deposits underlying the central portion of the site.

- Groundwater flow through the glacial outwash aquifer is generally to the northeast with discharge to surface water (West Branch of the Ramapo River) and adjacent wetlands.

- Groundwater travel times vary depending on the grain size and associated permeability of the aquifer material. Travel times through the coarser-grained, thicker deposits underlying the central portion of the site are likely on the order of 600 to 800 feet/year (see Section 3.0 and Figure 3-1 for additional discussion).

- COC concentrations are declining as a result of past remedial activities (excavations, pumping, biosparging) and natural degradation. As a result, COC concentrations are below SCGs at plume fringe and sentinel wells.

- The lower permeability fine Sands and Silts of the Aquifer, and Silt and Fine Sand of the Aquitard, retain residual levels of COCs.

- Residual levels of contamination are present underlying the main plant area and with the possible exception of the area identified in the RFI investigation as containing elevated levels of benzene, the presence of significant localized "hot spots" is unlikely.

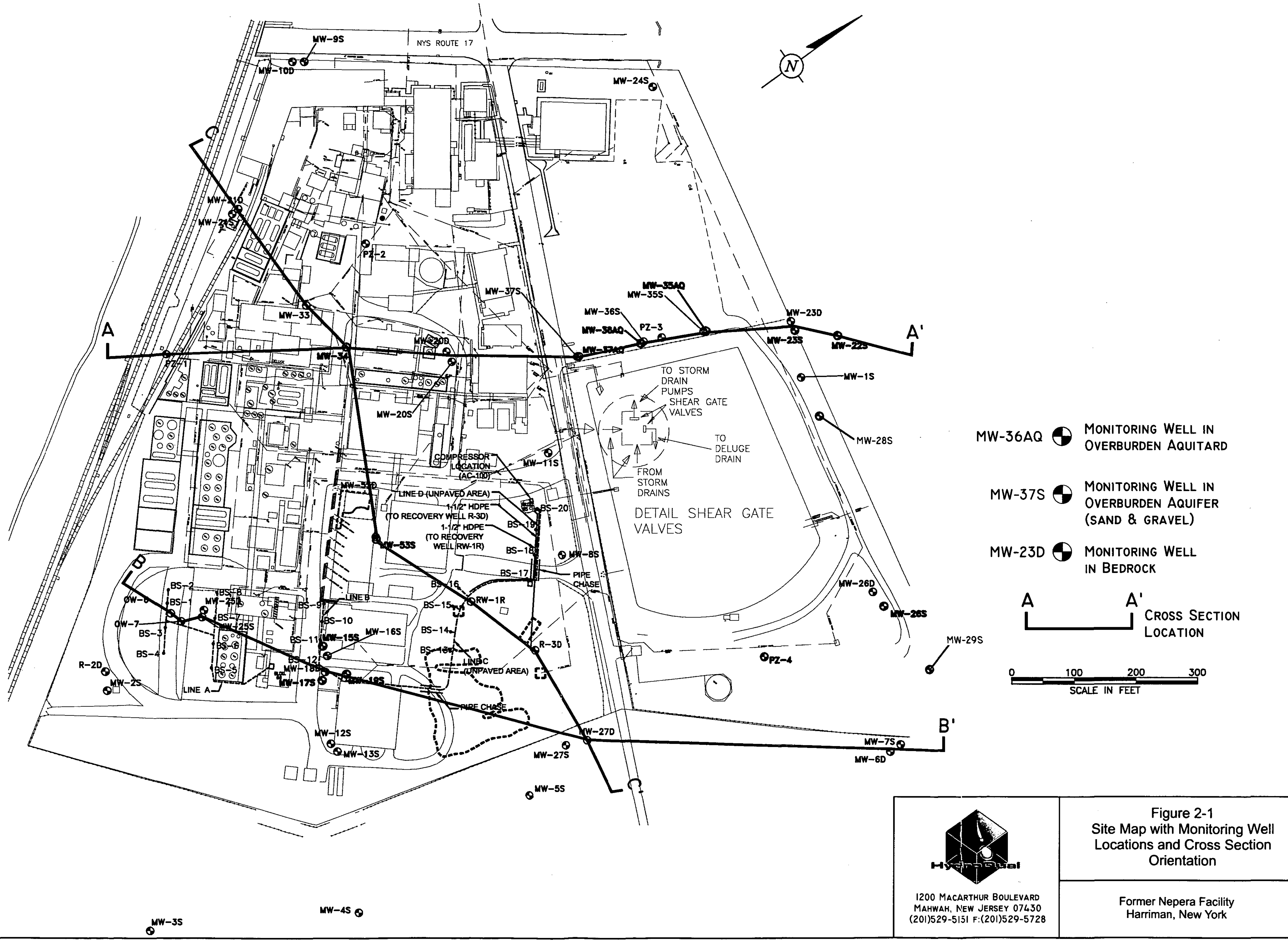

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Figure 2-1
Site Map with Monitoring Well Locations and Cross Section Orientation

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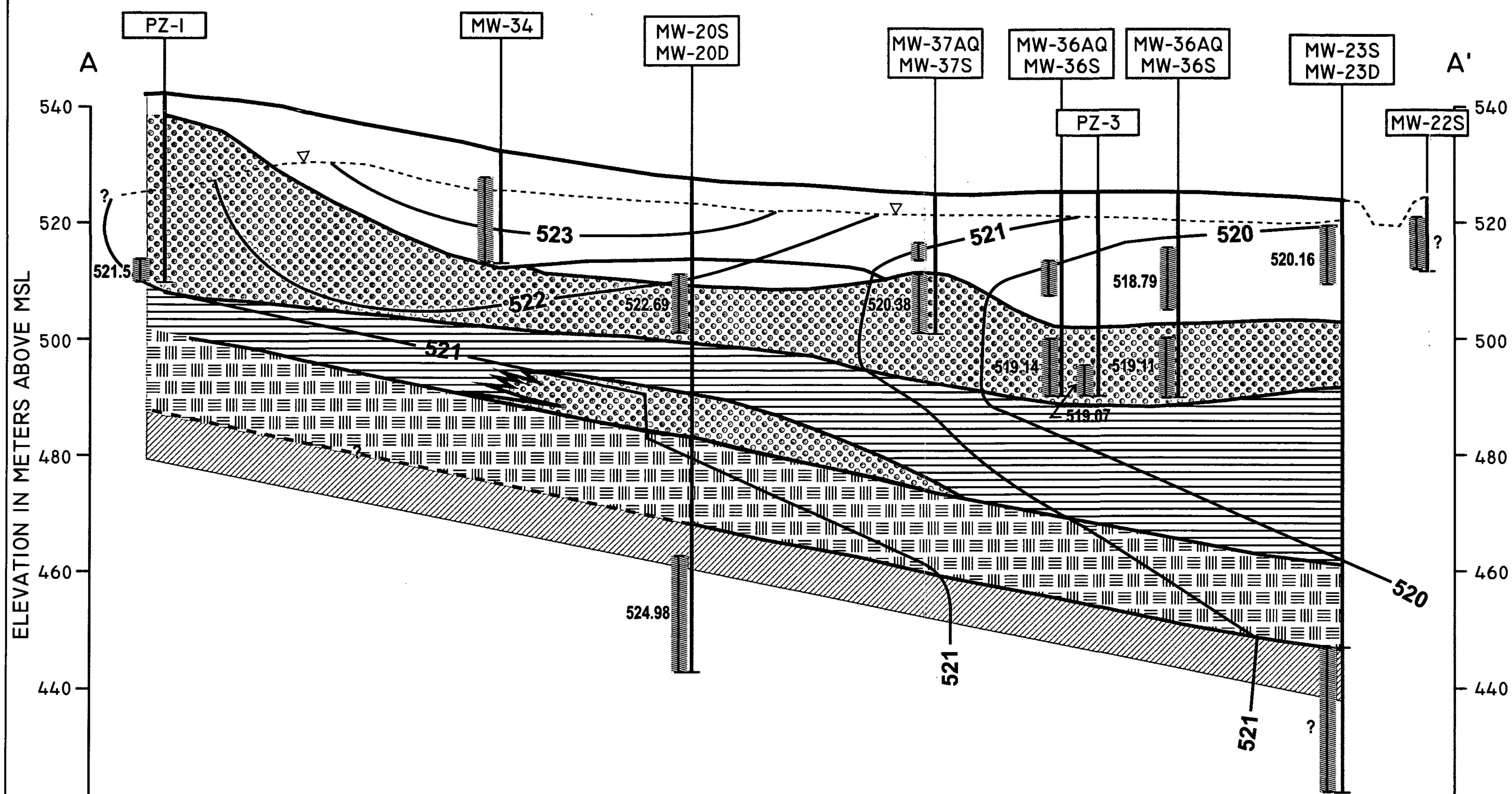
Harriman, New York



LEGEND:

301S 301M 301D — WELL DESIGNATION

GROUND SURFACE

GEOLOGIC CONTACT

LITHOLOGY (SEE BELOW)

SCREENED INTERVAL AND GROUNDWATER ELEVATION (10/15/07)

517 — EQUIPOTENTIAL LINE (DASHED WERE INFERRED)

LITHOLOGY:

- CLAYEY SILT
- FINE SAND
- MEDIUM SAND TO GRAVEL
- FINE SAND AND SILT W/LENSES OF FINE TO MEDIUM SAND
- GLACIAL TILL
- BEDROCK

GEOLOGICAL CONTACT (DASHED WHERE INFERRED)

NOTE: SURFICIAL FILL NOT SHOWN

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Figure 2-2
Hydrogeologic Cross Section A-A'

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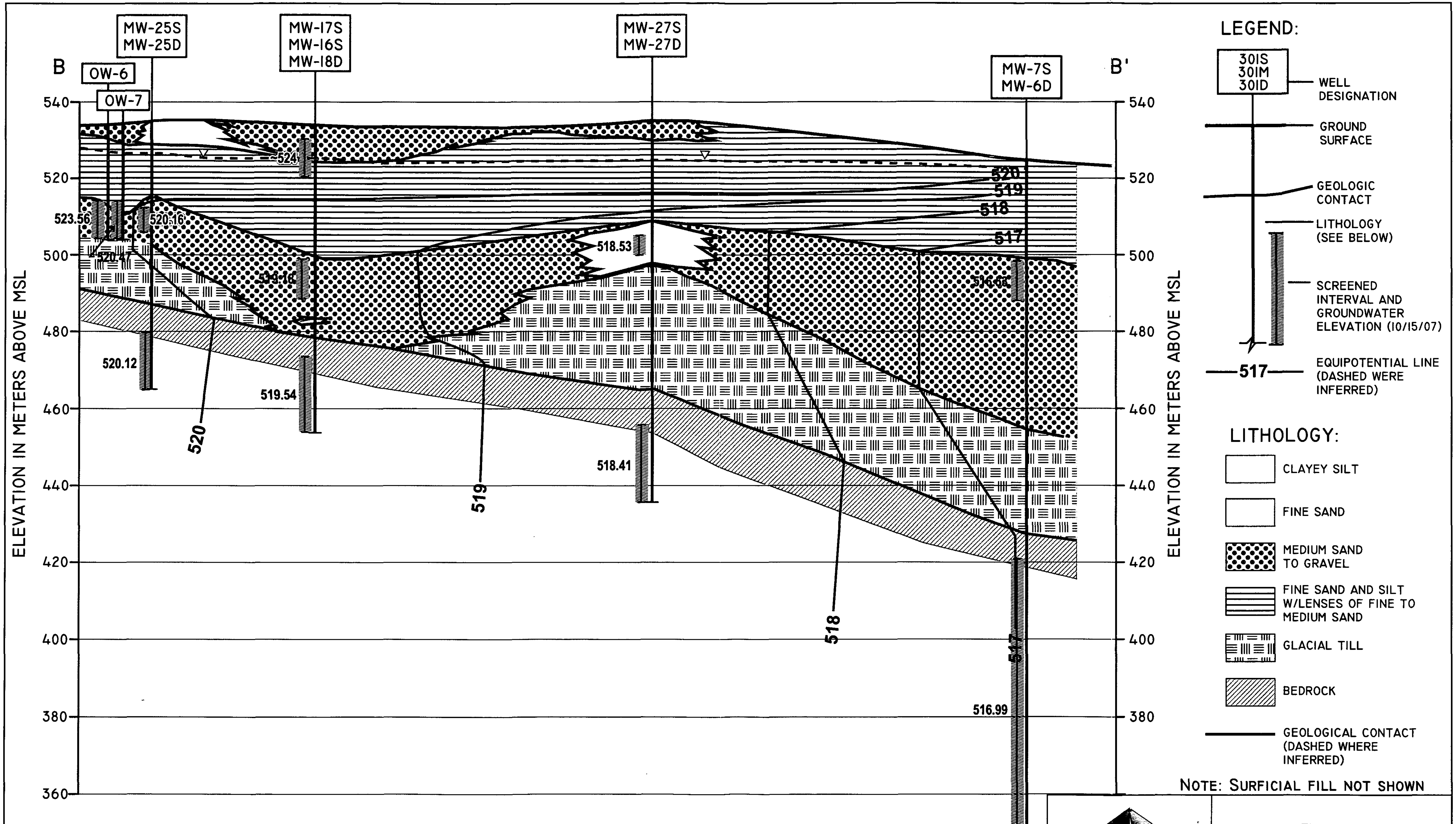

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Figure 2-3
Hydrogeolgic Cross Section B-B'

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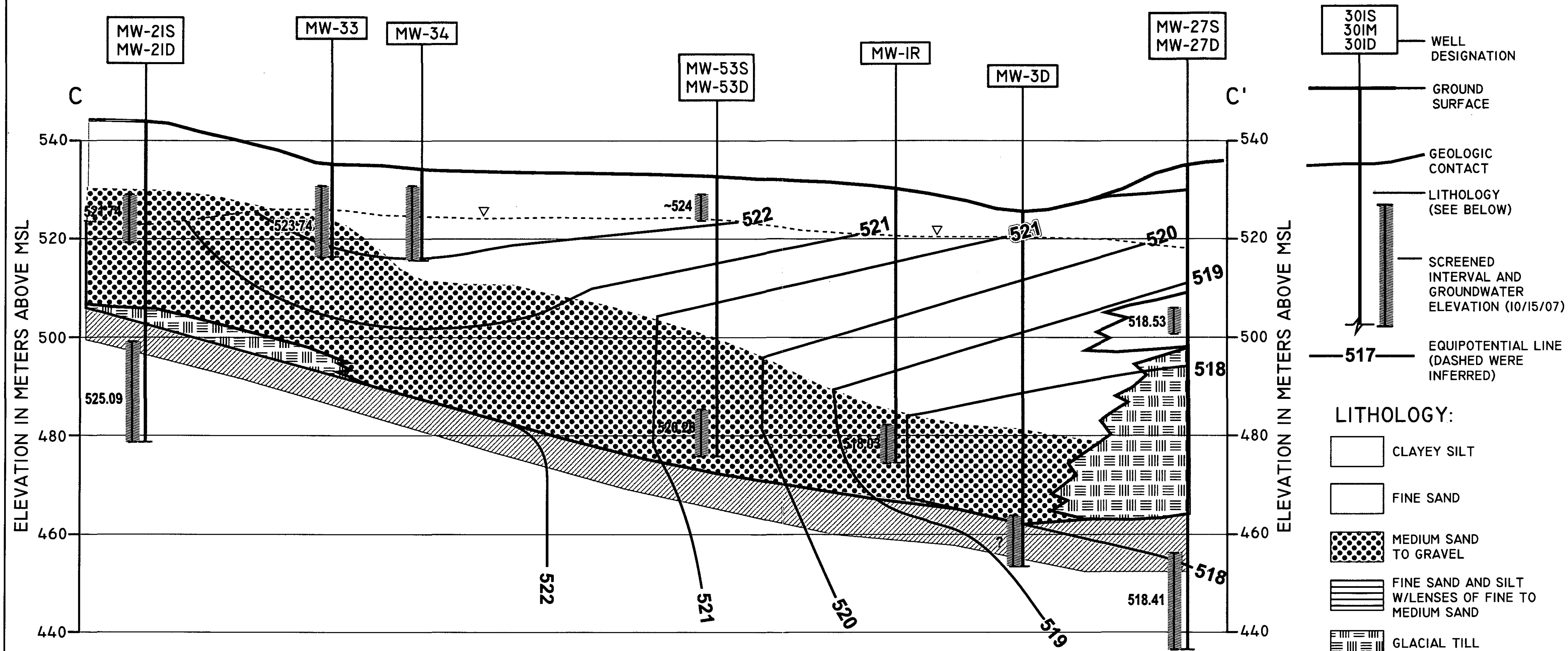

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Figure 2-4
Hydrogeologic Cross Section C-C'

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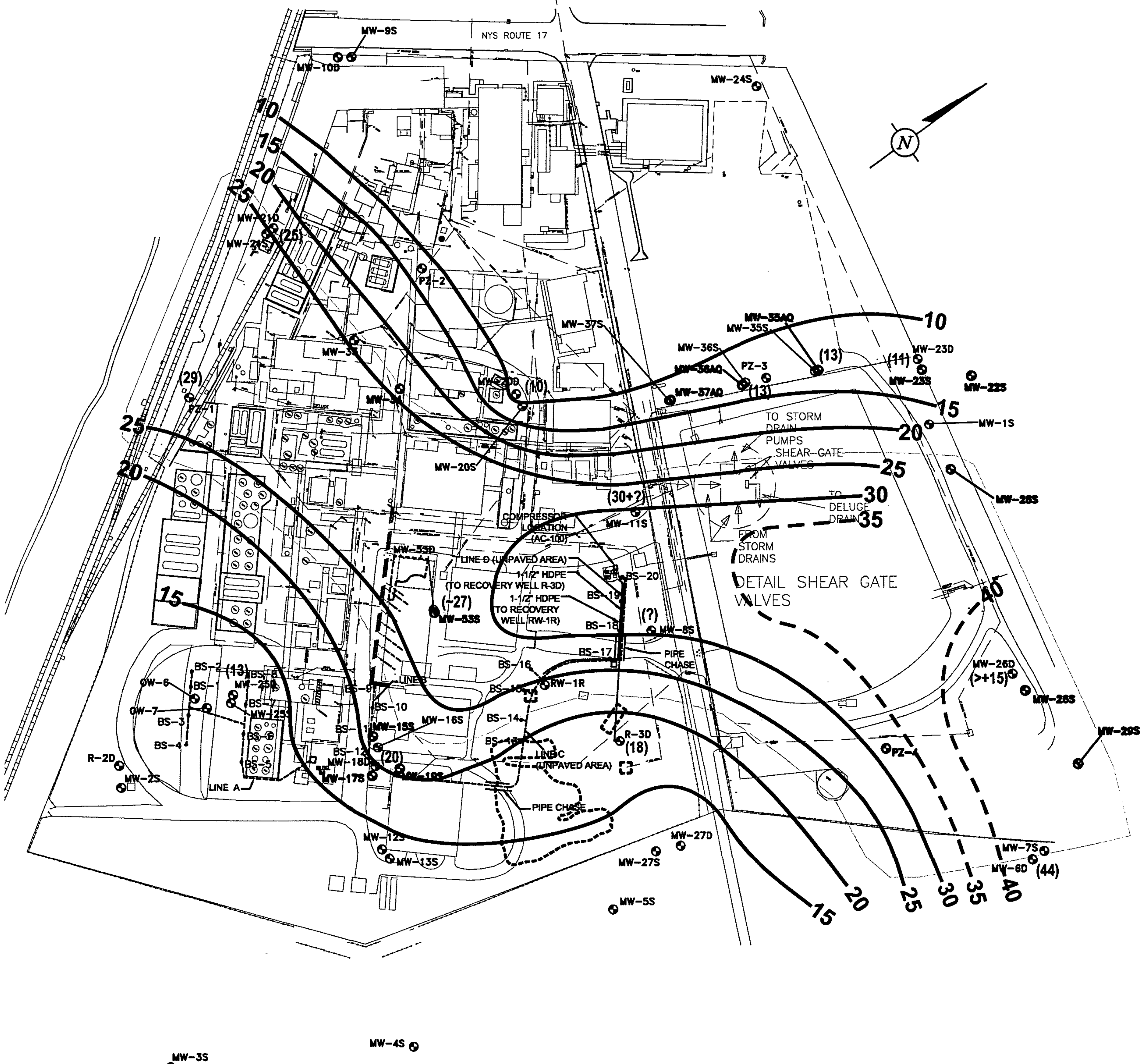

MW-36AQ Monitoring Well in Overburden Aquitard

MW-37S Monitoring Well in Overburden Aquifer (Sand & Gravel)

MW-23D Monitoring Well in Bedrock

(44) Approximate sand and gravel thickness observed at boring location

20 Approximate outwash thickness (does not include kame deposits)

Approximate extent of thicker sequence of sand & gravel underlying central portions of the facility

0 100 200 300
SCALE IN FEET

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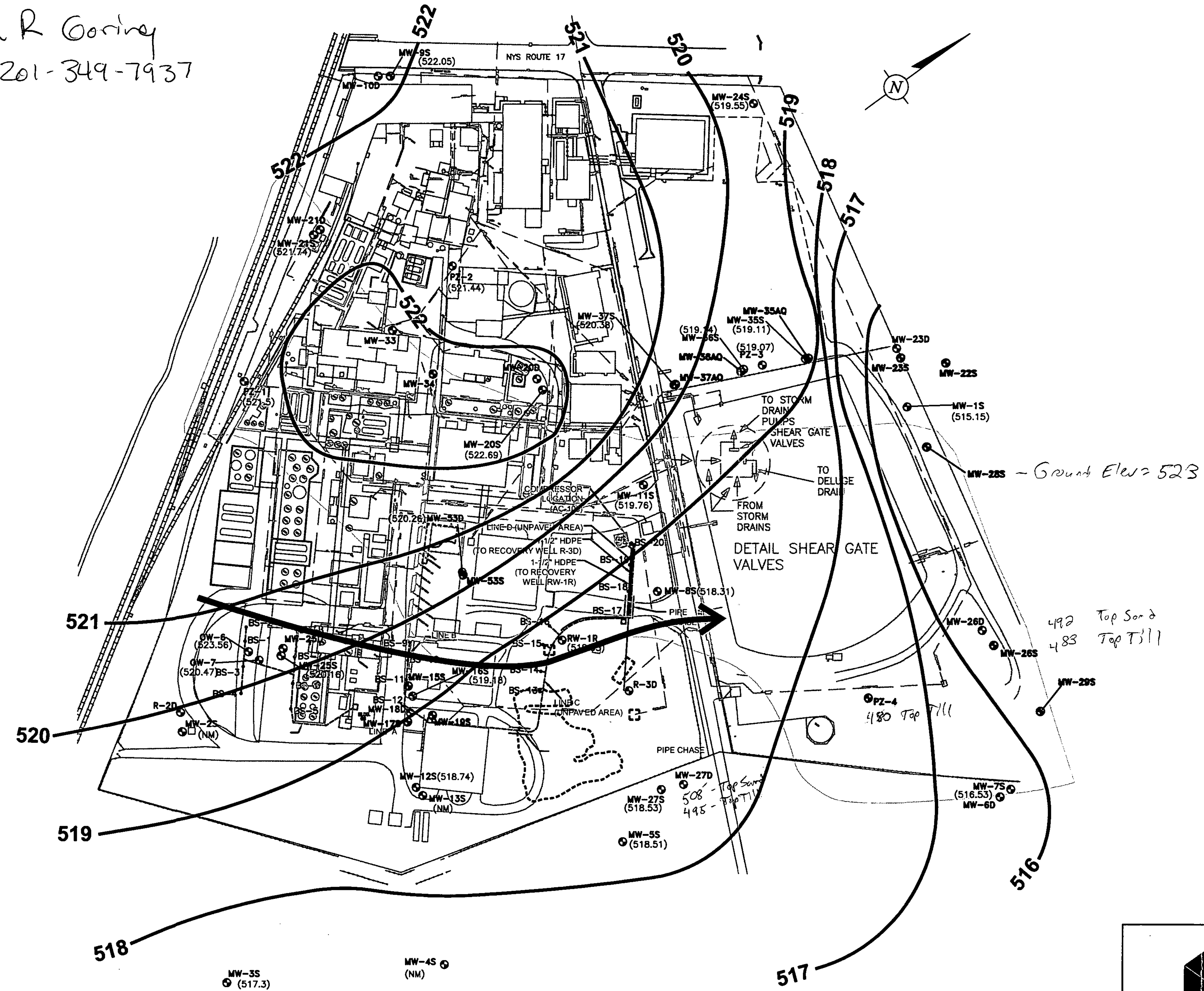
Figure 2-5
Isopach Map of Glacial Outwash Deposits (Overburden Aquifer)

Former Nepera Facility
Harriman, New York

Adam R Goring
Cell # 201-349-7937



MW-36AQ — Monitoring Well in Overburden Aquitard

MW-37S (520.38) — Monitoring Well in Overburden Aquifer (Sand & Gravel) with October 2007 Groundwater Elevation

MW-23D — Monitoring Well in Bedrock

Approximate Extent of Thicker Sequence of Sand & Gravel Underlying Central Portions of the Facility

Conceptualized Groundwater Flow Path Due to Anisotropy. See Text for Discussion

516 — Groundwater Elevation Contour (October 2007)

0 100 200 300
SCALE IN FEET

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Figure 2-6
Overburden Aquifer Potentiometric Surface, October 2007

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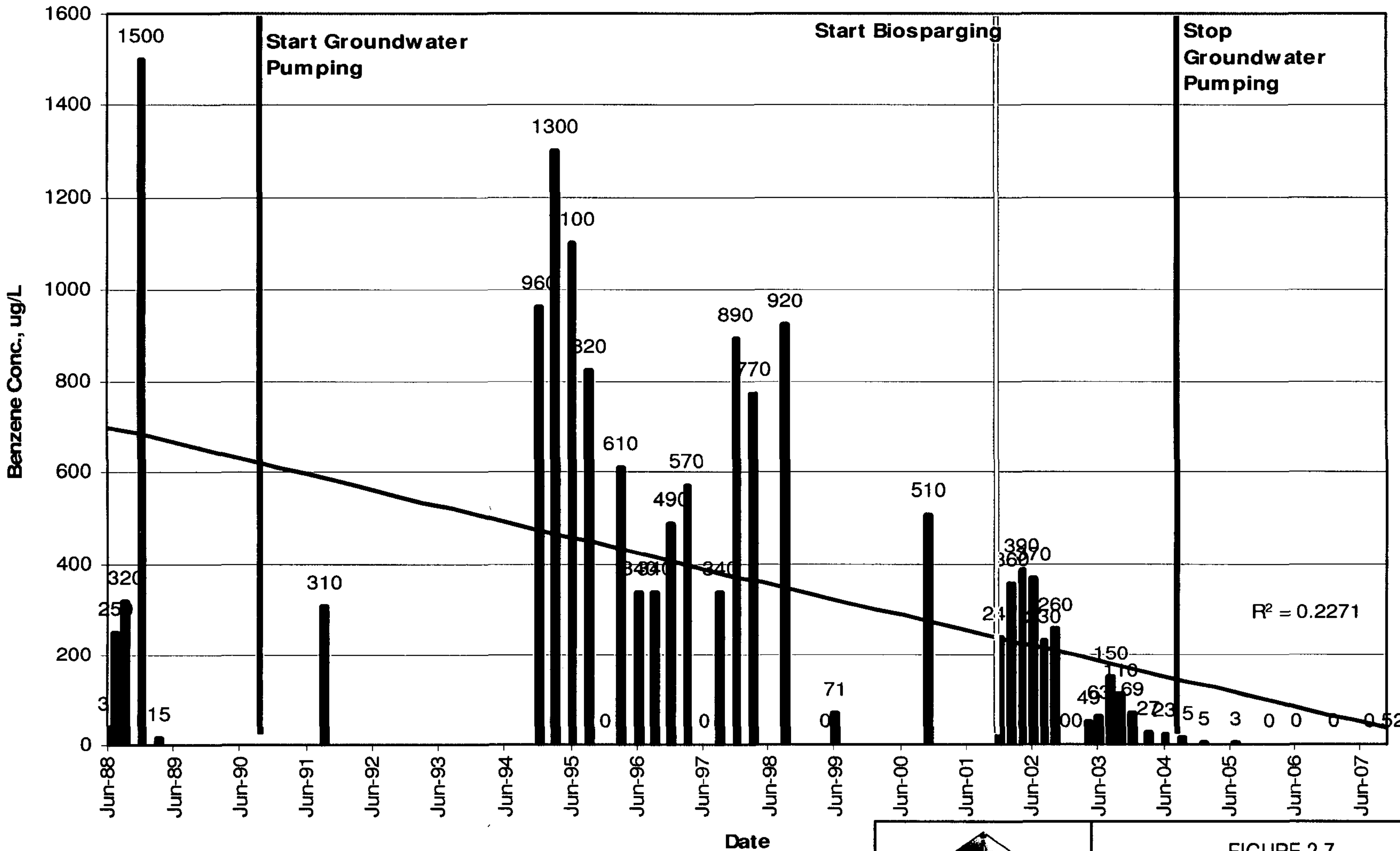

Non-detectable concentrations plotted as “0”.

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FIGURE 2-7
MW-8S Benzene Trend Plot
(Fine – Coarse Grained)

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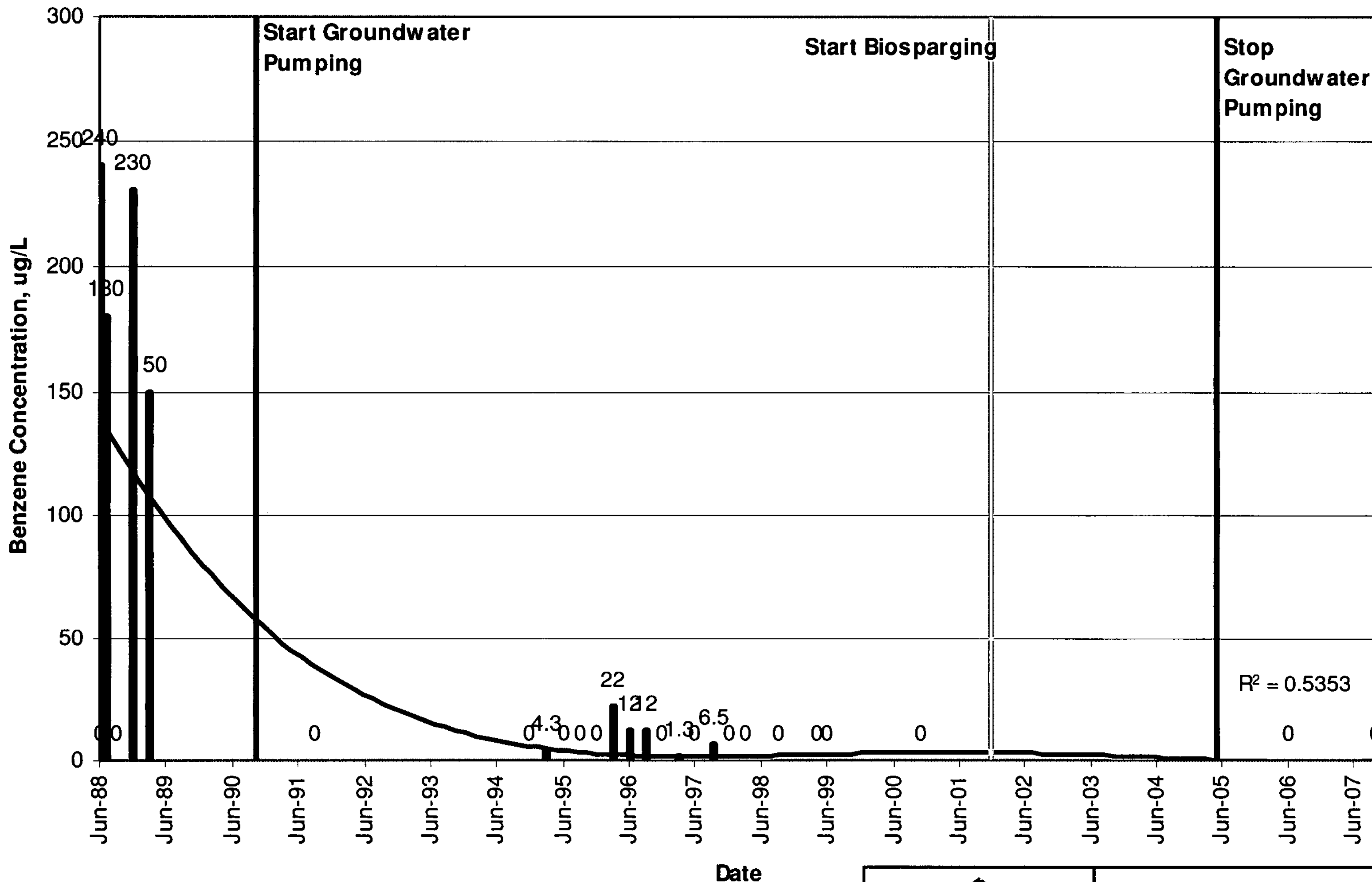
HARRIMAN, NEW YORK



Non-detectable concentrations plotted as "0".

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FIGURE 2-8
MW-11S Benzene Trend Plot
(Coarse Grained)

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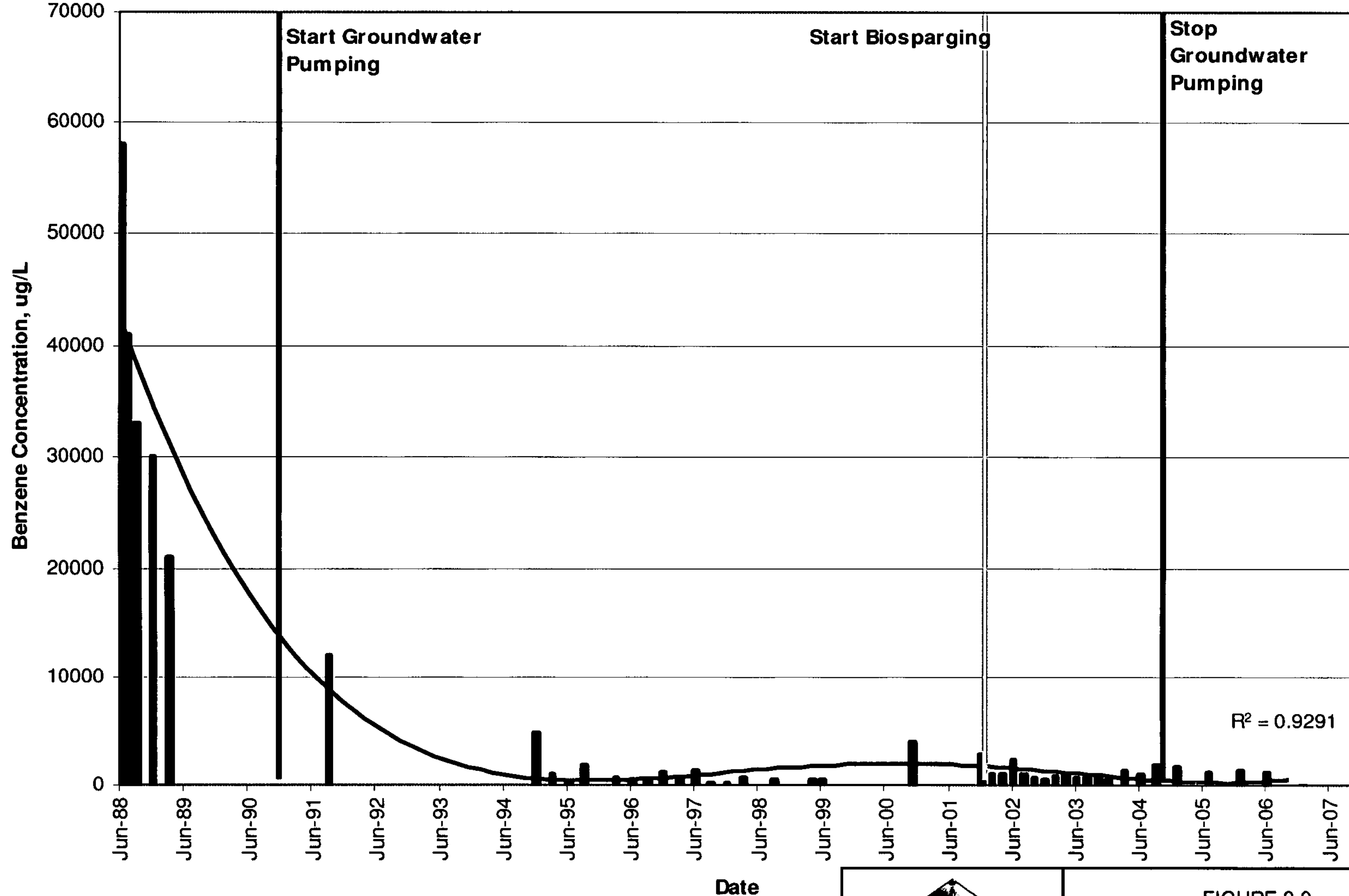

Non-detectable concentrations plotted as “0”.

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FIGURE 2-9
MW-16S Benzene Trend Plot
(Fine Grained)

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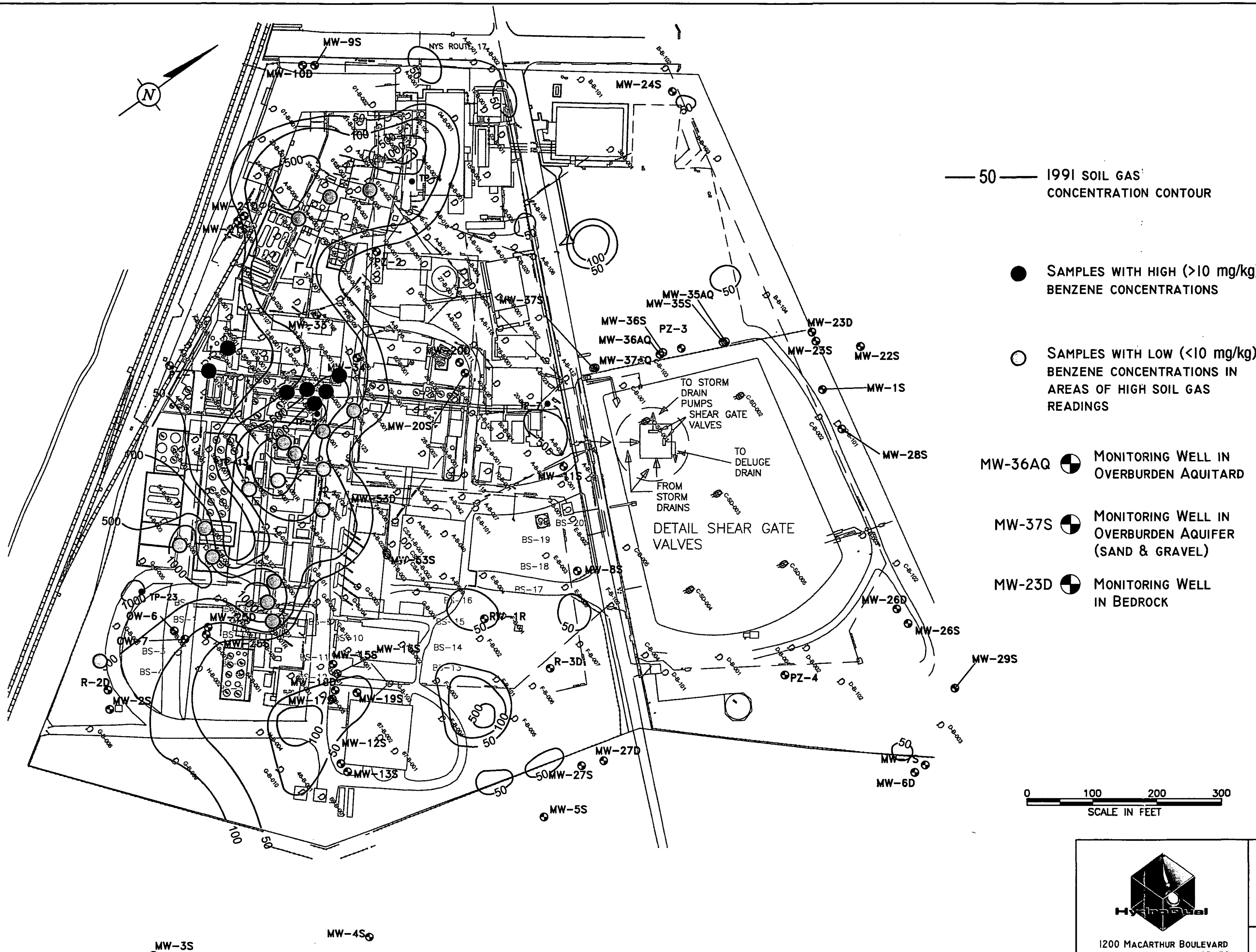

Sample	Depth	Benzene (mg/kg)
14-B-001	0-1	0.413
14-B-001	4-5	0.123
18-B-001	0-1	780
18-B-002	0-1	163
18-B-002	3-4	223
18-B-003	0-1	465
31-B-001	0-1	10.8
31-B-001	5-6	73.7
33-B-001	0-1	1.17 J
34-B-001	0-1	
34-B-001	5-6	
35-B-001	0-1	
35-B-001	4-5	0.744 J
50-B-001	0-1	33.5
50-B-001	4-5	10.3
55-B-001	3-4	
56-B-001	0-1	
56-B-001	4-5	
57-B-001	0-1	0.00171 J
60-B-001	0-1	75.1
61-B-002	0-1	0.124
63-B-001	0-1	
63-B-001	5-6	
63-B-001	5-6	
63-B-001R	0-1	
72-B-001	0-1	
72-B-001	5-6	
A-B-006	0-1	9.43
A-B-006	3-4	0.057
A-B-012	5-6	38.1 J
A-B-025	0-1	
A-B-025	3-4	
A-B-035	0-1	
A-B-035	4-5	0.191
A-B-113	3-4	
A-B-121	3-4	0.274
G-B-001	0-1	
G-B-006	0-1	
G-B-006	3-4	
G-B-012	0-1	
G-B-012	6-7	0.304
I-B-002	0-1	
I-B-002	5-6	

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Figure 2-10
Benzene concentrations from RFI soils data compared to 1991 soil gas data

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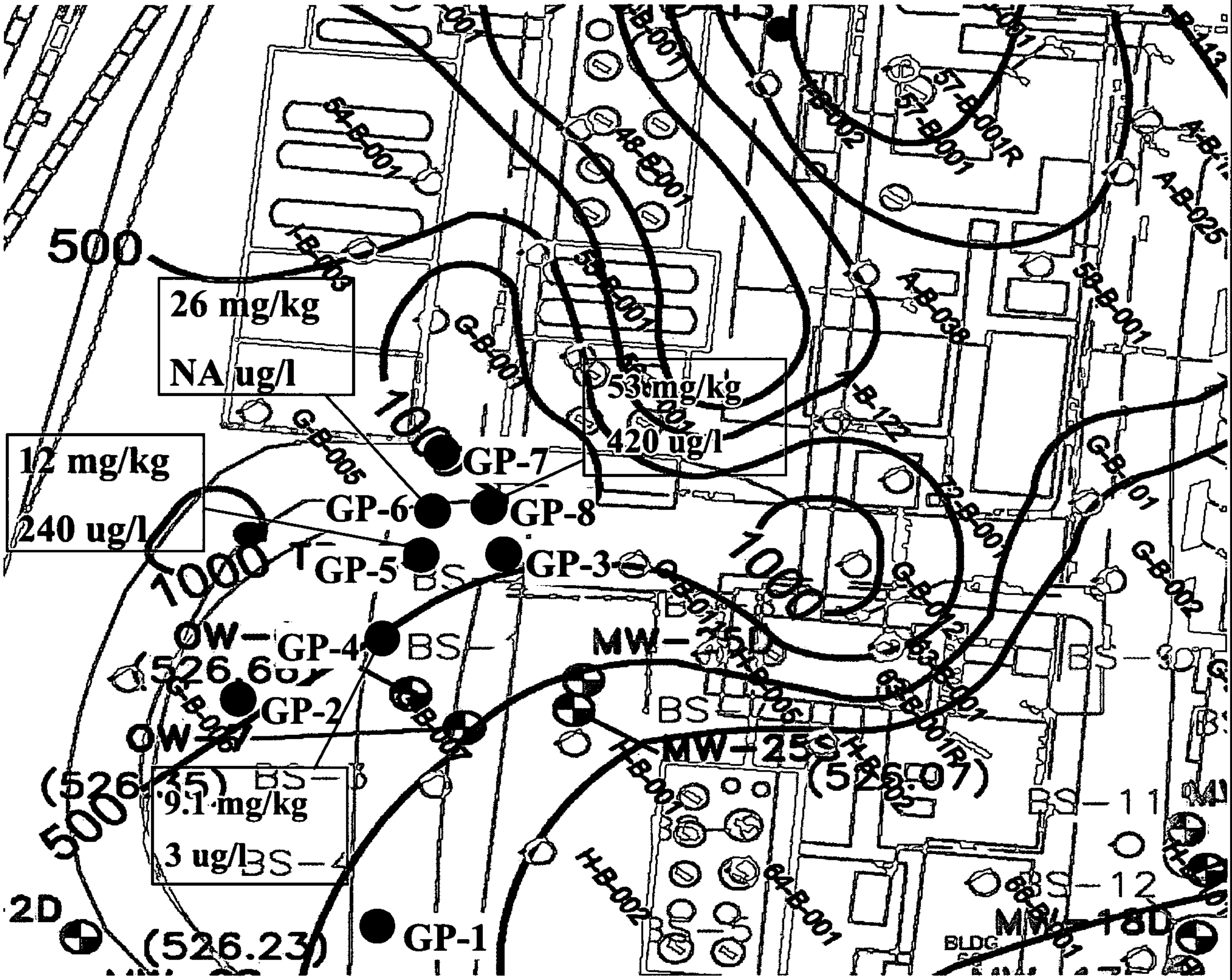
Harriman, New York



12 mg/kg
240 ug/l

GP-5

Geoprobe boring location
and Benzene concentration
in soil (mg/kg) and
groundwater (ug/L) sample

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Figure 2-11
October 2006 Geoprobe
Investigation results compared to
1991 soil gas data

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Harriman, New York

SECTION 3

WORK PLAN FOR ADDITIONAL DATA COLLECTION

3.1 DATA NEEDS

Based upon the CSM presented in Section 2.0, the following additional data needs have been identified:

- Additional water quality data in the Overburden Aquifer along the downgradient property boundary;
- Additional water quality data in the coarse sand and gravel deposits (Overburden Aquifer) underlying the central portion of the site along the expected primary groundwater flow paths;
- Additional analytical data to evaluate contaminant behavior absent influences from pumping and/or biosparging;
- Replacement of well MW-20D to further assess bedrock groundwater quality in this area.

A work plan for collection of these additional data is presented below.

3.2 MONITORING WELL INSTALLATION

A total of six new monitoring wells are proposed at the locations illustrated in Figure 3-1. Wells MW-101 and MW-102 would be located along the downgradient property boundary and serve to provide additional water quality data within the Overburden Aquifer in this area. MW-101 would roughly split the distance between existing wells MW-24S and MW-1S, while MW-102 would split the distance between MW-1S and MW-7S. In addition, the location of MW-102 has been selected to be near the projected center of the thick, coarser-grained outwash deposits underlying the central portion of the site.

Locations MW-103, MW-104 and MW-105 are located within the coarser-grained outwash deposits underlying the central portion of the site, west of Arden House Road. These locations provide additional coverage within the main plant site along potential groundwater flow paths. Finally, a replacement well MW-20DR would be installed adjacent to existing well MW-20D. This well would serve to supplement data collected from MW-20D which, while completed in the bedrock, is suspected to be influenced by groundwater in the overlying Overburden Aquifer based on water quality and water level information (Arcadis, October 2007). Replacement well MW-20DR will be advanced a minimum of ten feet into bedrock.

Specifics related to installation procedures are provided in Section 4.1.

3.3 TEMPORARY SHUT-DOWN OF BIOSPARGE SYSTEM

As described in detail within the Arcadis October 2007 Report, the water quality data demonstrates that the concentrations of site COCs are declining with time. This is attributed to remedial actions consisting of excavation and groundwater pumping as well as degradation of the COCs as a result of both natural conditions and biosparging. The degradability of the site COCs is well documented in the literature and the water quality data provide evidence that degradation is occurring at the site. The water quality data, however, have been collected over a period of time when remedial actions consisting of pumping and/or biosparging have been active. Therefore, it is currently unclear how the system is behaving under steady state conditions. In order to address this data need, it is recommended that the currently active biosparge system be temporarily shut-down for a period of six months, with the option to extend the shut-down period at additional six month intervals for up to two years depending on the observed groundwater conditions. During the shut-down period, groundwater quality would be monitored as described below in Section 3.4. The biosparge system will continue to be fully maintained with a contingency to return individual sections or the full system to operation based upon the observed water quality data.

3.4 INTERIM GROUNDWATER MONITORING PROGRAM

As described in Section 3.3, temporary shut-down of the biosparge system, with a contingency to return individual sections or the full system to operation based on observed water quality data, is recommended in order to evaluate how the groundwater system is behaving under steady state conditions. Table 3-1 presents a list of the existing overburden aquifer wells at the site, a comparison of wells currently monitored versus those proposed for the interim monitoring program, and the rationale for inclusion or exclusion of a given location in the interim program. As listed, the interim program calls for the monitoring of a greater number of well locations in order to evaluate water quality along anticipated flow paths as well as site interior and perimeter locations. The interim monitoring wells are then illustrated in Figure 3-1 and summarized in Table 3-2 along with the monitoring frequency and analytical parameters. In addition to wells completed in the overburden aquifer, the interim program also includes one new and 6 existing bedrock wells.

The monitoring frequency is at six month intervals (two times per year) based on the estimated groundwater flow velocity within the coarser-grained overburden aquifer underlying the central portion of the Site. As illustrated in Figure 3-1, travel time from the main plant area to Arden House Road and again from Arden House Road to the property boundary are estimated on the order of six to nine months based on aquifer testing completed during the RI. A sampling frequency of six months will thus allow sufficient time to collect, analyze and evaluate the sample results so that informed decisions can be made regarding to need to implement contingency plans for returning all or portions of the biosparge system to operation or to assess if an additional six month period of study is appropriate.

Details regarding groundwater sample collection and analysis are provided in Section 4.2.

3.5 REPORTING

Upon receipt of the analytical results, a summary report will be prepared presenting the most recent results and describing trends, noted observations, etc. as applicable. In addition, recommendations will be made regarding the need to restart individual sections or all of the biosparge system, continue for another six months with the biosparge system off, or, if sufficient data are available, recommendation for completion of an ESD, as applicable. The summary report will be supported with analytical summary tables, trend graphs, and figures as needed to present the data and/or proposed recommendations.

TABLE 3-1
Existing Overburden Aquifer Monitoring Wells and Rationale for Inclusion/Exclusion from Proposed Interim Groundwater Monitoring Program

Well ID	In 2007 Monitoring Program	Interim Monitoring Program	Inclusion/Exclusion Rationale
MW-1S	Yes	Yes	Downgradient Property Boundary
MW-2S	No	No	Upgradient Well Location
MW-3S	No	No	Up/Side Gradient Well Location
MW-4S	No	No	Side Gradient - Other wells (MW-12S) closer to Site
MW-5S	Yes	Yes	Side/Downgradient
MW-7S	No	Yes	Downgradient Property Boundary
MW-8S	Yes	Yes	Downgradient - Interior Property
MW-9S	No	No	Upgradient Well Location
MW-11S	Yes	Yes	Downgradient - Interior Property
MW-12S	No	Yes	Side/Downgradient
MW-13S	No	No	Adjacent to MW-12S
MW-16S	Yes	Yes	Plume Well - Interior Property
MW-20S	Yes	Yes	Plume Well - Interior Property
MW-21S	No	No	Upgradient Well Location
MW-24S	Yes	Yes	Downgradient Property Boundary
MW-25S	Yes	Yes	Plume Well - Interior Property
MW-27S	No	Yes	Side/Downgradient
MW-33S	Yes	Yes	Plume Well - Interior Property
MW-35S	No	Yes	Downgradient
MW-36S	No	No	Located just upgradient of MW-35S
MW-37S	Yes	Yes	Downgradient
OW-6	Yes	Yes	Plume Well - Interior Property
OW-7	Yes	Yes	Plume Well - Interior Property
RW-1R	Yes	Yes	Downgradient - Interior Property
MW-53D	Yes	Yes	Plume Well - Interior Property
PZ-1	No	No	Upgradient Well Location
PZ-2	No	No	Side Gradient - Interior well - Historically ND Concentrations
PZ-3	No	No	Located just upgradient of MW-35S

TABLE 3-2
INTERIM GROUNDWATER MONITORING PROGRAM

Well ID	Status	Hydrogeologic Unit	Frequency	Parameters[2,3]
MW-1S	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-5S	Existing	Overburden Aquifer	2X/Year	BTEX
MW-7S	Existing	Overburden Aquifer	2X/Year	BTEX
MW-8S	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-11S	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-12S	Existing	Overburden Aquifer	2X/Year	BTEX
MW-16S	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-20S	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-24S	Existing	Overburden Aquifer	2X/Year	BTEX, Mercury
MW-25S	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-33S	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-35S	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-37S	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
OW-6	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
OW-7	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
RW-1R	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-53D	Existing	Overburden Aquifer	2X/Year	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-101	Proposed	Overburden Aquifer	2X/Year[1]	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-102	Proposed	Overburden Aquifer	2X/Year[1]	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-103	Proposed	Overburden Aquifer	2X/Year[1]	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-104	Proposed	Overburden Aquifer	2X/Year[1]	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-105	Proposed	Overburden Aquifer	2X/Year[1]	BTEX, Sulfate, Ammonia, Nitrate, Manganese, Iron
MW-6D	Existing	Bedrock	2X/Year	BTEX
MW-20D	Existing	Bedrock	2X/Year	BTEX
MW-23D	Existing	Bedrock	2X/Year	BTEX
MW-26D	Existing	Bedrock	2X/Year	BTEX
MW-27D	Existing	Bedrock	2X/Year	BTEX
MW-20DR	Proposed	Bedrock	2X/Year[1]	BTEX

1 - Newly installed wells will be sampled for TCL VOCs, SVOCs, ammonia, sulfate, nitrate, manganese and iron approximately two weeks after installation and then two times/year for the parameters as indicated above. The parameters called for above may be supplemented with others based upon the initial sampling results.
2 - The compounds Pyridine, alpha-picoline, and 2-amino-pyridine will be added once per year.
3 - Field Parameters consisting of pH, DO, ORP, Temperature, Turbidity and Iron+2 will be measured during each sampling event at each of the above wells.

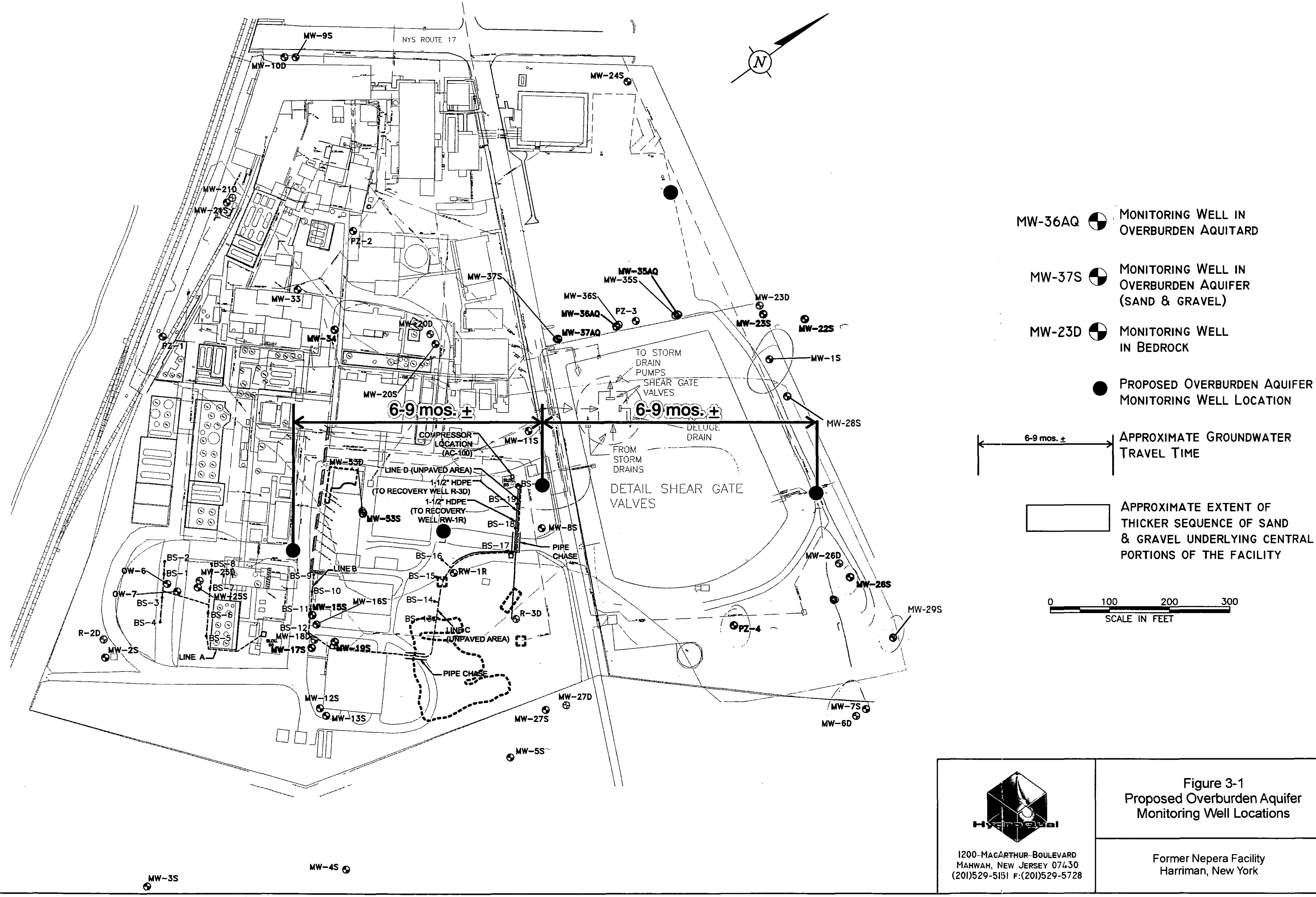

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Figure 3-1
Proposed Overburden Aquifer Monitoring Well Locations

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SECTION 4

FIELD SAMPLING AND DATA QUALITY ASSURANCE/ QUALITY CONTROL

The monitoring well installation and data collection activities presented in the Scope of Work in Section 3.0 will be completed in accordance with the methods and procedures presented in this section.

4.1 MONITORING WELL INSTALLATION

Overburden Aquifer Wells

The overburden aquifer wells will be installed by advancing a six-inch diameter borehole, with continuous split spoon sampling, to the base of the Overburden Aquifer. Immediately upon opening the split spoon, the sample will be screened with an organic vapor analyzer (OVA) and the peak reading recorded. The sample will then be described for grain size, visible laminations, etc. and a representative portion of the sample will be jarred for future reference. The drilling will proceed through the full thickness of the Overburden Aquifer (outwash deposits) until refusal of the split spoon on bedrock or identification of the top of the glacial till or kame deposits (interbeded lenses of fine sand and silt), whichever occurs first. The aquifer material is typically described as ranging from a coarse Sand with some gravel to a fine sand with some silt. The fine grained aquifer material can be distinguished from the overlying glacial lacustrine deposits by the slightly coarser grain size and the absence of interbeded silt. Similarly, it can also be distinguished from the underlying kame deposits again by the absence of interbeded silts, as well as lower blow counts (i.e., it is less dense than the kame deposits).

The monitoring well will be constructed of two-inch diameter PVC riser pipe attached to a ten foot long by two-inch diameter, no. 10 slot, PVC wire wrap screen. The depth of the screened interval will target the upper 10 - 15 feet of the Overburden Aquifer, consistent with the completion interval of the existing Overburden Aquifer monitoring wells. In the event that the aquifer is less than 10 feet in thickness, the screen length will be reduced so that it only spans the aquifer. The annular space around the screen will be backfilled with a clean silica sand pack to approximately two feet above the screened interval. This will be followed by a 6" thick layer of fine filter sand, followed by two feet of bentonite pellets and cement bentonite grout to the surface. Surface completions will consist of flush mount or stick up protective casing depending upon the location.

Following completion, and after allowing sufficient time for the grout to set up, the wells will be developed until they produce sediment free water or until there is no continued improvement in turbidity. Water generated during the drilling and well development will be discharged to the surrounding ground surface. Soil cuttings registering no reading on the OVA will be spread out on the surrounding ground while soils from which an OVA reading was recorded will be drummed for subsequent characterization and off-site disposal.

Following completion of the well installation activities, each well will be surveyed for vertical and horizontal control by a licensed surveyor.

Bedrock Monitoring Well

The bedrock monitoring well will be installed by advancing an eight-inch diameter borehole, with continuous split spoon sampling, to refusal on bedrock. A temporary eight-inch steel casing will then be set into the top of rock and drilling will proceed through the steel casing using a nominal eight-inch diameter roller bit to a depth of ten feet below the top of rock. A four-inch diameter steel casing will then be grouted in place. After allowing sufficient time for the grout to set (approximately 24 hours) drilling will continue through the four-inch casing an additional ten feet to a total depth of 20 feet below the top of rock The well will be developed until the water is sediment free or until there is no further improvement in turbidity. Water generated during the drilling and well development will be discharged to the surrounding ground surface. Soil cuttings registering no reading on the OVA will be spread out on the surrounding ground, while soils from which an OVA reading was recorded will be drummed for subsequent characterization and off-site disposal.

Following completion of the well installation activities, each well will be surveyed for vertical and horizontal control by a licensed surveyor.

4.2 WATER LEVEL MONITORING AND GROUNDWATER SAMPLING

Prior to the start of each groundwater sampling event, a complete round of water levels will be obtained from the existing site monitoring wells. This will include wells that are being sampled as well as those that are not being sampled. Water levels will be obtained by measuring and recording the depth to water from the top of casing (TOC).

Groundwater sampling will be conducted using low-flow purging and subsequent sample collection following the stabilization of measured and recorded field parameters consisting of oxidation-reduction potential, pH, conductivity, temperature, dissolved oxygen and turbidity. Field parameters will be measured via a Horiba U-22XD multi-parameter water quality monitoring system and flow-through cell. A submersible centrifugal pump (Grundfos Redi-Flo2) or bladder pump, placed at well-screen depth with per-well dedicated tubing, will be used for both purging and sample collection. Groundwater Sampling Logs documenting recorded data will be prepared for each sampling point and purge water will be discharged to the surrounding ground surface.

The samples will be collected directly from the dedicated tubing into laboratory provided sample bottles. The bottles will be labeled with the monitoring well ID, date and time of sampling, and sampler's initials, and placed in a cooler with ice. The samples will then be transported to Test America Laboratories under chain of custody. After collecting the laboratory samples, a field test will be conducted at designated locations for Ferrous Iron ($Fe+2$).

Quality assurance/quality control procedures and samples will include the following:

- The sampling pump will be cleaned internally and externally with an Alconox and water solution, followed by a fresh water rinse, prior to use at the next well location.
- One equipment blank, consisting of laboratory grade water poured over the decontaminated equipment and collected in laboratory jars, will be collected per sampling event. Analytical parameters will be for the same compounds as the samples.
- Trip blanks will accompany any cooler containing samples for volatile organics analysis.
- One blind duplicate sample will be collected per sampling event and analyzed for the same parameters as the original sample.
- The Horiba U-22XD water quality meter will be calibrated prior to each daily sampling event in accordance with the manufacturer's instructions.

4.3 GROUNDWATER SAMPLE ANALYSIS

Groundwater samples will be shipped to Test America Inc. for analysis of the parameters listed in Table 3-2. Sample volume requirements, preservatives, holding times and analytical methodology are presented in Table 4-1. Detection limits will be equal to or lower than current SCGs and those stipulated in the ROD, as summarized below:

Benzene – 5 ug/l	Chlorobenzene – 5 ug/l	Mercury – 2 ug/l
Toluene – 5 ug/l	Pyridine – 50 ug/l	
Xylenes – 5 ug/l	Alpha-picoline – 50 ug/l	
Ethylbenzene – 5 ug/l	2-Amino pyridine – 50 ug/l	

Note: The current SCGs for benzene and mercury are 1 ug/l and 0.7 ug/l respectively

TABLE 4-1

REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, HOLDING TIMES AND METHODOLOGY

Analytical Parameter	Typical Volume Required (mL)	Container[a]	Preservative	Maximum Holding Time	Analytical Method
Volatile organic compounds (VOCs)	(3) 40 mlVials	G/vial Teflon®-lined septum	Cool, 4°C & HCl to pH<2[b,]	14 days[b]	8260B
Semi volatile organic compounds	1000	AG/vial Teflon®-lined cap	Cool, 4°C	7 days/extraction +40 days/analysis	8270C
Metals	1000	P	HNO_3 to pH<2	6 months	6010/7841/7471
Miscellaneous					
Ammonia	500	P	Cool, 4°C & H_2SO_4 to pH<2	28 days	EPA 350.2+350.1
Alkalinity	100	P	Cool, 4°C	14 days	EPA 310.1
Nitrate/Nitrite	50	P	Cool, 4°C & H_2SO_4 to pH<2	28 days	EPA 353.2
Sulfate	100	P	Cool	28 DAYS	EPA 375.4
TOC	500	P	Cool, 4°C	7 DAYS	EPA 415.1

NOTES:
a. Polyethylene (P) or Glass (G) or Amber Glass (AG).
b. Samples receiving no pH adjustment must be analyzed within 7 days.

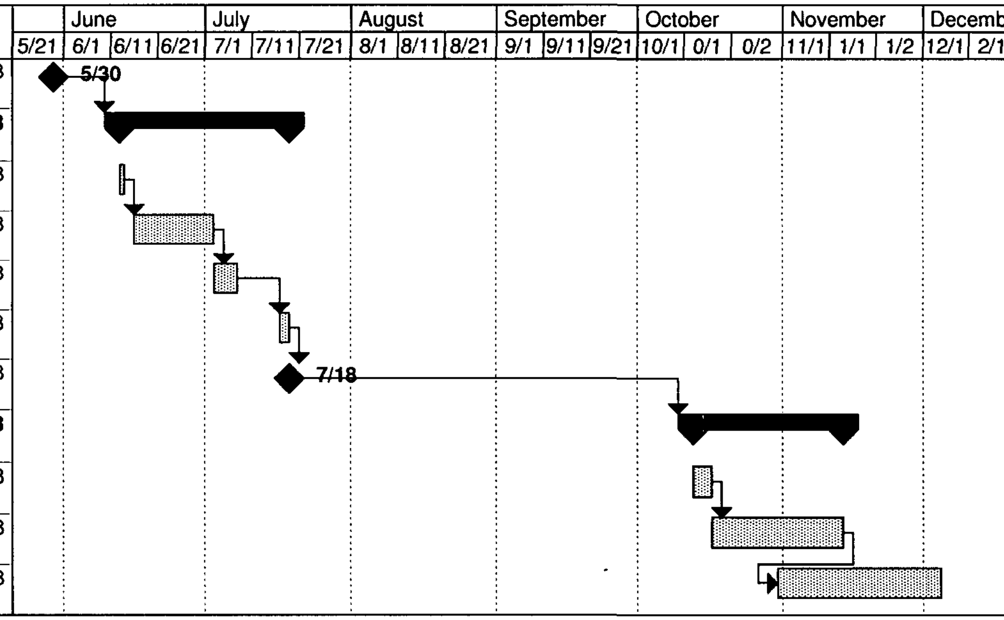
SECTION 5

SCHEDULE

The estimated schedule for implementation of the scope of work presented in this Work Plan is presented in Figure 5-1. An approval date of May 30, 2008 has been assumed for planning purposes. However, the actual date will depend on the review time required for approval. Upon completion of the work items presented in the schedule, decisions will be made with NYSDEC regarding the need for additional study, re-starting of portions or all of the biosparge system, etc.

FIGURE 5-1
ESTIMATED PROJECT SCHEDULE
Former Nepera Facility
Harriman, New York

ID	Task Name	Duration	Start	Finish
1	Work Plan Approval	0 days	Fri 5/30/08	Fri 5/30/08
2	**M.W. Installation**	**26 days?**	**Fri 6/13/08**	**Fri 7/18/08**
3	Mobilization	1 day?	Fri 6/13/08	Fri 6/13/08
4	Aquifer Wells (5)	13 days	Mon 6/16/08	Wed 7/2/08
5	Bedrock Well (1)	3 days	Thu 7/3/08	Mon 7/7/08
6	Baseline GW Sample	2 days	Thu 7/17/08	Fri 7/18/08
7	Turn 0ff Biosparge Wells	0 days	Fri 7/18/08	Fri 7/18/08
8	**Semi-Ann. GW Sampling**	**24 days**	**Mon 10/13/08**	**Thu 11/13/08**
9	Sampling	4 days	Mon 10/13/08	Thu 10/16/08
10	Analysis	20 days	Fri 10/17/08	Thu 11/13/08
11	Report/Recommendations	25 days	Fri 10/31/08	Thu 12/4/08



Project: schedule
Date: Fri 4/4/08

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Notes: Work Plan approval is assumed on May 30, 2008. Actual approval will depend on required review time.

SECTION 6

REFERENCES

Groundwater Quality Assessment, Groundwater Remediation Progress and Proposed Updated Remediation Program, Nepera Harriman Site, Harriman, New York Arcadis, January 2007

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