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CIVIL/SANITARY ENGINEERS

Municipal Services Engineering Company, P.A.

August 31, 2007

Received SEP 2007 Solid Waste Section

Mr. Bobby Lutfy, Hydrogeologist Permitting Branch
Solid Waste Section
Division of Waste Management
North Carolina Department of Environmental and Natural Resources
401 Oberlin Road, Suite 150
Raleigh, NC 27605

Re: Assessment of Corrective Measures
Wayne County #96-01, Greene County #40-02, and Lenoir County #54-03

Dear Mr. Lutfy:

Enclosed you will find the Assessment of Corrective Measures for Wayne County permit #96-01, Greene County Permit #40-02, and Lenoir County Permit #54-03. As per request by Jaclynne Drummond, one hard copy and one electronic copy for the above landfills are included.

Fill free to contact us by phone at (919) 772-5393, should you have any questions or comments regarding this report.

Sincerely,
MUNICIPAL ENGINEERING SERVICES CO., P.A.

Ethan J. Caldwell, P.G.
Professional Geologist

Enclosures

8776

PO Box 97, Garner, North Carolina 27529 (919) 772-5393
PO Box 828, Morehead City, NC 28557 (252) 726-9481
PO Box 349, Boone, NC 28607 (828) 262-1767

Assessment of Corrective Measures

Prepared for

Greene County Landfill - Permit #40-02
Walstonburg, Greene County, North Carolina

MESCO Project Number: G07061.0

Completed on 8/30/2007

Municipal Services Garner, NC
Engineering Company, P.A. Boone, NC

Municipal Engineering Services Company, P.A.
Garner, Boone and Morehead City, North Carolina

TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 Site Background 1
1.1.1 Site History 1
1.1.2 Sampling History 1
1.2 Site Characteristics 2
1.2.1 Site Description 2
1.2.2 Geology 2
1.2.3 Hydrogeology 2
1.2.4 Hydrology 3
Potable Sources 3
Groundwater Regime 3
Groundwater Flow Components 4
1.3 Site Conceptual Model 4
Boundaries 5
Model Calibration 6

2 CONTAMINATION CHARACTERIZATION 6

2.1 Contamination of Concern 6
2.1.1 Inorganic Constituents 6
2.1.2 Organic Constituents 7
2.2 Contamination Distribution 8
2.3 Source Control Measures 9
2.3.1 MT3D96 Modeling 9
2.3.2 Sorption 9
2.4 Groundwater End Use 10
2.5 Exposure Pathways 10
2.6 Human Health Risk Assessment 11
2.6.1 Carcinogenic 11
2.6.2 Non-Carcinogenic 12
2.7 Adult Risk 12
2.8 Child Risk 13
2.9 Sensitivity Receptor Pathways 13

3 CORRECTIVE MEASURES SCREENING AND EVALUATION 13

3.1 Overview 13
3.2 Institutional Controls 14
3.3 Infiltration Controls 14
3.4 Landfill Gas Controls 14
3.5 Groundwater Technologies 14
3.5.1 Monitored Natural Attenuation 15
3.5.2 Vapor Extraction System/Bioventing 15
3.5.3 Air Sparging 15
3.5.4 Enhanced Bioremediation 15
3.5.5 Phytoremediation 16
3.5.6 Constructed Wetland 16

4 SUMMARY CONCLUSIONS 16

4.1 Conclusions – Selection of Remedy 16
4.2 Public Meeting 17

REFERENCES 18

TABLES

Table 1 ..... Well Construction Details
Table 2 ..... Historical Groundwater Elevation Data
Table 3 ..... Slug Test Summary
Table 4 ..... Summary of Geologic Properties
Table 5 ..... Summary of Field Parameters
Table 6 ..... Historical Inorganic Groundwater Results
Table 7 ..... Historical Inorganic Surface Water Results
Table 8 ..... Statistically Significant Inorganics
Table 9 ..... Historical Organic Groundwater Results
Table 10 ..... Statistically Significant Organics
Table 11 ..... Current Groundwater Sampling Results
Table 12 ..... Carcinogenic Toxicity Values for Oral Ingestion Exposure
Table 13 ..... Carcinogenic Toxicity Values for Inhalation Exposure

Table 14 ..... Carcinogenic Toxicity Values for Dermal Exposure
Table 15 ..... Non-Carcinogenic Toxicity Values for Oral Ingestion Exposure
Table 16 ..... Non-Carcinogenic Toxicity Values for Inhalation Exposure
Table 17 ..... Non-Carcinogenic Toxicity Values for Dermal Exposure
Table 18 ..... Flow Rate Calculations
Table 19 ..... Remediation Alternatives

PLATESRZRR

Plate 1 ..... Topographical Map with Site Location
Plate 2 ..... Site Map
Plate 3 ..... Average Potentiometric Groundwater Map
Plate 4 ..... Cross-section
Plate 5 ..... Isoconcentration Map Total VOC's

APPENDIX

Appendix A ..... Boring Logs and Monitoring Well Construction Diagrams
Appendix B ..... Sampling History
Appendix C ..... Groundwater Modeling
Appendix D ..... Sampling and Analysis Plan

1 INTRODUCTION

1.1 Site Background

1.1.1 Site History

The Greene County Construction and Demolition (C&D) landfill is located at 105 Landfill Road (SR 1239), Walstonburg, Greene County, North Carolina. A topographical map showing the location of the site is included as Plate 1. Greene County C&D landfill operates under permit #40-02. Prior to operating as a C&D landfill, the site operated as a Municipal Solid Waste (MSW) unlined sanitary landfill. The MSW unit was closed with a cohesive cap of 18 inches of soil with a permeability of 1 x 10^{-5} cm/sec, and 18 inches of erosive layer. MSW unit stopped receiving waste by January 1, 1998 as part of the transition plan.[18] The C&D landfill is constructed and operating on top of the MSW unit. A site map is included as Plate 2.

1.1.2 Sampling History

Three monitoring wells (MW-1, MW-2 and MW-3) were installed in November 1981. Initial sampling of these monitoring wells occurred on October 8, 1988 and included pH, Biological Oxygen Demand, Chemical Oxygen Demand, Nitrate Nitrogen, Total Organic Carbon, Chloride, Fluoride, Total Dissolved Residue, Arsenic, Barium, Cadmium, Copper, Total Chromium, Iron, Lead, Manganese, Mercury, Selenium, Silver, Zinc, Total Organic Halides, Sulfate, Conductivity, Temperature, and Static Water Level. Additional sampling occurred on December 8, 1989, February 22, 1990, December 6, 1990, December 5, 1991, December 3, 1992 and June 15, 1993. Sample results for these events are available in the Transition Plan.

The Ground and Surface Water Monitoring System (SAP) was prepared in February 1994 and submitted as part of the Transition Plan.[18] The SAP is included in Appendix D. In August 1994, as part of the SAP, MW-2 and MW-3 were abandoned and MW-1R, MW-4, MW-5 and MW-6 were constructed; in October 1994 MW-1R was installed adjacent to MW-1 because the integrity of MW-1 was in question. Appendix I sampling was initiated in September 1994 with background sampling occurring on September 15, 1994, October 4, 1994, November 18, 1994, January 12, 1995, and February 6, 1995.

Appendix II sampling was performed on May 24, 2007 due to the detection of Appendix I constituents above 2L levels in MW-4. In addition to Appendix II sampling, two monitoring wells (MW-7 and MW-8) were installed on June 21, 2007, down gradient of MW-4. A sampling history table is included in Appendix B. Well boring and construction records are provided in Appendix A.

1.2 Site Characteristics

1.2.1 Site Description

The site lies within the Coastal Plain physiographic province that is characterized by flat or gently undulating topography dissected by drainage features with narrow to moderately sloped sides. There are approximately 20 feet of relief across the site. Surface drainage is northeast towards a tributary of Sandy Run. Sandy Run flows east towards little Contentnea Creek and ultimately to the Neuse River.

1.2.2 Geology

The geology, as addressed in the SAP, identified the site as having surficial sediments overlying the Pliocene Yorktown and Cretaceous Black Creek Formations. The surficial deposits are made up of sand, clay and gravel which dip to the southeast at less than 0.5 degree and are generally less than forty feet deep. The Yorktown formation underlies the surficial sediments. The Yorktown formation consists of an overlying confining unit of clay, silty clay, or sandy clay that is approximately 25 feet thick; followed by fine sand, silty sand, and clayey sand.[13]

Well construction details are included in Table 1 and well construction records for monitoring wells are included in Appendix A. Lithology for MW-1R consists of orange mottled silty clay to gray mottled sandy clay. MW-4 primarily consists of red-orange mottled clay/silty clay, to red sandy clay, to orange silty clay. MW-5 consists of tan silty clay, gray sandy clay to orange clayey sand. MW-6 consists of orange, mottled gray silty clay/sandy clay. MW-7 is in mottled gray/red/orange clay. MW-8 is primarily gray/red/orange mottled clay to orange clayey sand. A geologic cross section was prepared showing the generalized subsurface geology and hydrology for the site.

1.2.3 Hydrogeology

Hydrogeological properties of monitoring wells MW-1R, MW-4, MW-5, and MW-6 were reported in SAP. Slug tests were performed on monitoring wells MW-7 and MW-8 after completion of installation. Slug tests are provided in Appendix A. A summary of slug test results is provided as Table 3. Values ranged from 1.14 x 10^{-3} cm/sec in MW-8, to 1.10 x 10^{-4} cm/sec in MW-4, and an average of 3.16 x 10^{-4} cm/sec.

Porosities for MW-1R, MW-4, MW-5, and MW-6 were reported in a water quality monitoring system modifications report prepared by GAI consultants.[12] Porosities for MW-7 and MW-8 were calculated from Shelby Tube samples collected during installation of the monitoring wells. Geotechnical laboratory results for MW-7 and MW-8 are included in Appendix A. A summary of porosity values is shown on Table 4.

Values of total porosity ranged from a high of 43.2% in MW-6 to a low of 36.7% in MW-1R with an average of 40.1%.

Effective porosity for MW-1R, MW-4, MW-5, and MW-6 were reported in the SAP at 15%. Effective porosity for MW-7 and MW-8 was attempted using the relationship between effective porosity and grain-size distribution. Johnson (1967) compiled a number of published effective porosity values and developed a relationship between the grain size distribution and the effective porosity.[15] Grain size distribution from monitoring wells MW-7 and MW-8 was applied to the "trilinear graph of textural classification." Unfortunately, the grain size distribution fell into an area of no samples. The reported value of 15% does not conform with published values of silty clay or sandy clay. The published value of 7% will be used as the estimated effective porosity for the Sandy Clay.[15][page D-1] Grain size distribution and Johnson trilinear graphs are included in Appendix A.

1.2.4 Hydrology

Potable Sources

Municipal water is available to the surrounding area. A receptor survey performed as part of the Transition Plan did not identify any potable wells within 2000 feet of the facility. The receptor survey was reviewed along with a windshield survey of the area in 2007. No potable wells were observed within 2000 feet of the facility.

Groundwater Regime

Regionally the first aquifer occurs in unconsolidated soils. These unconsolidated soils overlie several regional confined aquifers. In the area south of Wootens Crossroads, the Yorktown aquifer underlies the surficial aquifer and is confined by a clay/sandy clay confining unit.

Locally, groundwater exhibits flow dynamics that are primarily controlled by the local drainage features. Groundwater elevations have been recorded during sampling events. A summary of historical groundwater elevation data is included in Table 2. Water elevations are fairly consistent. On average, groundwater in MW-1R and MW-6 is 5 to 6 feet below ground surface (bgs), groundwater in MW-4 and MW-5 is 16 to 17 feet bgs, and in new monitoring wells MW-7 and MW-8 groundwater is 10 to 11 feet bgs. Groundwater flow is generally west/southwest. A potentiometeric map is provided as Plate 3.

Groundwater Flow Components

The potentiometeric map was used to calculate the average linear velocity defined as:

$$v_x = \frac{K}{n_e}\frac{dh}{dl}$$

where

v_x is the average linear velocity

K is the hydraulic conductivity

n_e is the effective porosity

$\frac{dh}{dl}$ is the hydraulic gradient

The hydraulic gradient was calculated graphically by first drawing a line from each monitoring well to a perpendicular of the equipotential line. The elevations of the hydraulic head (*dh*) were calculated by subtracting the elevation of equipotential from the groundwater elevation for the corresponding piezometer. The lateral distance (*dl*) is the horizontal length of the line. *dl* values are further denoted on Plate 3. Calculation of the hydraulic gradient at a given piezometer location was determined by dividing *dh* by *dl*. Table 18 shows the results of the flow rate calculations in units of feet per year and the parameters used in the calculations.

1.3 Site Conceptual Model

A conceptual model of the site was developed with Visual MODFLOW designed by Waterloo Hydrogeologic, Inc. The visual MODFLOW package includes the USGS developed MODFLOW, the accompanying particle tracking program, MODPATH, as well as the contamination transport package MT3D[96] developed by Papadopulos and Associates, Inc.

The model grid consisted of an area 1700 feet x 1200 feet. The area was divided into 60 rows, 85 columns and 5 layers. To approximate the aquifer characteristics, each layer was defined with distinct hydraulic properties.

Layer 1 – Orange Mottled Silty Clay

Layer 2 – Orange/Red/Gray Sandy Clay

Layer 3 – Gray Silty Clay.

Layer 4 – Confining layer of the Yorktown Formation

Layer 5 – Yorktown Formation.

Estimated hydraulic properties

	Hydraulic Conductivity cm/sec	**Total Porosity**	**Effective Porosity**
Layer 1	1.15×10^{-4}	38.4	7
Layer 2	4.90×10^{-4}	40.4	7
Layer 3	1.15×10^{-4}	38.4	7
Layer 4	5.90×10^{-6}	37.6	9
Layer 5	7.7×10^{-3}	51.7	20

Layer 1 and Layer 3 - Estimated from MW-1R and MW-4
Layer 2 Estimated from MW-5, MW-6 and MW-8
Layer 4 and Layer 5 estimated from published values[13]

Hydraulic properties of the waste and cohesive cap were not applied as they are addressed in boundary conditions.

Boundaries

The integrity of Visual MODFLOW depends largely on the accurate definition of boundary conditions. The model was developed to simulate the observed hydrologic conditions. In a generalized hydrologic cycle, groundwater recharge is the result of precipitation, surface water inflow, evapotranspiration, surface water outflow, and change in aquifer storage. Precipitation data at the *Kinston Ag Research* station were reviewed on the State Climate Office of North Carolina web site.[24] The *Kinston Ag Research* station is located approximately 13.7 miles from the site. Annually, *Kinston Ag Research* station receives an average of 49.5 inches. Boundary conditions were limited. There were no surface water inflows to the site nor were there surface water outflow. Evapotranspiration is estimated at 33 inches per year, which was derived in Simulation of Ground-Water Flow in the Coastal Plain Aquifer System of North Carolina.[13] Aquifer "storativity, S, [was] developed primarily for the analysis of well hydraulics in confined aquifers."[11][page 61] Change in aquifer storage in an unconfined aquifer system results in an increase/decrease in water level.[10] Change in aquifer storage is considered negligible due to the unconfined nature of the system and the assumption that the system is under steady state conditions. [11][page 205] Estimation of overland run off to the drainage features is dependent on topography. Overland run off is estimated at 5 inches per year.[13] Based on these estimations, groundwater recharge is estimated at 12 inches per year. Recharge area is limited due to landfill activities, structures, and roads and was applied to areas that have limited impact.

Model Calibration

Calibration of the model was a trial and adjustment procedure. Alternative model parameters were run utilizing varied model input. The process was repeated to minimize the difference between the computed and observed values. The site conceptual model represents the most accurate conceptual model.

A graph of simulated heads versus observed heads is included in Appendix C. The calibration for the model is believed to be successful for the conditions at this site. Head variation was limited to a root mean square of 9.80 feet. The simulated heads show a linear relationship with the observed heads at a slightly higher elevation. These estimations may be due in part to the site not receiving the estimated 12 inches per year of recharge. Recharge is controlled by seasonal fluctuations, which were not accounted for in MODFLOW, or there may be an unrecognized groundwater divide.

2 CONTAMINATION CHARACTERIZATION

2.1 Contamination of Concern

2.1.1 Inorganic Constituents

Inorganic constituents Antimony, Barium, Beryllium, Cadmium, Chromium, Cobalt, Lead, Manganese, Nickel, Thallium, Vanadium, and Zinc, have all been detected in groundwater samples. Included in Table 7 is a summary of Historical Inorganic Groundwater Results. Constituents that have been identified as being statistically significant include Barium, Chromium, Lead, Vanadium, and Zinc. While all these constituents have been detected as statistically significant at least one time, only Chromium and Vanadium have been detected with consistency. A summary of statistically significant inorganics is provided in Table 8. Inorganic constituents detected above 2L include Cadmium, Chromium, Lead, and Manganese. Inorganic constituents Cadmium, Chromium, Lead, Vanadium, and Zinc have been detected in Surface water samples. A summary of Historical Surface water inorganics is provided in Table 7.

These results are used to identify if the detected inorganics are the result of the waste disposal activities. Ground and Surface water samples are collected as unfiltered samples. Unfiltered samples represent the total concentration of inorganics. Often times "(s)tatistical analysis of total metal concentrations may not provide an accurate representation of contamination at the facility."[21][page 79] In addition, sampling techniques play a role in the detection of inorganic constituents. Too high a purge velocity can increase the turbidity of the sample, which can over estimate sampling results.[9]

During installation of MW-7 and MW-8 soil samples were collected from inorganic analysis. In addition a background soil sample was collected adjacent to MW-1R. Soil results had detected Antimony, Arsenic,

Barium, Beryllium, Chromium, Lead, Nickel, Vanadium and Zinc. A summary of soil results is included in Appendix B. Background groundwater sampling detected Chromium, Lead, Nickel, and Zinc with Lead occurring above 2L levels. A summary of background groundwater sampling results is provided in Appendix B. Geochemistry of sediments for the USGS Walstonburg Quadrangle was retrieved from the USGS National Uranium Resources Evaluation (NURE)[25] database. The presence of metals in NURE soil samples include, but are not limited to, Manganese, Thallium, and Vanadium.

The presence of metals occurring in the background samples, surface water samples, soil samples, and NURE sediment samples indicate that Antimony, Barium, Beryllium, Cadmium, Chromium, Lead, Manganese, Nickel, Thallium, Vanadium and Zinc are falsely reported, or naturally occurring and don't represent contamination associated with the landfill. Cobalt, which has not been detected in background sampling, surface water sample, soil samples or NURE sediment samples, has only been detected three times in different monitoring wells during different sampling events. Cobalt is not a statistically significant constituent and has not been detected above 2L levels. The above results indicate that inorganics are <u>not</u> constituents of concern.

2.1.2 Organic Constituents

Organic constituents have been detected in the groundwater from recent sampling events. A sampling history is provided in Appendix B. A summary of detected Historical Organic Groundwater Results is included as Table 9. Table 10 shows constituents which have historically been detected as statistically significant. They are 1,4 Dichlorobenzene, cis-1,2-Dichloroethene, Methylbenzene, Chloroethene, Chloroethane, and Benzene. Organic constituents detected above 2L include Benzene, Chloroethene, and p-Dichlorobenzene.

Recent sampling has observed several detectable organic constituents. Provided in Table 11 is the May 2007 groundwater sample results. Organics detected include Carbon disulfide, Chloroethane, Chloroethene, 1,1-Dichloroethane, Ethylbenzene, p-Dichlorobenzene, Methylbenzene, Xylenes and cis-1,2-Dichloroethylene. Two organic compounds were detected above 2L standards. Chloroethene and p-Dichlorobenzene were both detected in MW-4. Included below is a summary of detected organic constituents.

Constituents of Summary

Constituent	Number of Sampling Events	Number of Sampling Events with Detections	Total Number Detects	Last date of Detect	Monitoring Wells Constituent Detected In
APPENDIX I VOC'S					
Benzene	26	1	1	3/19/2007	MW-4
Chloroethane	26	3	3	5/24/2007	MW-4
Chloroethene	26	2	2	5/24/07	MW-4
cis-1,2-Dichloroethene	26	4	4	5/24/2007	MW-4
Methylbenzene	26	2	2	5/24/2007	MW-4
Xylenes	26	1	1	5/24/2007	MW-4
p-Dichlorobenzene	26	2	2	5/24/2007	MW-4
1,1-Dichloroethane	26	1	1	5/24/2007	MW-4
Ethylbenzene	26	1	1	5/24/2007	MW-4
Carbon disulfide	26	1	1	5/24/2007	MW-1R

Carbon disulfide in MW-1R can be attributed to a false positive from the lab. Other recently detected organics also found on the statistically significant list are currently considered constituents of concern in MW-4.

2.2 Contamination Distribution

Contamination consists of Benzene, Chloroethane, Chloroethene (vinyl chloride), cis-1,2-Dichloroethylene, p-Dichlorobenzene and Methylbenzene (toluene); present in MW-4. Benzene and Methylbenzene are aromatic hydrocarbons, Chloroethane, Chloroethene, and cis-1,2-Dichloroethene are halogenated aliphatics, and p-Dichlorobenzene is a halogenated aromatic organic compound.[22]

Physical Characteristics of Constituents of Concern

Constituent	Density[1] (g/cm^3 at 20°C)	Henry's Constant[1] ($atm\text{-}m^3/mol$ 20°C)	Water Solubility[1] (mg/l at 20°C)	Octanol - Water Partitioning Coefficient[1] (log K_{ow})	Soil - Water Partitioning Coefficient[2] K_{oc} (mL/g)	Mobility Class[2]
Benzene	0.88	0.0055	1,780	2.13	97	High
Chloroethane	0.898	0.0093	5,740	1.49	42	Very high
Chloroethene	0.911	0.22	90	0.6	8[3]	-
p-Dichlorobenzene	1.24	0.0031	79	3.56	594	Low
cis-1,2-Dichloroethene	1.284	0.0029	-	-	-	-
Methylbenzene (toluene)	0.87	0.0066	535	2.69	242	Moderate

[1] *Data obtained from Environmental Biotechnology: Principles and Applications* [22]

[2] *Data obtained from Applied hydrogeology 3rd ed.*[10]

[3] *Data obtained from Chloroethenes contaminant in the environment: Still a cause for concern.*[20]

2.3 Source Control Measures

The landfill stopped receiving MSW by October 1998 and was closed with a cohesive cap of 18 inches of soil with a permeability of 1 x 10^{-5} cm/sec, and 18 inches of erosive layer. A passive horizontal gas venting system for methane extraction/collection was installed as part of the transition plan.

2.3.1 MT3D^{96} Modeling

MODFLOW with transport package MT3D^{96} was used to simulate a release. Modeling parameters assumed leakage occurred prior to installation of the cap systems. As with the development of the model in MODFLOW, MT3D^{96} transport was calibrated with a trial and adjustment procedure. The retardation coefficient and dispersion were calibrated in this trial and adjustment procedure. The plume model was calibrated to time periods 2006 and 2007. Target step periods of 5 years (1995), 16 years (2006), 17 years (2007), 25 years (2015), 35 years (2025), and 50 years (2040) were simulated. Included in Appendix C is the estimated extent of plume for the simulated time periods.

2.3.2 Sorption

The sorption (retardation) coefficients (R) used to calculate the expected migration rates for the constituents were calculated based on constituent specific soil water partitioning coefficient (K_d)

$$R = 1 + \frac{\rho_d}{n} K_d$$ [10][page 464]

where

R is the retardation coefficient

ρ_d is dry bulk density of the soil (g/cm^3)

n is the porosity (unit less)

K_d is the distribution coefficient (mL/g)

The dry bulk density was calculated from laboratory dry unit weights collected from MW-7 and MW-8 and was 97.4 pcf (1.56 g/cm^3) and 99.3 pcf (1.59 g/cm^3). The distribution coefficient (K_d) can be estimated as the Soil – Water Partitioning Coefficient K_{oc} times the fraction of organic carbon in the soil. [10] An overly conservative soil organic carbon was estimated to be 1%. "Soils vary in the amount of soil organic carbon they contain, ranging from less than 1 percent in many sandy soils to greater than 20 percent in soils found in wetlands and bogs."[17]

Coefficient of Retardation

Constituent	R
Benzene	4.82
Chloroethane	2.65
Chloroethene	1.32
p-Dichlorobenzene	24.39
cis-1,2-Dichloroethene	-
Methylbenzene	10.53

The transport velocity of the contamination is

$$v_c = \frac{v_x}{R} \text{ [6]}$$

v_c is the velocity of the solute front (ft/yr)

v_x is the average linear velocity (ft/yr)

R is the retardation coefficient

Constituent Velocity

Monitoring Well	MW-4	Time to relevant point of compliance (approx. 125 ft from MW-4)
Benzene	3.46 ft/year	36.1 years
Chloroethane	6.29 ft/year	19.9 years
Chloroethene	12.6 ft/year	9.9 years
p-Dichlorobenzene	0.68 ft/year	183.8 year
Methylbenzene	1.58 ft/year	79.1 years

Linear velocity was obtained from Plate 3.

2.4 Groundwater End Use

Groundwater flow is easterly toward Sandy Run, which appears to be the groundwater discharge feature. There are no known users of groundwater within 2000 feet of the property.

2.5 Exposure Pathways

Evaluation of exposure pathways is designed to establish how a population is at risk of contamination exposure. If there is no method of exposure there is no risk for adverse effects. There are four components that comprise the exposure pathways: (1) source and mechanism of constituent release into the environment,

(2) retention and transport system, (3) exposure point, and (4) route of exposure to receptor at determined exposure point.

(1) Source of release has been identified as the landfill site. Mechanism of the release was the result of water percolating through the waste, thus picking up contamination and encountering the groundwater.
(2) Mechanism for transport of the contamination includes groundwater flow and vapor migration.
(3) Exposure points are the pathways in which contamination can be contacted - water supply wells, surface water, and vapor contact.
(4) Route of exposure is the method of contact at the exposure points – ingestion, inhalation and dermal contact.

Possible exposure pathways are assessed based on completeness, plausibility, and importance in relation to human health and the environment. The pathways for population exposure are limited to ingestion of contaminated groundwater through drinking, ingestion of contaminated groundwater through dermal contact and inhalation of vapors. Source control measures limit direct contact with the contamination.

2.6 Human Health Risk Assessment

Human health was assessed for possible risk factors for contamination associated with the landfill. An evaluation of toxicity levels, presence of carcinogenic vs. non-carcinogenic constituents, as well as lifetime average daily dose calculations were computed for the constituents of concern. The primary purpose of toxicity assessment is to identify susceptible populations and lifestyles.

2.6.1 Carcinogenic

Cancer is caused through a complex series of reactions and processes, that may produce tumors at the point of contact or throughout the body in other tissues once they have been dispersed throughout the system of the host.[5] Various chemicals elicit different responses and different doses of the same chemical can create different responses. The USEPA has five recommended hazard descriptors, “Carcinogenic to humans”, “Likely to be carcinogenic to humans”, “Suggestive evidence of Carcinogenic Potential”, “Inadequate information to assess carcinogenic potential”, “Not likely to be carcinogenic to humans”.[5] For the purpose of this report focus will be placed on the first two descriptors.

The current guidelines approach the situation with the assumption that any exposure to a known carcinogen has a possibility of causing cancer. The EPA’s Integrated Risk Information System (IRIS) was queried to evaluate carcinogenic risks for the constituents of concern, Benzene, Chloroethane, cis-1,2-Dichloroethene, Methylbenzene and p-Dichlorobenzene.[4] Benzene and Chloroethene are considered “carcinogenic to humans.” Chloroethane, cis-1,2-Dichloroethene, Methylbenzene and p-Dichlorobenzene are reported to have

"not undergone a complete evaluation and determination under USEAP's IRIS program for evidence of human carcinogenic potential" or do not have enough information to be classifiable.[4]

Results for Benzene and Chloroethene were compared with the Carcinogenic Slope factor (Sfo or Sfi) found in the section 9 tables from the EPA. Hazard Index values were assessed and are shown on Table 12, Table 13, and Table 14. Carcinogenic hazard index is significantly less than 1 for Oral, Inhalation and Dermal exposure for observed concentration of contamination observed.

2.6.2 Non-Carcinogenic

The non-carcinogenic effects typically require overcoming the body's ability of resistance, therefore, creating a threshold below which effects will not occur. Similarly to carcinogenic effects, constituents may enduce adverse effects based on dose, exposure rate, duration, and individual susceptibility. Also like cancer, they can show up at the point of contact or spread throughout the system affecting tissue sporadically. Most chemicals can produce a range of effects depending on the aforementioned variables.

Human health risk assessment for non-carcinogenic effects was developed by the USEPA based on a series of toxicity studies, to calculate the risk for non-carcinogenic effects. These constituent specific reference dose (RfD) values represent daily exposure levels that are not harmful to human health, over a lifetime. These values for constituents of concern are shown on Table 15 for oral ingestion, Table 16 for inhalation, and Table 17 for dermal exposure.

2.7 Adult Risk

Adults can potentially be exposed to contaminants of concern through consumption of contaminated water, bathing in contaminated water, or inhalation of vapors arising from contaminated groundwater. Risk assessments were performed assuming adults would consume 2 liters of water each day with an exposure duration of 30 years.[*] Dermal exposure risks assumed contact through bathing based on one 15 minute bath per day. Inhalation exposure assumed 20 cubic meters of air per day.[∂] Risk assessment is based on worst case scenario, where exposure is to the maximum observed concentrations and the current concentrations for the contamination of concern.

Chloroethane, cis-1,2-Dichloroethene, Methylbenzene and p-Dichlorobenzene are not listed as having carcinogenic properties. Non-carcinogenic, Lifetime Average Daily Dose (LADD), values were calculated for the constituents of concern and then compared to RfD values by generating hazard index values. If a hazard

[*] Non-Carcinogenic values assume a 30 year exposure. Carcinogenic values assume a 70 year exposure.

[∂] Assumed values based on EPA published values. [5][7][8][9]

index is greater than 1, there may be a concern for remedial action. Hazard index values for adults were shown on Table 15, Table 16, and Table 17, to be less than 1. Risk associated with contact of contamination is considered minimal based on historic and current concentrations and the limited location of contamination to within the facility boundaries.

2.8 Child Risk

Children can potentially be exposed to contaminants of concern through consumption of contaminated water, bathing in contaminated water, or inhalation of vapors arising from contaminated groundwater. Risk assessments were performed assuming children would consume 1 liter of water each day with an exposure duration of 8 years. Dermal exposure risks assumed contact through bathing based on one 15 minute bath per day. Inhalation exposure assumed 12 cubic meters of air per day.[∂] Risk assessment is based on worst case scenario, where exposure is to the maximum observed concentrations and the current concentrations for the contaminants of concern.

Chloroethane, cis-1,2-dichloroethene, methylbenzene and p-dichlorobenzene are not listed as having carcinogenic properties. Non-carcinogenic, LADD, values were calculated and compared to RfD values by generating hazard index values. If a hazard index is greater than 1, there may be a concern for remedial action. Hazard index values for children were shown on Table 15, Table 16, and Table 17 to be less than 1. Risk associated with contact with the contamination is considered minimal, to non-existent, based on historic and current concentrations and the limited location of contamination to within the facility boundaries.

2.9 Sensitivity Receptor Pathways

Current human exposure to the contamination at the site is very minimal or non-existent. Institutional controls, as discussed in Section 3.2, limit access to the site. There are no identified potable groundwater users within 2000 feet of the facility. Contamination is contained on the property and is within the relevant point of compliance. The site can be considered low risk.

3 CORRECTIVE MEASURES SCREENING AND EVALUATION

3.1 Overview

A remediation system needs to be designed that will be both cost effective and efficient in properly cleaning-up the contamination. Contamination of concern is made up of aromatic hydrocarbons, halogenated aliphantics and halogenated aromatics. Aromatic hydrocarbons tend to decompose under aerobic conditions while the halogenated aliphantics and aromatics tend to decompose under anaerobic conditions.[22] Due to the nature of the contamination a single treatment method may be effective.

3.2 Institutional Controls

Several institutional control measures have been implemented to restrict access and control access to the site and possible contact with contamination. Public access to the site is limited during operation hours. A chain link fence runs the length of Landfill Road. Vegetation limits access from other areas. Public water is available to the surrounding area and there are no known users of groundwater within 2000 feet of the facility.

3.3 Infiltration Controls

Prior to becoming a C&D landfill, the MSW sanitary landfill was closed with a cohesive cap of 18 inches of soil with a permeability of 1 x 10^{-5} cm/sec, and 18 inches of erosive layer. A grass vegetative cover has been established on the MSW sanitary landfill which is currently not receiving C&D waste. The vegetative cover acts as both an erosion control measure and aides in the evapotranspiration process to reduce infiltration. "(T)he natural evapotranspiration process of vegetation has been recognized and harnessed as an alternative cover method to reduce landfill infiltration."[19][page 392]

3.4 Landfill Gas Controls

A passive horizontal gas venting system for methane extraction/collection was installed as part of the transition plan.

3.5 Groundwater Technologies

Various methods are available for remediation of contaminated groundwater. These methods include:

- Removal processes that physically remove the contamination or contamination medium.
- Extraction processes that remove the contamination for the impacted medium.
- Destructive processes that chemically or biologically destroy the contaminant.
- Encapsulation processes that prevent the contamination from migrating.

Each type of remediation process has specific advantages and disadvantages. The process should be tailored to meet the site specific requirements. Corrective measures need to be such that compliance is achieved by 250 feet from the waste limit. Monitoring wells MW-7 and MW-8 were installed at the relevant point of compliance. A number of corrective measures will be examined herein. Several common methods were not addressed due to their limitations. Physical removal of the contaminated medium through the measure of pump and treat was not addressed. Pump and treat is limited in that it utilizes water as a carrier and is not affective at totally removing the contamination.[19] Permeable Treatment Barriers, which require groundwater to flow past the barrier, were not addressed due to the low velocity of the groundwater.

3.5.1 Monitored Natural Attenuation

Monitored Natural Attenuation (MNA) consists of monitoring the natural attenuation process to demonstrate that contamination is degrading prior to reaching the relevant point of compliance. While MNA passively treats the contamination, it does not provide containment of contamination, nor does it address the source area of contamination. In addition, MNA is not appropriate as a remediation alternative if there is a threat to human health. Natural Attenuation is achieved through processes of dilution, sorption, volatilization, dispersion and degradation of contamination.

3.5.2 Vapor Extraction System/Bioventing

Vapor Extraction (VE) and Bioventing induce air flow in the subsurface to volatilize the contamination. Vapor Extraction actively treats the contamination medium. This type of remediation more readily addresses contaminated soil and vadose contamination. To adequately strip contamination from the groundwater, the constituents of concern need to be susceptible to volatilization. A low Henry's Constant is favorable. In addition, site soil conditions must be favorable to allow for air flow. Air flow can be limited in clayey soils. Implementation of the system requires pilot testing to adequately engineer an effective system.

3.5.3 Air Sparging

Air Sparging directly volatilized the contamination *in situ* and provides oxygen for biodegradation. Air sparging is performed by forcing air into the groundwater through injection wells. Typically much of the mass removal of contamination occurs within the initial weeks/months of operation with biodegradation becoming more significant during long-term operation. As with VE systems, contamination and site soil conditions need to be favorable for sparging to be an adequate treatment alternative. Contamination of concern needs to readily volatilize and degrade under aerobic conditions. High clay content and tightly packed soils limit the effectiveness of air sparging requiring more air injection wells. The system needs to be finely tuned to achieve break out pressure in wells and control air flow. Implementation of the system requires a pilot testing to adequately engineer an effective system.

3.5.4 Enhanced Bioremediation

Enhanced Bioremediation (EB) is a unique, evolving, *in situ* treatment technology. EB introduces chemical compounds and/or organisms to stimulate and enhance the biodegradation process. The uniqueness of EB is that it can be tailored to the constituent of concern. Typical application is with injection of the chemical into the substrate. Application can use single injection points or permanent injection points.

Typically injected compounds include HRC®, ORC®, emulsified edible oils (soy bean oil, molasses, EOS®), and hydrogen peroxide. As with VE and AS, site conditions need to be favorable for proper application. A

dense formation limits the injection density and may require multiple closely spaced injection points. The life expectancy of compounds is generally less than a year and periodic re-injections may be required to achieve desired results. Implementation of the system requires state regulation permitting prior to injection of chemicals.

3.5.5 Phytoremediation

Phytoremediation is the use of plants to remediate the contamination. Remediation is addressed through rizosphere biodegradation, phytoextraction, phytodegradation and phytostabilization. Rizosphere biodegradation is the microbiological breakdown of organic contamination in the soil. Phytoextraction is the uptake of organics and inorganics into the roots and above ground portions of the plants. Phytodegradation occurs within the plant where the contamination is either degraded within or volitalized from the plant. Phytostabilization immobilizes organic and inorganic contamination through adsorption and accumulation of roots and precipitation in the rhizosphere Direct uptake of the plants is dependent on the relationship of the octanol-water partition coefficent (K_{ow}), where uptake is achieved when the log of K_{ow} ranges from 0.5 to 3.5.[19]

3.5.6 Constructed Wetland

Constructed wetlands have been used for treatment of municipal waste water, industrial waste water, agricultural waste water and stormwaters. While constructed wetlands can be used for treatment of contaminated groundwater water, the groundwater must be shallow or channeled into the wetland. Constructed wetlands passively purify contamination through enhancement of the natural processes of degradation, sorption, and phytoremediation.

4 SUMMARY CONCLUSIONS

4.1 Conclusions – Selection of Remedy

Remediation alternatives are shown in Table 19. A number of factors influenced selection of remediation alternatives.

- Contamination is within the relevant point of compliance.
- There are no potable wells located within 2000 feet of the facility.
- Contamination is below risk exposure levels.
- Contamination is limited to the surficial aquifer.
- Through sorption alone contamination will reach the relevant point of compliance in 10 years. This does not include dilution and volatilization, dispersion or degradation of contamination.

- Contamination is limited to surficial aquifer.
- Modeling shows that contamination is maintained within the relevant point of compliance of the 250 feet from the waste limit.
- Direction of groundwater flow is owned and controlled by Lenoir County.
- Contamination has not reached MW-11 or MW-12 which are located approximately 150 feet from the waste.

Based the above factors, corrective action is not warranted. The most cost effective action would be to return to detection monitoring to assure the relevant point of compliance remains non-impacted.

4.2 Public Meeting

Upon acceptance of the remediation alternative, a public meeting will be conducted to discuss the results of the Assessment of Corrective Measures. Prior to the meeting, the ACM report will be made available for public review.

Respectfully submitted
MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

Madeline Clement
Geoscientist

Ethan J. Caldwell, P.G.
Professional Geologist

NORTH CAROLINA LICENSED SEAL 1931 GEOLOGIST ETHAN J. CALDWELL

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TABLES

Table 1: Well Construction Details

Monitoring Well	Date Installed	Ground Elevation	Datum Elevation	Northing	Easting	Well Diameter	Boring Diameter	Screen Interval (BGS)	Confining Layer	Status
MW-1	11/19/1981	-	-	-	-	2	-	9 - 19	-	Not Sampled
MW-1R	8/26/1994	119.79	121.78	648587.3426	2388246.5017	2	8	3.2 - 18.2	-	Sampling Plan
MW-4	8/26/1994	115.14	117.89	649243.8400	2389067.3100	2	8	9.1 - 24.1	-	Sampling Plan
MW-5	8/28/1994	113.16	115.76	648960.8900	2389109.3900	2	8	14 - 29	-	Sampling Plan
MW-6	8/29/1994	114.54	117.41	648550.1348	2389058.2699	2	8	13.8 - 28.8	-	Sampling Plan
MW-7	6/21/2007	107.75	110.48	649145.8872	2389228.1449	2	8	6.5 - 18.5	-	Sampling Point
MW-8	6/21/2007	108.71	111.36	649291.4753	2389224.0574	2	8	6.98 - 17.98	-	Sampling Point

NOTE:
1. Ground and datum elevation are in units of feet, well and boring diameter are in units of inches.

Table 2: Historical Groundwater Elevation Data

WELL	9/15/1994	11/18/1994	1/12/1995	2/6/1995	9/12/1995	9/15/1995	4/19/1996	3/17/1997	3/3/1998	9/9/1998
MW-1R	115.85	114.88	116.04	116.54	113.91	115.85	116.26	116.89	116.66	117.87
MW-4	97.91	97.05	96.75	97.50	98.06	97.91	103.46	105.43	105.52	101.36
MW-5	97.14	96.01	95.94	96.64	96.63	97.14	101.45	103.53	103.15	99.75
MW-6	108.33	106.53	109.09	110.83	104.32	108.33	111.62	112.61	113.42	111.09
MW-7	-	-	-	-	-	-	-	-	-	-
MW-8	-	-	-	-	-	-	-	-	-	-

WELL	3/25/1999	10/5/1999	3/1/2000	9/21/2000	3/8/2001	9/27/2001	3/27/2002	9/19/2002	3/19/2003	9/11/2003
MW-1R	116.84	117.00	116.53	116.87	116.96	116.09	117.91	116.28	117.87	116.37
MW-4	104.66	105.27	105.31	99.85	101.25	98.22	98.85	96.45	103.65	103.35
MW-5	101.62	101.60	102.29	98.61	99.25	97.05	97.45	95.06	100.49	100.73
MW-6	112.85	112.51	112.66	111.21	112.95	108.86	112.49	108.01	113.62	110.44
MW-7	-	-	-	-	-	-	-	-	-	-
MW-8	-	-	-	-	-	-	-	-	-	-

WELL	3/18/2004	9/30/2004	3/29/2005	9/29/2005	3/3/2006	9/21/2006	3/19/2007	5/24/2007	6/22/2007
MW-1R	116.37	116.25	117.61	115.61	116.65	117.20	116.78	116.17	-
MW-4	104.30	99.19	104.09	91.73	104.32	104.62	104.56	102.11	-
MW-5	101.76	98.23	100.56	87.42	101.12	101.09	101.76	99.26	-
MW-6	112.56	110.84	113.37	107.16	113.01	111.85	112.74	112.10	-
MW-7	-	-	-	-	-	-	-	-	98.60
MW-8	-	-	-	-	-	-	-	-	101.26

WELL	Observed High	Observed Low	Difference	Average
MW-1R	117.91	113.91	4.00	116.50
MW-4	105.52	91.73	13.79	101.17
MW-5	103.53	87.42	16.11	99.03
MW-6	113.62	104.32	9.30	110.91
MW-7	-	-	-	-
MW-8	-	-	-	-

Table 3: Slug Test Summary

Well	Screen Interval (BGS)	Initial DTW (BTOP)	Initial Head Change	K (cm/sec)	Lithology
MW-1R*	3.2 - 18.2	7.47	7.47	1.20E-04	Silty Clay/Sandy Clay
MW-4*	9.1 - 24.1	20.22	16.22	1.10E-04	Sandy Clay/Silty Clay
MW-5*	14 - 29	19.30	18.30	1.40E-04	Sandy Clay
MW-6*	13.8 - 28.8	9.99	8.99	1.90E-04	Sandy Clay
MW-7	6.5 - 18.5	11.88	5.93	1.98E-04	Clay
MW-8	6.98 - 17.98	10.10	3.63	1.14E-03	Sandy Clay

Summary Statistics			
Mean	3.16E-04	Maximum	1.14E-03
Median	1.65E-04	Minimum	1.10E-04
Standard Deviation	4.05E-04	Count	6

*Information for MW-1R, MW-4, MW-5, MW-6 obtained from Greene County Water Quality Monitoring System Modifications (1994)

Table 4: Summary of Geologic Properties

Well	Lithology	Specific Gravity	Dry Density	Total Porosity (%)	Effective Porosity (%)
MW-1R*	Silty Clay/Sandy Clay	-	-	36.7	15
MW-4*	Sandy Clay/Silty Clay	-	-	40.0	15
MW-5*	Sandy Clay	-	-	37.2	15
MW-6*	Sandy Clay	-	-	43.2	15
MW-7	Clay	2.71	97.4	42.4	7
MW-8	Sandy Clay	2.69	99.3	40.8	7

*Information for MW-1R, MW-4, MW-5, MW-6 obtained from Greene County Water Quality Monitoring System Modifications (1994)

Table 5: Summary of Field Parameters

	Name	9/15/1994	11/18/1994	1/12/1995	2/6/1995	9/12/1995	9/15/1995	4/19/1996	3/17/1997	3/3/1998	9/9/1998	3/25/1999
MW-1R	pH	5.1	4.7	4.6	4.9	4.8	5.1	6.5	5	4.3	4.7	4.7
	Temperature	25	19	14	10	24	25	13	14	13	22	13
	Conductivity	68	70	5.74	92	57	68	110	120	100	100	110
MW-4	pH	5.8	4.3	4.4	4.5	4.6	5.8	5.1	7.3	5.4	4.8	4.7
	Temperature	18	18	17	15	19	18	15	15	15	17	16
	Conductivity	43	52	55	59	68	43	85	79	100	58	53
MW-5	pH	6.5	4.4	4.4	4.7	4.7	6.5	5	6.4	5.4	4.55	4.6
	Temperature	19	17	17	16	19	19	15	15	15	17	16
	Conductivity	32	36	38	39	34	32	48	54	44	46	52
MW-6	pH	7.5	5.2	5	5.2	5.2	7.5	5	5.9	5.4	5.2	4.7
	Temperature	22	19	16	12	19	22	14	15	15	18	15
	Conductivity	54	73	59	56	60	54	39	56	44	47	43
UP	pH	-	-	5.5	5.4	-	-	5.1	5.8	5.9	5.4	6
	Temperature	-	-	10	4	-	-	16	11	7	21	14
	Conductivity	-	-	62	82	-	-	77	88	95	38	80
DOWN	pH	-	-	5.2	5.4	-	-	4.5	5.8	5.6	5.6	6.8
	Temperature	-	-	12	4	-	-	14	10	9	21	14
	Conductivity	-	-	74	75	-	-	57	87	120	130	320

	Name	10/5/1999	3/1/2000	9/21/2000	3/8/2001	9/27/2001	3/27/2002	9/19/2002	3/19/2003	9/11/2003	3/18/2004	9/30/2004
MW-1R	pH	4.7	4.6	4.3	4.4	4.1	4.3	4.6	4.4	4.8	4.5	4.2
	Temperature	21	13	22	13	23	15	23	13	23	15	22
	Conductivity	82	100	100	110	120	100	135	557	257	68	513
MW-4	pH	4.6	5.3	4.2	4.2	3.9	4	4.8	5.3	5.5	5.5	4.3
	Temperature	18	16	20	16	18	17	23	16	19	16	19
	Conductivity	54	56	40	38	50	44	50	78	92	81	64
MW-5	pH	4.7	4.6	4.3	4.3	4.1	4.4	4.9	5.2	4.8	5.5	5
	Temperature	19	17	22	16	19	17	22	15	19	16	19
	Conductivity	48	39	40	42	48	46	49	132	167	132	66
MW-6	pH	5	4.8	4.6	4.8	4.4	4.4	5.3	5.1	5	4.9	4.8
	Temperature	20	15	21	14	19	16	22	15	20	15	21
	Conductivity	41	28	38	36	40	31	46	52	49	74	43
UP	pH	6	5.7	5	5.6	-	5.8	-	6.1	6	6.5	-
	Temperature	19	13	23	9	-	16	-	13	20	12	-
	Conductivity	110	76	37	85	-	75	-	96	70	128	-
DOWN	pH	6.4	6.2	5.3	5.7	-	5.6	6.3	6.4	6.8	6.4	5.8
	Temperature	18	12	22	7	-	15	25	13	19	10	21
	Conductivity	240	260	82	130	-	82	172	199	647	175	169

Table 5: Summary of Field Parameters

	Name	3/29/2005	9/29/2005	3/3/2006	9/21/2006	3/19/2007
MW-1R	pH	4.2	4	4.5	4.4	4.6
	Temperature	14	24	14	24	14
	Conductivity	944	560	598	484	488
MW-4	pH	4.9	5.3	5.2	5.4	5.4
	Temperature	16	20	18	21	16
	Conductivity	97	93	137	260	194
MW-5	pH	4.9	5	5.2	5.2	5.5
	Temperature	17	21	18	20	16
	Conductivity	77	64	155	131	150
MW-6	pH	4.9	4.9	5.1	5	5.4
	Temperature	15	22	15	20	13
	Conductivity	43	48	43	46	49
UP	pH	6	-	5.9	5.8	6.4
	Temperature	12	-	11	17	13
	Conductivity	106	-	110	82	255
DOWN	pH	6.4	6.3	5.8	6.2	6
	Temperature	13	23	12	19	9
	Conductivity	181	159	210	269	106

Table 6: Historical Inorganic Groundwater Results

Well ID	Parameter Name [1]	Sample Date	Result	Unit	PQL [2]	NCGW2L [3]	Exceedance
MW-1R	Antimony	09/15/1997	0.03	mg/l	0.03		
MW-1R	Barium, total	03/19/2007	152	ug/l	100	2000	
MW-1R	Barium, total	05/24/2007	172	ug/l	0.2	2000	
MW-4	Barium, total	04/19/1996	0.896	mg/l	0.5	2	
MW-4	Barium, total	03/17/1997	0.588	mg/l	0.5	2	
MW-4	Barium, total	09/19/2002	0.678	mg/l	0.5	2	
MW-4	Barium, total	05/24/2007	52.2	ug/l	0.2	2000	
MW-6	Barium, total	03/17/1997	0.683	mg/l	0.5	2	
MW-6	Barium, total	03/03/1998	0.638	mg/l	0.5	2	
MW-6	Barium, total	09/09/1998	0.539	mg/l	0.5	2	
MW-7	Barium, total	06/22/2007	0.0427	mg/l	0.001	2	
MW-8	Barium, total	06/22/2007	0.0332	mg/l	0.001	2	
MW-4	Beryllium, total	03/17/1997	0.009	mg/l	0.002		
MW-4	Beryllium, total	03/03/1998	0.0077	mg/l	0.002		
MW-4	Beryllium, total	09/09/1998	0.0032	mg/l	0.002		
MW-4	Beryllium, total	10/05/1999	0.003	mg/l	0.002		
MW-4	Beryllium, total	09/19/2002	0.005	mg/l	0.002		
MW-4	Beryllium, total	03/29/2005	0.004	mg/l	0.002		
MW-5	Beryllium, total	04/19/1996	0.007	mg/l	0.002		
MW-5	Beryllium, total	03/17/1997	0.004	mg/l	0.002		
MW-5	Beryllium, total	03/03/1998	0.0023	mg/l	0.002		
MW-6	Beryllium, total	09/12/1995	0.002	mg/l	0.002		
MW-6	Beryllium, total	03/17/1997	0.011	mg/l	0.002		
MW-6	Beryllium, total	03/03/1998	0.0124	mg/l	0.002		
MW-6	Beryllium, total	09/09/1998	0.0084	mg/l	0.002		
MW-6	Beryllium, total	10/05/1999	0.002	mg/l	0.002		
MW-1R	Cadmium, total	03/25/1999	0.001	mg/l	0.001	0.0018	
MW-4	Cadmium, total	03/25/1999	0.001	mg/l	0.001	0.0018	
MW-4	Cadmium, total	03/29/2005	0.001	mg/l	0.001	0.0018	
MW-6	Cadmium, total	03/25/1999	0.001	mg/l	0.001	0.0018	
MW-6	**Cadmium, total**	**09/19/2002**	**0.005**	**mg/l**	**0.001**	**0.0018**	**0.0033**
MW-1R	Chromium, total	09/15/1994	0.026	mg/l	0.01	0.05	
MW-1R	Chromium, total	11/18/1994	0.04	mg/l	0.01	0.05	
MW-1R	Chromium, total	02/06/1995	0.01	mg/l	0.01	0.05	
MW-1R	Chromium, total	09/12/1995	0.016	mg/l	0.01	0.05	
MW-1R	Chromium, total	03/17/1997	0.011	mg/l	0.01	0.05	
MW-1R	Chromium, total	03/03/1998	0.039	mg/l	0.01	0.05	
MW-1R	Chromium, total	09/09/1998	0.022	mg/l	0.01	0.05	
MW-1R	Chromium, total	03/25/1999	0.017	mg/l	0.01	0.05	
MW-1R	Chromium, total	10/05/1999	0.036	mg/l	0.01	0.05	
MW-1R	Chromium, total	03/01/2000	0.039	mg/l	0.01	0.05	
MW-1R	Chromium, total	09/21/2000	0.034	mg/l	0.01	0.05	
MW-1R	Chromium, total	03/27/2002	0.016	mg/l	0.01	0.05	
MW-1R	Chromium, total	09/19/2002	0.033	mg/l	0.01	0.05	
MW-4	Chromium, total	11/18/1994	0.015	mg/l	0.01	0.05	
MW-4	Chromium, total	04/19/1996	0.027	mg/l	0.01	0.05	
MW-4	Chromium, total	03/17/1997	0.019	mg/l	0.01	0.05	
MW-4	Chromium, total	03/03/1998	0.028	mg/l	0.01	0.05	
MW-4	Chromium, total	09/09/1998	0.011	mg/l	0.01	0.05	
MW-4	Chromium, total	03/25/1999	0.011	mg/l	0.01	0.05	

Table 6: Historical Inorganic Groundwater Results

Well ID	Parameter Name [1]	Sample Date	Result	Unit	PQL [2]	NCGW2L [3]	Exceedance
MW-4	**Chromium, total**	**10/05/1999**	**0.057**	**mg/l**	**0.01**	**0.05**	**0.007**
MW-4	Chromium, total	03/08/2001	0.013	mg/l	0.01	0.05	
MW-4	**Chromium, total**	**09/27/2001**	**0.052**	**mg/l**	**0.01**	**0.05**	**0.002**
MW-4	Chromium, total	03/27/2002	0.028	mg/l	0.01	0.05	
MW-4	**Chromium, total**	**09/19/2002**	**0.136**	**mg/l**	**0.01**	**0.05**	**0.086**
MW-4	Chromium, total	03/19/2003	0.028	mg/l	0.01	0.05	
MW-4	Chromium, total	09/11/2003	0.021	mg/l	0.01	0.05	
MW-4	Chromium, total	03/18/2004	0.022	mg/l	0.01	0.05	
MW-5	Chromium, total	02/06/1995	0.013	mg/l	0.01	0.05	
MW-5	Chromium, total	04/19/1996	0.01	mg/l	0.01	0.05	
MW-5	Chromium, total	03/17/1997	0.029	mg/l	0.01	0.05	
MW-5	Chromium, total	03/03/1998	0.021	mg/l	0.01	0.05	
MW-5	Chromium, total	03/01/2000	0.023	mg/l	0.01	0.05	
MW-5	Chromium, total	09/21/2000	0.021	mg/l	0.01	0.05	
MW-5	Chromium, total	03/08/2001	0.014	mg/l	0.01	0.05	
MW-5	Chromium, total	09/19/2002	0.015	mg/l	0.01	0.05	
MW-5	Chromium, total	03/19/2003	0.021	mg/l	0.01	0.05	
MW-6	Chromium, total	09/15/1994	0.013	mg/l	0.01	0.05	
MW-6	Chromium, total	11/18/1994	0.032	mg/l	0.01	0.05	
MW-6	Chromium, total	01/12/1995	0.01	mg/l	0.01	0.05	
MW-6	Chromium, total	09/12/1995	0.02	mg/l	0.01	0.05	
MW-6	Chromium, total	04/19/1996	0.013	mg/l	0.01	0.05	
MW-6	Chromium, total	03/17/1997	0.039	mg/l	0.01	0.05	
MW-6	Chromium, total	09/15/1997	0.022	mg/l	0.01	0.05	
MW-6	Chromium, total	03/03/1998	0.041	mg/l	0.01	0.05	
MW-6	Chromium, total	09/09/1998	0.05	mg/l	0.01	0.05	
MW-6	Chromium, total	03/25/1999	0.028	mg/l	0.01	0.05	
MW-6	**Chromium, total**	**10/05/1999**	**0.074**	**mg/l**	**0.01**	**0.05**	**0.024**
MW-6	Chromium, total	03/01/2000	0.013	mg/l	0.01	0.05	
MW-6	Chromium, total	09/21/2000	0.014	mg/l	0.01	0.05	
MW-6	Chromium, total	03/08/2001	0.046	mg/l	0.01	0.05	
MW-6	Chromium, total	09/27/2001	0.033	mg/l	0.01	0.05	
MW-6	Chromium, total	03/27/2002	0.026	mg/l	0.01	0.05	
MW-6	**Chromium, total**	**09/19/2002**	**0.065**	**mg/l**	**0.01**	**0.05**	**0.015**
MW-6	**Chromium, total**	**03/19/2003**	**0.056**	**mg/l**	**0.01**	**0.05**	**0.006**
MW-6	Chromium, total	09/11/2003	0.015	mg/l	0.01	0.05	
MW-6	**Chromium, total**	**03/18/2004**	**0.115**	**mg/l**	**0.01**	**0.05**	**0.065**
MW-6	Chromium, total	09/30/2004	0.013	mg/l	0.01	0.05	
MW-6	Chromium, total	03/03/2006	0.013	mg/l	0.01	0.05	
MW-6	Chromium, total	09/21/2006	0.015	mg/l	0.01	0.05	
MW-1R	Cobalt, total	09/11/2003	0.011	mg/l	0.01		
MW-4	Cobalt, total	09/19/2002	0.012	mg/l	0.01		
MW-6	Cobalt, total	03/03/1998	0.011	mg/l	0.01		
MW-7	Copper	06/22/2007	0.0018	mg/l	0.0018	1	
MW-1R	Iron, total	03/19/2007	80	ug/l	50	300	
MW-4	**Iron, total**	**03/19/2007**	**29050**	**ug/l**	**50**	**300**	**28750**
MW-5	**Iron, total**	**03/19/2007**	**29725**	**ug/l**	**50**	**300**	**29425**
MW-6	**Iron, total**	**03/19/2007**	**1221**	**ug/l**	**50**	**300**	**921**
MW-1R	Lead, total	09/15/1994	0.015	mg/l	0.01	0.015	
MW-1R	**Lead, total**	**11/18/1994**	**0.032**	**mg/l**	**0.01**	**0.015**	**0.017**

Table 6: Historical Inorganic Groundwater Results

Well ID	Parameter Name [1]	Sample Date	Result	Unit	PQL [2]	NCGW2L [3]	Exceedance
MW-1R	**Lead, total**	**03/03/1998**	**0.026**	**mg/l**	**0.01**	**0.015**	**0.011**
MW-1R	Lead, total	09/09/1998	0.015	mg/l	0.01	0.015	
MW-1R	Lead, total	10/05/1999	0.011	mg/l	0.01	0.015	
MW-1R	Lead, total	03/27/2002	0.013	mg/l	0.01	0.015	
MW-1R	Lead, total	09/19/2002	0.012	mg/l	0.01	0.015	
MW-1R	Lead, total	09/29/2005	0.014	mg/l	0.01	0.015	
MW-1R	Lead, total	05/24/2007	3.1	ug/l	2	15	
MW-4	**Lead, total**	**11/18/1994**	**0.023**	**mg/l**	**0.01**	**0.015**	**0.008**
MW-4	Lead, total	01/12/1995	0.01	mg/l	0.01	0.015	
MW-4	**Lead, total**	**09/12/1995**	**0.016**	**mg/l**	**0.01**	**0.015**	**0.001**
MW-4	**Lead, total**	**04/19/1996**	**0.149**	**mg/l**	**0.01**	**0.015**	**0.134**
MW-4	**Lead, total**	**03/17/1997**	**0.083**	**mg/l**	**0.01**	**0.015**	**0.068**
MW-4	**Lead, total**	**09/15/1997**	**0.025**	**mg/l**	**0.01**	**0.015**	**0.01**
MW-4	**Lead, total**	**03/03/1998**	**0.062**	**mg/l**	**0.01**	**0.015**	**0.047**
MW-4	**Lead, total**	**09/09/1998**	**0.021**	**mg/l**	**0.01**	**0.015**	**0.006**
MW-4	Lead, total	03/25/1999	0.012	mg/l	0.01	0.015	
MW-4	**Lead, total**	**10/05/1999**	**0.049**	**mg/l**	**0.01**	**0.015**	**0.034**
MW-4	**Lead, total**	**09/27/2001**	**0.033**	**mg/l**	**0.01**	**0.015**	**0.018**
MW-4	**Lead, total**	**03/27/2002**	**0.027**	**mg/l**	**0.01**	**0.015**	**0.012**
MW-4	**Lead, total**	**09/19/2002**	**0.096**	**mg/l**	**0.01**	**0.015**	**0.081**
MW-4	**Lead, total**	**03/19/2003**	**0.032**	**mg/l**	**0.01**	**0.015**	**0.017**
MW-4	**Lead, total**	**09/11/2003**	**0.018**	**mg/l**	**0.01**	**0.015**	**0.003**
MW-4	**Lead, total**	**03/18/2004**	**0.03**	**mg/l**	**0.01**	**0.015**	**0.015**
MW-4	Lead, total	09/30/2004	0.012	mg/l	0.01	0.015	
MW-4	**Lead, total**	**03/29/2005**	**0.048**	**mg/l**	**0.01**	**0.015**	**0.033**
MW-4	**Lead, total**	**09/29/2005**	**0.026**	**mg/l**	**0.01**	**0.015**	**0.011**
MW-5	Lead, total	02/06/1995	0.01	mg/l	0.01	0.015	
MW-5	Lead, total	04/19/1996	0.014	mg/l	0.01	0.015	
MW-5	**Lead, total**	**03/17/1997**	**0.054**	**mg/l**	**0.01**	**0.015**	**0.039**
MW-5	**Lead, total**	**03/03/1998**	**0.028**	**mg/l**	**0.01**	**0.015**	**0.013**
MW-5	**Lead, total**	**03/01/2000**	**0.016**	**mg/l**	**0.01**	**0.015**	**0.001**
MW-5	Lead, total	03/27/2002	0.011	mg/l	0.01	0.015	
MW-5	Lead, total	09/19/2002	0.012	mg/l	0.01	0.015	
MW-5	**Lead, total**	**03/19/2003**	**0.027**	**mg/l**	**0.01**	**0.015**	**0.012**
MW-5	Lead, total	09/29/2005	0.012	mg/l	0.01	0.015	
MW-6	Lead, total	09/15/1994	0.014	mg/l	0.01	0.015	
MW-6	**Lead, total**	**11/18/1994**	**0.017**	**mg/l**	**0.01**	**0.015**	**0.002**
MW-6	**Lead, total**	**09/12/1995**	**0.02**	**mg/l**	**0.01**	**0.015**	**0.005**
MW-6	Lead, total	04/19/1996	0.014	mg/l	0.01	0.015	
MW-6	**Lead, total**	**03/17/1997**	**0.101**	**mg/l**	**0.01**	**0.015**	**0.086**
MW-6	Lead, total	09/15/1997	0.015	mg/l	0.01	0.015	
MW-6	**Lead, total**	**03/03/1998**	**0.081**	**mg/l**	**0.01**	**0.015**	**0.066**
MW-6	**Lead, total**	**09/09/1998**	**0.075**	**mg/l**	**0.01**	**0.015**	**0.06**
MW-6	**Lead, total**	**10/05/1999**	**0.03**	**mg/l**	**0.01**	**0.015**	**0.015**
MW-6	**Lead, total**	**03/27/2002**	**0.016**	**mg/l**	**0.01**	**0.015**	**0.001**
MW-6	**Lead, total**	**09/19/2002**	**0.03**	**mg/l**	**0.01**	**0.015**	**0.015**
MW-6	**Lead, total**	**03/19/2003**	**0.023**	**mg/l**	**0.01**	**0.015**	**0.008**
MW-6	**Lead, total**	**03/18/2004**	**0.028**	**mg/l**	**0.01**	**0.015**	**0.013**
MW-6	Lead, total	03/03/2006	0.013	mg/l	0.01	0.015	
MW-6	**Lead, total**	**09/21/2006**	**0.03**	**mg/l**	**0.01**	**0.015**	**0.015**

Table 6: Historical Inorganic Groundwater Results

Well ID	Parameter Name [1]	Sample Date	Result	Unit	PQL [2]	NCGW2L [3]	Exceedance
MW-1R	Manganese	03/19/2007	37	ug/l	10	50	
MW-4	**Manganese**	**03/19/2007**	**105**	**ug/l**	**10**	**50**	**55**
MW-5	Manganese	03/19/2007	18	ug/l	10	50	
MW-6	Manganese	03/19/2007	10	ug/l	10	50	
MW-1R	Nickel, total	11/18/1994	0.067	mg/l	0.05	0.1	
MW-1R	Nickel, total	05/24/2007	2	ug/l	2	100	
MW-5	Nickel, total	09/21/2000	0.067	mg/l	0.05	0.1	
MW-1R	Thallium	05/24/2007	0.193	ug/l	0.044		
MW-4	Thallium	05/24/2007	0.057	ug/l	0.044		
MW-8	Thallium	06/22/2007	0.046	ug/l	0.044		
MW-1R	Vanadium	03/03/1998	0.057	mg/l	0.04		
MW-1R	Vanadium	09/09/1998	0.069	mg/l	0.04		
MW-1R	Vanadium	10/05/1999	0.047	mg/l	0.04		
MW-1R	Vanadium	03/01/2000	0.055	mg/l	0.04		
MW-1R	Vanadium	09/19/2002	0.043	mg/l	0.04		
MW-1R	Vanadium	05/24/2007	3	ug/l	1		
MW-4	Vanadium	03/03/1998	0.079	mg/l	0.04		
MW-4	Vanadium	10/05/1999	0.119	mg/l	0.04		
MW-4	Vanadium	09/27/2001	0.092	mg/l	0.04		
MW-4	Vanadium	03/27/2002	0.054	mg/l	0.04		
MW-4	Vanadium	09/19/2002	0.239	mg/l	0.04		
MW-4	Vanadium	03/19/2003	0.065	mg/l	0.04		
MW-5	Vanadium	03/17/1997	0.046	mg/l	0.04		
MW-5	Vanadium	03/01/2000	0.046	mg/l	0.04		
MW-5	Vanadium	03/19/2003	0.047	mg/l	0.04		
MW-6	Vanadium	03/17/1997	0.059	mg/l	0.04		
MW-6	Vanadium	03/03/1998	0.044	mg/l	0.04		
MW-6	Vanadium	09/09/1998	0.165	mg/l	0.04		
MW-6	Vanadium	10/05/1999	0.086	mg/l	0.04		
MW-6	Vanadium	03/08/2001	0.056	mg/l	0.04		
MW-6	Vanadium	09/19/2002	0.073	mg/l	0.04		
MW-6	Vanadium	03/19/2003	0.074	mg/l	0.04		
MW-6	Vanadium	03/18/2004	0.136	mg/l	0.04		
MW-8	Vanadium	06/22/2007	0.0017	mg/l	0.0017		
MW-1R	Zinc	09/15/1994	0.053	mg/l	0.05	1.05	
MW-1R	Zinc	11/18/1994	0.103	mg/l	0.05	1.05	
MW-1R	Zinc	03/03/1998	0.067	mg/l	0.05	1.05	
MW-1R	Zinc	05/24/2007	23	ug/l	1	1050	
MW-4	Zinc	04/19/1996	0.238	mg/l	0.05	1.05	
MW-4	Zinc	03/17/1997	0.079	mg/l	0.05	1.05	
MW-4	Zinc	09/15/1997	0.079	mg/l	0.05	1.05	
MW-4	Zinc	03/03/1998	0.081	mg/l	0.05	1.05	
MW-4	Zinc	10/05/1999	0.078	mg/l	0.05	1.05	
MW-4	Zinc	09/27/2001	0.056	mg/l	0.05	1.05	
MW-4	Zinc	09/19/2002	0.142	mg/l	0.05	1.05	
MW-4	Zinc	03/29/2005	0.092	mg/l	0.05	1.05	
MW-4	Zinc	09/29/2005	0.085	mg/l	0.05	1.05	
MW-4	Zinc	05/24/2007	3.6	ug/l	1	1050	
MW-6	Zinc	03/17/1997	0.161	mg/l	0.05	1.05	
MW-6	Zinc	03/03/1998	0.191	mg/l	0.05	1.05	

Table 6: Historical Inorganic Groundwater Results

Well ID	Parameter Name [1]	Sample Date	Result	Unit	PQL [2]	NCGW2L [3]	Exceedance
MW-6	Zinc	09/09/1998	0.178	mg/l	0.05	1.05	
MW-6	Zinc	10/05/1999	0.103	mg/l	0.05	1.05	
MW-6	Zinc	09/19/2002	0.076	mg/l	0.05	1.05	
MW-6	Zinc	03/18/2004	0.081	mg/l	0.05	1.05	
MW-7	Zinc	06/22/2007	0.001	mg/l	0.001	1.05	
MW-8	Zinc	06/22/2007	0.001	mg/l	0.001	1.05	

[1] Table only contains detected constituents.

[2] PQL = Practical Quantitation Limit

[3] NCGW2L = North Carolina Ground Water 2L Standard

Table 7: Historical Inorganic Surface Water Results

Well ID	Parameter Name [1]	Sample Date	Result	Unit	PQL [2]	SWSTD [3]	Exceedance
Downstream	Cadmium, total	03/27/2002	0.001	mg/l	0.001	0.002	
Upstream	Cadmium, total	03/19/2003	0.002	mg/l	0.001	0.002	
Upstream	**Cadmium, total**	**03/18/2004**	**0.003**	**mg/l**	**0.001**	**0.002**	**0.001**
Downstream	Chromium, total	09/19/2002	0.026	mg/l	0.01	0.05	
Downstream	Lead, total	09/19/2002	0.021	mg/l	0.01	0.025	
Downstream	Vanadium	09/19/2002	0.043	mg/l	0.04		
Downstream	**Zinc**	**09/19/2002**	**0.07**	**mg/l**	**0.05**	**0.05**	**0.02**
Downstream	Zinc	03/18/2004	0.021	mg/l	0.05	0.05	
Upstream	Zinc	03/18/2004	0.032	mg/l	0.05	0.05	
Upstream	**Zinc**	**03/29/2005**	**0.062**	**mg/l**	**0.05**	**0.05**	**0.012**

[1] Table only contains detected constituents.

[2] PQL = Practical Quantitation Limit

[3] SWSTD = North Carolina Surface Water Standard Class C or Class IV as applicable

Table 8: Statistically Significant Inorganics

Sampling Event	Well	Statistically Significant Constituents				
Mar-04	MW-6	Chromium				
Mar-03	MW-3	Chromium		Vanadium		
Sep-02	MW-4	Barium	Chromium	Lead	Vanadium	Zinc
	MW-6	Chromium		Vanadium		
Sep-01	MW-4	Chromium	Lead	Vanadium		
Oct-99	MW-4	Chromium		Vanadium		
	MW-6	Lead		Vanadium		

Table 9: Historical Organic Groundwater Results

Well ID	Parameter Name [1]	Sample Date	Result	Unit	PQL [2]	NCGW2L [3]	Exceedance
MW-4	1,1-Dichloroethane	05/24/2007	2	ug/l	0.09	70	
MW-4	**Benzene**	**03/19/2007**	**3.9**	**ug/l**	**3**	**1**	**2.9**
MW-1R	Carbon disulfide	05/24/2007	1.8	ug/l	0.12		
MW-4	Chloroethane	09/21/2006	20.1	ug/l	10		
MW-4	Chloroethane	03/19/2007	12.5	ug/l	5		
MW-4	Chloroethane	05/24/2007	9.5	ug/l	0.4		
MW-4	**Chloroethene**	**03/19/2007**	**5.5**	**ug/l**	**5**	**0.015**	**5.485**
MW-4	**Chloroethene**	**05/24/2007**	**2.6**	**ug/l**	**0.15**	**0.015**	**2.585**
MW-4	cis-1,2-Dichloroethylene	03/29/2005	9.4	ug/l	5	70	
MW-4	cis-1,2-Dichloroethylene	03/03/2006	10.8	ug/l	5	70	
MW-4	cis-1,2-Dichloroethylene	09/21/2006	14.3	ug/l	5	70	
MW-4	cis-1,2-Dichloroethylene	05/24/2007	10	ug/l	0.14	70	
MW-4	Ethylbenzene	05/24/2007	0.43	ug/l	0.17	550	
MW-4	Methylbenzene	09/29/2005	10.4	ug/l	5	1000	
MW-4	Methylbenzene	05/24/2007	1.1	ug/l	0.15	1000	
MW-4	**p-Dichlorobenzene**	**03/19/2007**	**3.4**	**ug/l**	**3**	**1.4**	**2**
MW-4	**p-Dichlorobenzene**	**05/24/2007**	**2.4**	**ug/l**	**0.15**	**1.4**	**1**
MW-4	Xylenes	05/24/2007	0.3	ug/l	0.21	530	

[1] Table only contains detected constituents.
[2] PQL = Practical Quantitation Limit
[3] NCGW2L = North Carolina Ground Water 2L Standard

Table 10: Statistically Significant Organics

Sampling Event	Well	Statistically Significant Constituents			
May-07	MW-4	1,4 dichlorobenzene	cis-1,2-dichloroethene	methylbenzene	chloroethene
Mar-07	MW-4	1,4 dichlorobenzene	benzene	chloroethane	chloroethene
Sep-06	MW-4	cis-1,2 dichloroethene		chloroethane	
Mar-06	MW-4	cis-1,2 dichloroethene			
Sep-05	MW-4	methylbenzene			
Mar-05	MW-4	cis-1,2 dichloroethene			

Table 11: Current Groundwater Sampling Results

Well ID	Parameter Name [1]	Sample Date	Result	Unit	PQL [2]	NCGW2L [3]	Exceedance
MW-1R	Carbon disulfide	05/24/2007	1.8	ug/l	0.12		
MW-4	Chloroethane	05/24/2007	9.5	ug/l	0.4		
MW-4	**Chloroethene**	**05/24/2007**	**2.6**	**ug/l**	**0.15**	**0.015**	**2.585**
MW-4	1,1-Dichloroethane	05/24/2007	2	ug/l	0.09	70	
MW-4	Ethylbenzene	05/24/2007	0.43	ug/l	0.17	550	
MW-4	**p-Dichlorobenzene**	**05/24/2007**	**2.4**	**ug/l**	**0.15**	**1.4**	**1**
MW-4	Methylbenzene	05/24/2007	1.1	ug/l	0.15	1000	
MW-4	Xylenes	05/24/2007	0.3	ug/l	0.21	530	
MW-4	cis-1,2-Dichloroethylene	05/24/2007	10	ug/l	0.14	70	

[1] Table only contains detected constituents.

[2] PQL = Practical Quantitation Limit

[3] NCGW2L = North Carolina Ground Water 2L Standard

Table 12: Carcinogenic Toxicity Values from Oral Ingestion Exposure

Contaminant	Well	Reference Dose	Maximum Concentration (ug/L)	LADD Maximum		Concentration 3/19/2007 (ug/L)	LADD 2007		HI Risk Maximum		HI Risk 2007	
		Oral Sfo (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)	Adult	Child	Adult	Child
Benzene	MW-4	55	3.9	0.05	0.02	3.9	0.05	0.02	8.68E-04	2.87E-04	8.68E-04	2.87E-04
Vinyl Chloride	MW-4	150	5.5	0.07	0.02	2.6	0.03	0.01	4.49E-04	1.49E-04	2.12E-04	7.02E-05

NOTE:
1. LADD is lifetime average daily dose from ingested groundwater at the specified concentration.
2. Sfo values taken from the Region 9 Risk Based Concentration Table. These values represent a carcinogenic slope factor.
3. During 2007 sampling "-" designates none of this constituent was detected.
4. HI is the Hazard Index Risk = LADD/RfD
5. Formula used for calculations:

LADD = (C*IR*ED)/(BW*AT)

C = Constituent Concentration (ug/L)

IR = Ingestion Rate (L/day)	An ingestion rate of 2L/day was used for adults 1L/day for children
ED = Exposure Duration (days)	An exposure duration of 30 years was used for adults, 8 for children
BW = Body Weight (kg)	An average weight of 70 kg was used for adults, 28.2 kg for children
AT = Average Time (days)	A time of 70 years for adults and children was used

Table 13: Carcinogenic Toxicity Values for Inhalation Exposure

Contaminant	Well	Reference Dose	Maximum Concentration (ug/L)	LADD Maximum		Concentration 2007 (ug/L)	LADD 2007		HI Risk Maximum		HI Risk 2007	
		Inhalation Sfi (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)	Adult	Child	Adult	Child
Benzene	MW-4	27	3.9	0.24	0.09	3.9	0.24	0.95	8.84E-03	3.51E-03	8.84E-03	3.52E-02
Vinyl Chloride	MW-4	1500	5.5	0.34	0.13	2.6	0.16	0.63	2.24E-04	8.92E-05	1.06E-04	4.22E-04

NOTE:
1. LADD is lifetime average daily dose from inhaled at the specified concentration.
2. Sfi values taken from the Region 9 Risk Based Concentration Table. These values represent a cancer slope factor.
3. During 2007 sampling "-" designates none of this constituent was detected.
4. HI is the Hazard Index Risk = LADD/RfD
5. Formula used for calculations:

LADD = (C*IR*ED*K)/(BW*AT)

C = Constituent Concentration (ug/L)	
K = Volatilization Factor (L/m^3)	A Volatilization factor of 0.5 (L/m3) was used based on EPA published values
IR = Inhalation Rate (m^3/day)	An inhalation rate of 20 m^3/day was used for adults and 12m^3/day was used for children
ED = Exposure Duration (days)	An exposure duration of 30 years was used for adults, 8 for children
BW = Body Weight (kg)	An average weight of 70 kg was used for adults, 28.2 kg for children
AT = Average Time (days)	A time of 70 years for adults and children was used

Table 14: Carcinogenic Toxicity Values for Dermal Exposure

Contaminant	Well	Reference Dose	Maximum Concentration (ug/L)	LADD Maximum		Concentration 2007 (ug/L)	LADD 2007		HI Risk Maximum		HI Risk 2007	
		Oral Sfo (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)	Adult	Child	Adult	Child
Benzene	MW-4	55	3.9	2.50E-04	7.75E-05	3.9	2.50E-04	7.75E-05	4.55E-06	1.41E-06	4.55E-06	1.41E-06
Vinyl Chloride	MW-4	150	5.5	1.23E-04	3.80E-05	2.6	5.80E-05	1.80E-05	8.18E-07	2.53E-07	3.87E-07	1.20E-07

NOTE:
1. LADD is lifetime average daily dose from dermal contact with contaminated groundwater at the specified concentration.
2. Sfo values taken from the Region 9 Risk Based Concentration Table. These values represent the cancer slope factor.
3. During 2007 sampling "-" designates none of this constituent was detected.
4. Dermal Values used the same RfD values as those used for Oral.
5. HI is the Hazard Index Risk = LADD/RfD
6. Formula used for calculations:

LADD = (C*K*EV*ED*EF*SA)/(BW*AT)

C = Constituent Concentration (ug/L)	
K = Permeability Coefficient (cm/day)	contaminant dependent
EV = Event Frequency	15 min/day
ED = Exposure Duration (years)	30 years for an adult, 8 years for a child
EF = Exposure Frequency (days/year)	365 days per year
SA = Skin Surface Area (cm^2)	20,000cm^2 for adults and 9360 cm^2 for children
BW = Body Weight (kg)	70 kg was used for adults, 28.2 kg for children
AT = Average Time (days)	70 years for adults and children

Table 15: Non-Carcinogenic Toxicity Values from Oral Ingestion Exposure

Contaminant	Well	Reference Dose	Maximum Concentration (ug/L)	LADD Maximum		2007 Concentration (ug/L)	LADD 2007		HI Risk Maximum		HI Risk 2007	
		Oral RfD (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)	Adult	Child	Adult	Child
Chloroethane	MW-4	400	20.1	0.57	0.71	9.5	0.27	0.34	1.44E-03	1.78E-03	6.79E-04	8.42E-04
Benzene	MW-4	4	3.9	0.11	0.14	3.9	0.11	0.14	0.03	0.03	0.03	0.03
cis-1,2-dichloroethene	MW-4	10	14.3	0.41	0.51	10	0.29	0.35	0.04	0.05	0.03	0.04
methylbenzene	MW-4	200	10.4	0.30	0.37	1.1	0.03	0.04	1.49E-03	1.84E-03	1.57E-04	1.95E-04
p-Dichlorobenzene	MW-4	30	3.4	0.10	0.12	2.4	0.07	0.09	3.24E-03	4.02E-03	2.29E-03	2.84E-03
Vinyl Chloride	MW-4	3	5.5	0.16	0.20	2.6	0.07	0.09	0.05	0.07	0.02	0.03

NOTE:
1. LADD is lifetime average daily dose from ingested groundwater at the specified concentration.
2. RfD values taken from the Region 9 Risk Based Concentration Table. These values represent a daily exposure level that is not harmful to human health, over a lifetime.
3. During 2007 sampling "-" designates none of this constituent was detected.
4. HI is the Hazard Index Risk = LADD/RfD
5. Formula used for calculations:

LADD = (C*IR*ED)/(BW*AT)

C = Constituent Concentration (ug/L)
IR = Ingestion Rate (L/day) — An ingestion rate of 2L/day was used for adults 1L/day for children
ED = Exposure Duration (days) — An exposure duration of 30 years was used for adults, 8 for children
BW = Body Weight (kg) — An average weight of 70 kg was used for adults, 28.2 kg for children
AT = Average Time (days) — Times of 30 years for adults and 8 for children were used

Table 16: Non-Carcinogenic Toxicity Values for Inhalation Exposure

Contaminant	Well	Reference Dose	Maximum Concentration (ug/L)	LADD Maximum		2007 Concentration (ug/L)	LADD 2007		HI Risk Maximum		HI Risk 2007	
		Inhalation RfD (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)	Adult	Child	Adult	Child
Chloroethane	MW-4	2900	20.1	2.87	4.28	9.5	1.36	2.02	9.90E-04	1.47E-03	4.68E-04	6.97E-04
Benzene	MW-4	8.6	3.9	0.56	0.83	3.9	0.56	0.83	0.06	0.10	0.06	0.10
cis-1,2-dichloroethene	MW-4	10	14.3	2.04	3.04	10	1.43	2.13	0.20	0.30	0.14	0.21
methylbenzene	MW-4	110	10.4	1.49	2.21	1.1	0.16	0.23	0.01	0.02	1.43E-03	2.13E-03
p-Dichlorobenzene	MW-4	230	3.4	0.49	0.72	2.4	0.34	0.51	2.11E-03	3.15E-03	1.49E-03	2.22E-03
Vinyl Chloride	MW-4	29	5.5	0.79	1.17	2.6	0.37	0.55	0.03	0.04	0.01	0.02

NOTE:
1. LADD is lifetime average daily dose from inhaled at the specified concentration.
2. RfD values taken from the Region 9 Risk Based Concentration Table. These values represent a daily exposure level that is not harmful to human health, over a lifetime.
3. During 2007 sampling "-" designates none of this constituent was detected.
4. HI is the Hazard Index Risk = LADD/RfD
5. Formula used for calculations:

LADD = (C*IR*ED*K)/(BW*AT)

C = Constituent Concentration (ug/L)

K = Volatilization Factor (L/m^3)	A Volatilization factor of 0.5 (L/m3) was used based on EPA published values
IR = Inhalation Rate (m^3/day)	An inhalation rate of 20 m^3/day was used for adults and 12m^3/day was used for children
ED = Exposure Duration (days)	An exposure duration of 30 years was used for adults, 8 for children
BW = Body Weight (kg)	An average weight of 70 kg was used for adults, 28.2 kg for children
AT = Average Time (days)	Times of 30 years for adults and 8 for children were used

Table 17: Non-Carcinogenic Toxicity Values for Dermal Exposure

Contaminant	Well	Reference Dose	Maximum Concentration (ug/L)	LADD Maximum		2007 Concentration (ug/L)	LADD 2007		HI Risk Maximum		HI Risk 2007	
		Oral RfD (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)		Adult (ug/kg-day)	Child (ug/kg-day)	Adult	Child	Adult	Child
Chloroethane	MW-4	400	20.1	1.15E-03	1.33E-03	9.5	5.42E-04	6.30E-04	2.87E-06	3.33E-06	1.35E-06	1.57E-06
Benzene	MW-4	4	3.9	5.84E-04	6.79E-04	3.9	5.84E-04	6.79E-04	1.46E-04	1.70E-04	1.46E-04	1.70E-04
cis-1,2-dichloroethene	MW-4	10	14.3	1.02E-03	1.18E-03	10	7.13E-04	8.28E-04	1.02E-04	1.18E-04	7.13E-05	8.28E-05
methylbenzene	MW-4	200	10.4	3.34E-03	3.88E-03	1.1	3.53E-04	4.10E-04	1.67E-05	1.94E-05	1.77E-06	2.05E-06
p-Dichlorobenzene	MW-4	30	3.4	1.50E-03	1.75E-03	2.4	1.06E-03	1.23E-03	5.01E-05	5.82E-05	3.54E-05	4.11E-05
Vinyl Chloride	MW-4	3	5.5	2.86E-04	3.33E-04	2.6	1.35E-04	1.57E-04	9.54E-05	1.11E-04	4.51E-05	5.24E-05

NOTE:
1. LADD is lifetime average daily dose from dermal contact with contaminated groundwater at the specified concentration.
2. RfD values taken from the Region 9 Risk Based Concentration Table. These values represent a daily exposure level that is not harmful to human health, over a lifetime.
3. During 2007 sampling "-" designates none of this constituent was detected.
4. Dermal Values used the same RfD values as those used for Oral.
5. HI is the Hazard Index Risk = LADD/RfD
6. Formula used for calculations:

LADD = (C*K*EV*ED*EF*SA)/(BW*AT)

C = Constituent Concentration (ug/L)	
K = Permeability Coefficient (cm/day)	contaminant dependent
EV = Event Frequency	15 min/day
ED = Exposure Duration (years)	30 years for an adult, 8 years for a child
EF = Exposure Frequency (days/year)	365 days per year
SA = Skin Surface Area (cm^2)	20,000cm^2 for adults and 9360 cm^2 for children
BW = Body Weight (kg)	70 kg was used for adults, 28.2 kg for children
AT = Average Time (days)	30 years for adults and 8 for children

Table 18: Flow rate calculations

Well	h_1 (ft)	h_2 (ft)	dh (ft)	dl (ft)	i	K (cm/sec)	n_e (%)	v (ft/yr)	Lithology
MW-1	116.50	115.00	1.50	73.00	0.0205	1.20E-04	15%	17.01	Silty Clay/Sandy Clay
MW-4	101.17	105.00	3.83	174.10	0.0220	1.10E-04	15%	16.69	Sandy Clay/Silty Clay
MW-5	99.03	105.00	5.97	205.10	0.0291	1.40E-04	15%	28.11	Sandy Clay
MW-6	110.91	110.00	0.91	30.89	0.0295	1.90E-04	15%	38.61	Sandy Clay
MW-7	98.60	100.00	1.40	72.86	0.0192	1.98E-04	7%	56.23	Clay
MW-8	101.26	100.00	1.26	56.68	0.0222	1.14E-03	7%	374.58	Sandy Clay

NOTES:

1. Parameters *dh* and *dl* denote the difference in the hydraulic head and the horizontal distance, respectively, between two measurement points. A line is constructed from a piezometers to a perpendicular of the potentiometric contour in Plate 3 *Average Groundwater Elevations.* The hydraulic head is the absolute value of the difference in the groundwater elevation at the piezometer, h_1, and the elevation of the corresponding potentiometric contour, h_2. The horizontal distance, *dl,* is the length of the line.
2. Parameter *i* denotes the hydraulic gradient associate with the line, and is defined by the equation:

$$i = \frac{dh}{dl}$$

3. Parameter n_e denotes the effective porosity.
4. *K* denotes the hydraulic conductivity determined from field slug tests.
5. Parameter *v* denotes the average linear velocity. The average linear velocity, denoted by *v*, is defined by the equation:

$$v = -\frac{K}{n_e}\frac{dh}{dl}$$

Table 19: Remediation Alternatives

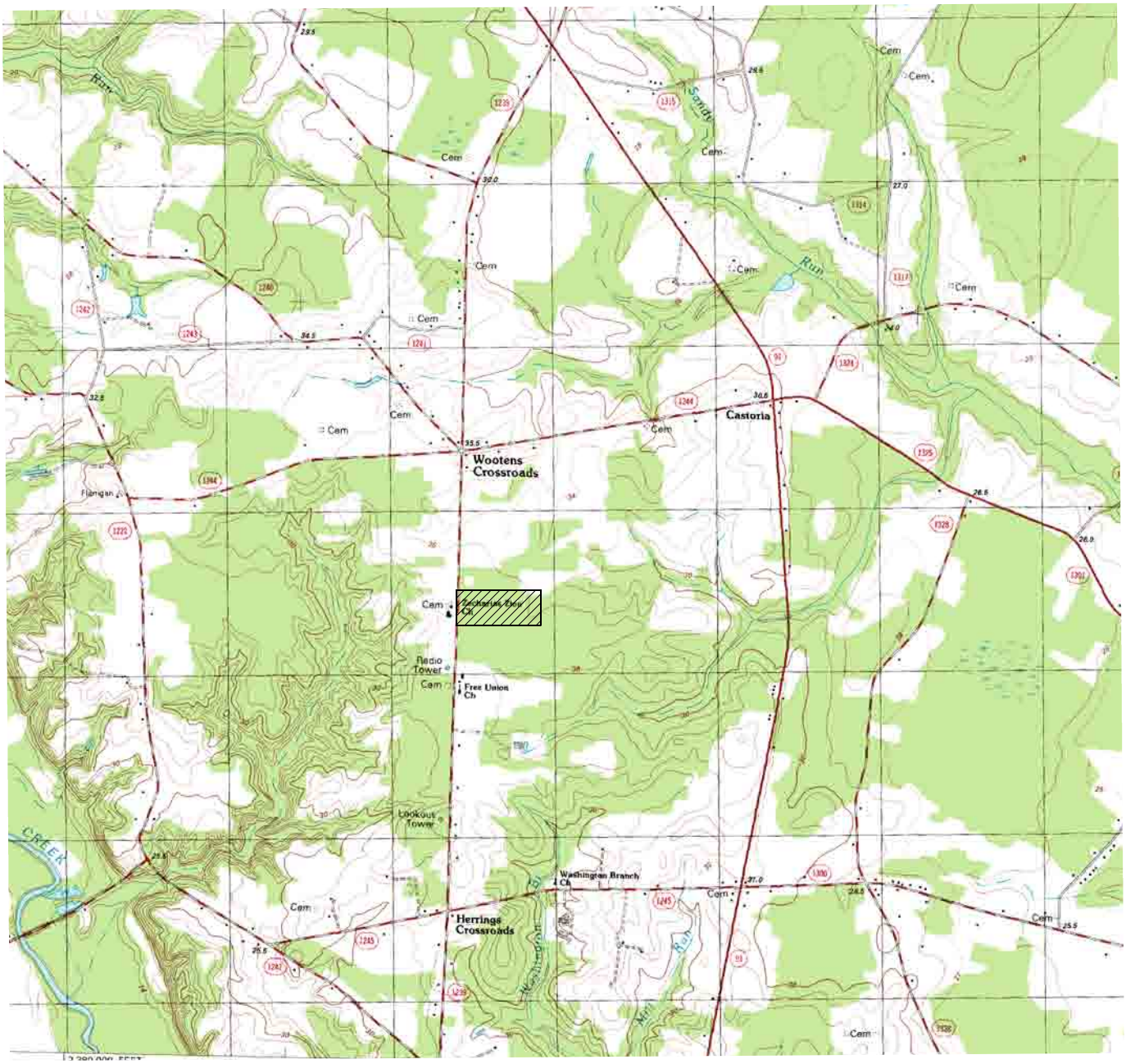
Remediation Technology	Contamination Treatment	Advantages	Disadvantages	Site Specific Information	Costs
Monitored Natural Attenuation	Passively treats contaminated medium	▪ Inexpensive and easy to implement ▪ Often applicable when low levels of contamination are present and low migration potential exists ▪ Often applicable on sites with low significant threats to public health and the environment exist	▪ Other than natural biodegradation, minimal reduction in contamination levels. ▪ Provides no containment of groundwater ▪ Requires long-term monitoring ▪ Not appropriate for high risk sites	▪ Low potential of off site migration ▪ Low health risks ▪ Community water available ▪ No users of potable groundwater within 2000 feet of the facility	Already incorporated into facility operation
Vapor Extraction/Bioventing	Actively treats contaminated medium	▪ Controls contamination migration	▪ Contamination must be susceptible to air stripping ▪ Expensive start up cost and operation ▪ Focuses more on contaminated soil and the vadose zone. ▪ Need favorable soil conditions ▪ Pilot test required for adequate engineering design	▪ Clay content would limit air flow ▪ Chloroethene limited susceptibility to air stripping.	$100,000 Pilot test and engineering $300,000 Installation and start up $15,000 Annual operation and maintenance
Air Sparging	Actively treats contaminated medium	▪ Controls contamination migration ▪ Immediate reduction in contamination during initial weeks/months	▪ Contamination must be susceptible to volatilization ▪ Often used in conjunction with vapor extraction ▪ Need favorable soil conditions ▪ Long-term system operation ▪ Expensive start up cost and operation ▪ Extensive operation and maintenance ▪ Pilot test required for adequate engineering design	▪ Contamination of concern degrades under both anaerobic and aerobic conditions ▪ Clay content would limit injection radius of influence	$100,000 Pilot test and engineering $300,000 Installation and start up $15,000 Annual operation and maintenance
Enhanced Bioremediation	Actively treats contaminated medium	▪ Can be tailored to fit the contamination of concern ▪ Minimally invasive ▪ Chemicals can be applied directly to the contamination ▪ Can be applied into fracture zones	▪ Degradation of chemicals may require repeat applications ▪ Permitting requirements can be extensive	▪ Nature of contamination being both aerobic and anaerobic limits application options	$20,000 Design and permitting costs $30,000 Installation of injection points and additional monitoring points $80,000 Initial injection of compound $80,000 Sub sequential injection of compound
Phytoremediation	Passively treats contaminated medium	▪ Environmentally friendly ▪ Inexpensive and easy to implement ▪ Potential source of revenue	▪ Does not work with deep groundwater contamination	▪ Shallow Groundwater ▪ COC's have Kow susceptible to phytoremediation. ▪ Possible alternative	$3,000 Hybrid Willow trees.
Constructed Wetlands	Passively treats contaminated medium	▪ Environmentally friendly ▪ Inexpensive and easy to implement	▪ Does not work with deep groundwater contamination	▪ Groundwater is shallow	
Passive Landfill Gas Ventilation System	Removes source area recharge contamination	▪ Inactively controls contamination recharge ▪ Inexpensive implementation and operation	▪ Generally not efficient for remediation of dissolved phase contamination		Currently in operation
Active Landfill Gas Ventilation System	Actively removes source area recharge contamination	▪ Actively controls contamination recharge ▪ Possible use as alternative energy source	▪ Expensive start up cost and operation		$750,000 Total turn key expense $50,000 annual operating expense
Pump and Treat	Actively removes source area contamination	▪ Controls contamination migration	▪ Total removal of contamination is limited ▪ Requires operation and maintenance of equipment ▪ Ineffective at treating sites with high soil – water partition coefficent		
Permeable Treatment Barrier	Does not address source area contamination	▪ Controls contamination migration	▪ Impractical on large deep plumes. ▪ Relies on groundwater flow to treat contamination		

PLATES

Topographic Map with Site Location

Assessment of Corrective Measures
Greene County

PLATE 1



Date Completed	5/31/2007
Created By	M. Clement
Project Name	Assessment of Corrective Measures
Site Name	Greene County
Project Number	G07061.0

Municipal Engineering Services Company, PA

QUADRANGLE LEGEND

ROAD CLASSIFICATION

Primary highway, hard surface

Light-duty road, hard or improved surface

Secondary highway, hard surface

Unimproved road

Interstate Route

U. S. Route

State Route

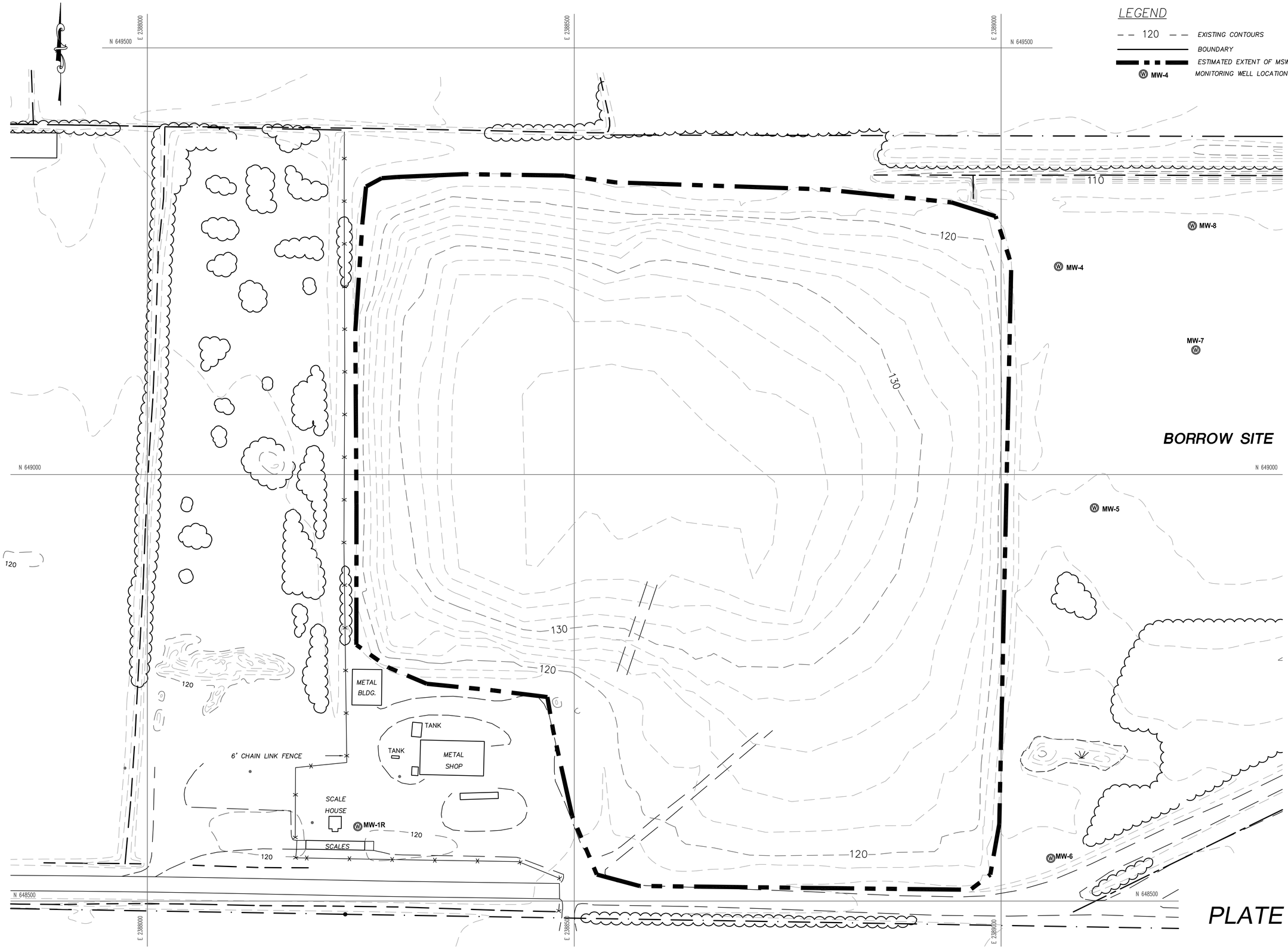


PLATE 2

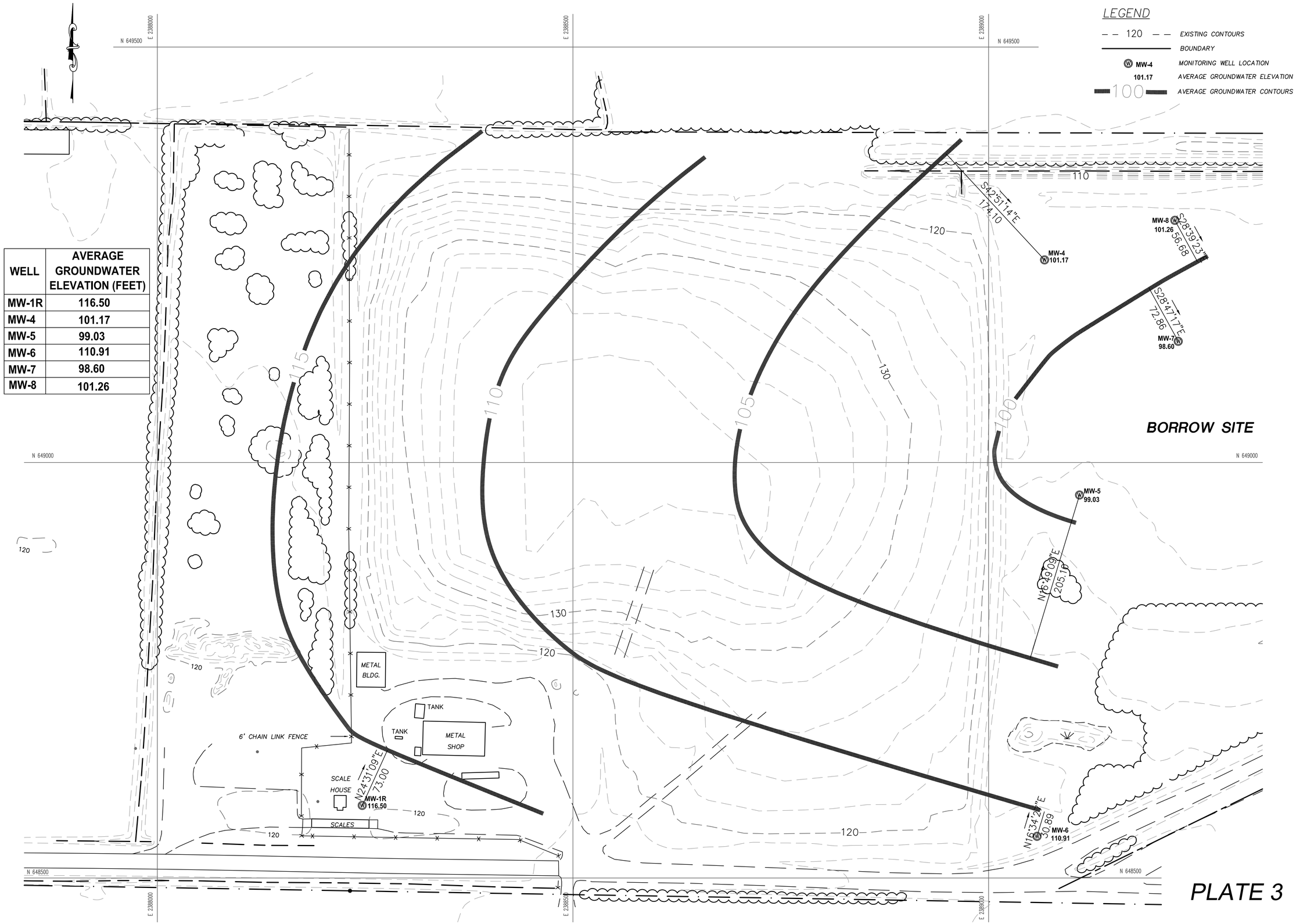
Municipal Services Engineering Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
P.O. BOX 278 MOREHEAD CITY, N.C. 28557 (252) 726-9481

GREENE COUNTY
CONSTRUCTION & DEMOLITION
LANDFILL FACILITY REVISION
GREENE COUNTY, NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

SITE MAP

SCALE:	1" = 50'
DATE:	8/24/2007
DRWN. BY:	E. CALDWELL
CHKD. BY:	E. CALDWELL
PROJECT NUMBER	G07061.0
DRAWING NO.	PLATE 2
SHEET NO.	1 OF 1



WELL	AVERAGE GROUNDWATER ELEVATION (FEET)
MW-1R	116.50
MW-4	101.17
MW-5	99.03
MW-6	110.91
MW-7	98.60
MW-8	101.26

PLATE 3

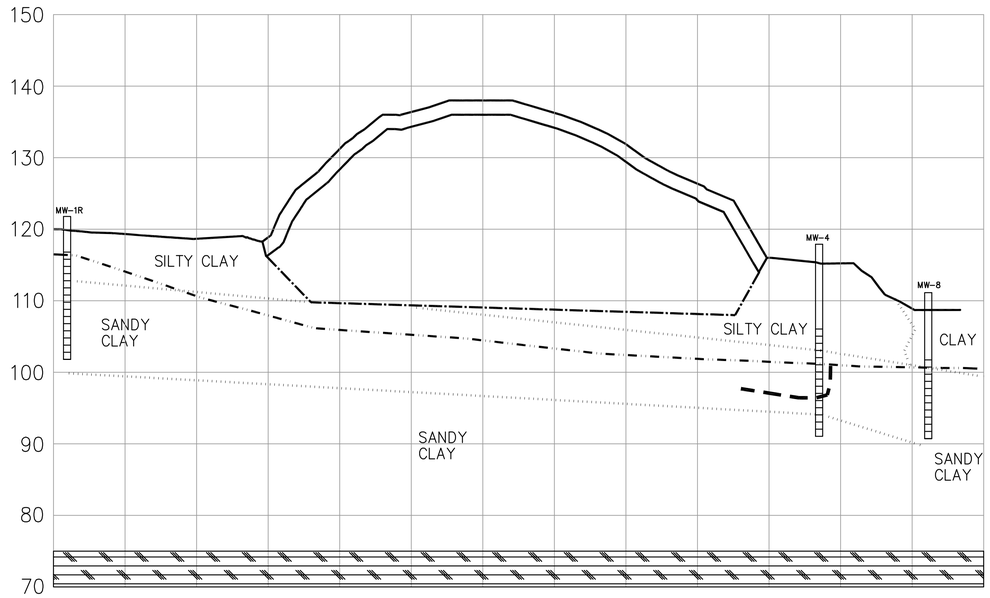
Municipal Services Engineering Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
P.O. BOX 278 MOREHEAD CITY, N.C. 28557 (252) 726-9481

GREENE COUNTY
CONSTRUCTION & DEMOLITION
LANDFILL FACILITY REVISION
GREENE COUNTY, NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

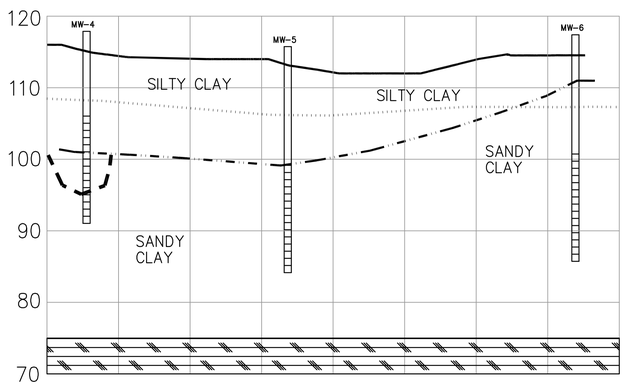
AVERAGE POTENTIOMETRIC GROUNDWATER MAP

SCALE: 1" = 50'
DATE: 7/26/2007
DRWN. BY: M. CLEMENT
CHKD. BY: E. CALDWELL
PROJECT NUMBER G07061.0
DRAWING NO. PLATE 3
SHEET NO. 1 OF 1



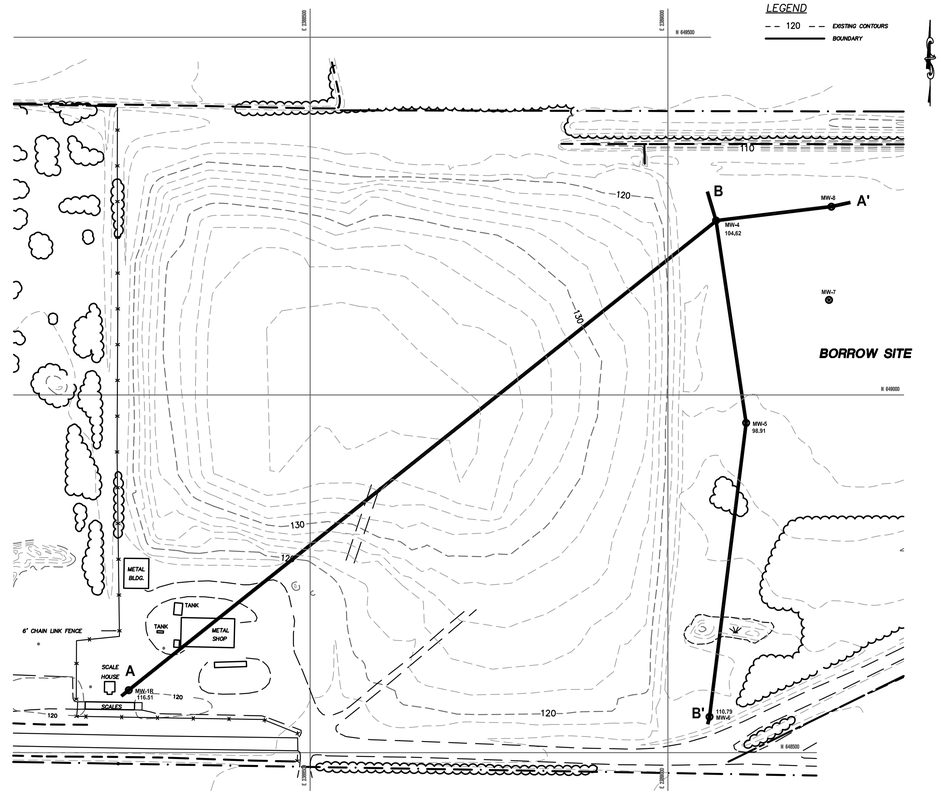
SECTION A-A'

APPROX. SCALE HORIZ. 1" = 50'
VERT. 1" = 10'



SECTION B-B'

APPROX. SCALE HORIZ. 1" = 50'
VERT. 1" = 10'



NOTE:
- NUMBERS SHOWN IN THIS PLATE ARE IN UNITS OF FEET UNLESS INDICATED OTHERWISE.
- SOIL PROFILES SHOWN HEREIN ARE INTERPOLATED FROM AVAILABLE BORING RECORDS.
- SOIL PROFILE BOUNDARIES DO NOT NECESSARILY INDICATE ABRUPT CHANGE IN SOIL TEXTURES.

PLATE 4

Municipal Engineering Services Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
P.O. BOX 278 MOREHEAD CITY, N.C. 28557 (252) 726-9481

GREENE COUNTY
CONSTRUCTION & DEMOLITION
LANDFILL FACILITY REVISION
GREENE COUNTY, NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

CROSS-SECTION

SCALE:	AS SHOWN
DATE:	8/17/2007
DRWN. BY:	M. CLEMENT
CHKD. BY:	E. CALDWELL
PROJECT NUMBER	G07061.0
DRAWING NO.	PLATE 4
SHEET NO.	1 OF 1

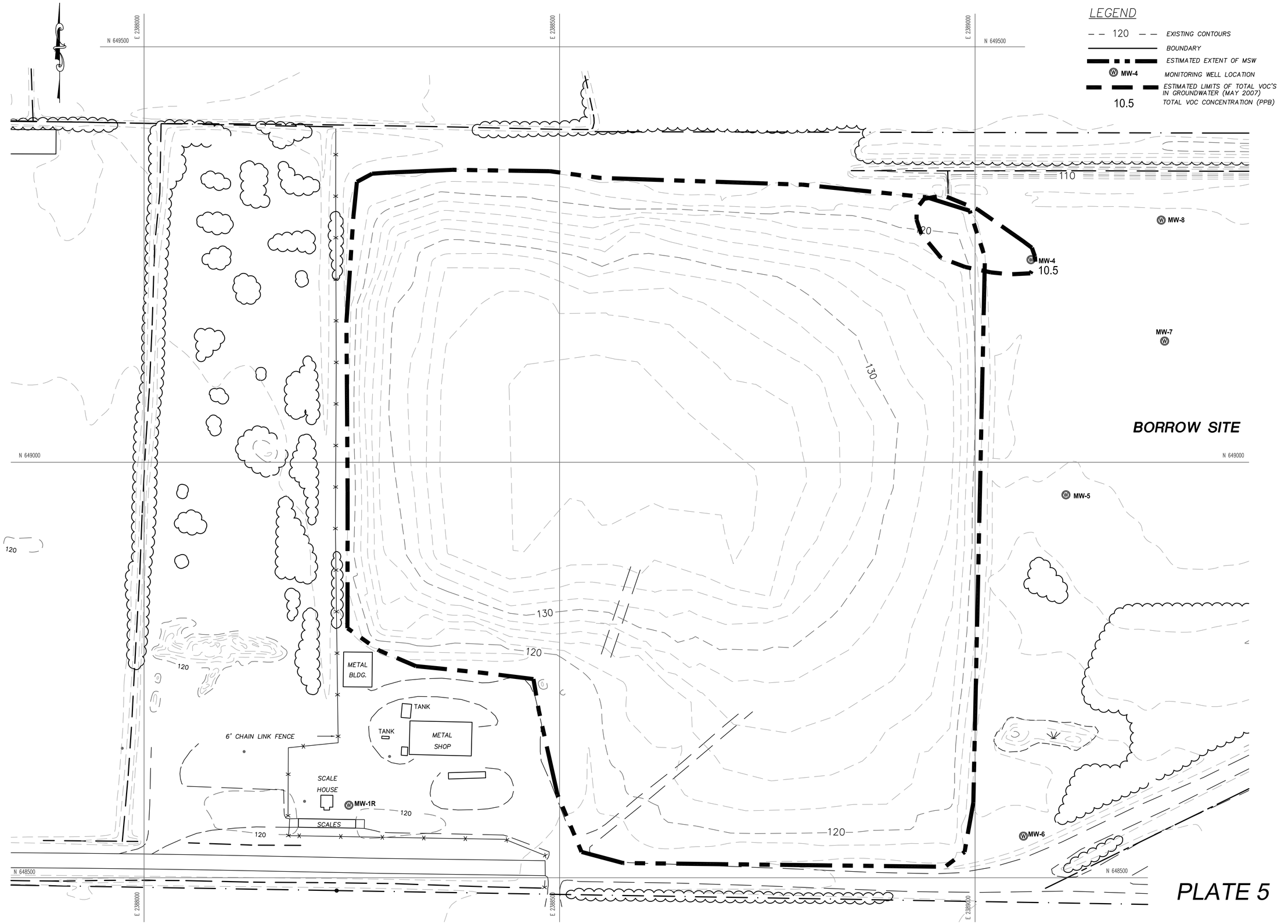


PLATE 5

Municipal Engineering Services Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
P.O. BOX 278 MOREHEAD CITY, N.C. 28557 (252) 726-9481

GREENE COUNTY
CONSTRUCTION & DEMOLITION
LANDFILL FACILITY REVISION
GREENE COUNTY, NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ISOCONCENTRATION MAP
TOTAL VOC's

SCALE:	1" = 50'
DATE:	8/20/07
DRWN. BY:	M. CLEMENT
CHKD. BY:	E. CALDWELL
PROJECT NUMBER	G07061.0
DRAWING NO.	PLATE 5
SHEET NO.	1 OF 1

APPENDIX A

North Carolina - Department of Environment, Health, and Natural Resources
Division of Environmental Management - Groundwater Section
P.O. Box 29535 - Raleigh, N.C. 27626-0535
Phone (919) 733-3221

FOR OFFICE USE ONLY
QUAD. NO. _____ SERIAL NO. _____
Lat. _____ Long. _____ RO _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

DRILLING CONTRACTOR: GAI Consultants

DRILLER REGISTRATION NUMBER: 446

STATE WELL CONSTRUCTION PERMIT NUMBER: N/A

1. WELL LOCATION: (Show sketch of the location below)
Nearest Town: Wootens Crossroads County: Greene
SR 1239
(Road, Community, or Subdivision and Lot No.)

2. OWNER Greene County Attn: Jessie Tyndall
ADDRESS 229 Kingold Blvd
(Street or Route No.)
Snow Hill NC 28580
City or Town State Zip Code

3. DATE DRILLED 8-26-94 USE OF WELL Monitoring
4. TOTAL DEPTH 20.9'
5. CUTTINGS COLLECTED YES [X] NO [ ]
6. DOES WELL REPLACE EXISTING WELL? YES [X] NO [ ]
7. STATIC WATER LEVEL Below Top of Casing: 5.63 FT.
(Use "+" if Above Top of Casing)
8. TOP OF CASING IS 2.0 FT. Above Land Surface*
* Casing Terminated at/or below land surface is illegal unless a variance is issued in accordance with 15A NCAC 2C .0118
9. YIELD (gpm): N/A METHOD OF TEST _____
10. WATER ZONES (depth): N/A
11. CHLORINATION: Type N/A Amount _____
12. CASING:

	Depth From	Depth To	Diameter	Wall Thickness or Weight/Ft.	Material
	+2.0	3.2	2"	Sch 40	PVC

13. GROUT:

	Depth From	Depth To	Material	Method
	0	1.0	Cement	Grout
	1.0	2.0	Bentonite	Pellets

14. SCREEN:

	Depth From	Depth To	Diameter	Slot Size	Material
	3.2	18.2	2 in.	.010 in.	PVC

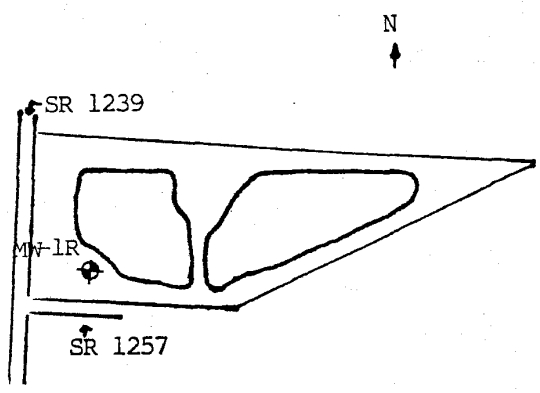
15. SAND/GRAVEL PACK:

	Depth From	Depth To	Size	Material
	2.0	20.9		Silica

DEPTH From - To	DRILLING LOG Formation Description
3.5 - 5.5	Orange mottled gray clay down grades silty clay
8.5 - 10.5	Gray faintly mottled sandy clay down sand decreases
13.5 - 15.5	Red gray fine sandy clay
18.5 - 20.9	Faint or mottled gray sandy clay

If additional space is needed use back of form

LOCATION SKETCH
(Show direction and distance from at least two State Roads, or other map reference points)



16. REMARKS: Replacement for Monitoring Well 1(Not abandoned) MW-1R 3.63' water level after 24 hours

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Wendell W. Parker 8-26-94
SIGNATURE OF CONTRACTOR OR AGENT DATE

GW-1 REV 9-91
Submit original to Division of Environmental Management and copy to well owner

North Carolina - Department of Environment, Health, and Natural Resources
Division of Environmental Management - Groundwater Section
P.O. Box 29535 - Raleigh, N.C. 27626-0535
Phone (919) 733-3221

FOR OFFICE USE ONLY
QUAD. NO. _____ SERIAL NO. _____
Lat. _____ Long. _____ RO _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

DRILLING CONTRACTOR: GAI Consultants

DRILLER REGISTRATION NUMBER: 446

STATE WELL CONSTRUCTION PERMIT NUMBER: N/A

1. WELL LOCATION: (Show sketch of the location below)
   Nearest Town: Wootens Crossroads County: Greene
   SR 1239
   (Road, Community, or Subdivision and Lot No.)
2. OWNER Greene County Attn: Jessie Tyndall
   ADDRESS 229 Kingold Blvd
   (Street or Route No.)
   Snow Hill NC 28580
   City or Town State Zip Code
3. DATE DRILLED 8-26-94 USE OF WELL Monitoring
4. TOTAL DEPTH 26.0
5. CUTTINGS COLLECTED YES [x] NO [ ]
6. DOES WELL REPLACE EXISTING WELL? YES [ ] NO [x]
7. STATIC WATER LEVEL Below Top of Casing: 19.74 FT.
   (Use "+" if Above Top of Casing)
8. TOP OF CASING IS 2.74 FT. Above Land Surface*
   * Casing Terminated at/or below land surface is illegal unless a variance is issued in accordance with 15A NCAC 2C .0118
9. YIELD (gpm): N/A METHOD OF TEST _____
10. WATER ZONES (depth): _____
11. CHLORINATION: Type N/A Amount _____
12. CASING:

	Depth From	Depth To	Ft.	Diameter	Wall Thickness or Weight/Ft.	Material
	+2.74	9.1		2"	Sch 40	PVC

13. GROUT:

	Depth From	Depth To	Ft.	Material	Method
	0	6.3		Cement	Grout
	6.3	7.5		Bentonite	Pellet

14. SCREEN:

	Depth From	Depth To	Ft	Diameter	in.	Slot Size	in.	Material
	9.1	24.1		2"		.010		PVC

15. SAND/GRAVEL PACK:

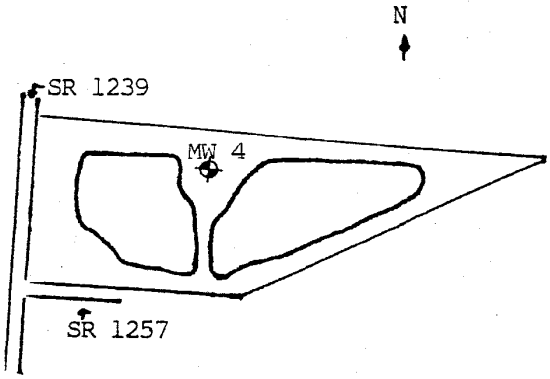
	Depth From	Depth To	Ft.	Size	Material
	7.5	26.0			Silica

16. REMARKS: Monitoring Well 4 17.15' - water level after 24 hours

DEPTH From To	DRILLING LOG Formation Description
3.5 - 5.5	Red orange mottled
	gray clay few f sand
8.5 - 10.5	Orange mot gr silty
	clay
13.5 - 15.5	Red sandy clay down
	thin seams of f sand
18.5 - 20.5	Red sandy clay down
	rd sand w/thin seams
	of clay
23.5 - 25.5	Orange gr silty clay
	w/few f sand down
	grades lt gr clay
26.0	Bottom of boring

If additional space is needed use back of form

LOCATION SKETCH
(Show direction and distance from at least two State Roads, or other map reference points)



I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Wendell W. Parks 10-6-94
SIGNATURE OF CONTRACTOR OR AGENT DATE

GW-1 REV 9/91

Submit original to Division of Environmental Management and copy to well owner

North Carolina - Department of Environment, Health, and Natural Resources
Division of Environmental Management - Groundwater Section
P.O. Box 29535 - Raleigh, N.C. 27626-0535
Phone (919) 733-3221

FOR OFFICE USE ONLY
QUAD. NO. _____ SERIAL NO. _____
Lat. _____ Long. _____ RO _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent.

WELL CONSTRUCTION RECORD

DRILLING CONTRACTOR: GAI Consultants

DRILLER REGISTRATION NUMBER: 446

STATE WELL CONSTRUCTION PERMIT NUMBER: N/A

1. WELL LOCATION: (Show sketch of the location below)
   Nearest Town: Wootens Crossroads County: Greene
   SR 1239
   (Road, Community, or Subdivision and Lot No.)
2. OWNER Greene County Attn: Jessie Tyndall
   ADDRESS 229 Kingold Blvd
   (Street or Route No.)
   Snow Hill NC 28580
   City or Town State Zip Code
3. DATE DRILLED 8-28-94 USE OF WELL Monitoring
4. TOTAL DEPTH 30.4
5. CUTTINGS COLLECTED YES [x] NO [ ]
6. DOES WELL REPLACE EXISTING WELL? YES [ ] NO [x]
7. STATIC WATER LEVEL Below Top of Casing: 19.1 FT.
   (Use "+" if Above Top of Casing)
8. TOP OF CASING IS 2.6 FT. Above Land Surface*

* Casing Terminated at/or below land surface is illegal unless a variance is issued in accordance with 15A NCAC 2C .0118

9. YIELD (gpm): N/A METHOD OF TEST _____
10. WATER ZONES (depth): _____
11. CHLORINATION: Type N/A Amount _____
12. CASING:

	Depth From	Depth To	Ft.	Diameter	Wall Thickness or Weight/Ft.	Material
	+2.6	14		2"	Sch 40	PVC

13. GROUT:

	Depth From	Depth To	Ft.	Material	Method
	0	11.5		Cement	Grout
	11.5	12.8		Bentonite	Pellets

14. SCREEN:

	Depth From	Depth To	Ft	Diameter	in.	Slot Size	in.	Material
	14	29.0		2		.010		PVC

15. SAND/GRAVEL PACK:

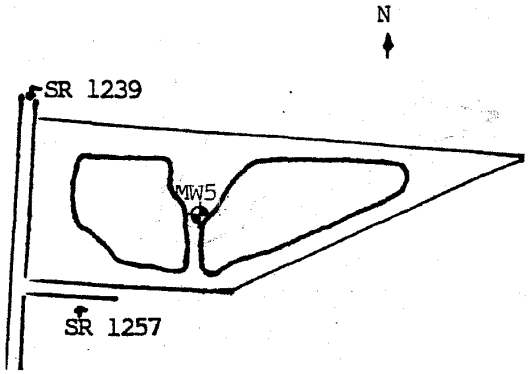
	Depth From	Depth To	Ft.	Size	Material
	12.8	30.4			Silica

16. REMARKS: Monitoring Well 5 16.4' - water level after 24 hours

DEPTH From	DEPTH To	DRILLING LOG Formation Description
0	0.5	Tan silty clay
3.5	5.5	Faintly orange mot gr silty clay down abundan rd mot silty clay
8.5	10.5	Med gray f sandy clay
13.5	15.5	Red mot gr f sandy clay down abundant rd mot gr sandy clay
18.5	20.5	Red mot sandy clay down red sand
23.5	25.5	Orange sandy clay grades or sandy clay
28.5	30.4	Orange clayey sand down seams clay & clean sand

If additional space is needed use back of form

LOCATION SKETCH
(Show direction and distance from at least two State Roads, or other map reference points)



I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Wendell W. Park 8-28-94
SIGNATURE OF CONTRACTOR OR AGENT DATE

GW-1 REV. 9/91

Submit original to Division of Environmental Management and copy to well owner

North Carolina - Department of Environment, Health, and Natural Resources
Division of Environmental Management - Groundwater Section
P.O. Box 29535 - Raleigh, N.C. 27626-0535
Phone (919) 733-3221

FOR OFFICE USE ONLY
QUAD. NO. _____ SERIAL NO. _____
Lat. _____ Long. _____ RO _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

DRILLING CONTRACTOR: GAI Consultants

DRILLER REGISTRATION NUMBER: 446

STATE WELL CONSTRUCTION PERMIT NUMBER: N/A

1. WELL LOCATION: (Show sketch of the location below)
   Nearest Town: Wootens Crossroads County: Greene
   SR 1239
   (Road, Community, or Subdivision and Lot No.)
2. OWNER Greene County Attn: Jessie Tyndall
   ADDRESS 229 Kingold Blvd
   (Street or Route No.)
   Snow Hill NC 28580
   City or Town State Zip Code
3. DATE DRILLED 8-29-94 USE OF WELL Monitoring
4. TOTAL DEPTH 30.8
5. CUTTINGS COLLECTED YES [X] NO [ ]
6. DOES WELL REPLACE EXISTING WELL? YES [ ] NO [X]
7. STATIC WATER LEVEL Below Top of Casing: 9.37 FT.
   (Use "+" if Above Top of Casing)
8. TOP OF CASING IS 2.87 FT. Above Land Surface*

* Casing Terminated at/or below land surface is illegal unless a variance is issued in accordance with 15A NCAC 2C .0118

9. YIELD (gpm): N/A METHOD OF TEST _____
10. WATER ZONES (depth): _____
11. CHLORINATION: Type N/A Amount _____
12. CASING:

	Depth From	Depth To	Ft.	Diameter	Wall Thickness or Weight/Ft.	Material
	+2.87	13.8		2"	Sch 40	PVC

13. GROUT:

	Depth From	Depth To	Ft.	Material Cement	Method Grout
	0	10.5			
	10.5	12.0		Bentonite	Pellet

14. SCREEN:

	Depth From	Depth To	Ft.	Diameter	Slot Size	Material
	13.8	28.8		2 in.	.010 in.	PVC

15. SAND/GRAVEL PACK:

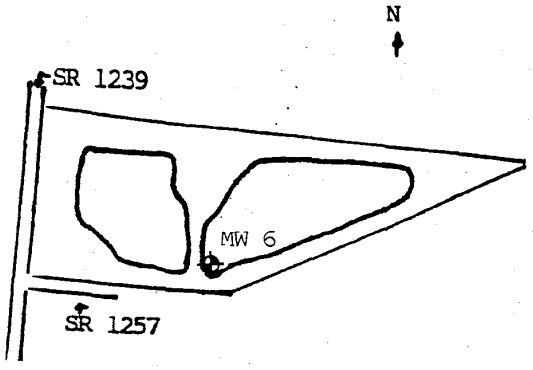
	Depth From	Depth To	Ft.	Size	Material
	12.0	30.8			Silica

16. REMARKS: Monitoring Well 6 6.48' - water level after 24 hours

DEPTH From - To	DRILLING LOG Formation Description
3.5 - 5.5	Orange mot gr silty clay w/f sand
8.5 - 10.5	Orange mot gr sandy clay down clay increase
13.5 - 15.5	Light gr f sandy clay down becomes mot clay content increases
18.5 - 20.5	Gray f sandy clay down few or mot
23.5 - 25.5	Med gr f sandy clay w/ thin seams f sand
28.5 - 30.8	Dark gray sandy clay

If additional space is needed use back of form

LOCATION SKETCH
(Show direction and distance from at least two State Roads, or other map reference points)



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Wendell W. Park 8-29-94
SIGNATURE OF CONTRACTOR OR AGENT DATE

GW-1 REV 9 91

Submit original to Division of Environmental Management and copy to well owner

MONITORING WELL 1R

PROJECT: Greene County Landfill
Wootens Crossroads, North Carolina
LOCATION: see Landfill Plans

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION	SPT VALUE
			Orange mottled gray silty clay	
5		X		7
			Gray fine sandy clay	
10		X		14
15		X	-grades red gray	13
20		X	-grades mottled gray	10
			End of Boring	
25				
30				
35				
40				
45				

COMPLETION DEPTH: 20.9 ft DATE: 8-26-94
DEPTH TO WATER: 1.1 ft while drilling, 3.63 ft after 24 hrs

MONITORING WELL 4

PROJECT: Greene County Landfill
Wootens Crossroads, North Carolina
LOCATION: see Landfill Plans

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION	SPT VALUE
			Red orange mottled gray clay, trace fine sand	
5		X		10
			Orange mottled gray silty clay	
10		X		9
			Red sandy clay, with thin fine sand seams	
15		X		7
20		X	-grades more sandy, with thin clay seams	14
			Orange gray silty clay, trace fine sand	
25		X	-grades light gray	4
			End of Boring	
30				
35				
40				
45				

COMPLETION DEPTH: 26.0 ft DATE: 8-26-94
DEPTH TO WATER: 17 ft while drilling, 17.15 ft after 24 hrs

MONITORING WELL 5

PROJECT: Greene County Landfill
Wootens Crossroads, North Carolina
LOCATION: see Landfill Plans

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION	SPT VALUE
			Tan silty clay	
5		X	-grades faintly orange mottled gray	8
			-grades red mottled	
			Gray fine sandy clay	
10		X		14
15		X	-grades red mottled gray	8
20		X	-with red sand seams	10
25		X	Orange clayey sand	8
30		X	-with seams of clay and fine sand	21
			End of Boring	
35				
40				
45				

COMPLETION DEPTH: 30.4 ft DATE: 8-28-94
DEPTH TO WATER: 16.5 ft while drilling, 16.4 ft after 24 hrs

MONITORING WELL 6

PROJECT: Greene County Landfill
Wootens Crossroads, North Carolina
LOCATION: see Landfill Plans

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION	SPT VALUE
			Orange mottled gray silty clay, trace fine sand	
5		X		9
			Orange mottled gray sandy clay	
10		X		12
15		X	-grades light gray	8
20		X	-grades gray	9
25		X	-grades with fine sand seams	6
30		X	-grades dark gray	5
			End of Boring	
35				
40				
45				

COMPLETION DEPTH: 30.8 ft DATE: 8-29-94
DEPTH TO WATER: 16 ft while drilling, 6.48 ft after 24 hrs

LOG OF BORING: MW-7

Greene County Closed Landfill **Project No. G07061.0**

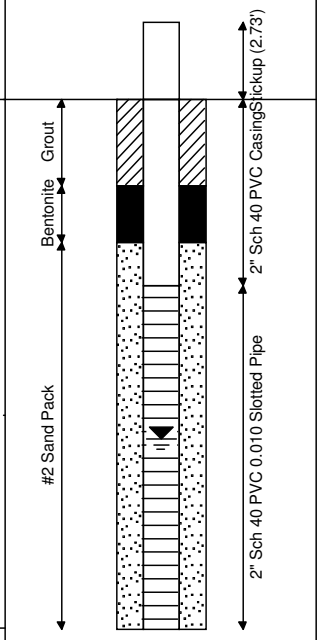
Drilling contractor: Derry's Well Drilling
Drill rig & method: 8" OD HSA w/SS
Logged by: J.Pfohl

Date started: 6/21/2007
Date ended: 6/21/2007
Completion depth: 18.50 ft
Stickup height: 2.73 ft

Surface elevation: 107.75 ft (MSL)
Top of pipe elevation: 110.48 ft (MSL)
Depth to water (TOB): 11.99 ft
Depth to water (24hrs): 11.88 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	14			Clay; gray, red-orange, mottled, extremely cohesive, moist
5	15			Clay; Same as above
				Clay with Sand (CL) Brown, Gravel = 0.00%, Sand = 29.67%, Silt = 32.33%, Clay = 35%, LL = 35%, PL = 12%, PI = 23%
10				Clay; transition from mottled to dark purple, red
	16			Clay; Dark purple red, very cohesive, uniform, moist
15				
20				Boring terminated at 18.5 feet
25				
30				
35				
40				
45				

Well Diagram



Municipal Engineering Services Company, P.A.
Operation/Construction Managers Civil/Sanitary EngineersEnvironmental Studies
PO Box 97, Garner, North Carolina 27529 (919) 772-5393PO Box 349, Boone, North Carolina 28607 (828) 262-1767

LOG OF BORING: MW-8

Greene County Closed Landfill **Project No. G07061.0**

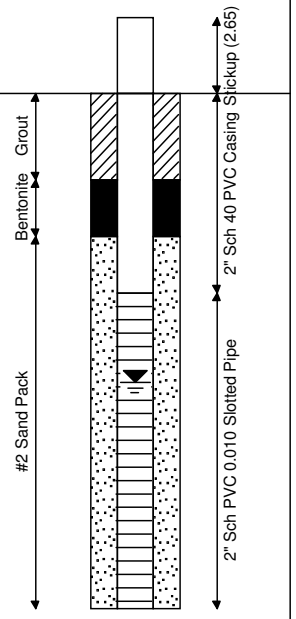
Drilling contractor: Derry's Well Drilling
Drill rig & method: 8" OD HSA w/ SS
Logged by: J. Pfohl

Date started: 6/21/2007
Date ended: 6/21/2007
Completion depth: 17.98 ft
Stickup height: 2.65 ft

Surface elevation: 108.71 ft (MSL)
Top of pipe elevation: 111.36 ft (MSL)
Depth to water (TOB): 10.15 ft
Depth to water (24hrs): 10.10 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
	13			Clay; Gray, red-orange, mottled, cohesive, moist
5	12			Clay; Same as above, more gray, moist
				Clayey Sand (SC) Gray Orange, Gravel = 0.00%, Sand = 63.86%, Silt = 11.14%, Clay = 25%, LL = 32%, PL = 11%, PI = 21%
10	4			Clayey Sand; Orange, fine grained sand with few grey clay noduels, wet
15	3			Clayey Sand; Orange, fine grained sand, saturated
				Boring terminated at 18.0 feet
20				
25				
30				
35				
40				
45				

Well Diagram



Municipal Engineering Services Company, P.A.
Operation/Construction Managers Civil/Sanitary EngineersEnvironmental Studies
PO Box 97, Garner, North Carolina 27529 (919) 772-5393PO Box 349, Boone, North Carolina 28607 (828) 262-1767

Geotechnics

.....GEOTECHNICAL, GEOENVIRONMENTAL, AND GEOSYNTHETIC LABORATORIES

June 29, 2007

Project No. 2007-626-01

Mr. Jonathon Pfohl
Municipal Engineering Co.
P.O. Box 98
Garner, NC 27529

Transmittal
Laboratory Test Results
Greene Co. Landfill

Please find attached the laboratory test results for the above referenced project. The tests were outlined on the Project Verification Form that was faxed to your firm prior to the testing. The testing was performed in general accordance with the methods listed on the enclosed data sheets. The test results are believed to be representative of the samples that were submitted for testing and are indicative only of the specimens which were evaluated. We have no direct knowledge of the origin of the samples and imply no position with regard to the nature of the test results, i.e. pass/fail and no claims as to the suitability of the material for its intended use.

The test data and all associated project information provided shall be held in strict confidence and disclosed to other parties only with authorization by our Client. The test data submitted herein is considered integral with this report and is not to be reproduced except in whole and only with the authorization of the Client and Geotechnics. The remaining sample materials for this project will be retained for a minimum of 90 days as directed by the Geotechnics' Quality Program.

We are pleased to provide these testing services. Should you have any questions or if we may be of further assistance, please contact our office.

Respectively submitted,
Geotechnics, Inc.

Michael P. Smith
Regional Manager

We understand that you have a choice in your laboratory services and we thank you for choosing Geotechnics.

2200 Westinghouse Boulevard • Suite 105 • Raleigh, NC 27604 • Phone (919) 876-0405 • Fax (919) 876-0460

geotechnics
INTEGRITY IN TESTING

MOISTURE CONTENT

ASTM D 2216 (SOP-S1)

Client	MESCO
Client Reference	GREENE CO. LF
Project No.	2007-626-01

Lab ID	.001	.002
Boring No.	MW-8	MW-7
Depth (ft)	7-8.15	8-10
Sample No.	TUBE	TUBE
Tare Number	212	216
Wt. of Tare & WS (gm)	526.27	645.2
Wt. of Tare & DS (gm)	457.94	554.29
Wt. of Tare (gm)	171.55	170.72
Wt. of Water (gm)	68.33	90.91
Wt. of DS (gm)	286.39	383.57
Water Content (%)	**23.9**	**23.7**

Notes : *NA*

Tested By *KMS* *Date* *6/29/2007* *Checked By* GM *Date* 6-29-07

page 1 of 1 DCN: CT-S1 DATE 6-30-98 REVISION: 2 *Z:\2007 PROJECTS\2007-626 MESCO\[2007-626-01 WATCONT.XLS]Sheet1*

2200 Westinghouse Boulevard • Suite 105 • Raleigh, NC 27604 • Phone (919) 876-0405 • Fax (919) 876-0460

geotechnics
INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	MESCO	Boring No.	MW-8
Client Reference	GREENE CO. LF	Depth (ft)	7-8.15
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-01	Soil Description	**GRAY ORANGE LEAN CLAY**

(Minus No. 40 sieve material, Airdried)

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description.

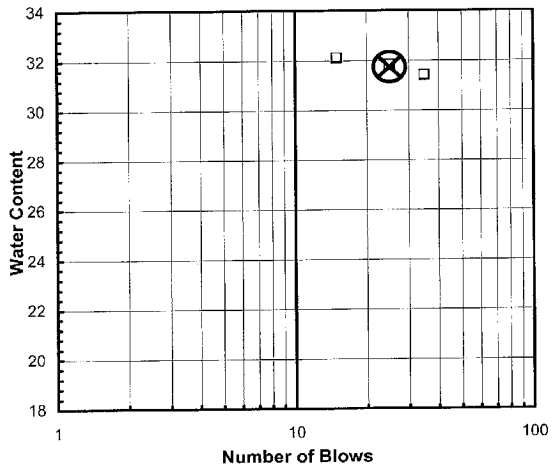
Liquid Limit Test	**1**	**2**	**3**	
Tare Number	S	A	E	MULTIPOINT
Wt. of Tare & WS (gm)	42.82	32.22	33.08	
Wt. of Tare & DS (gm)	36.11	28.12	28.83	
Wt. of Tare (gm)	15.21	15.24	15.30	
Wt. of Water (gm)	6.7	4.1	4.3	
Wt. of DS (gm)	20.9	12.9	13.5	
Moisture Content (%)	**32.1**	**31.8**	**31.4**	
Number of Blows	**15**	**25**	**35**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	N	I	
Wt. of Tare & WS (gm)	21.64	21.77	
Wt. of Tare & DS (gm)	20.98	21.13	
Wt. of Tare (gm)	15.31	15.23	
Wt. of Water (gm)	0.7	0.6	
Wt. of DS (gm)	5.7	5.9	
Moisture Content (%)	**11.6**	**10.8**	**0.8**

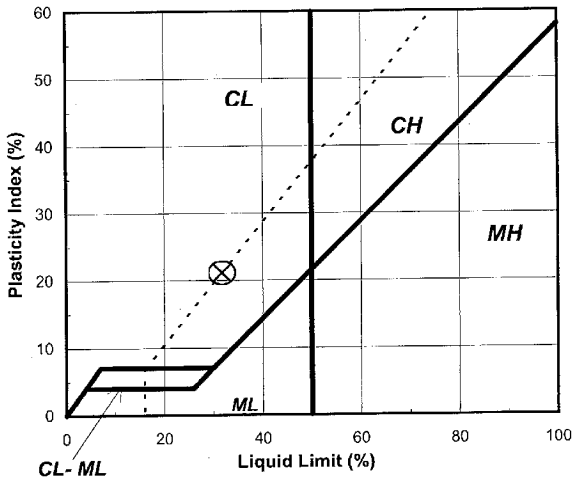
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**32**
Plastic Limit (%)	**11**
Plasticity Index (%)	**21**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



Tested By JBD *Date* 6/28/2007 *Checked By* GKM *Date* 6-29-07

page 1 of 1 **DCN:** CT-S4B **DATE:** 10/8/2001 **REVISION:** 2

Z:\2007 PROJECTS\2007-626 MESCO\[2007-626-01-01 3ptlimit.xls]Sheet1

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INTEGRITY IN TESTING

ATTERBERG LIMITS

ASTM D 4318-98 / AASHTO T89 (SOP - S4A)

Client	MESCO	Boring No.	MW-7
Client Reference	GREENE CO. LF	Depth (ft)	8-10
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-02	Soil Description	**BROWN LEAN CLAY**

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

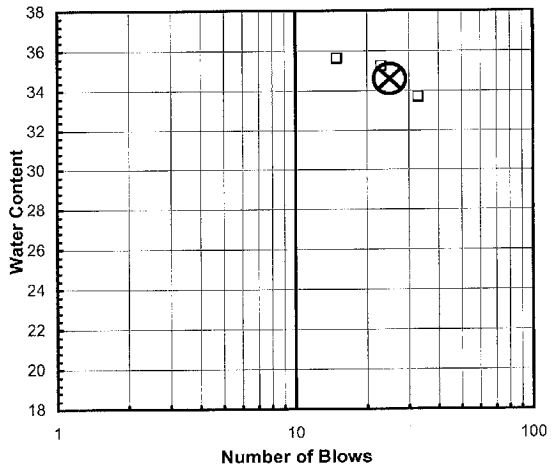
Liquid Limit Test	**1**	**2**	**3**	
Tare Number	B	K	O	MULTIPOINT
Wt. of Tare & WS (gm)	35.98	31.89	32.67	
Wt. of Tare & DS (gm)	30.52	27.56	28.28	
Wt. of Tare (gm)	15.19	15.27	15.25	
Wt. of Water (gm)	5.5	4.3	4.4	
Wt. of DS (gm)	15.3	12.3	13.0	
Moisture Content (%)	**35.6**	**35.2**	**33.7**	
Number of Blows	**15**	**23**	**33**	

Plastic Limit Test	**1**	**2**	**Range**
Tare Number	G	D	
Wt. of Tare & WS (gm)	22.84	21.94	
Wt. of Tare & DS (gm)	21.98	21.21	
Wt. of Tare (gm)	15.08	15.21	
Wt. of Water (gm)	0.9	0.7	
Wt. of DS (gm)	6.9	6.0	
Moisture Content (%)	**12.5**	**12.2**	**0.3**

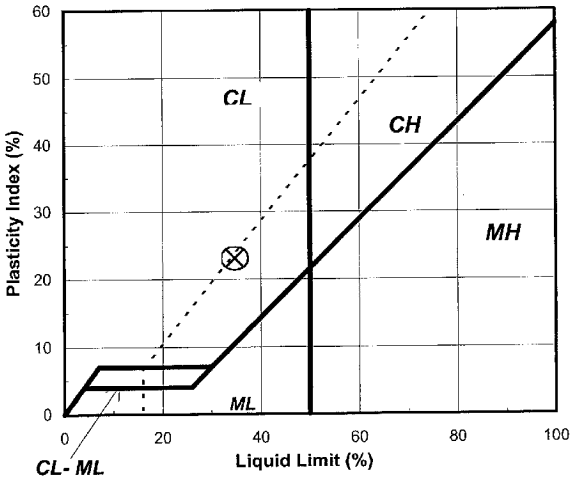
Note: The acceptable range of the two Moisture contents is ± 2.6

Test Results	
Liquid Limit (%)	**35**
Plastic Limit (%)	**12**
Plasticity Index (%)	**23**
USCS Symbol	**CL**

Flow Curve



Plasticity Chart



Tested By *KMR* *Date* *6/27/2007* *Checked By* GEM *Date* 6-29-07

page 1 of 1 **DCN:** CT-S4B **DATE:** 10/8/2001 **REVISION:** 2

\\Lab1\c\2007 PROJECTS\2007-626 MESCO\[2007-626-01-02 LIMIT.xls]Sheet1

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SPECIFIC GRAVITY

ASTM D 854-00 (SOP - S5)

Client	MESCO	Boring No.	MW-8
Client Reference	GREENE CO. LF	Depth (ft)	7-8.15
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-01	Visual Description	**GRAY ORANGE SANDY CLAY** (MInus No.4 sieve material, airdried)

Replicate Number	**1**	**2**
Pycnometer ID	R 27	R 280
Weight of Pycnometer + Soil + Water (gm)	718.53	716.2
Temperature, T (°Celsius)	26.9	26.8
Weight of Pycnometer + Water (gm)	687.63	684.99
Tare Number	211	209
Weight of Tare + Dry Soil (gm)	220.57	221.24
Weight of Tare (gm)	171.15	171.69
Weight of Dry Soil (gm)	49.42	49.55
Specific Gravity of Soil @ T	2.668	2.702
Specific Gravity of Water @ T	0.9966	0.9966
Conversion Factor for Temperature T	0.9984	0.9984
Specific Gravity @ 20° Celsius	2.673	2.706

Average Specific Gravity @ 20° Celsius	2.69

Tested By KMR *Date* 6/26/2007 *Checked By* GM *Date* 6-28-07

DCN: CT-S5 Date: 03/24/05 Revision: 10R

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INTEGRITY IN TESTING

SPECIFIC GRAVITY

ASTM D 854-00 (SOP - S5)

Client	MESCO	Boring No.	MW-7
Client Reference	GREENE CO. LF	Depth (ft)	8-10
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-02	Visual Description	**BROWN CLAY**
			(MInus No.4 sieve material, airdried)

Replicate Number		**1**		**2**
Pycnometer ID	R	242	R	312
Weight of Pycnometer + Soil + Water (gm)		707.63		696.72
Temperature, T (°Celsius)		28.7		28.7
Weight of Pycnometer + Water (gm)		669.46		665.98
Tare Number		202		P-12
Weight of Tare + Dry Soil (gm)		257.75		245.48
Weight of Tare (gm)		197.32		196.49
Weight of Dry Soil (gm)		60.43		48.99
Specific Gravity of Soil @ T		2.715		2.684
Specific Gravity of Water @ T		0.9961		0.9961
Conversion Factor for Temperature T		0.9978		0.9978
Specific Gravity @ 20° Celsius		2.721		2.690

Average Specific Gravity @ 20° Celsius	2.71

Tested By KMR *Date* 6/26/2007 *Checked By* GRM *Date* 6-28-07

DCN: CT-S5 Date: 03/24/05 Revision: 10R

\\Lab1\c\2007 PROJECTS\2007-626 MESCO\[2007-626-01-02 SP GRAV.xls]Sheet1

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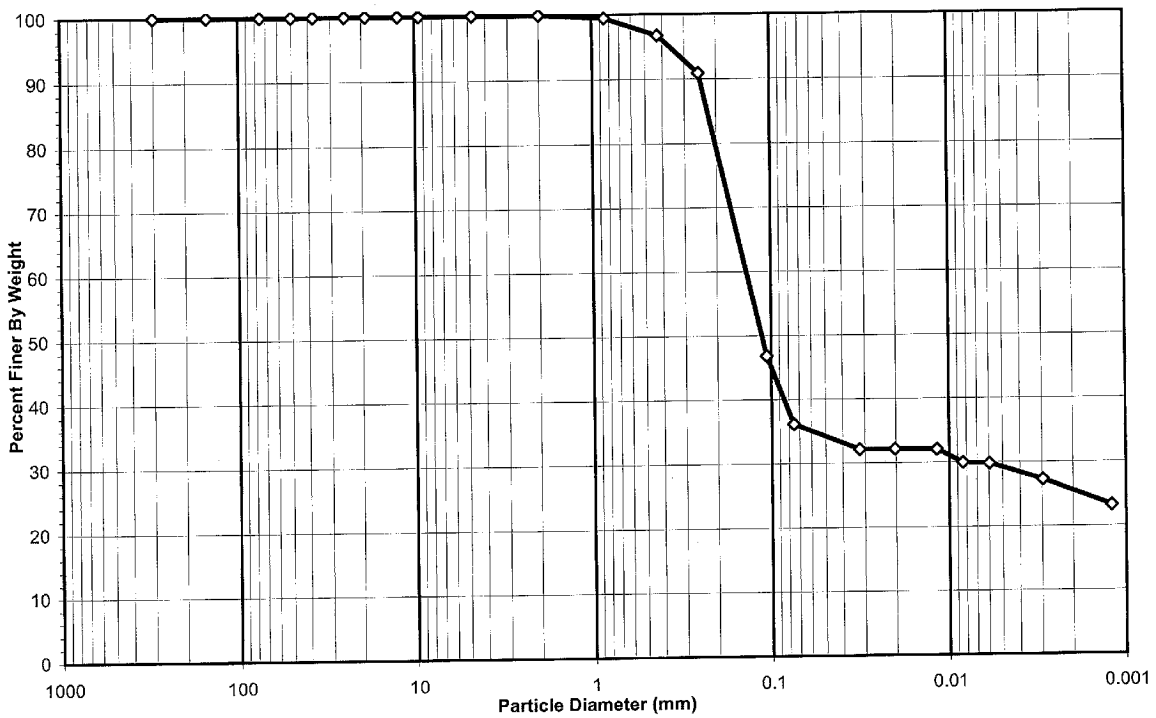
SIEVE AND HYDROMETER ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	MESCO	Boring No.	MW-8
Client Reference	GREENE CO. LF	Depth (ft)	7-8.15
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-01	Soil Color	**GRAY ORANGE**

	SIEVE ANALYSIS					HYDROMETER	
USCS	cobbles	gravel		sand		silt and clay fraction	
USDA	cobbles	gravel		sand		silt	clay

12" 6" 3" 3/4" 3/8" #4 #10 #20 #40 #140 #200



USCS Summary		
Sieve Sizes (mm)		**Percentage**
Greater Than #4	*Gravel*	0.00
#4 To #200	*Sand*	63.86
Finer Than #200	*Silt & Clay*	36.14

USCS Symbol ***SC, TESTED***

USCS Classification ***CLAYEY SAND***

page 1 of 4 DCN: CT-S3P DATE:02/15/05 REVISION:8 *Z:\2007 PROJECTS\2007-626 MESCO\[2007-626-01-01 #10 Split Hydro rev 8.xls]Sheet1*

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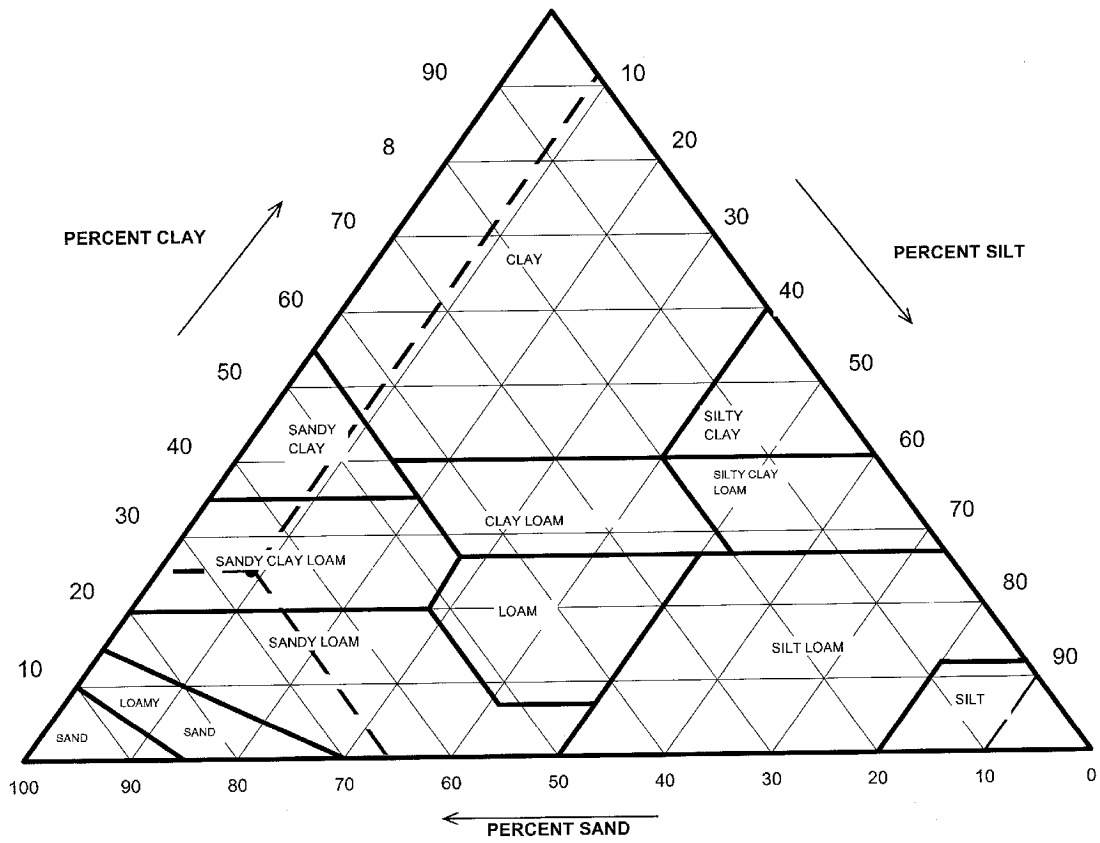
INTEGRITY IN TESTING

USDA CLASSIFICATION CHART

Client	MESCO	Boring No.	MW-8
Client Reference	GREENE CO. LF	Depth (ft)	7-8.15
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-01	Soil Color	GRAY ORANGE



Particle Size (mm)	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
		Gravel	0.00	**0.00**
2	100.00	*Sand*	65.78	**65.78**
0.05	34.22	*Silt*	8.77	**8.77**
0.002	25.45	*Clay*	25.45	**25.45**

USDA Classification: ***SANDY CLAY LOAM***

page 2 of 4 DCN: CT-S3P DATE:02/15/05 REVISION:8 Z:\2007 PROJECTS\2007-626 MESCO\[2007-626-01-01 #10 Split Hydro rev 8.xls]Sheet1

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WASH SIEVE ANALYSIS #10 SPLIT

ASTM D 422-63 (SOP-S3)

Client	MESCO	Boring No.	MW-8
Client Reference	GREENE CO. LF	Depth (ft)	7-8.15
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-01	Soil Color	**GRAY ORANGE**

Moisture Content/sieve +10 Material		Moisture Content for Hydrometer Portion	
Tare No.	212	Tare No.	P-1
Wgt.Tare + Wet Soil (gm)	526.27	Wgt.Tare + Wet Soil (gm)	59.40
Wgt.Tare + Dry Soil (gm)	457.94	Wgt.Tare + Dry Soil (gm)	58.84
Weight of Tare (gm)	171.55	Weight of Tare (gm)	21.99
Weight of Water (gm)	68.33	Weight of Water (gm)	0.56
Weight of Dry Soil (gm)	286.39	Weight of Dry Soil (gm)	36.85
Moisture Content (%)	**23.9**	**Moisture Content (%)**	**1.5**

Soil Specimen Data			
Wet Weight +#10 Material (gm)	354.72	Weight of the Dry Sample (gm)	335.64
Dry Weight +#10 Material(gm)	286.4	Weight of minus #200 material (gm)	17.80
Wet Weight Hydro. Material.(gm)	50.00	Weight of plus #200 material (gm)	317.84
Dry Weight Hydro. Material (gm)	49.25		
Total Dry Weight Sample (gm)	335.64	**J-FACTOR (%FINER THAN #10)**	**1.0000**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	0.00	0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00	100.00	**100.00**
1/2"	12.5	0.00	0.00	0.00	100.00	**100.00**
3/8"	9.50	0.00	0.00	0.00	100.00	**100.00**
#4	4.75	0.00	0.00	0.00	100.00	**100.00**
#10	2.00	0.00	0.00	0.00	100.00	**100.00**
#20	0.85	0.26	0.53	0.53	99.47	**99.47**
#40	0.425	1.33	2.70	3.23	96.77	**96.77**
#60	0.250	2.91	5.91	9.14	90.86	**90.86**
#140	0.106	21.70	44.06	53.20	46.80	**46.80**
#200	0.075	5.25	10.66	63.86	36.14	**36.14**
Pan	-	17.80	36.14	100.00	-	-

Notes :

Tested By SGH Date 6/29/2007 Checked By GEM Date 6-29-07

page 3 of 4 DCN: CT-S3P DATE:02/15/05 REVISION:8 *Z:\2007 PROJECTS\2007-626 MESCO\[2007-626-01-01 #10 Split Hydro rev 8.xls]Sheet1*

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HYDROMETER ANALYSIS

ASTM D 422-63 (SOP-S3)

Client	MESCO	Boring No.	MW-8
Client Reference	GREENE CO. LF	Depth (ft)	7-8.15
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-01	Soil Color	**GRAY ORANGE**

Elapsed Time (min)		R Measured	Temp. (°C)	Composite Correction	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	19.0	19.0	26.6	3.03	16.0	32.2	0.01248	0.0320	**32.2**
5		19.0	26.6	3.03	16.0	32.2	0.01248	0.0203	**32.2**
15		19.0	26.4	3.09	15.9	32.0	0.01251	0.0117	**32.0**
30		18.0	26.3	3.12	14.9	30.0	0.01253	0.0084	**30.0**
60		18.0	26.0	3.21	14.8	29.8	0.01257	0.0059	**29.8**
250		17.0	25.1	3.47	13.5	27.2	0.01270	0.0030	**27.2**
1440		14.0	28.5	2.48	11.5	23.2	0.01223	0.0012	**23.2**

Soil Specimen Data		Other Corrections	
Tare + Dry Material (gm)	49.25	a - Factor	0.992
Weight of Tare (gm)	0		
Weight of Deflocculant (gm)	5.0	Percent Finer than # 10	100.00
Weight of Dry Material (gm)	49.25		
		Specific Gravity	2.69 Measured

Note:

Tested By KMR Date 6/28/2007 Checked By GEM Date 6-29-07

page 4 of 4 DCN: CT-S3P DATE:02/15/05 REVISION:8 *Z:\2007 PROJECTS\2007-626 MESCO\[2007-626-01-01 #10 Split Hydro rev 8.xls]Sheet1*

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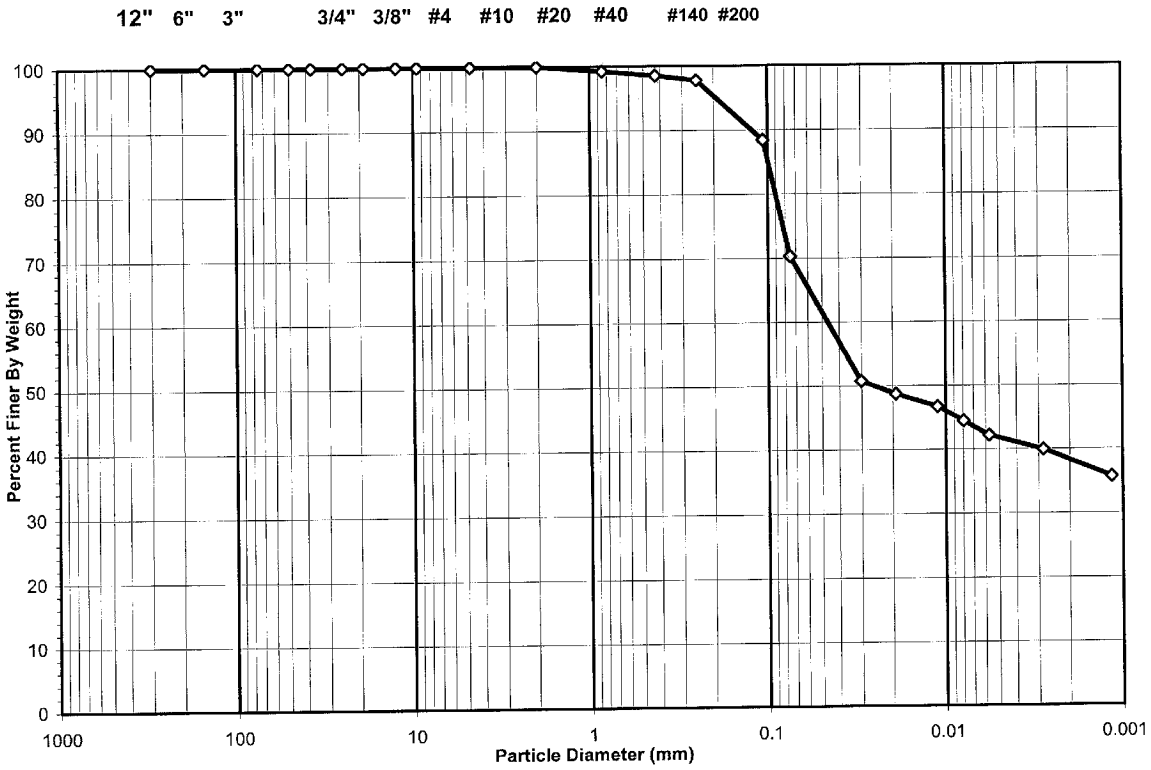
SIEVE AND HYDROMETER ANALYSIS
ASTM D 422-63 (SOP-S3)

Client	MESCO	Boring No.	MW-7
Client Reference	GREENE CO. LF	Depth (ft)	8-10
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-02	Soil Color	**BROWN**

	SIEVE ANALYSIS			HYDROMETER	
USCS	cobbles	gravel	sand	silt and clay fraction	
USDA	cobbles	gravel	sand	silt	clay



Sieve Sizes (mm)	USCS Summary	Percentage
Greater Than #4	*Gravel*	0.00
#4 To #200	*Sand*	29.67
Finer Than #200	*Silt & Clay*	70.33

USCS Symbol ***CL, TESTED***

USCS Classification ***LEAN CLAY WITH SAND***

page 1 of 4 DCN: CT-S3P DATE:02/15/05 REVISION:8 *Z:\2007 PROJECTS\2007-626 MESCO\[2007-626-01-02 #10 Split Hydro rev 8.xls]Sheet1*

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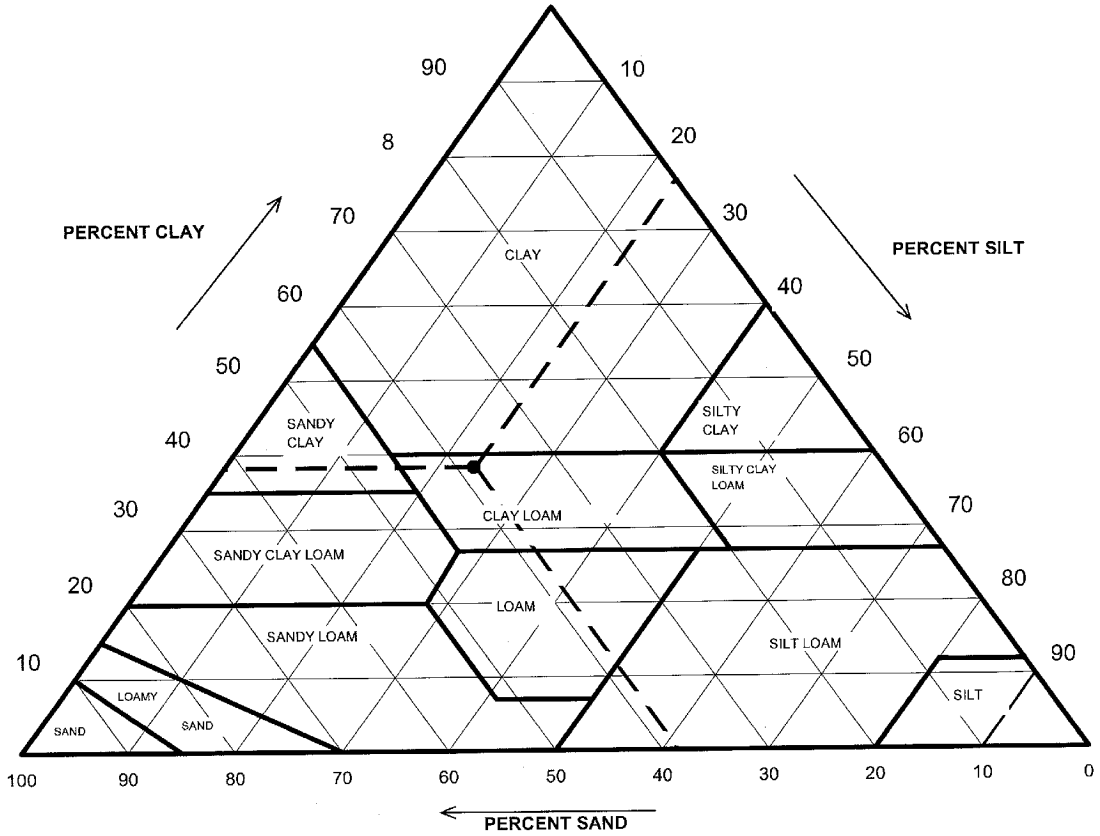
USDA CLASSIFICATION CHART

Client	MESCO	Boring No.	MW-7
Client Reference	GREENE CO. LF	Depth (ft)	8-10
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-02	Soil Color	BROWN



Particle Size (mm)	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
		Gravel	0.00	**0.00**
2	100.00	*Sand*	38.36	**38.36**
0.05	61.64	*Silt*	23.37	**23.37**
0.002	38.27	*Clay*	38.27	**38.27**

USDA Classification: ***CLAY LOAM***

page 2 of 4 DCN: CT-S3P DATE:02/15/05 REVISION:8 Z:\2007 PROJECTS\2007-626 MESCO\[2007-626-01-02 #10 Split Hydro rev 8.xls]Sheet1

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WASH SIEVE ANALYSIS #10 SPLIT

ASTM D 422-63 (SOP-S3)

Client	MESCO	Boring No.	MW-7
Client Reference	GREENE CO. LF	Depth (ft)	8-10
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-02	Soil Color	**BROWN**

Moisture Content/sieve +10 Material		Moisture Content for Hydrometer Portion	
Tare No.	216	Tare No.	U-1
Wgt.Tare + Wet Soil (gm)	645.20	Wgt.Tare + Wet Soil (gm)	65.51
Wgt.Tare + Dry Soil (gm)	554.29	Wgt.Tare + Dry Soil (gm)	64.46
Weight of Tare (gm)	170.72	Weight of Tare (gm)	28.90
Weight of Water (gm)	90.91	Weight of Water (gm)	1.05
Weight of Dry Soil (gm)	383.57	Weight of Dry Soil (gm)	35.56
Moisture Content (%)	**23.7**	**Moisture Content (%)**	**3.0**

Soil Specimen Data			
Wet Weight +#10 Material (gm)	474.48	Weight of the Dry Sample (gm)	432.14
Dry Weight +#10 Material(gm)	383.6	Weight of minus #200 material (gm)	34.16
Wet Weight Hydro. Material.(gm)	50.00	Weight of plus #200 material (gm)	397.98
Dry Weight Hydro. Material (gm)	48.57		
Total Dry Weight Sample (gm)	432.14	**J-FACTOR (%FINER THAN #10)**	**1.0000**

Sieve Size	Sieve Opening (mm)	Wgt.of Soil Retained (gm)	Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00	0.00	0.00	100.00	**100.00**
6"	150	0.00	0.00	0.00	100.00	**100.00**
3"	75	0.00	0.00	0.00	100.00	**100.00**
2"	50	0.00	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00	0.00	0.00	100.00	**100.00**
1"	25.0	0.00	0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00	0.00	0.00	100.00	**100.00**
1/2"	12.5	0.00	0.00	0.00	100.00	**100.00**
3/8"	9.50	0.00	0.00	0.00	100.00	**100.00**
#4	4.75	0.00	0.00	0.00	100.00	**100.00**
#10	2.00	0.00	0.00	0.00	100.00	**100.00**
#20	0.85	0.36	0.74	0.74	99.26	**99.26**
#40	0.425	0.35	0.72	1.46	98.54	**98.54**
#60	0.250	0.37	0.76	2.22	97.78	**97.78**
#140	0.106	4.55	9.37	11.59	88.41	**88.41**
#200	0.075	8.78	18.08	29.67	70.33	**70.33**
Pan	-	34.16	70.33	100.00	-	**-**

Notes :

Tested By SGH Date 6/29/2007 Checked By GEM Date 6-29-07

page 3 of 4 DCN: CT-S3P DATE:02/15/05 REVISION:8 *Z:\2007 PROJECTS\2007-626 MESCO\[2007-626-01-02 #10 Split Hydro rev 8.xls]Sheet1*

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HYDROMETER ANALYSIS

ASTM D 422-63 (SOP-S3)

Client	MESCO	Boring No.	MW-7
Client Reference	GREENE CO. LF	Depth (ft)	8-10
Project No.	2007-626-01	Sample No.	TUBE
Lab ID	2007-626-01-02	Soil Color	**BROWN**

Elapsed Time (min)		R Measured	Temp. (°C)	Composite Correction	R Corrected	N (%)	K Factor	Diameter (mm)	N' (%)
0	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	28.0	28.0	26.5	3.06	24.9	50.7	0.01243	0.0301	**50.7**
5		27.0	26.5	3.06	23.9	48.7	0.01243	0.0191	**48.7**
15		26.0	26.5	3.06	22.9	46.7	0.01243	0.0111	**46.7**
30		25.0	26.2	3.15	21.9	44.5	0.01247	0.0079	**44.5**
60		24.0	25.8	3.27	20.7	42.2	0.01252	0.0057	**42.2**
250		23.0	25.4	3.38	19.6	39.9	0.01258	0.0028	**39.9**
1440		20.0	28.5	2.48	17.5	35.6	0.01215	0.0012	**35.6**

Soil Specimen Data		Other Corrections	
Tare + Dry Material (gm)	48.57	a - Factor	0.988
Weight of Tare (gm)	0		
Weight of Deflocculant (gm)	5.0	Percent Finer than # 10	100.00
Weight of Dry Material (gm)	48.57		
		Specific Gravity	2.71 Measured

Note:

Tested By SGH Date 6/28/2007 Checked By GEM Date 6-29-07

page 4 of 4 DCN: CT-S3P DATE:02/15/05 REVISION:8 *Z:\2007 PROJECTS\2007-626 MESCO\[2007-626-01-02 #10 Split Hydro rev 8.xls]Sheet1*

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FLEXIBLE WALL PERMEABILITY TEST

geotechnics
INTEGRITY IN TESTING

PERMOMETER METHOD

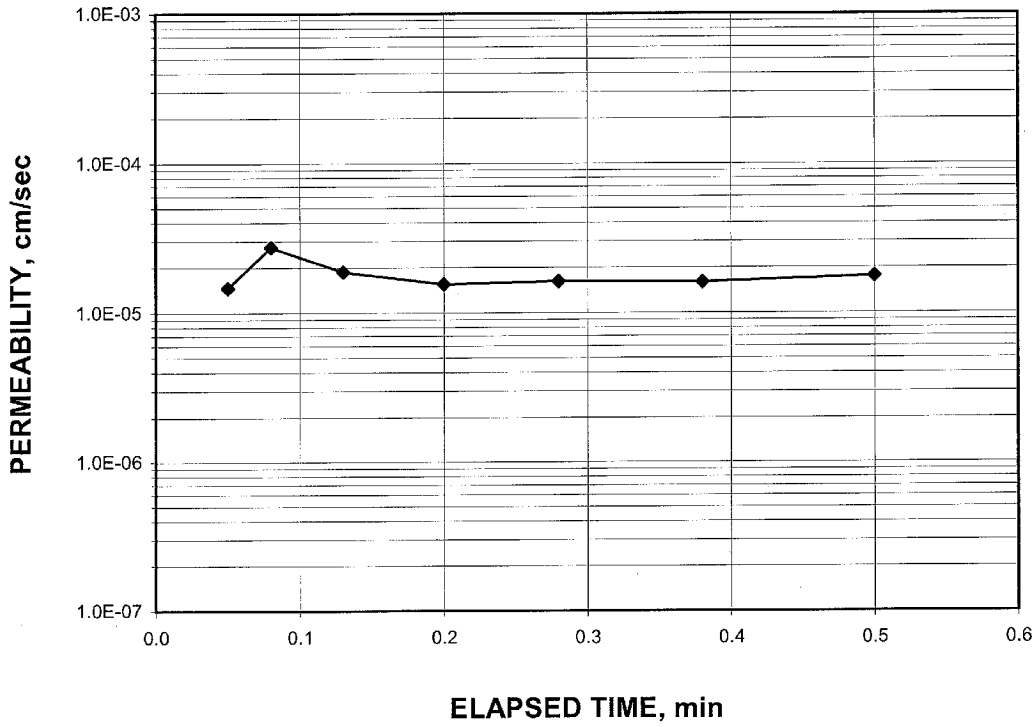
ASTM D 5084-97
(SOP-S22C)

Client	MESCO	Boring No.	MW-8
Client Project	GREENE CO. LF	Depth (ft.)	7-8.15
Project No.	2007-626-01	Sample No.	TUBE
Lab ID No.	2007-626-01-01		

Visual Description: GRAY & ORANGE CLAYEY SAND

AVERAGE PERMEABILITY = 1.6E-05 cm/sec @ 20°C
AVERAGE PERMEABILITY = 1.6E-07 m/sec @ 20°C

PERMEABILITY vs. TIME



Tested By: TMS Date: 6/26/2007 Checked By: GEM Date: 6-29-07

Page 1 of 3 DCN: CT-22A DATE:12-21-98 REVISION: 4 \\Lab1\c\2007 PROJECTS\2007-626 MESCO\[2007-626-01-01 Permom.xls]Sheet1

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FLEXIBLE WALL PERMEABILITY TEST

geotechnics INTEGRITY IN TESTING

PERMOMETER METHOD

ASTM D 5084-97
(SOP-S22A & B)

Client	MESCO	Boring No.	MW-8
Client Project	GREENE CO. LF	Depth (ft.)	7-8.15
Project No.	2007-626-01	Sample No.	TUBE
Lab ID No.	2007-626-01-01		

Specific Gravity	2.69	Measured
Sample Condition		Undisturbed

Visual Description: GRAY & ORANGE CLAYEY SAND

MOISTURE CONTENT:	BEFORE TEST	AFTER TEST
Tare Number	212	320
Wt. of Tare & WS (gm.)	526.27	723.01
Wt. of Tare & DS (gm.)	457.94	596.65
Wt. of Tare (gm.)	171.55	86.28
Wt. of Water (gm.)	68.33	126.36
Wt. of DS (gm.)	286.39	510.37
Moisture Content (%)	**23.9**	**24.8**

SPECIMEN:	BEFORE TEST	AFTER TEST
Wt. of Tube & WS (gm.)	872.80	NA
Wt. of Tube (gm.)	230.02	NA
Wt. of WS (gm.)	642.78	647.45
Length 1 (in.)	3.069	3.094
Length 2 (in.)	3.061	3.018
Length 3 (in.)	3.057	3.043
Top Diameter (in.)	2.872	2.753
Middle Diameter (in.)	2.881	2.807
Bottom Diameter (in.)	2.876	2.800
Average Length (in.)	3.06	3.05
Average Area (in.^{2})	6.50	6.10
Sample Volume (cm^3)	326.08	305.00
Unit Wet Wt. (gm./ cm^3)	1.971	2.123
Unit Wet Wt. (pcf)	123.0	132.5
Unit Dry Wt. (pcf)	99.3	106.2
Unit Dry Wt. (gm./ cm^3)	1.592	1.702
Void Ratio, e	0.690	0.581
Porosity, n	0.408	0.367
Pore Volume (cm^3)	133.2	112.1

Tested By: TMS Date: 6/26/2007 Checked By: GEM Date: 6-29-07

Page 2 of 3 DCN: CT-22A DATE:12-21-98 REVISION: 4 \\Lab1\c\2007 PROJECTS\2007-626 MESCO\[2007-626-01-01 Permom.xls]Sheet1

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FLEXIBLE WALL PERMEABILITY TEST

geotechnics INTEGRITY IN TESTING

PERMOMETER METHOD

ASTM D 5084-97
(SOP-S22A & B)

Client	MESCO	Boring No.	MW-8
Client Project	GREENE CO. LF	Depth (ft.)	7-8.15
Project No.	2007-626-01	Sample No.	TUBE
Lab ID No.	2007-626-01-01		

Test Pressures		Final Sample Dimensions	
Cell Pressure(psi)	46.0	Sample Length (cm), L	7.75
Back Pressure(psi)	40.0	Sample Area (cm^2), A	39.35
Eff. Cons. Pressure(psi)	6.0	Pipette Area (cm^2), a_p	0.03142
Response (%)	95	Annulus Area (cm^2), a_a	0.76712
		Equilibrium Level (cm), R_{eq}	1.75

AVERAGE PERMEABILITY = 1.6E-05 cm/sec @ 20°C
AVERAGE PERMEABILITY = 1.6E-07 m/sec @ 20°C

DATE (mm/dd/yy)	TIME (hr)	TIME (min)	ELAPSED TIME t (min)	PIPETTE READI NG R_p (cm)	INCREMENT GRADIENT i (cm/cm)	FLOW CONDITION (0 flow) (1 stop)	TEMP. (°C)	INCREMENTAL PERMEABILITY @ 20°C (cm/sec)
6/26/2007	13	41.12	0	11.5	16.4	0	26.7	NA
6/26/2007	13	41.17	0	10.5	14.7	0	26.7	1.5E-05
6/26/2007	13	41.2	0	9.5	13.1	0	26.7	2.7E-05
6/26/2007	13	41.25	0	8.5	11.4	0	26.7	1.9E-05
6/26/2007	13	41.32	0	7.5	9.7	0	26.7	1.5E-05
6/26/2007	13	41.4	0	6.5	8.0	0	26.7	1.6E-05
6/26/2007	13	41.5	0	5.5	6.3	0	26.7	1.6E-05
6/26/2007	13	41.62	1	4.5	4.6	1	26.7	1.7E-05

Tested By: TMS Date: 6/26/2007 Checked By: Gem Date: 6-29-07

Page 3 of 3

DCN: CT-22A DATE:12-21-98 REVISION: 4 \\Lab1\c\2007 PROJECTS\2007-626 MESCO\[2007-626-01-01 Permom.xls]Sheet1

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FLEXIBLE WALL PERMEABILITY TEST

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PERMOMETER METHOD

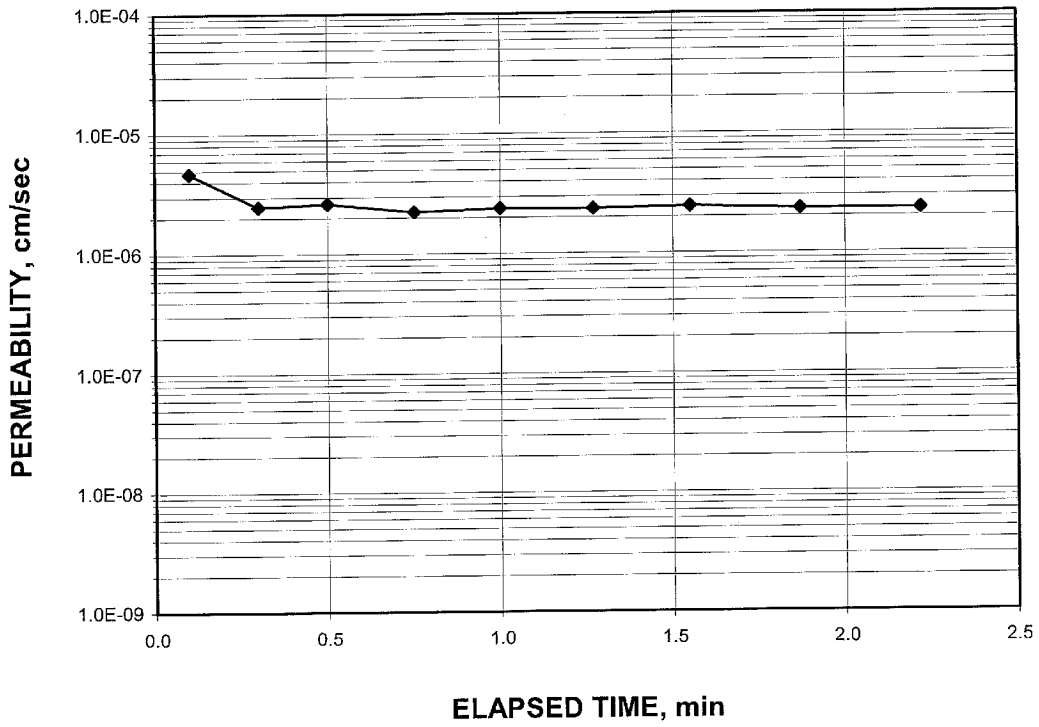
ASTM D 5084-97
(SOP-S22C)

Client	MESCO	Boring No.	MW-7
Client Project	GREENE CO. LF	Depth (ft.)	8-10
Project No.	2007-626-01	Sample No.	TUBE
Lab ID No.	2007-626-01-02		

Visual Description: BROWN LEAN CLAY WITH SAND

AVERAGE PERMEABILITY = 2.4E-06 cm/sec @ 20°C
AVERAGE PERMEABILITY = 2.4E-08 m/sec @ 20°C

PERMEABILITY vs. TIME



Tested By: TMS Date: 6/22/2007 Checked By: GEM Date: 6-29-07

 DCN: CT-22A DATE:12-21-98 REVISION: 4 \\Lab1\c\2007 PROJECTS\2007-626 MESCO\[2007-626-01-02 Permom.xls]Sheet1

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FLEXIBLE WALL PERMEABILITY TEST

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INTEGRITY IN TESTING

PERMOMETER METHOD

ASTM D 5084-97
(SOP-S22A & B)

Client	MESCO	Boring No.	MW-7
Client Project	GREENE CO. LF	Depth (ft.)	8-10
Project No.	2007-626-01	Sample No.	TUBE
Lab ID No.	2007-626-01-02		

Specific Gravity	2.71	Measured
Sample Condition		Undisturbed

Visual Description: BROWN LEAN CLAY WITH SAND

MOISTURE CONTENT:	BEFORE TEST	AFTER TEST
Tare Number	F-4	306
Wt. of Tare & WS (gm.)	265.45	747
Wt. of Tare & DS (gm.)	233.49	618.03
Wt. of Tare (gm.)	100.56	88.12
Wt. of Water (gm.)	31.96	128.97
Wt. of DS (gm.)	132.93	529.91
Moisture Content (%)	**24.0**	**24.3**

SPECIMEN:	BEFORE TEST	AFTER TEST
Wt. of Tube & WS (gm.)	832.82	NA
Wt. of Tube (gm.)	0.00	NA
Wt. of WS (gm.)	832.82	834.80
Length 1 (in.)	4.040	3.991
Length 2 (in.)	4.043	3.990
Length 3 (in.)	4.038	3.975
Top Diameter (in.)	2.907	2.819
Middle Diameter (in.)	2.883	2.838
Bottom Diameter (in.)	2.840	2.840
Average Length (in.)	4.04	3.99
Average Area (in.^{2})	6.50	6.30
Sample Volume (cm^3)	430.32	411.48
Unit Wet Wt. (gm./ cm^3)	1.935	2.029
Unit Wet Wt. (pcf)	120.8	126.6
Unit Dry Wt. (pcf)	97.4	101.9
Unit Dry Wt. (gm./ cm^3)	1.560	1.632
Void Ratio, e	0.737	0.661
Porosity, n	0.424	0.398
Pore Volume (cm^3)	182.6	163.7

Tested By: TMS Date: 6/22/2007 Checked By: GEM Date: 6-29-07

Page 2 of 3 DCN: CT-22A DATE:12-21-98 REVISION: 4 \\Lab1\c\2007 PROJECTS\2007-626 MESCO\[2007-626-01-02 Permom.xls]Sheet1

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FLEXIBLE WALL PERMEABILITY TEST

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PERMOMETER METHOD

ASTM D 5084-97
(SOP-S22A & B)

Client	MESCO	Boring No.	MW-7
Client Project	GREENE CO. LF	Depth (ft.)	8-10
Project No.	2007-626-01	Sample No.	TUBE
Lab ID No.	2007-626-01-02		

Test Pressures		Final Sample Dimensions	
Cell Pressure(psi)	56.0	Sample Length (cm), L	10.12
Back Pressure(psi)	49.0	Sample Area (cm^2), A	40.65
Eff. Cons. Pressure(psi)	7.0	Pipette Area (cm^2), a_p	0.03142
Response (%)	95	Annulus Area (cm^2), a_a	0.76712
		Equilibrium Level (cm), R_{eq}	1.75

AVERAGE PERMEABILITY = 2.4E-06 cm/sec @ 20°C
AVERAGE PERMEABILITY = 2.4E-08 m/sec @ 20°C

DATE (mm/dd/yy)	TIME (hr)	TIME (min)	ELAPSED TIME t (min)	PIPETTE READI NG R_p (cm)	INCREMENT GRADIENT i (cm/cm)	FLOW CONDITION (0 flow) (1 stop)	TEMP. (°C)	INCREMENTAL PERMEABILITY @ 20°C (cm/sec)
6/25/2007	15	8.63	0	11.5	12.6	0	24.8	NA
6/25/2007	15	8.73	0	11.0	11.9	0	24.8	4.7E-06
6/25/2007	15	8.93	0	10.5	11.3	0	24.8	2.5E-06
6/25/2007	15	9.13	1	10.0	10.6	0	24.8	2.6E-06
6/25/2007	15	9.38	1	9.5	10.0	0	24.8	2.2E-06
6/25/2007	15	9.63	1	9.0	9.4	0	24.8	2.4E-06
6/25/2007	15	9.9	1	8.5	8.7	0	24.8	2.4E-06
6/25/2007	15	10.2	2	8.0	8.1	0	24.8	2.5E-06
6/25/2007	15	10.5	2	7.5	7.4	0	24.8	2.3E-06
6/25/2007	15	10.9	2	7.0	6.8	1	24.8	2.3E-06

Tested By: TMS Date: 6/22/2007 Checked By: GEM Date: 6-29-07

Page 3 of 3

DCN: CT-22A DATE:12-21-98 REVISION: 4 \\Lab1\c\2007 PROJECTS\2007-626 MESCO\[2007-626-01-02 Permom.xls]Sheet1

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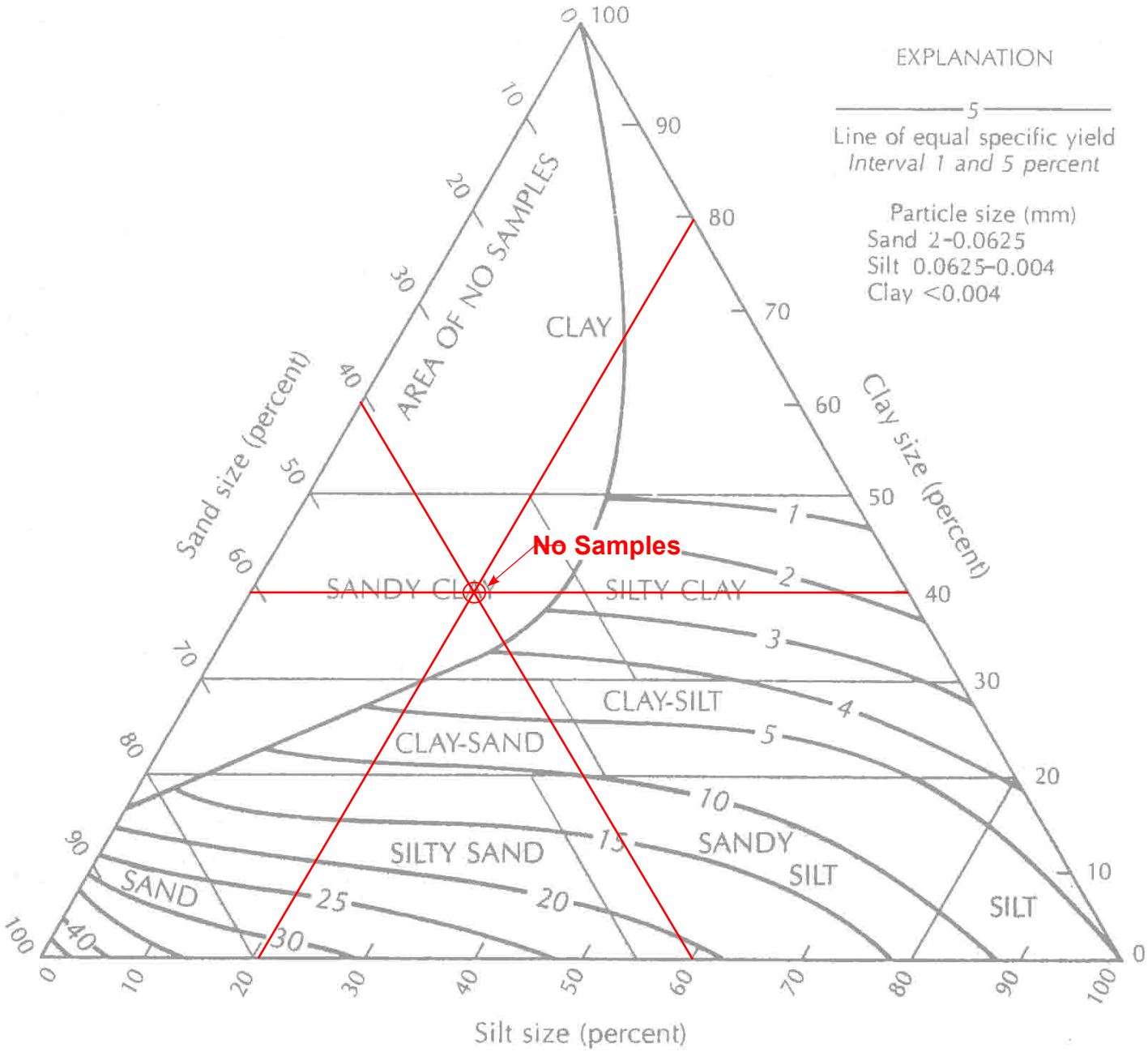
Figure B-1: Calculation of effective porosity from re-calculated grain size distribution, MW-7 8-10.0'



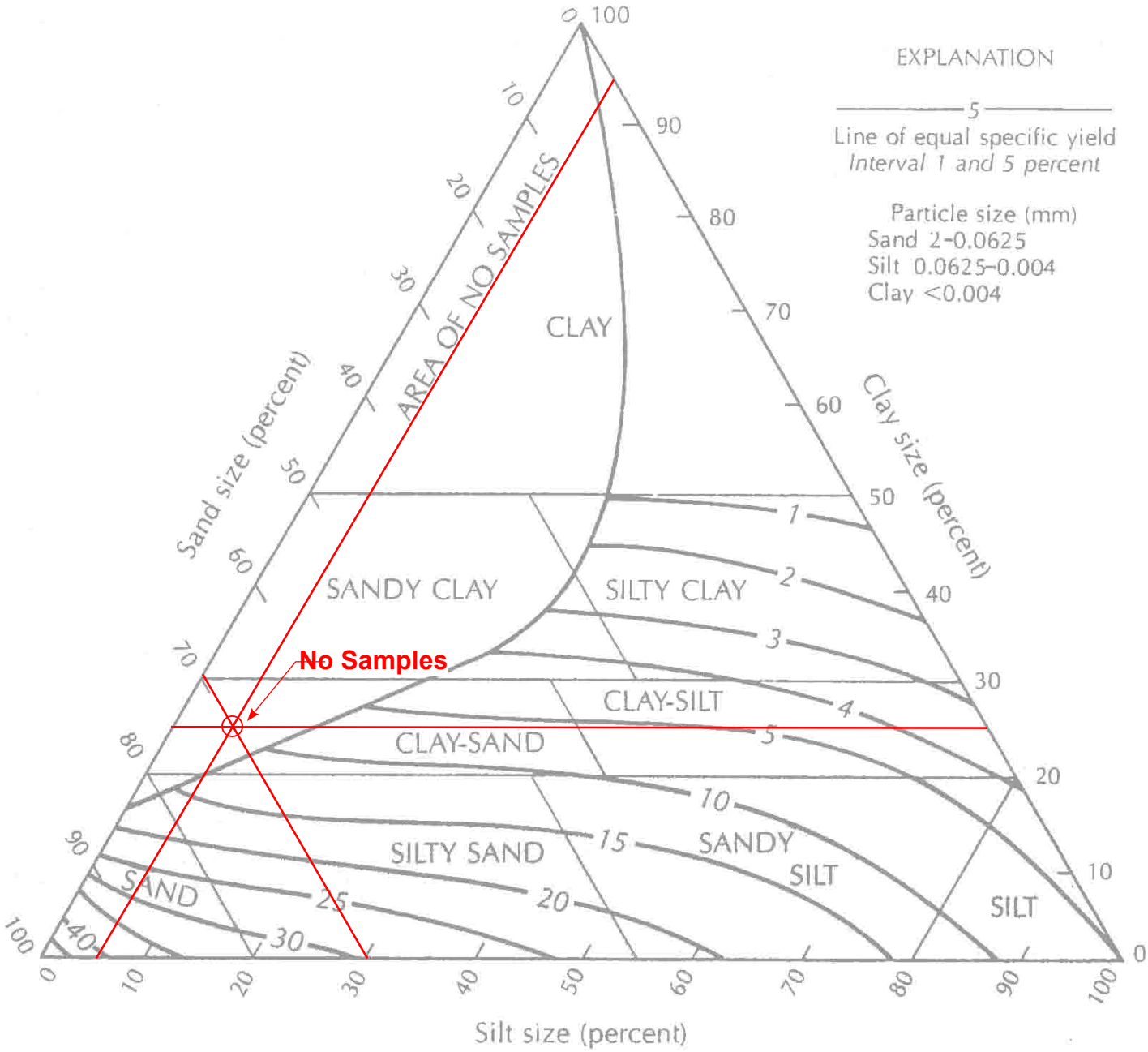
MW-7 8-10.0'

Soil Type	Proportion (%)
Sand	40.0%
Silt	20.0%
Clay	40.0%

AGU Soil Classification
Sandy Clay

Effective Porosity
N/A

Figure B-2: Calculation of effective porosity from re-calculated grain size distribution, MW-8 7-8.15'



P3-9 3-4.92'

Soil Type	Proportion (%)
Sand	8.0%
Silt	32.4%
Clay	59.6%

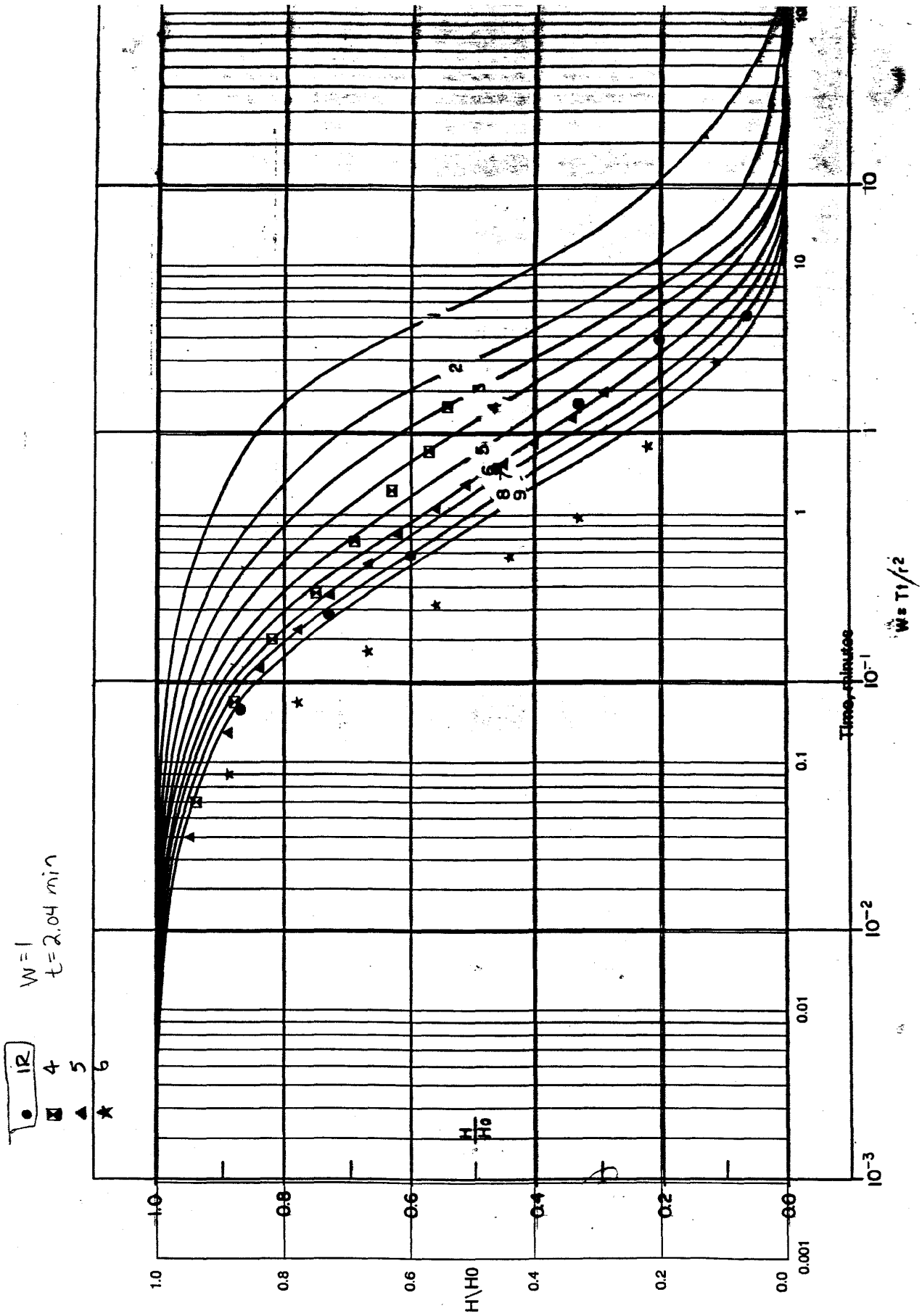
AGU Soil Classification
Sandy Clay

Effective Porosity
N/A

SLUG TEST MW1R GREENE

DEPTH TO GW	4.83	RADIUS, in.	1
HT OF STICKUP	2.64	WET SCREEN, ft	15
INITIAL GW READING	0	t, min	2.04
INITIAL TIME	46.82	k, cm/sec	1.2E-04
INITIAL GW BELOW TOC	7.47		
HO	7.47		

GW READING	DH	H	H/HO	HOUR	MIN	SEC	TIME
1	1	6.47	0.87	0	46	59	0.16
2	2	5.47	0.73	0	47	12	0.38
3	3	4.47	0.60	0	47	30	0.68
4	4	3.47	0.46	0	48	19	1.50
5	5	2.47	0.33	0	49	28	2.65
6	6	1.47	0.20	0	51	38	4.81
7	7	0.47	0.06	0	52	51	6.03


W = 1
t = 2.04 min
IR
4
5
6
H/Ho
H\H0
1.0
0.8
0.6
0.4
0.2
0.0
0.001
0.01
0.1
1
10
10^{-3}
10^{-2}
10^{-1}
Time, minutes
W = T1/r2

PZ #1 4.36
PZ #2 14.28

SLUG TEST DATA SHEET

CLIENT: MESCO
PROJECT: Greene Co. L.F

JOB No. 94205.04
TESTED BY: RTW
DATE 10-5-94

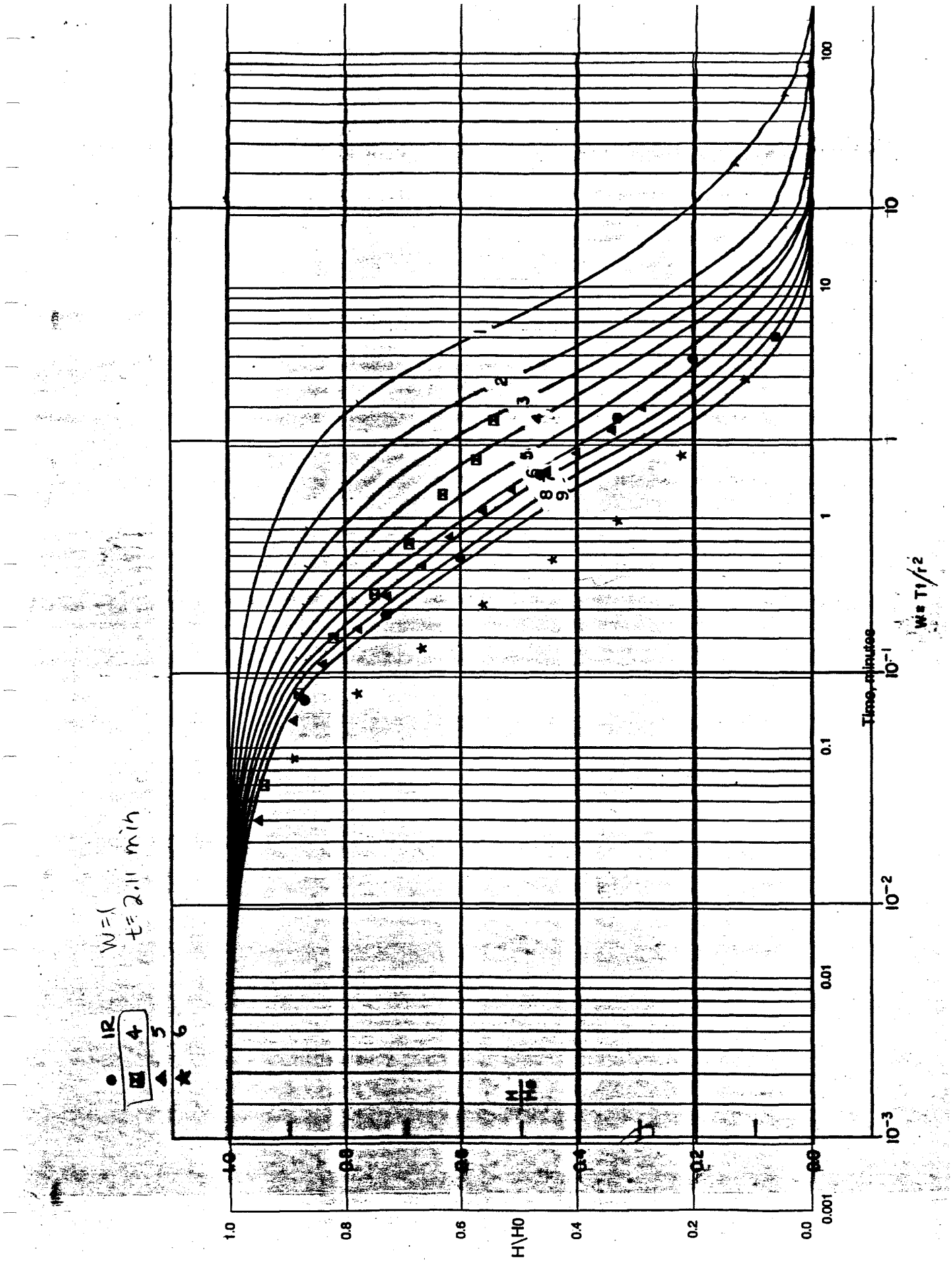
WELL 1R
DEPTH TO GW (BELOW GROUND) 4.83
HT OF STICKUP 2.64
DEPTH TO TOP OF SCREEN (BELOW TOC) 7.47
SCREEN 15'
APPROXIMATE WATER ADDED TO WELL 10 gals

TIME (HRS, MIN, SEC)	DEPTH TO WATER (BELOW TOC)
46:49	0
46:59	1
47:12	2
47:30	3
48:19	4
49:28	5
51:38	6
52:51	7

SLUG TEST MW4 GREENE

DEPTH TO GW	17.82	RADIUS, in.	1
HT OF STICKUP	2.4	WET SCREEN, ft	15
INITIAL GW READING	4	t, min	2.11
INITIAL TIME	28.2	k, cm/sec	1.1E-04
INITIAL GW BELOW TOC	20.22		
H0	16.22		

GW READING	DH	H	H/H0	HOUR	MIN	SEC	TIME
5	1	15.22	0.94	0	28	16	0.07
6	2	14.22	0.88	0	28	22	0.17
7	3	13.22	0.82	0	28	30	0.30
8	4	12.22	0.75	0	28	40	0.47
9	5	11.22	0.69	0	28	59	0.78
10	6	10.22	0.63	0	29	26	1.23
11	7	9.22	0.57	0	29	56	1.73
11.4	7.4	8.82	0.54	0	30	47	2.58


H/H0
1.0
0.8
0.6
0.4
0.2
0.0
0.001
0.01
0.1
1
10
100
10^{-3}
10^{-2}
10^{-1}
1
10
10
Time, minutes
$W = T1/r^2$
1
2
3
4
5
6
7
8
9
W=1
t=2.11 min

SLUG TEST DATA SHEET

CLIENT: MESCO
JOB NO. 94205.02
PROJECT: Greene Co. L.F.
TESTED BY: RTW
DATE 10-5-94

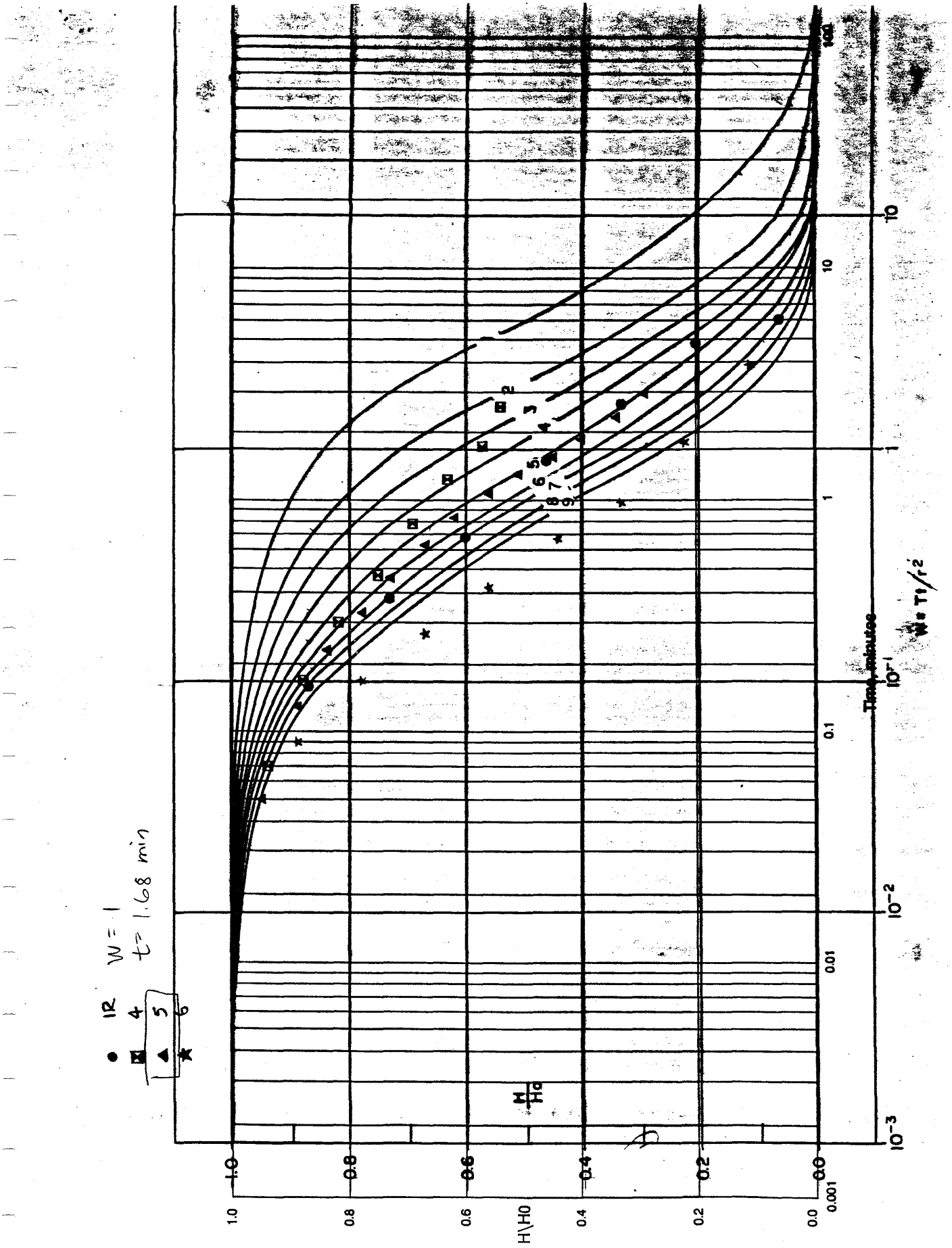
WELL 4
DEPTH TO GW (BELOW GROUND) 17.82
HT OF STICKUP 2.40
DEPTH TO TOP OF SCREEN (BELOW TOC) 11.40
SCREEN 15'
APPROXIMATE WATER ADDED TO WELL

TIME (HRS, MIN, SEC)	DEPTH TO WATER (BELOW TOC)
28:12	4
28:16	5
28:22	6
28:30	7
28:40	8
28:59	9
29:26	10
29:56	11
30:47	11.40

SLUG TEST MW5 GREENE

DEPTH TO GW	17	RADIUS, in.	1
HT OF STICKUP	2.3	WET SCREEN, ft	15
INITIAL GW READING	1	t, min	1.68
INITIAL TIME	0.77	k, cm/sec	1.4E-04
INITIAL GW BELOW TOC	19.3		
HO	18.3		

GW READING	DH	H	H/HO	HOUR	MIN	SEC	TIME
2	1	17.3	0.95	0	0	49	0.05
3	2	16.3	0.89	0	0	54	0.13
4	3	15.3	0.84	0	1	0	0.23
5	4	14.3	0.78	0	1	6	0.33
6	5	13.3	0.73	0	1	14	0.46
7	6	12.3	0.67	0	1	24	0.63
8	7	11.3	0.62	0	1	36	0.83
9	8	10.3	0.56	0	1	50	1.06
10	9	9.3	0.51	0	2	4	1.30
11	10	8.3	0.45	0	2	20	1.56
12	11	7.3	0.40	0	2	38	1.86
13	12	6.3	0.34	0	3	5	2.31
14	13	5.3	0.29	0	3	42	2.93


H/Ho
1.0
0.8
0.6
0.4
0.2
0.0
0.001
0.01
0.1
1
10
100
10^{-3}
10^{-2}
10^{-1}
1
10
Time, minutes
$W = T_1/r^2$
1
2
3
4
5
6
7
8
9
10
IR
4
5
6
W = 1
t = 1.68 min

SLUG TEST DATA SHEET

CLIENT: Mesco
JOB NO. 94205.02
PROJECT: Greene Co landfill
TESTED BY: RTW
DATE 10-5-94

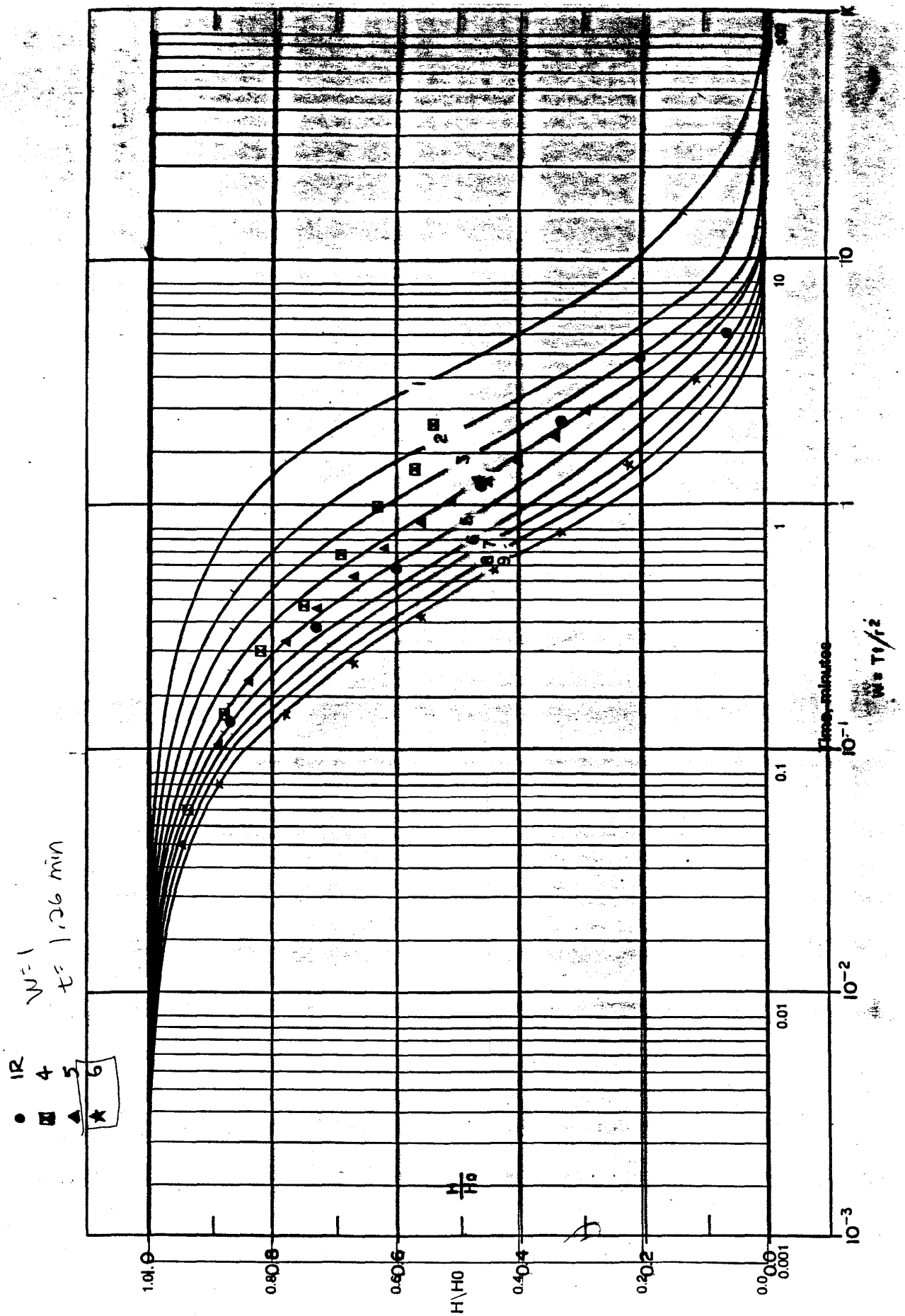
WELL 5
DEPTH TO GW (BELOW GROUND) 17'
HT OF STICKUP 2.30
DEPTH TO TOP OF SCREEN 16.30
(BELOW TOC)
SCREEN 15'
APPROXIMATE WATER ADDED TO WELL 20 gals

TIME (HRS, MIN, SEC)	DEPTH TO WATER (BELOW TOC)
00:46	1
00:49	2
00:54	3
01:00	4
01:06	5
01:14	6
01:24	7
01:36	8
01:50	9
02:04	10
02:20	11
02:38	12
03:05	13
03:42	14
04:26	15
05:18	16
06:22	17
07:07	18

SLUG TEST MW6 GREENE

DEPTH TO GW	7.53	RADIUS, in.	1
HT OF STICKUP	2.46	WET SCREEN, ft	15
INITIAL GW READING	1	t, min	1.26
INITIAL TIME	40.48	k, cm/sec	1.9E-04
INITIAL GW BELOW TOC	9.99		
H0	8.99		

GW READING	DH	H	H/H0	HOUR	MIN	SEC	TIME
2	1	7.99	0.89	0	40	34	0.09
3	2	6.99	0.78	0	40	39	0.17
4	3	5.99	0.67	0	40	45	0.27
5	4	4.99	0.56	0	40	54	0.42
6	5	3.99	0.44	0	41	9	0.67
7	6	2.99	0.33	0	41	27	0.97
8	7	1.99	0.22	0	42	17	1.80
9	8	0.99	0.11	0	44	22	3.89

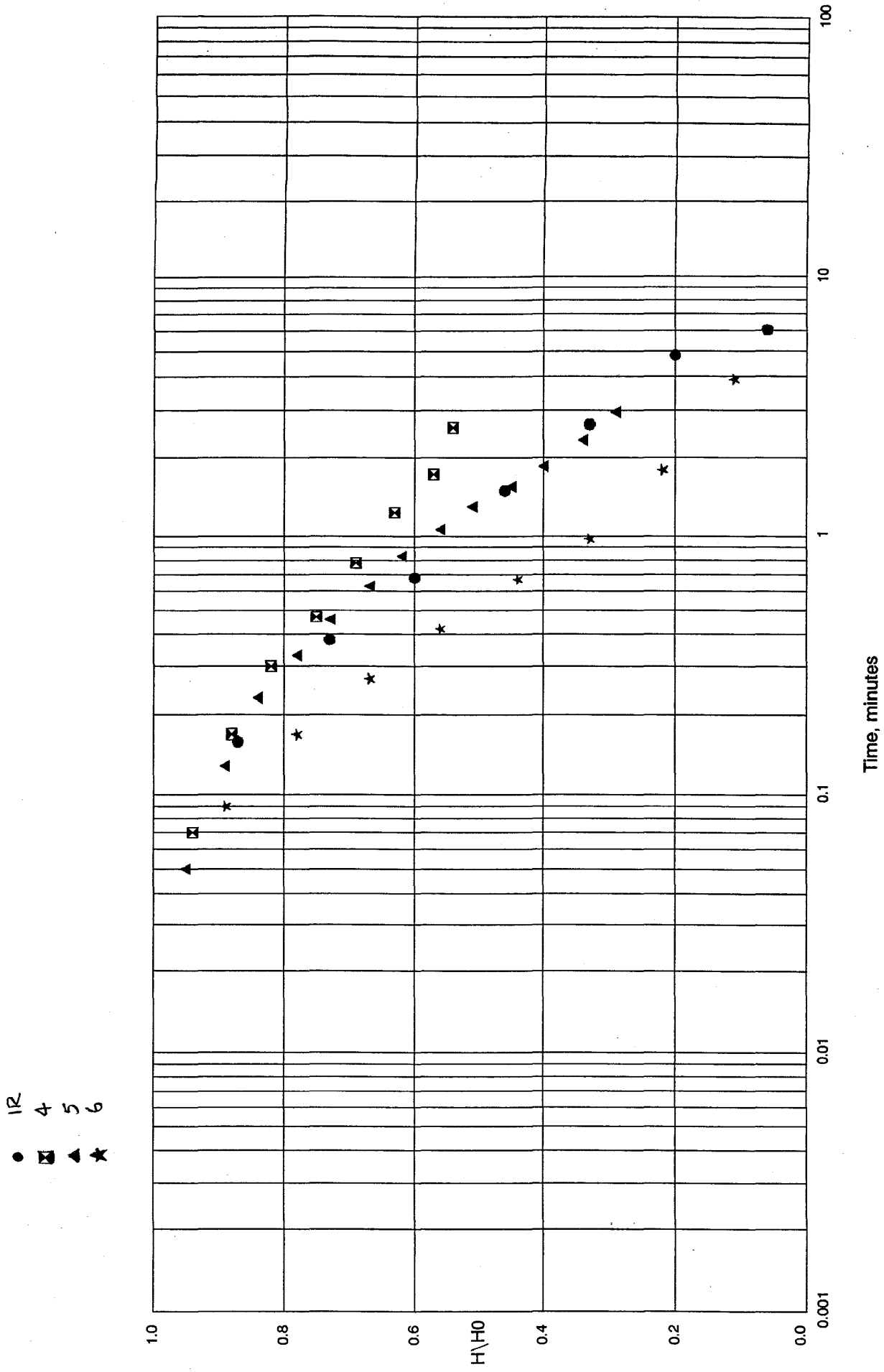

H/Ho
1.0
0.8
0.6
0.4
0.2
0.0
0.001
0.01
0.1
1
10
10^{-3}
10^{-2}
10^{-1}
1
10
Time, minutes
W = T1/r²
1R
4
5
6
W = 1
t = 1.26 min

SLUG TEST DATA SHEET

CLIENT: MESCO
JOB NO. 94205.02
PROJECT: Greene Co L.F.
TESTED BY: RTW
DATE 10-5-94

WELL 6
DEPTH TO GW (BELOW GROUND) 7.53
HT OF STICKUP 2.46
DEPTH TO TOP OF SCREEN (BELOW TOC) 16.46
SCREEN 15'
APPROXIMATE WATER ADDED TO WELL 10 gals

TIME (HRS, MIN, SEC)	DEPTH TO WATER (BELOW TOC)
40:29	1
40:34	2
40:39	3
40:45	4
40:54	5
41:09	6
41:27	7
42:17	8
44:22	9


IR
4
5
6
1.0
0.8
0.6
0.4
0.2
0.0
H\H0
0.001
0.01
0.1
1
10
100
Time, minutes

Slug Test MW-7

Initial offset in logger reading (feet):	-0.022	Date:	06/22/2007
Offset increment in logger reading (feet/sec):	0.000179		
Initial depth to water table (feet):	11.88		
Depth of probe below water table (feet):	7.743		

Time	Time (sec)	Elapsed Time (sec)	Logger Reading (ft)	Adjusted Reading (ft)	dh (ft)	Log of dh
6/22/2007 14:31:08	52268.5	0.0	1.99	1.817	5.927	0.77280
6/22/2007 14:31:10	52270.5	2.0	2.15	1.976	5.767	0.76094
6/22/2007 14:31:11	52271.5	3.0	2.3	2.129	5.614	0.74928
6/22/2007 14:31:15	52275.5	7.0	2.43	2.259	5.484	0.73908
6/22/2007 14:31:21	52281.0	12.5	2.57	2.393	5.350	0.72834
6/22/2007 14:31:27	52287.0	18.5	2.69	2.516	5.227	0.71824
6/22/2007 14:31:33	52293.5	25.0	2.82	2.641	5.102	0.70774
6/22/2007 14:31:41	52301.0	32.5	2.94	2.759	4.984	0.69761
6/22/2007 14:31:48	52308.5	40.0	3.06	2.876	4.867	0.68724
6/22/2007 14:31:55	52315.5	47.0	3.17	2.989	4.754	0.67706
6/22/2007 14:32:04	52324.0	55.5	3.28	3.099	4.644	0.66694
6/22/2007 14:32:12	52332.0	63.5	3.39	3.208	4.535	0.65657
6/22/2007 14:32:20	52340.5	72.0	3.5	3.312	4.431	0.64655
6/22/2007 14:32:29	52349.5	81.0	3.61	3.419	4.324	0.63589
6/22/2007 14:32:38	52358.5	90.0	3.71	3.519	4.224	0.62569
6/22/2007 14:32:48	52368.0	99.5	3.81	3.620	4.123	0.61525
6/22/2007 14:32:57	52377.5	109.0	3.91	3.720	4.023	0.60456
6/22/2007 14:33:07	52387.0	118.5	4.01	3.815	3.928	0.59415
6/22/2007 14:33:16	52396.5	128.0	4.1	3.906	3.838	0.58405
6/22/2007 14:33:26	52406.5	138.0	4.19	3.994	3.749	0.57395
6/22/2007 14:33:37	52417.0	148.5	4.28	4.082	3.661	0.56362
6/22/2007 14:33:47	52427.5	159.0	4.37	4.166	3.577	0.55353
6/22/2007 14:33:57	52437.5	169.0	4.45	4.249	3.494	0.54331
6/22/2007 14:34:07	52447.0	178.5	4.54	4.333	3.411	0.53283
6/22/2007 14:34:17	52457.0	188.5	4.62	4.414	3.329	0.52236
6/22/2007 14:34:27	52467.0	198.5	4.7	4.490	3.253	0.51230
6/22/2007 14:34:38	52478.0	209.5	4.78	4.566	3.177	0.50204
6/22/2007 14:34:49	52489.5	221.0	4.85	4.642	3.101	0.49153
6/22/2007 14:35:00	52500.5	232.0	4.93	4.717	3.026	0.48089
6/22/2007 14:35:11	52511.5	243.0	5	4.788	2.955	0.47058
6/22/2007 14:35:22	52522.5	254.0	5.08	4.859	2.884	0.46001
6/22/2007 14:35:33	52533.0	264.5	5.14	4.925	2.818	0.44994
6/22/2007 14:35:44	52544.0	275.5	5.21	4.992	2.751	0.43949
6/22/2007 14:35:55	52555.5	287.0	5.28	5.056	2.687	0.42927
6/22/2007 14:36:07	52567.5	299.0	5.35	5.122	2.621	0.41850
6/22/2007 14:36:19	52579.5	311.0	5.41	5.184	2.559	0.40813
6/22/2007 14:36:32	52592.0	323.5	5.47	5.243	2.501	0.39804
6/22/2007 14:36:46	52606.0	337.5	5.53	5.301	2.442	0.38776
6/22/2007 14:36:59	52619.5	351.0	5.59	5.358	2.386	0.37758
6/22/2007 14:37:13	52633.5	365.0	5.65	5.412	2.331	0.36755
6/22/2007 14:37:27	52647.5	379.0	5.71	5.466	2.278	0.35747
6/22/2007 14:37:43	52663.0	394.5	5.76	5.520	2.223	0.34701
6/22/2007 14:37:56	52676.0	407.5	5.82	5.571	2.172	0.33679
6/22/2007 14:38:09	52689.0	420.5	5.87	5.621	2.122	0.32675

Slug Test MW-7

Time	Time (sec)	Elapsed Time (sec)	Logger Reading (ft)	Adjusted Reading (ft)	dh (ft)	Log of dh
6/22/2007 14:38:21	52701.5	433.0	5.92	5.671	2.072	0.31644
6/22/2007 14:38:36	52716.0	447.5	5.97	5.719	2.024	0.30618
6/22/2007 14:38:50	52730.5	462.0	6.02	5.767	1.976	0.29589
6/22/2007 14:39:06	52746.5	478.0	6.07	5.814	1.929	0.28541
6/22/2007 14:39:22	52762.0	493.5	6.12	5.858	1.885	0.27534
6/22/2007 14:39:37	52777.5	509.0	6.17	5.902	1.841	0.26503
6/22/2007 14:39:52	52792.5	524.0	6.21	5.945	1.799	0.25493
6/22/2007 14:40:06	52806.5	538.0	6.26	5.987	1.756	0.24455
6/22/2007 14:40:20	52820.5	552.0	6.3	6.029	1.715	0.23416
6/22/2007 14:40:36	52836.0	567.5	6.34	6.071	1.672	0.22334
6/22/2007 14:40:51	52851.5	583.0	6.39	6.110	1.633	0.21303
6/22/2007 14:41:10	52870.0	601.5	6.43	6.152	1.591	0.20180
6/22/2007 14:41:28	52888.5	620.0	6.47	6.188	1.555	0.19168
6/22/2007 14:41:47	52907.0	638.5	6.51	6.225	1.518	0.18131
6/22/2007 14:42:05	52925.0	656.5	6.55	6.262	1.481	0.17066
6/22/2007 14:42:23	52943.0	674.5	6.59	6.296	1.448	0.16065
6/22/2007 14:42:38	52958.5	690.0	6.63	6.331	1.412	0.14995
6/22/2007 14:42:57	52977.0	708.5	6.66	6.364	1.379	0.13947
6/22/2007 14:43:15	52995.0	726.5	6.7	6.397	1.346	0.12902
6/22/2007 14:43:34	53014.5	746.0	6.73	6.429	1.314	0.11874
6/22/2007 14:43:53	53033.0	764.5	6.77	6.460	1.283	0.10814
6/22/2007 14:44:12	53052.5	784.0	6.8	6.490	1.253	0.09804
6/22/2007 14:44:31	53071.5	803.0	6.84	6.519	1.224	0.08766
6/22/2007 14:44:49	53089.5	821.0	6.87	6.549	1.194	0.07696
6/22/2007 14:45:10	53110.5	842.0	6.9	6.578	1.165	0.06620
6/22/2007 14:45:29	53129.5	861.0	6.93	6.606	1.137	0.05579
6/22/2007 14:45:50	53150.5	882.0	6.96	6.632	1.111	0.04565
6/22/2007 14:46:10	53170.5	902.0	6.99	6.658	1.085	0.03560
6/22/2007 14:46:33	53193.5	925.0	7.02	6.684	1.060	0.02512
6/22/2007 14:46:57	53217.5	949.0	7.05	6.708	1.035	0.01488
6/22/2007 14:47:18	53238.0	969.5	7.08	6.733	1.011	0.00455
6/22/2007 14:47:42	53262.0	993.5	7.11	6.757	0.986	-0.00619
6/22/2007 14:48:05	53285.0	1016.5	7.14	6.781	0.962	-0.01683
6/22/2007 14:48:26	53306.0	1037.5	7.16	6.803	0.940	-0.02699
6/22/2007 14:48:49	53329.5	1061.0	7.19	6.825	0.918	-0.03717
6/22/2007 14:49:10	53350.0	1081.5	7.21	6.847	0.896	-0.04786
6/22/2007 14:49:36	53376.0	1107.5	7.24	6.869	0.874	-0.05833
6/22/2007 14:49:55	53395.5	1127.0	7.26	6.889	0.854	-0.06864
6/22/2007 14:50:17	53417.5	1149.0	7.29	6.909	0.834	-0.07896
6/22/2007 14:50:42	53442.5	1174.0	7.31	6.931	0.812	-0.09031
6/22/2007 14:51:07	53467.5	1199.0	7.34	6.952	0.791	-0.10197
6/22/2007 14:51:30	53490.5	1222.0	7.36	6.971	0.772	-0.11246
6/22/2007 14:51:54	53514.5	1246.0	7.38	6.989	0.754	-0.12253
6/22/2007 14:52:21	53541.5	1273.0	7.41	7.007	0.736	-0.13311
6/22/2007 14:52:49	53569.0	1300.5	7.43	7.026	0.717	-0.14451
6/22/2007 14:53:22	53602.0	1333.5	7.45	7.043	0.700	-0.15498
6/22/2007 14:53:52	53632.0	1363.5	7.48	7.060	0.683	-0.16541
6/22/2007 14:54:17	53657.0	1388.5	7.5	7.076	0.667	-0.17604
6/22/2007 14:54:49	53689.0	1420.5	7.52	7.092	0.651	-0.18609

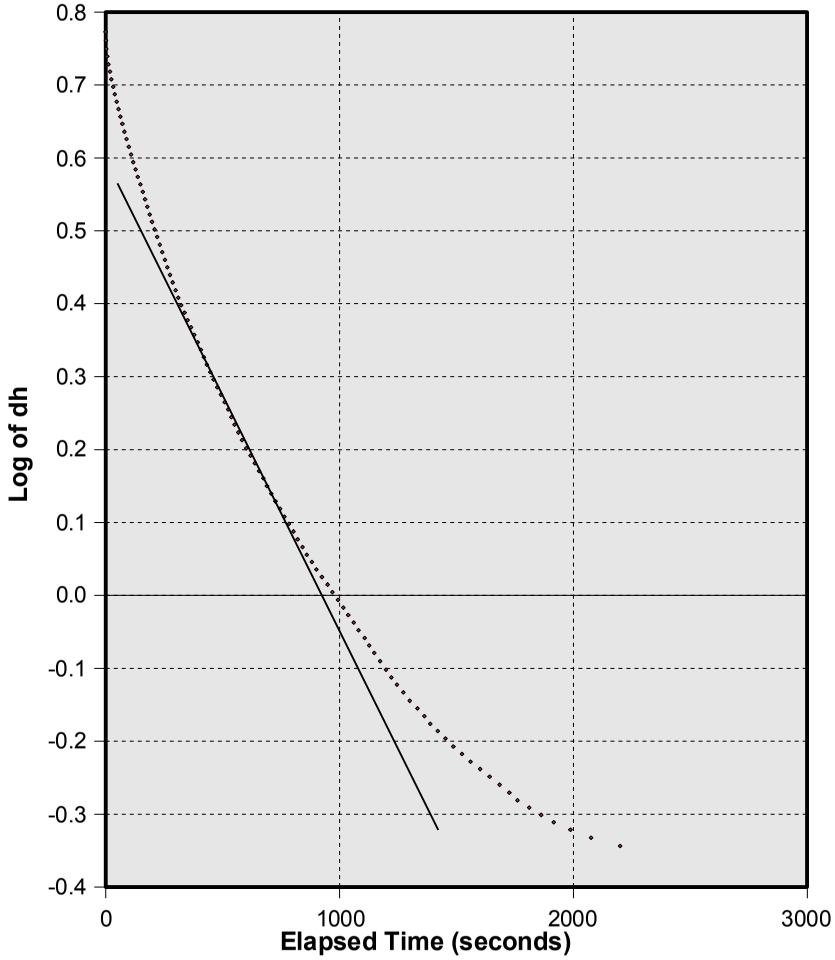
Slug Test MW-7

Time	Time (sec)	Elapsed Time (sec)	Logger Reading (ft)	Adjusted Reading (ft)	dh (ft)	Log of dh
6/22/2007 14:55:21	53721.5	1453.0	7.54	7.107	0.636	-0.19632
6/22/2007 14:55:55	53755.5	1487.0	7.56	7.123	0.620	-0.20731
6/22/2007 14:56:32	53792.5	1524.0	7.58	7.137	0.606	-0.21748
6/22/2007 14:57:09	53829.0	1560.5	7.6	7.152	0.592	-0.22796
6/22/2007 14:57:50	53870.0	1601.5	7.62	7.165	0.578	-0.23809
6/22/2007 14:58:30	53910.5	1642.0	7.65	7.179	0.564	-0.24853
6/22/2007 14:59:13	53953.0	1684.5	7.67	7.193	0.550	-0.25973
6/22/2007 14:59:55	53995.0	1726.5	7.69	7.207	0.536	-0.27050
6/22/2007 15:00:29	54029.5	1761.0	7.71	7.220	0.524	-0.28099
6/22/2007 15:01:19	54079.5	1811.0	7.73	7.232	0.512	-0.29108
6/22/2007 15:02:11	54131.5	1863.0	7.75	7.243	0.500	-0.30110
6/22/2007 15:03:05	54185.0	1916.5	7.77	7.255	0.489	-0.31112
6/22/2007 15:04:16	54256.0	1987.5	7.79	7.266	0.477	-0.32124
6/22/2007 15:05:44	54344.5	2076.0	7.82	7.278	0.465	-0.33241
6/22/2007 15:07:48	54468.5	2200.0	7.86	7.290	0.453	-0.34351
6/22/2007 15:12:15	54735.5	2467.0	7.92	7.301	0.442	-0.35426
6/22/2007 15:14:59	54899.5	2631.0	7.93	7.290	0.453	-0.34413
6/22/2007 15:19:15	55155.5	2887.0	7.97	7.279	0.464	-0.33375
6/22/2007 15:22:18	55338.0	3069.5	7.99	7.268	0.475	-0.32288
6/22/2007 15:24:42	55482.0	3213.5	8	7.254	0.489	-0.31041
6/22/2007 15:26:41	55601.5	3333.0	8.01	7.242	0.501	-0.30037
6/22/2007 15:28:25	55705.5	3437.0	8.02	7.231	0.512	-0.29036
6/22/2007 15:29:43	55783.5	3515.0	8.02	7.219	0.524	-0.28031
6/22/2007 15:31:58	55918.5	3650.0	8.03	7.206	0.537	-0.27030
6/22/2007 15:33:36	56016.5	3748.0	8.04	7.194	0.549	-0.26023
6/22/2007 15:35:20	56120.5	3852.0	8.04	7.180	0.563	-0.24955
6/22/2007 15:37:03	56223.0	3954.5	8.05	7.167	0.576	-0.23934
6/22/2007 15:38:29	56309.0	4040.5	8.05	7.153	0.590	-0.22933
6/22/2007 15:40:17	56417.0	4148.5	8.06	7.139	0.604	-0.21886
6/22/2007 15:41:39	56499.5	4231.0	8.06	7.124	0.619	-0.20835
6/22/2007 15:43:23	56603.0	4334.5	8.06	7.110	0.634	-0.19824
6/22/2007 15:45:02	56702.0	4433.5	8.06	7.095	0.648	-0.18823
6/22/2007 15:46:31	56791.0	4522.5	8.06	7.072	0.671	-0.17310
6/22/2007 15:46:32	56792.0	4523.5	8.07	7.088	0.655	-0.18346
6/22/2007 15:47:05	56825.5	4557.0	8.07	7.085	0.658	-0.18147

Slug Test MW-7

Slug Test by Bouwer and Rice

Displacement Method:	Pump	
Well depth:	18.50	ft
Stick up height:	3.00	ft
Depth to sand pack (BGS):	5.00	ft
Depth to screened interval (BGS):	6.50	ft
Well diameter:	2.00	in
Diameter of annular space:	8.00	in
Initial depth to water table from top of pipe:	11.88	ft
Initial Head Change:	5.93	ft
Total well length:	21.50	ft
Radius of well casing:	0.0833	ft
Assumed porosity of sand/gravel pack:	30%	
Adjusted radius of well casing:	0.1954	ft
r_c:	0.1954	ft
Radius of gravel pack (r_w):	0.3333	ft
Screened interval:	12.00	ft
Length of open section (L_e):	9.62	ft
L_e / r_w:	28.8600	
A (dimensionless):	2.522	
B (dimensionless):	0.420	
Drawdown at time = 0 (y_0):	3.16	ft
Drawdown at time = t (y_t):	1.30	ft
Elapsed Time between y_0 and y_t (t):	539	sec
Initial water column in well (L_w):	9.62	ft
$\ln(R_e/r_w)$ =	1.99	
K =	6.49E-06	ft/sec
	1.98E-04	**cm/sec**
	204.72	ft/yr



Water above sand pack:	No
%Duration below sand pack:	100.00%
Water above screen:	No
%Duration below screen:	100.00%

Slug Test MW-8

Initial offset in logger reading (feet):	0.097	Date:	06/22/2007
Offset increment in logger reading (feet/sec):	0.000080		
Initial depth to water table (feet):	10.1		
Depth of probe below water table (feet):	8.005		

Time	Time (sec)	Elapsed Time (sec)	Logger Reading (ft)	Adjusted Reading (ft)	dh (ft)	Log of dh
6/22/2007 14:24:15	51855.5	0.0	4.54	4.373	3.632	0.56016
6/22/2007 14:24:16	51856.0	0.5	4.62	4.458	3.547	0.54988
6/22/2007 14:24:17	51857.0	1.5	4.72	4.550	3.455	0.53848
6/22/2007 14:24:17	51857.5	2.0	4.8	4.633	3.372	0.52792
6/22/2007 14:24:18	51858.5	3.0	4.91	4.747	3.258	0.51300
6/22/2007 14:24:20	51860.0	4.5	5	4.839	3.166	0.50058
6/22/2007 14:24:21	51861.5	6.0	5.08	4.916	3.090	0.48990
6/22/2007 14:24:23	51863.5	8.0	5.17	5.009	2.997	0.47665
6/22/2007 14:24:25	51865.0	9.5	5.25	5.080	2.926	0.46626
6/22/2007 14:24:27	51867.0	11.5	5.34	5.170	2.835	0.45256
6/22/2007 14:24:28	51868.5	13.0	5.41	5.241	2.764	0.44156
6/22/2007 14:24:30	51870.0	14.5	5.48	5.310	2.695	0.43060
6/22/2007 14:24:31	51871.5	16.0	5.55	5.379	2.626	0.41936
6/22/2007 14:24:33	51873.0	17.5	5.61	5.441	2.565	0.40901
6/22/2007 14:24:34	51874.5	19.0	5.67	5.504	2.502	0.39822
6/22/2007 14:24:36	51876.0	20.5	5.74	5.571	2.435	0.38646
6/22/2007 14:24:37	51877.5	22.0	5.81	5.640	2.366	0.37399
6/22/2007 14:24:39	51879.0	23.5	5.86	5.697	2.308	0.36324
6/22/2007 14:24:40	51880.5	25.0	5.92	5.751	2.254	0.35298
6/22/2007 14:24:42	51882.0	26.5	5.98	5.810	2.195	0.34148
6/22/2007 14:24:43	51883.5	28.0	6.03	5.862	2.143	0.33109
6/22/2007 14:24:45	51885.0	29.5	6.08	5.916	2.089	0.32004
6/22/2007 14:24:46	51886.5	31.0	6.14	5.968	2.038	0.30912
6/22/2007 14:24:48	51888.0	32.5	6.19	6.024	1.982	0.29704
6/22/2007 14:24:49	51889.5	34.0	6.24	6.072	1.934	0.28642
6/22/2007 14:24:51	51891.0	35.5	6.29	6.121	1.884	0.27507
6/22/2007 14:24:52	51892.5	37.0	6.34	6.168	1.837	0.26413
6/22/2007 14:24:54	51894.0	38.5	6.38	6.216	1.789	0.25266
6/22/2007 14:24:55	51895.5	40.0	6.43	6.262	1.743	0.24138
6/22/2007 14:24:57	51897.5	42.0	6.48	6.314	1.691	0.22827
6/22/2007 14:24:59	51899.0	43.5	6.53	6.364	1.642	0.21527
6/22/2007 14:25:00	51900.5	45.0	6.57	6.406	1.600	0.20404
6/22/2007 14:25:02	51902.5	47.0	6.62	6.448	1.558	0.19253
6/22/2007 14:25:05	51905.5	50.0	6.66	6.486	1.519	0.18159
6/22/2007 14:25:08	51908.0	52.5	6.69	6.521	1.484	0.17153
6/22/2007 14:25:10	51910.5	55.0	6.73	6.560	1.446	0.16002
6/22/2007 14:25:13	51913.0	57.5	6.77	6.598	1.408	0.14851
6/22/2007 14:25:15	51915.0	59.5	6.8	6.633	1.373	0.13763
6/22/2007 14:25:17	51917.0	61.5	6.84	6.669	1.336	0.12582
6/22/2007 14:25:19	51919.0	63.5	6.87	6.703	1.302	0.11468
6/22/2007 14:25:21	51921.0	65.5	6.9	6.733	1.272	0.10461
6/22/2007 14:25:23	51923.5	68.0	6.93	6.764	1.242	0.09397
6/22/2007 14:25:26	51926.5	71.0	6.97	6.798	1.208	0.08199
6/22/2007 14:25:29	51929.0	73.5	7	6.825	1.180	0.07188

Slug Test MW-8

Time	Time (sec)	Elapsed Time (sec)	Logger Reading (ft)	Adjusted Reading (ft)	dh (ft)	Log of dh
6/22/2007 14:25:32	51932.0	76.5	7.03	6.857	1.148	0.06003
6/22/2007 14:25:34	51934.5	79.0	7.06	6.884	1.121	0.04977
6/22/2007 14:25:37	51937.0	81.5	7.08	6.913	1.093	0.03847
6/22/2007 14:25:39	51939.5	84.0	7.11	6.940	1.066	0.02769
6/22/2007 14:25:42	51942.0	86.5	7.14	6.966	1.039	0.01663
6/22/2007 14:25:44	51944.5	89.0	7.16	6.991	1.014	0.00614
6/22/2007 14:25:47	51947.5	92.0	7.19	7.018	0.987	-0.00547
6/22/2007 14:25:50	51950.0	94.5	7.22	7.045	0.961	-0.01742
6/22/2007 14:25:52	51952.0	96.5	7.24	7.068	0.938	-0.02787
6/22/2007 14:25:54	51954.5	99.0	7.26	7.090	0.915	-0.03856
6/22/2007 14:25:57	51957.0	101.5	7.29	7.113	0.892	-0.04952
6/22/2007 14:25:59	51959.5	104.0	7.31	7.134	0.871	-0.05977
6/22/2007 14:26:02	51962.0	106.5	7.33	7.158	0.848	-0.07179
6/22/2007 14:26:05	51965.0	109.5	7.35	7.180	0.826	-0.08309
6/22/2007 14:26:07	51967.5	112.0	7.38	7.201	0.804	-0.09471
6/22/2007 14:26:10	51970.0	114.5	7.39	7.220	0.785	-0.10498
6/22/2007 14:26:13	51973.0	117.5	7.42	7.241	0.765	-0.11662
6/22/2007 14:26:16	51976.0	120.5	7.44	7.262	0.744	-0.12857
6/22/2007 14:26:19	51979.0	123.5	7.46	7.280	0.725	-0.13967
6/22/2007 14:26:21	51981.5	126.0	7.47	7.297	0.708	-0.14985
6/22/2007 14:26:24	51984.0	128.5	7.49	7.314	0.691	-0.16028
6/22/2007 14:26:26	51986.5	131.0	7.51	7.331	0.675	-0.17096
6/22/2007 14:26:28	51988.5	133.0	7.52	7.348	0.658	-0.18194
6/22/2007 14:26:31	51991.0	135.5	7.54	7.364	0.641	-0.19318
6/22/2007 14:26:33	51993.0	137.5	7.56	7.379	0.626	-0.20335
6/22/2007 14:26:35	51995.0	139.5	7.57	7.396	0.609	-0.21519
6/22/2007 14:26:37	51997.5	142.0	7.59	7.414	0.591	-0.22807
6/22/2007 14:26:39	51999.5	144.0	7.61	7.431	0.575	-0.24061
6/22/2007 14:26:41	52001.0	145.5	7.62	7.446	0.560	-0.25201
6/22/2007 14:26:42	52002.5	147.0	7.64	7.461	0.545	-0.26371
6/22/2007 14:26:44	52004.0	148.5	7.65	7.474	0.531	-0.27492
6/22/2007 14:26:45	52005.5	150.0	7.66	7.487	0.518	-0.28558
6/22/2007 14:26:47	52007.0	151.5	7.68	7.500	0.505	-0.29651
6/22/2007 14:26:49	52009.5	154.0	7.69	7.515	0.490	-0.30943
6/22/2007 14:26:52	52012.0	156.5	7.7	7.527	0.479	-0.32000
6/22/2007 14:26:54	52014.0	158.5	7.72	7.540	0.466	-0.33181
6/22/2007 14:26:57	52017.0	161.5	7.73	7.552	0.453	-0.34388
6/22/2007 14:27:00	52020.0	164.5	7.74	7.564	0.441	-0.35530
6/22/2007 14:27:03	52023.5	168.0	7.75	7.575	0.431	-0.36598
6/22/2007 14:27:07	52027.5	172.0	7.77	7.590	0.416	-0.38105
6/22/2007 14:27:10	52030.5	175.0	7.78	7.600	0.405	-0.39243
6/22/2007 14:27:13	52033.5	178.0	7.79	7.610	0.395	-0.40302
6/22/2007 14:27:16	52036.0	180.5	7.8	7.620	0.386	-0.41393
6/22/2007 14:27:18	52038.0	182.5	7.81	7.629	0.377	-0.42400
6/22/2007 14:27:20	52040.0	184.5	7.82	7.638	0.368	-0.43431
6/22/2007 14:27:23	52043.0	187.5	7.83	7.647	0.358	-0.44599
6/22/2007 14:27:25	52045.0	189.5	7.84	7.656	0.349	-0.45685
6/22/2007 14:27:28	52048.5	193.0	7.85	7.666	0.340	-0.46911
6/22/2007 14:27:31	52051.0	195.5	7.85	7.674	0.332	-0.47920

Slug Test MW-8

Time	Time (sec)	Elapsed Time (sec)	Logger Reading (ft)	Adjusted Reading (ft)	dh (ft)	Log of dh
6/22/2007 14:27:34	52054.0	198.5	7.86	7.682	0.323	-0.49082
6/22/2007 14:27:36	52056.5	201.0	7.87	7.691	0.314	-0.50282
6/22/2007 14:27:39	52059.5	204.0	7.88	7.699	0.306	-0.51368
6/22/2007 14:27:42	52062.5	207.0	7.89	7.707	0.299	-0.52482
6/22/2007 14:27:44	52064.5	209.0	7.9	7.714	0.292	-0.53488
6/22/2007 14:27:48	52068.5	213.0	7.9	7.721	0.284	-0.54647
6/22/2007 14:27:51	52071.5	216.0	7.91	7.729	0.276	-0.55849
6/22/2007 14:27:55	52075.0	219.5	7.92	7.738	0.268	-0.57242
6/22/2007 14:27:57	52077.5	222.0	7.93	7.746	0.260	-0.58526
6/22/2007 14:28:01	52081.5	226.0	7.94	7.753	0.252	-0.59829
6/22/2007 14:28:04	52084.0	228.5	7.94	7.759	0.246	-0.60839
6/22/2007 14:28:06	52086.5	231.0	7.95	7.766	0.240	-0.62055
6/22/2007 14:28:10	52090.5	235.0	7.96	7.772	0.234	-0.63097
6/22/2007 14:28:12	52092.5	237.0	7.96	7.777	0.228	-0.64195
6/22/2007 14:28:16	52096.0	240.5	7.97	7.783	0.222	-0.65298
6/22/2007 14:28:20	52100.0	244.5	7.97	7.790	0.216	-0.66623
6/22/2007 14:28:23	52103.5	248.0	7.98	7.795	0.210	-0.67791
6/22/2007 14:28:27	52107.0	251.5	7.99	7.801	0.204	-0.68991
6/22/2007 14:28:31	52111.5	256.0	7.99	7.807	0.199	-0.70207
6/22/2007 14:28:35	52115.5	260.0	8	7.813	0.193	-0.71467
6/22/2007 14:28:38	52118.0	262.5	8	7.817	0.188	-0.72562
6/22/2007 14:28:42	52122.0	266.5	8.01	7.822	0.183	-0.73656
6/22/2007 14:28:45	52125.5	270.0	8.01	7.828	0.178	-0.75032
6/22/2007 14:28:50	52130.0	274.5	8.02	7.833	0.172	-0.76433
6/22/2007 14:28:52	52132.5	277.0	8.03	7.838	0.167	-0.77662
6/22/2007 14:28:58	52138.0	282.5	8.03	7.844	0.162	-0.79130
6/22/2007 14:29:00	52140.5	285.0	8.04	7.848	0.158	-0.80163
6/22/2007 14:29:02	52142.5	287.0	8.04	7.851	0.154	-0.81233
6/22/2007 14:29:07	52147.0	291.5	8.04	7.855	0.150	-0.82271
6/22/2007 14:29:10	52150.0	294.5	8.05	7.859	0.147	-0.83371
6/22/2007 14:29:13	52153.0	297.5	8.05	7.863	0.143	-0.84499
6/22/2007 14:29:15	52155.5	300.0	8.06	7.866	0.139	-0.85669
6/22/2007 14:29:19	52159.0	303.5	8.06	7.870	0.135	-0.86847
6/22/2007 14:29:22	52162.5	307.0	8.06	7.874	0.132	-0.88057
6/22/2007 14:29:26	52166.0	310.5	8.07	7.877	0.128	-0.89302
6/22/2007 14:29:29	52169.5	314.0	8.07	7.882	0.123	-0.90935
6/22/2007 14:29:33	52173.0	317.5	8.08	7.886	0.119	-0.92266
6/22/2007 14:29:37	52177.0	321.5	8.08	7.890	0.116	-0.93625
6/22/2007 14:29:38	52178.0	322.5	8.08	7.887	0.119	-0.92485
6/22/2007 14:29:38	52178.5	323.0	8.08	7.890	0.115	-0.93956
6/22/2007 14:29:43	52183.0	327.5	8.09	7.894	0.111	-0.95354
6/22/2007 14:29:47	52187.5	332.0	8.09	7.898	0.108	-0.96799
6/22/2007 14:29:52	52192.0	336.5	8.09	7.902	0.103	-0.98712
6/22/2007 14:29:56	52196.5	341.0	8.1	7.905	0.100	-0.99840
6/22/2007 14:30:01	52201.5	346.0	8.1	7.909	0.097	-1.01426
6/22/2007 14:30:05	52205.5	350.0	8.11	7.912	0.093	-1.03110
6/22/2007 14:30:12	52212.0	356.5	8.11	7.915	0.091	-1.04283
6/22/2007 14:30:13	52213.5	358.0	8.11	7.918	0.088	-1.05686
6/22/2007 14:30:14	52214.0	358.5	8.11	7.915	0.091	-1.04207

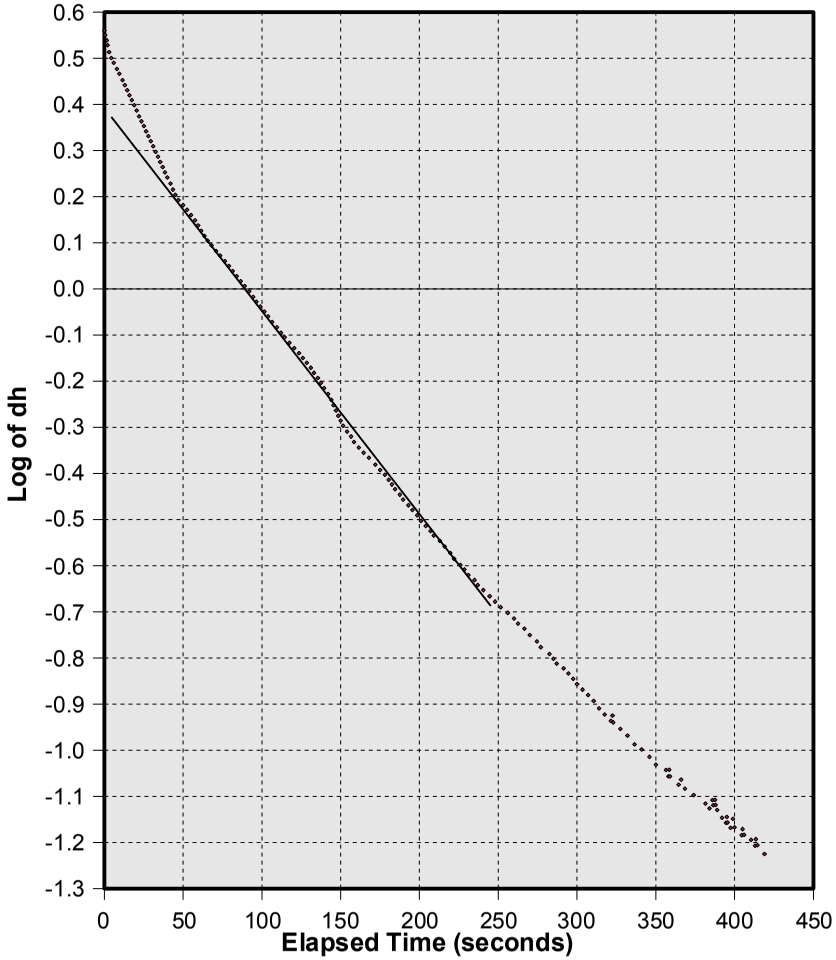
Slug Test MW-8

Time	Time (sec)	Elapsed Time (sec)	Logger Reading (ft)	Adjusted Reading (ft)	dh (ft)	Log of dh
6/22/2007 14:30:14	52214.5	359.0	8.11	7.918	0.088	-1.05647
6/22/2007 14:30:20	52220.0	364.5	8.12	7.921	0.084	-1.07444
6/22/2007 14:30:21	52221.5	366.0	8.11	7.919	0.086	-1.06365
6/22/2007 14:30:24	52224.0	368.5	8.12	7.923	0.083	-1.08319
6/22/2007 14:30:29	52229.5	374.0	8.12	7.925	0.080	-1.09688
6/22/2007 14:30:37	52237.0	381.5	8.12	7.929	0.077	-1.11574
6/22/2007 14:30:39	52239.5	384.0	8.13	7.931	0.075	-1.12607
6/22/2007 14:30:41	52241.5	386.0	8.12	7.927	0.078	-1.10810
6/22/2007 14:30:42	52242.0	386.5	8.13	7.929	0.076	-1.11916
6/22/2007 14:30:43	52243.0	387.5	8.12	7.927	0.078	-1.10743
6/22/2007 14:30:43	52243.5	388.0	8.13	7.929	0.076	-1.11847
6/22/2007 14:30:44	52244.5	389.0	8.13	7.931	0.074	-1.12957
6/22/2007 14:30:47	52247.5	392.0	8.13	7.934	0.071	-1.14603
6/22/2007 14:30:50	52250.0	394.5	8.13	7.936	0.070	-1.15711
6/22/2007 14:30:50	52250.5	395.0	8.13	7.934	0.072	-1.14458
6/22/2007 14:30:51	52251.0	395.5	8.13	7.936	0.070	-1.15662
6/22/2007 14:30:53	52253.0	397.5	8.13	7.938	0.068	-1.16823
6/22/2007 14:30:54	52254.5	399.0	8.13	7.934	0.071	-1.14872
6/22/2007 14:30:55	52255.5	400.0	8.13	7.937	0.068	-1.16696
6/22/2007 14:31:00	52260.0	404.5	8.14	7.940	0.065	-1.18413
6/22/2007 14:31:00	52260.5	405.0	8.14	7.938	0.067	-1.17080
6/22/2007 14:31:01	52261.5	406.0	8.14	7.940	0.066	-1.18334
6/22/2007 14:31:06	52266.0	410.5	8.14	7.941	0.064	-1.19434
6/22/2007 14:31:08	52268.5	413.0	8.14	7.943	0.062	-1.20675
6/22/2007 14:31:09	52269.0	413.5	8.14	7.941	0.064	-1.19272
6/22/2007 14:31:10	52270.0	414.5	8.14	7.943	0.062	-1.20591
6/22/2007 14:31:14	52274.5	419.0	8.14	7.946	0.060	-1.22474

Slug Test MW-8

Slug Test by Bouwer and Rice

Displacement Method:	Pump	
Well depth:	17.98	ft
Stick up height:	3.00	ft
Depth to sand pack (BGS):	5.00	ft
Depth to screened interval (BGS):	6.98	ft
Well diameter:	2.00	in
Diameter of annular space:	8.00	in
Initial depth to water table from top of pipe:	10.10	ft
Initial Head Change:	3.63	ft
Total well length:	20.98	ft
Radius of well casing:	0.0833	ft
Assumed porosity of sand/gravel pack:	30%	
Adjusted radius of well casing:	0.1954	ft
r_c:	0.1954	ft
Radius of gravel pack (r_w):	0.3333	ft
Screened interval:	11.00	ft
Length of open section (L_e):	10.88	ft
L_e / r_w:	32.6400	
A (dimensionless):	2.644	
B (dimensionless):	0.441	
Drawdown at time = 0 (y_0):	1.61	ft
Drawdown at time = t (y_t):	0.63	ft
Elapsed Time between y_0 and y_t (t):	92.5	sec
Initial water column in well (L_w):	10.88	ft
$\ln(R_e/r_w)$ =	2.09	
K =	3.73E-05	ft/sec
	1.14E-03	**cm/sec**
	1175.14	ft/yr



Water above sand pack:	No
%Duration below sand pack:	100.00%
Water above screen:	No
%Duration below screen:	100.00%

APPENDIX B

Greene County Sampling History

Date	Action
November 1981	MW-1,2,3 installed
February 1994	Completed Ground and Surface Water Monitoring System
August 26, 1994	MW-1R, MW-4 installed; MW-2, MW-3 abandoned
August 28, 1994	MW-5 installed
August 29, 1994	MW-6 installed
September 15, 1994	Background Sampling – Appendix I
October 4,1994	MW-1R replaces MW-1
November 18, 1994	Background Sampling – Appendix I
January 12, 1995	Background Sampling – Appendix I
February 6, 1995	Background Sampling – Appendix I
September 12, 1995	Sampling – Appendix I
April 19, 1996	Sampling – Appendix I
March 17, 1997	Sampling – Appendix I
May 8, 1997	Sampling – Appendix I
September 15, 1997	Sampling – Appendix I
March 3, 1998	Sampling – Appendix I
September 9, 1998	Sampling – Appendix I
March 25, 1999	Sampling – Appendix I
October 5, 1999	Sampling – Appendix I
March 1, 2000	Sampling – Appendix I
September 21, 2000	Sampling – Appendix I
March 8, 2001	Sampling – Appendix I
September 27, 2001	Sampling – Appendix I
March 27, 2002	Sampling – Appendix I
September 19, 2002	Sampling – Appendix I
March 19, 2003	Sampling – Appendix I
September 11, 2003	Sampling – Appendix I
March 18, 2004	Sampling – Appendix I
September 30, 2004	Sampling – Appendix I
March 29, 2005	Sampling – Appendix I
September 29, 2005	Sampling – Appendix I
March 3, 2006	Sampling – Appendix I
September 21, 2006	Sampling – Appendix I
May 24, 2007	Sampling – Appendix II (MW-1R and MW-4)
June 21, 2007	Install MW-7 and MW-8

Summary of Soil Results

Well ID	Parameter Name[1]	Sample Date	Result	Unit	PQL[2]
HA-1 (2')	Antimony	06/22/2007	0.16	mg/kg dry	0.13
MW-7 (7')	Antimony	05/21/2007	0.36	mg/kg dry	0.13
HA-1 (2')	Arsenic	06/22/2007	1.76	mg/kg dry	0.13
MW-7 (7')	Arsenic	05/21/2007	3.62	mg/kg dry	0.13
MW-8 (6')	Arsenic	06/21/2007	0.23	mg/kg dry	0.13
HA-1 (2')	Barium	06/22/2007	26.3	mg/kg dry	0.013
MW-7 (7')	Barium	05/21/2007	15.3	mg/kg dry	0.013
MW-8 (6')	Barium	06/21/2007	5.38	mg/kg dry	0.013
MW-7 (7')	Beryllium	05/21/2007	0.197	mg/kg dry	0.046
MW-8 (6')	Beryllium	06/21/2007	0.186	mg/kg dry	0.046
HA-1 (2')	Chromium	06/22/2007	8.23	mg/kg dry	0.13
MW-7 (7')	Chromium	05/21/2007	14.1	mg/kg dry	0.13
MW-8 (6')	Chromium	06/21/2007	7.27	mg/kg dry	0.13
HA-1 (2')	Lead	06/22/2007	14	mg/kg dry	0.13
MW-7 (7')	Lead	05/21/2007	5.87	mg/kg dry	0.13
MW-8 (6')	Lead	06/21/2007	5.78	mg/kg dry	0.13
HA-1 (2')	Nickel	06/22/2007	0.51	mg/kg dry	0.13
MW-8 (6')	Nickel	06/21/2007	0.48	mg/kg dry	0.13
HA-1 (2')	Vanadium	06/22/2007	35.6	mg/kg dry	0.066
MW-7 (7')	Vanadium	05/21/2007	18	mg/kg dry	0.066
MW-8 (6')	Vanadium	06/21/2007	10.7	mg/kg dry	0.066
HA-1 (2')	Zinc	06/22/2007	9.45	mg/kg dry	0.066
MW-7 (7')	Zinc	05/21/2007	7.23	mg/kg dry	0.066
MW-8 (6')	Zinc	06/21/2007	3.39	mg/kg dry	0.066

[1] Table only contains detected constituents.
[2] PQL = Practical Quantitation Limit

Background Sampling

Well ID	Parameter Name [1]	Sample Date	Result	Unit	PQL [2]	NCGW2L [3]	Exceedance
MW-1R	Zinc	09/15/1994	0.053	mg/l	0.05	1.05	
MW-1R	Lead, total	09/15/1994	0.015	mg/l	0.01	0.015	
MW-1R	Chromium, total	09/15/1994	0.026	mg/l	0.01	0.05	
MW-1R	**Lead, total**	**11/18/1994**	**0.032**	**mg/l**	**0.01**	**0.015**	**0.017**
MW-1R	Chromium, total	11/18/1994	0.04	mg/l	0.01	0.05	
MW-1R	Zinc	11/18/1994	0.103	mg/l	0.05	1.05	
MW-1R	Nickel, total	11/18/1994	0.067	mg/l	0.05	0.1	
MW-1R	Chromium, total	02/06/1995	0.01	mg/l	0.01	0.05	
MW-4	Chromium, total	11/18/1994	0.015	mg/l	0.01	0.05	
MW-4	**Lead, total**	**11/18/1994**	**0.023**	**mg/l**	**0.01**	**0.015**	**0.008**
MW-4	Lead, total	01/12/1995	0.01	mg/l	0.01	0.015	
MW-5	Chromium, total	02/06/1995	0.013	mg/l	0.01	0.05	
MW-5	Lead, total	02/06/1995	0.01	mg/l	0.01	0.015	
MW-6	Chromium, total	09/15/1994	0.013	mg/l	0.01	0.05	
MW-6	Lead, total	09/15/1994	0.014	mg/l	0.01	0.015	
MW-6	**Lead, total**	**11/18/1994**	**0.017**	**mg/l**	**0.01**	**0.015**	**0.002**
MW-6	Chromium, total	11/18/1994	0.032	mg/l	0.01	0.05	
MW-6	Chromium, total	01/12/1995	0.01	mg/l	0.01	0.05	

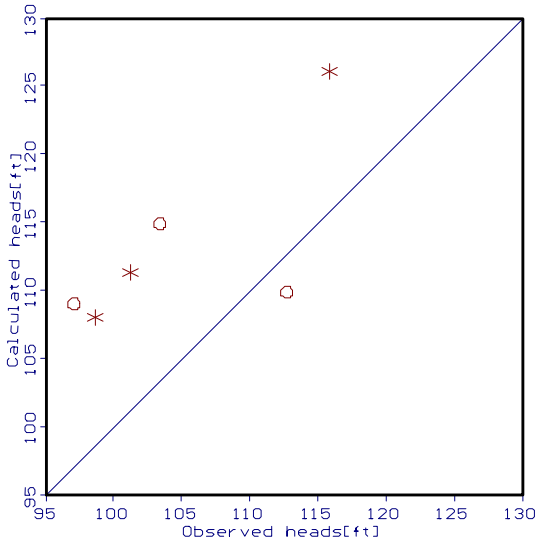
[1] Table only contains detected constituents.
[2] PQL = Practical Quantitation Limit
[3] NCGW2L = North Carolina Ground Water 2L Standard

Summary of NURE Sample Results

REC_NO	PRIME_ID	LATITUDE	LONGITUDE	SRLID	SMPMEDIA	SAMPSRC	SEDCOND	SAMPDAT	SEDTYPE	SEDCOLR	Distance to Site Miles
5298768	NCGE011S1	35.5473	-77.7412	NCGE011S1	SEDIMENT	STREAM	WET	5/10/1978	SAND	WHITE/BUFF	3.0
5298770	NCGE013S1	35.6043	-77.683	NCGE013S1	SEDIMENT	STREAM	WET	5/10/1978	OTHER	BROWN	5.4
5298771	NCGE014S1	35.6112	-77.709	NCGE014S1	SEDIMENT	STREAM	WET	5/10/1978	OTHER	BROWN	5.9
5298773	NCGE016S1	35.5095	-77.7161	NCGE016S1	SEDIMENT	STREAM	WET	5/11/1978	SAND	WHITE/BUFF	1.7
5298775	NCGE018S1	35.5822	-77.6337	NCGE018S1	SEDIMENT	STREAM	WET	5/11/1978	OTHER	BROWN	5.2
5298776	NCGE019S1	35.5318	-77.6553	NCGE019S1	SEDIMENT	STREAM	WET	5/11/1978	OTHER	BROWN	2.2
5298777	NCGE020S1	35.5086	-77.6283	NCGE020S1	SEDIMENT	STREAM	WET	5/11/1978	OTHER	BROWN	4.7
5298968	NCPI030S1	35.6139	-77.6483	NCPI030S1	SEDIMENT	STREAM	WET	5/6/1978	SILT	BROWN	6.7

REC_NO	AL_PCT	CE_PPM	DY_PPM	MN_PPM	NA_PCT	SC_PPM	SM_PPM	TH_PPM	TI_PPM	V_PPM
5298768	0.85	59	1.7	240	0.05	1.3	4	18	8500	20
5298770	1.59	36		130	0.04	2.3	3	10	6700	30
5298771	2.68	52	3.7	90	0.07	5.5		9	6100	40
5298773	0.83	-8	2.4	150	0.04	2.2	3	8	6000	20
5298775	2.73	55	3.4	120	0.07	5.2	2	11	6900	40
5298776	5.6	55	5	120	0.03	4.4	3	10	10000	90
5298777	2.75	95	7	90	0.04	3.2	4	10	8100	50
5298968	1.33	45	1.7	120	0.04	1.9	2	8	5600	30

APPENDIX C



Period: 1

Step: 1

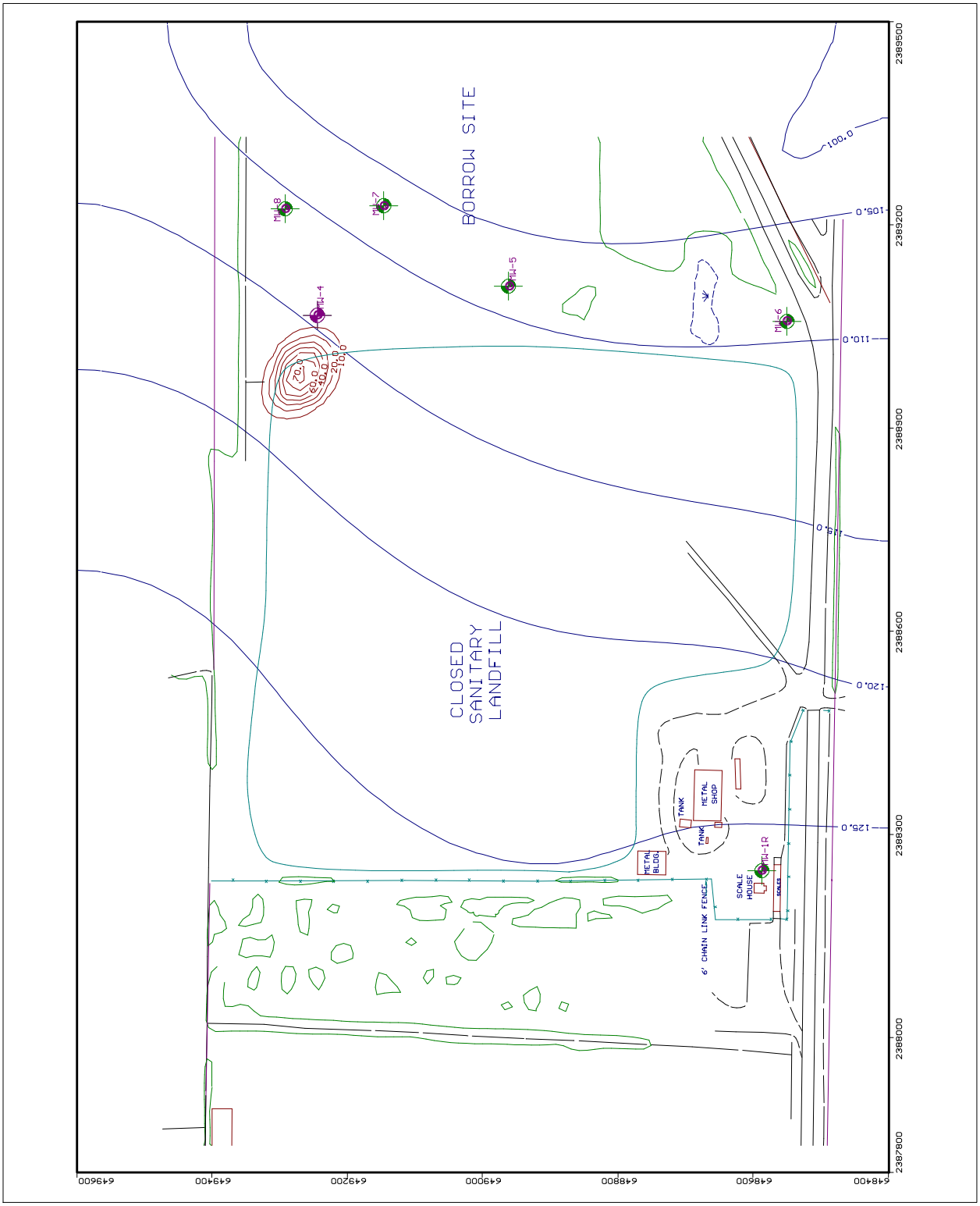
Mean error: 8.36259

Mean abs. err: 9.32876

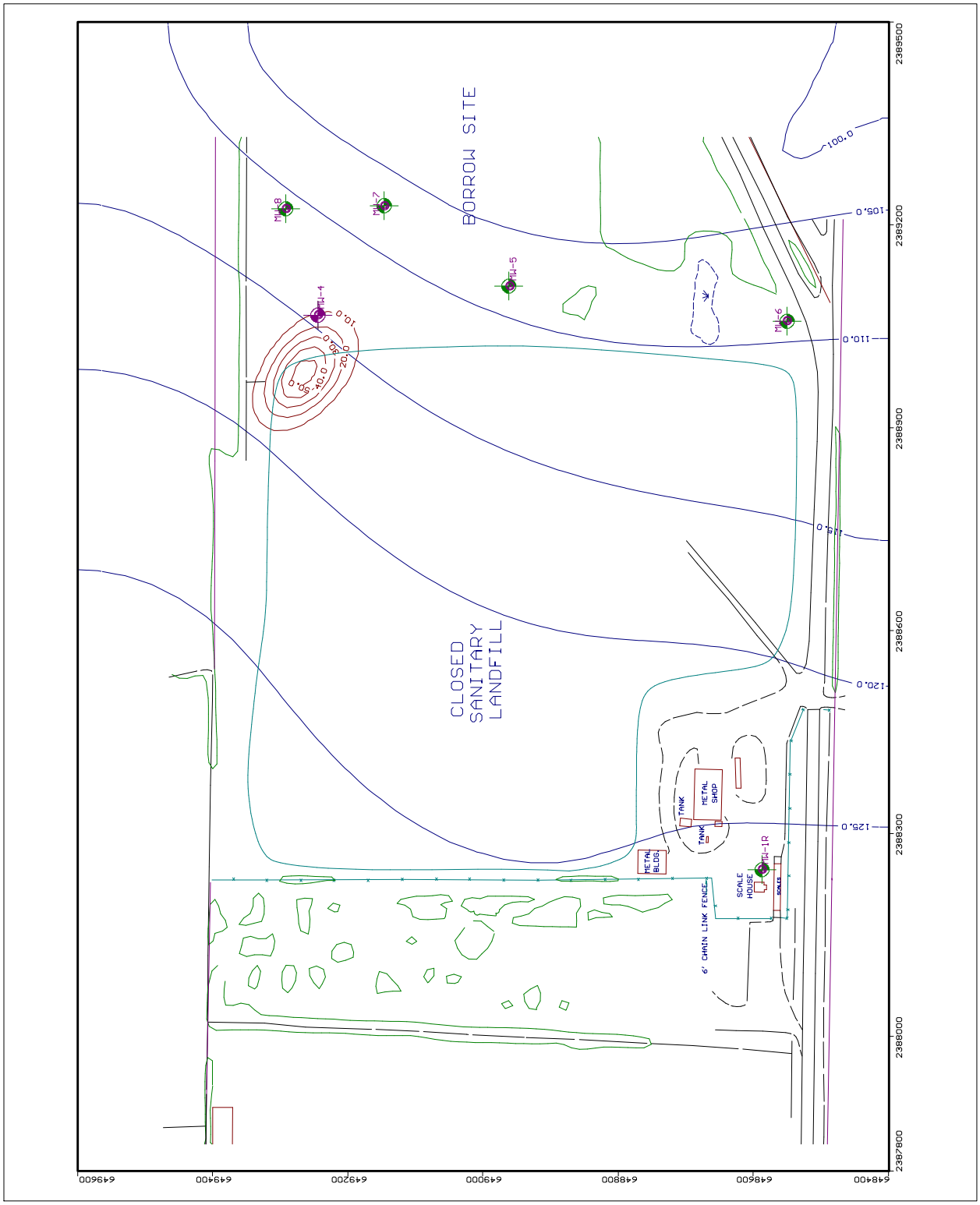
RMS error: 9.80095

Scaled RMS: 52.1327

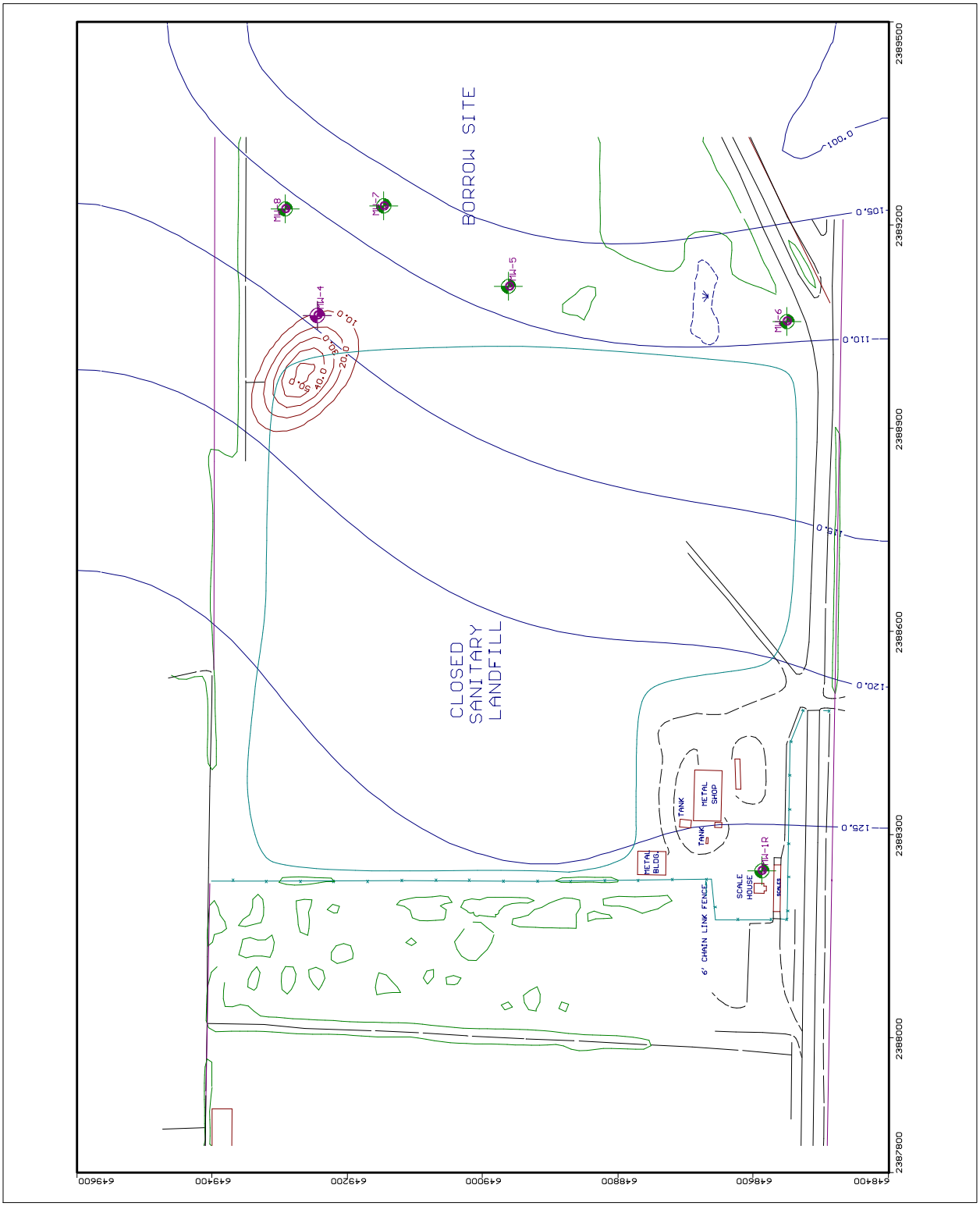
MODFLOW Water Elevation Calibration



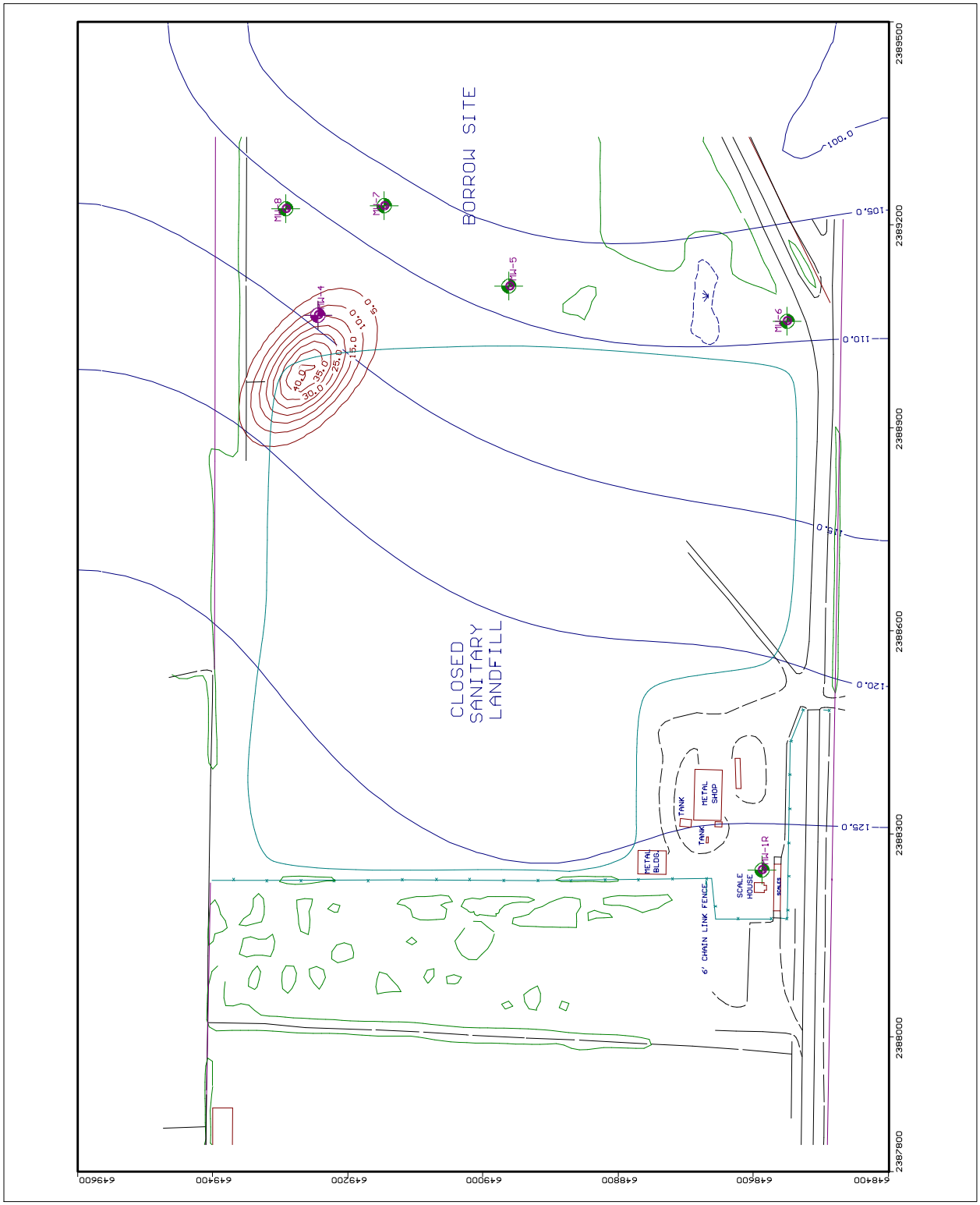
MODFLOW 5 Year Simulation
1995 VOC Contamination



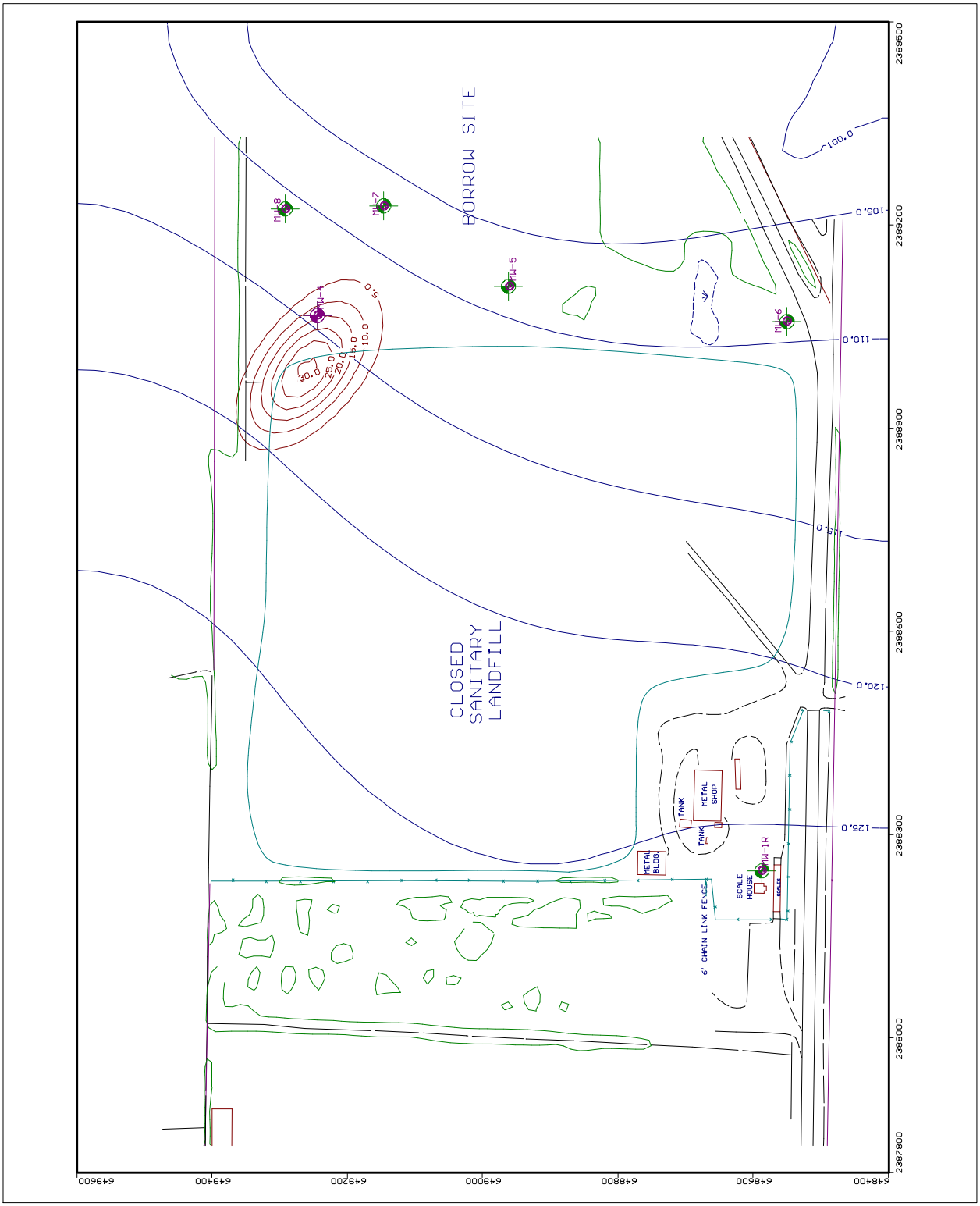
MODFLOW 16 Year Simulation
2006 VOC Contamination



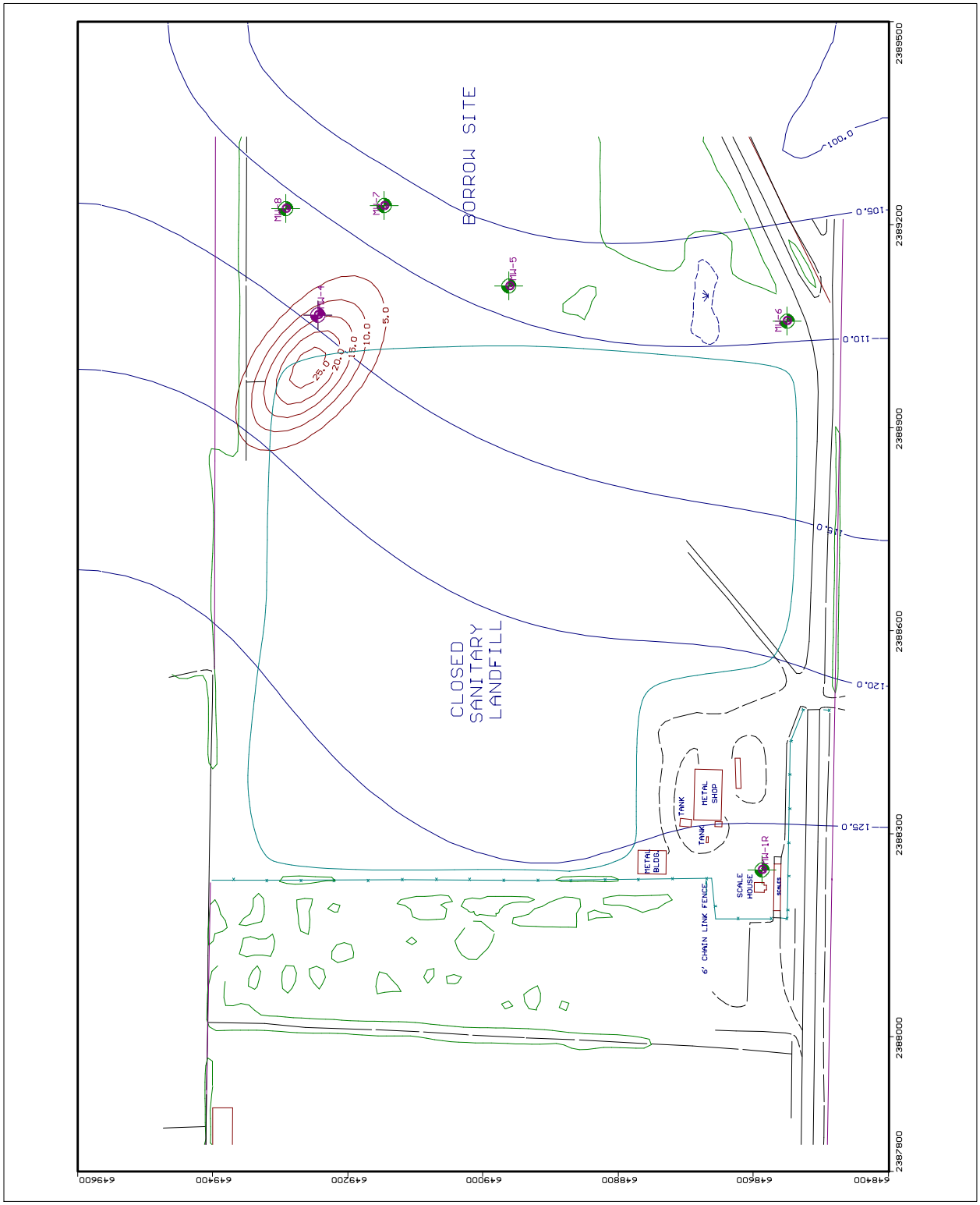
MODFLOW 17 Year Simulation
2007 VOC Contamination



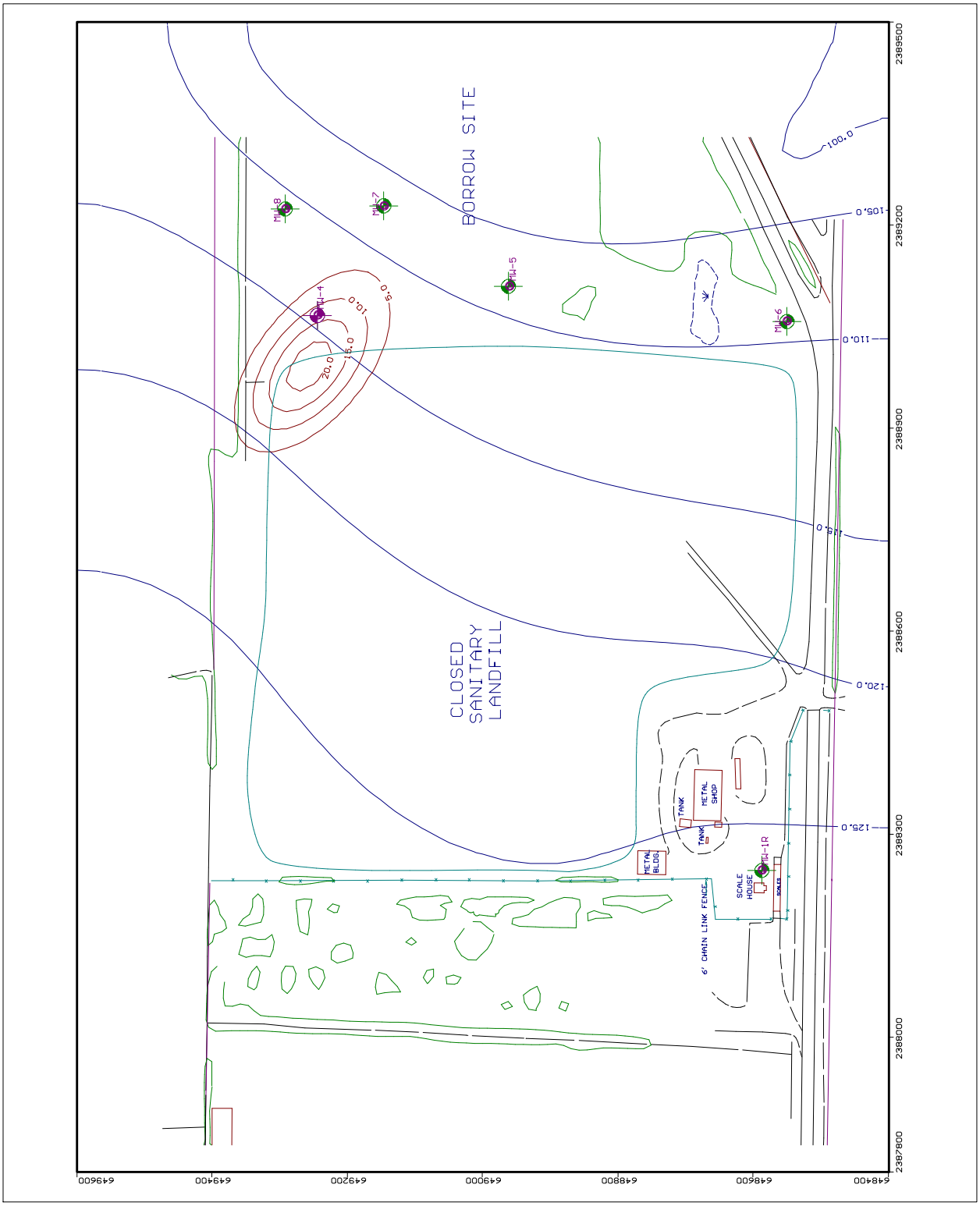
MODFLOW 25 Year Simulation
2015 VOC Contamination



MODFLOW 35 Year Simulation
2025 VOC Contamination



MODFLOW 40 Year Simulation
2030 VOC Contamination



MODFLOW 50 Year Simulation
2040 VOC Contamination

APPENDIX D

WATER

QUALITY

MONITORING

PLAN

GAI CONSULTANTS

GROUND AND SURFACE WATER MONITORING SYSTEM
EXISTING GREENE COUNTY LANDFILL
WOOTENS CROSSROADS, NORTH CAROLINA

FOR

MUNICIPAL ENGINEERING SERVICES COMPANY
FEB 3 1994

MUNICIPAL ENGINEERING SERVICES COMPANY
RALEIGH, NORTH CAROLINA

PROJECT NO. 94103.02

FEBRUARY 1994

4000 Blue Ridge Road
Suite 500
Raleigh, NC 27612
919/783-4783
FAX 919/783-0241

February 2, 1994

Mr. Wayne Sullivan
Municipal Engineering Services Company, P.A.
Post Office Box 97
Garner, North Carolina 27529

Re: Ground and Surface Water Monitoring System
Existing Greene County Landfill
Wootens Crossroads, North Carolina
Project No. 94103.02

Dear Mr. Sullivan:

INTRODUCTION

The groundwater monitoring system for the existing municipal landfill of Greene County, North Carolina, near Wootens Crossroads, North Carolina is being evaluated as a part of the transition from previous North Carolina regulations to current North Carolina regulations (Subtitle D). This letter presents data and information pertaining to the existing groundwater monitoring system, discusses the geology of the area, and makes recommendations for improving the groundwater monitoring system.

GEOLOGY

The landfill is located in the Coastal Plain physiographic province south of Wootens Crossroads, North Carolina on State Road 1239. The land surface is characterized by a slightly rolling topography with approximately 20 feet of relief across the landfill site. Surface drainage is northeast towards a tributary of Sandy Run which flows eastward to Little Contentnea Creek which flows southeast into Contentnea Creek and subsequently the Neuse River. The landfill is immediately underlain by surficial sediments which may be underlain by the Pliocene Yorktown Formation. The surficial sediments and possibly Yorktown Formation unconformably overlie the Cretaceous Black Creek Formation. The Black Creek Formation increases in thickness and dips to the southeast at less than 0.5°.

The surficial deposits consist of sand, clay, and gravel and are generally less than 40 feet thick. In the area of the landfill, the surficial sediments probably consist of weathered Yorktown Formation sediments (Johnson and Peebles, 1986, and Ward, et al, 1991).

The Yorktown Formation varies in thickness from 1 to 15 feet (Brown, 1959), and consists of shelly, silty

sands and interbedded fine grained silty sand, sandy silt, and silty clay (Ward, et al 1991). The shelly sands generally are more abundant in the downdip direction. The surficial sediments and Yorktown Formation comprise the surficial aquifer at the landfill (Winner and Coble, 1989).

The Black Creek Formation consists of thinly laminated gray to black clay interbedded with gray to tan fine to medium grained sand. The clays and sands generally contain abundant lignitic wood with associated pyrite (Sohl and Owens, 1991) with occasional shell fragments and glauconite present. The sand units occur as both thin beds and thicker channel sands (Benson, 1968). Approximately 10 to 25 feet of clay, silty clay, and sandy clay on the top of the Black Creek Formation acts as a confining layer separating the surficial unconfined aquifer from the underlying Black Creek confined aquifer (Winner and Coble, 1989).

There are no reported Holocene Faults at or in the vicinity of the site (Howard, et al, 1978). The landfill is not in a seismic impact zone (Algermissen, et al, 1990).

A geologic map was not prepared, since the entire site is covered by surficial sediments. References used in the geologic study are listed in Table 1.

SITE REVIEW

Three existing groundwater monitoring wells at the approximate locations shown on Plate 1 were reviewed on January 27, 1994. Well completion records for these monitoring wells are presented in Appendix A. Installation data, including depth to groundwater, are presented in Table 2 along with depth of installation. Table 3 presents information on the condition of the three wells.

The groundwater monitoring wells have either aluminum or steel caps and casing grouted inside and outside around a two-inch diameter PVC stand pipe well (see Table 3). Groundwater Monitoring Wells 2 and 3 were locked; Well 1 was not locked. None of the wells were numbered or tagged; all wells had vented PVC caps. These three wells appear to have been constructed in accordance with North Carolina Regulations. However, a 5 foot discrepancy is noted in reported total depth and measured depth of Well 3. Possibly a ten foot screen was installed instead of the five foot screen reported on the well construction record. Well 1 is located within 250 feet of the waste boundary. Wells 2 and 3 are located over 1800 feet from the waste boundary.

MODIFICATIONS TO MONITORING SYSTEM

The locations of the three existing groundwater monitoring wells make it difficult to prepare a

groundwater potentiometric map. The general conclusion reached is that the groundwater is probably flowing to the east from Groundwater Monitoring Well 1 towards Groundwater Monitoring Wells 2 and 3, and the tributary of Sandy Run, and probably mirrors the topography. Three additional groundwater monitoring wells, numbered Groundwater Monitoring Wells 4, 5 and 6, should be installed as shown on Plate 1. These three groundwater monitoring wells will be located between the fill area and the borrow site, and within 250 feet of the existing waste boundary. These three additional wells will allow a more accurate determination of the direction of groundwater flow, the groundwater potential, and allow detection of any development of a plume of contamination from the landfill. Table 4 presents recommended approximate installation data for three additional monitoring wells.

The wells should be installed in general accordance with North Carolina regulations. Well construction should be in accordance with Plate 2 which shows a typical monitoring well schematic as recommended by the state of North Carolina. Groundwater monitoring wells should be constructed considering actual static groundwater levels, soil and rock types, and conditions encountered during well installation. All wells should be tagged, labeled, and provided with locks. The location of all groundwater monitoring wells should be surveyed.

It is recommended that existing Groundwater Monitoring Wells 2 and 3 either be abandoned or removed from the groundwater monitoring plan for the existing landfill. Both wells are located to far away from the existing landfill to be used for groundwater monitoring associated with the landfill.

A tributary of Sandy Run flows by the landfill. Surface water sampling should be done upstream and downstream of the landfill in the general area of the surface water sample locations shown on Plate 3.

Respectfully submitted,
GAI Consultants - NC, Inc.

Edward S. Custer, Jr., Ph.D., P.G.
Staff Geologist

Wendell W. Parker, Ph.D., P.E.
Vice President

WWP/kla

cc: Mr. Bobby Lutfy, Division of Solid Waste

TABLES

TABLE 1

REFERENCES

Algermissen, S. T., Perkins, D. M., Thenhaus, P. C., Hanson, S. L., and Bender, B. L., 1990, Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico: U. S. Geological Survey Miscellaneous Field Studies Map MF-2120, scale 1:7,500,000.

Benson, P. H., 1968, The depositional environment of the Upper Cretaceous Black Creek Formation in North and South Carolina [Ph.D. dissertation]: Chapel Hill, University of North Carolina, 149 p.

Brown, P. M., 1959, Geology and Ground-water Resources in the Greenville Area, North Carolina: North Carolina Department of Conservation and Development, Division of Mineral Resources Bulletin 73, 87 p.

Howard, K. A., Aaron, J. M., Brabb, E. E., Brock, M. R., Gower, H. D., Hunt, S. J., Milton, D. J., Muelhberger, W. R., Nagata, J. K., Plafker, G., Prowell, D. C., Wallace, R. E., and Witkind, I. J., 1978, Preliminary map of young faults in the United States as a guide to possible fault activity: U. S. Geological Survey Miscellaneous Field Studies Map MF-916, scale 1:5,000,000.

Johnson, G. H., and Peebles, P. C., 1986, Quaternary geologic map of the Hatteras 4° x 6° quadrangle, in Richmond, G. M., Fullerton, D. S., and Weide, D. L., eds., Quaternary Geologic Atlas of the United States: U. S. Geological Survey, Miscellaneous Investigations Series Map I-1420 (NI-18), scale 1:1,000,000.

Sohl, N. F., and Owens, J. P., 1991, Cretaceous Stratigraphy of the Carolina Coastal Plain, in Horton, J. W., Jr., and Zullo, V. A., eds., The Geology of the Carolinas: The University of Tennessee Press, p. 191-220.

Ward, L. W., Bailey, R. H., and Carter, J. G., 1991, Pliocene and Early Pleistocene Stratigraphy, Depositional History, and Molluscan Paleobiogeography of the Coastal Plain, in Horton, J. W.,Jr., and Zullo, V. A., eds., The Geology of the Carolinas: The University of Tennessee Press, p. 274-289.

Winner, M. D., and Coble, R. W., 1989, Hydrogeologic Framework of the North Carolina Coastal Plain Aquifer System: U. S. Geological Survey Open-File Report 87-690, 155 p.

TABLE 2

INSTALLATION DATA FOR GROUNDWATER MONITORING WELLS

Well Number	Depth of Water Below Ground Surface (ft)	Total Depth Below Ground Surface (ft)
1	11.0	19.0
2	13.0	20.0
3	3.0	10.0

All wells were reportedly installed with four inch diameter outer galvanized steel casing and two inch diameter inner PVC casing. A letter dated November 19, 1981 from Law Engineering Testing Company (see Appendix A) states that bentonite seals 1 foot thick were installed between the bottom of the grout and top of the sand pack.

TABLE 3

INFORMATION ON CURRENT CONDITION OF GROUNDWATER MONITORING WELLS

Well Number	Depth of Water Below Ground Surface (ft)	Total Depth Below Ground Surface (ft)
1	3.40	18.75
2	4.71	18.01
3	3.40	15.20

Wells 2 and 3 were locked; the locking mechanism on Well 1 was broken. A replacement outer cap and lock reportedly are available and should be installed shortly. None of the wells had numbers or tags. The numbering system for the wells was shown on a map at the site. The wells were grouted inside and outside the outer casing. Well 2 had an aluminum cap; the other two wells had steel caps. All three wells had vented inner PVC caps. There is a 5 foot discrepancy between the reported total depth for Well 3 and the measured depth. A 10 foot screen may have been installed instead of the 5 feet reported on the well construction record. None of the well locations have been surveyed.

TABLE 4

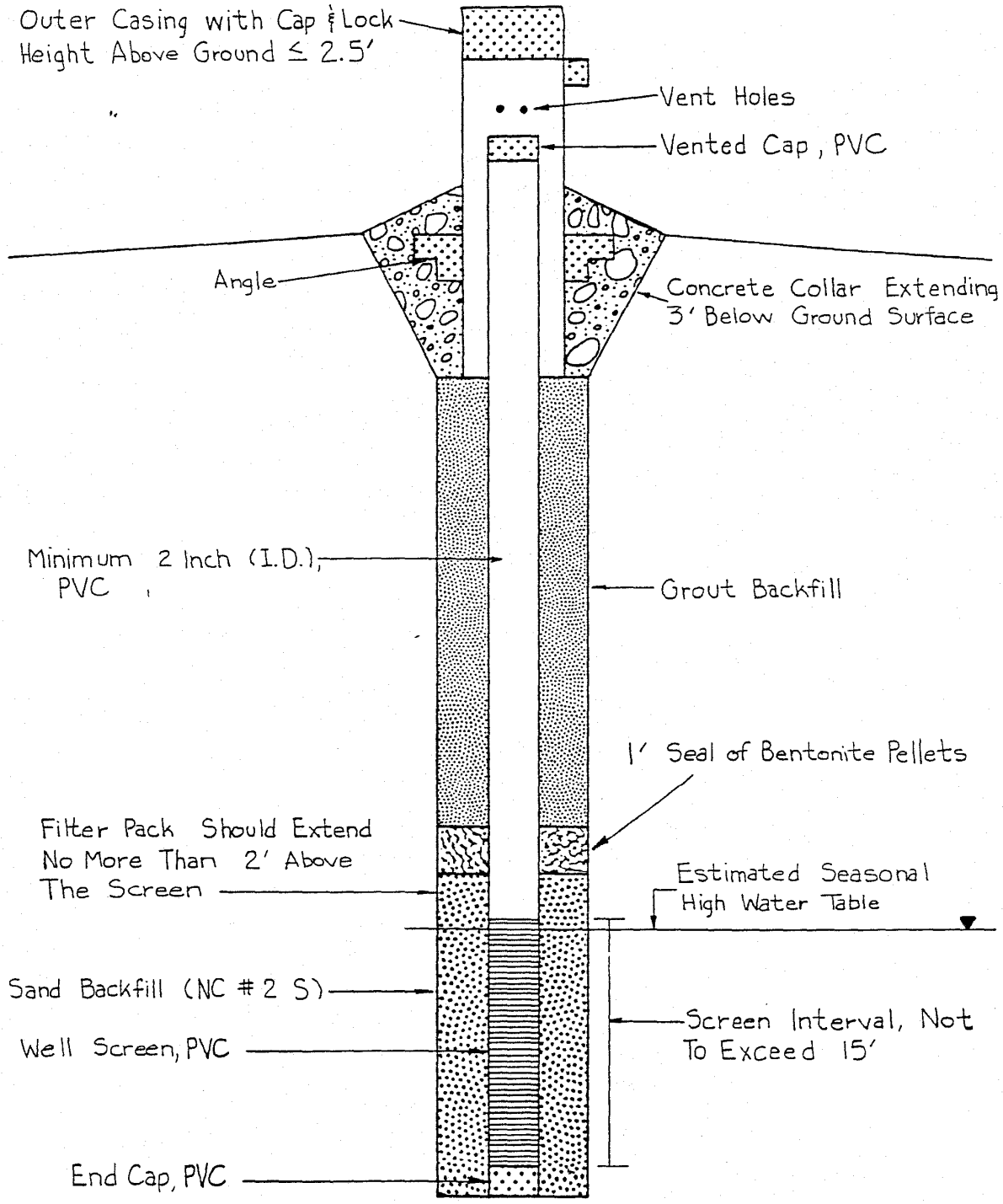
PROPOSED GROUNDWATER MONITORING WELL INSTALLATIONS

Proposed Groundwater Monitoring Well	Ground Surface Elevation (ft)	Groundwater Elevation (ft)	Screen Elevation (ft) Top	Bottom	Well Depth (ft)
4	117	113	113	103	15
5	114.5	110.5	110	100	15.5
6	116	112	112	102	15

Note: All elevations were estimated from a topographic map and are approximate. Groundwater elevation estimated at the time of the site review.

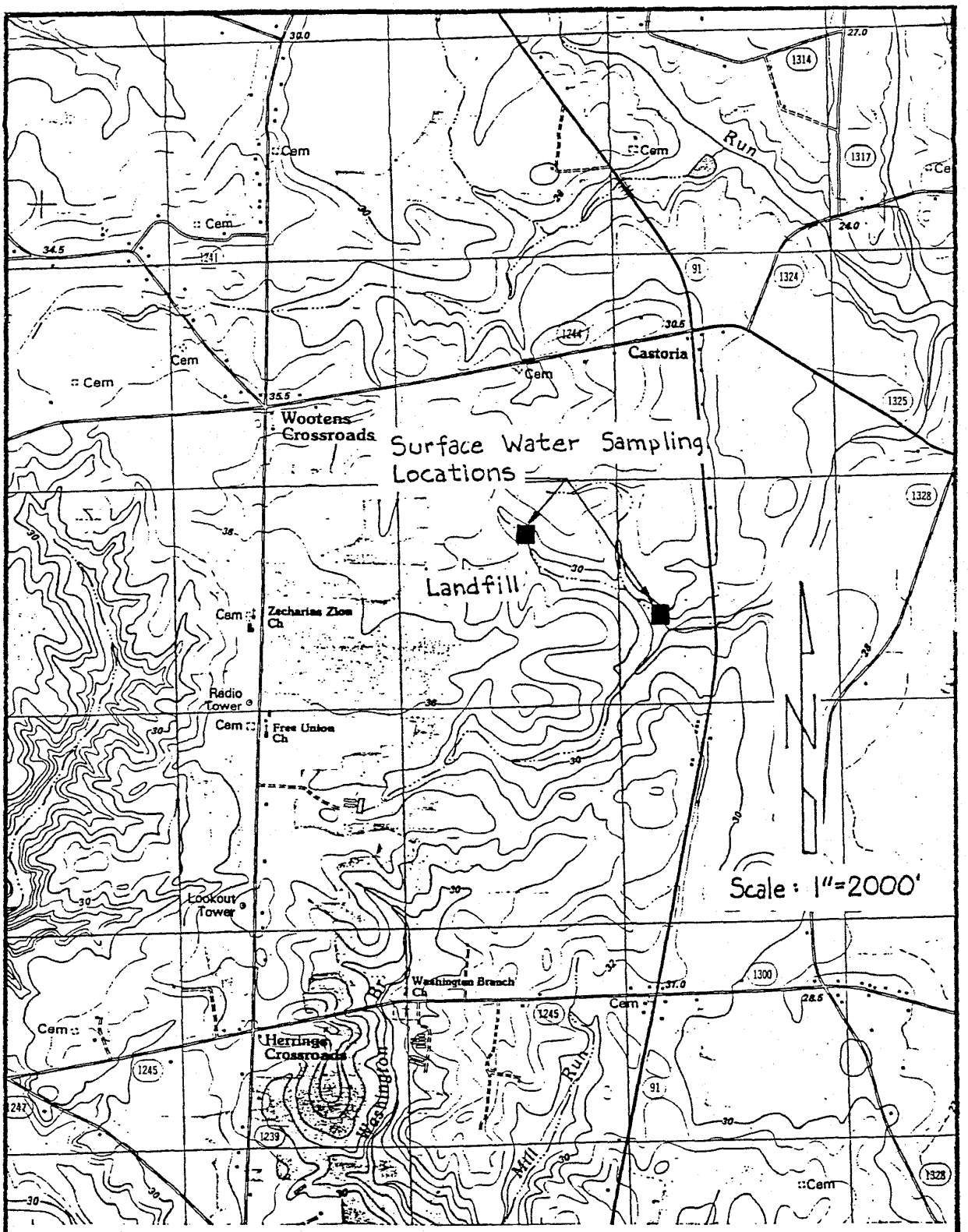
PLATES

9 4103.02



TYPICAL MONITORING WELL
PLATE 2

94103.02



Note: Contours In Meters

Proposed Surface Water Sampling Locations
Plate 3

APPENDIX A

WELL CONSTRUCTION RECORDS

NORTH CAROLINA DEPARTMENT OF ...
DIVISION OF ENVIRONMENTAL MANAGEMENT - GROUNDWATER SECTION
P.O. BOX 27687 - RALEIGH, N.C. 27611, PHONE (919) 733-5083

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

PZ-1
WELL CONSTRUCTION RECORD

DRILLING CONTRACTOR Law Engineering
DRILLER REGISTRATION NUMBER 332

STATE WELL CONSTRUCTION PERMIT NUMBER: _____

WELL LOCATION: (Show sketch of the location below)
Nearest Town: Snow Hill, N.C.
(Road, Community, or Subdivision and Lot No.)
OWNER Greene County
ADDRESS P.O. Box 5 (Street or Route No.)
Snow Hill (City or Town) N.C. (State) 28580 (Zip Code)

County: Greene County

DATE DRILLED Nov 19, 81 USE OF WELL Monitoring
TOTAL DEPTH 19.0' CUTTINGS COLLECTED ☐ Yes ☒ No
DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No
STATIC WATER LEVEL: 11.0 FT. ☐ above ☒ below TOP OF CASING. Ground Level
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.
YIELD (gpm): - METHOD OF TEST -
WATER ZONES (depth): 11.0 -

CHLORINATION: Type - Amount -

Depth From	Depth To	DRILLING LOG Formation Description

If additional space is needed use back of form.

CASING:

	Depth From	Depth To	Diameter	Wall Thickness or Weight/Ft.	Material
	0	9	2"	40 sch	PVC

GROUT:

	Depth From	Depth To	Material	Method
	0	7'	Type I	pump

SCREEN:

	Depth From	Depth To	Diameter	Slot Size	Material
	9'	19'	2"	.010 in.	PVC

GRAVEL PACK:

	Depth From	Depth To	Size	Material
	8'	19.0'	20-30	Torpedo sand

LOCATION SKETCH
(Show direction and distance from at least two State Roads, or other map reference points)

attached map

REMARKS: _____

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Floyd C Cox — SIGNATURE OF CONTRACTOR OR AGENT
9-21-89 — DATE

Revised 11/84
Submit original to Division of Environmental Management and copy to well owner

P.O. BOX 27687 - RALEIGH, N.C. 27611, PHONE (919) 733-5083

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

PZ-2

WELL CONSTRUCTION RECORD

DRILLING CONTRACTOR Law Engineering

DRILLER REGISTRATION NUMBER 332

STATE WELL CONSTRUCTION PERMIT NUMBER: ?

WELL LOCATION: (Show sketch of the location below)

Nearest Town: Snow Hill, N.C.

County: Greene County

(Road, Community, or Subdivision and Lot No.)

OWNER Greene County

ADDRESS P.O. Box 5 (Street or Route No.)

Snow Hill (City or Town) N.C. (State) 28580 (Zip Code)

DATE DRILLED Nov 19, 81 USE OF WELL Monitoring

TOTAL DEPTH 20.0' CUTTINGS COLLECTED ☐ Yes ☒ No

DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

STATIC WATER LEVEL: 13 FT. ☐ above ☒ below TOP OF CASING, ground level

TOP OF CASING IS _____ FT. ABOVE LAND SURFACE

YIELD (gpm): _____ METHOD OF TEST _____

WATER ZONES (depth): 13.0' —

RINATION: Type _____ Amount _____

CASING:

	Depth From	Depth To	Diameter	Wall Thickness or Weight/Ft.	Material
	0'	10.0 Ft.	2"	40 sch	PVC
		Ft.			
		Ft.			

GROUT:

	Depth From	Depth To	Material	Method
	0	7.0' Ft.	Type I	pump
		Ft.		

SCREEN:

	Depth From	Depth To	Diameter	Slot Size	Material
	10.0'	20.0' Ft.	2" in.	.010 in.	PVC
		Ft.	in.	in.	
		Ft.	in.	in.	

GRAVEL PACK:

	Depth From	Depth To	Size	Material
	8.0'	20.0' Ft.	#0-28	Torpedo sand
		Ft.		

REMARKS: _____

DRILLING LOG

Depth From	Depth To	Formation Description

If additional space is needed use back of form.

LOCATION SKETCH

(Show direction and distance from at least two State Roads, or other map reference points)

attached map

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Floyd Cox 9-21-89

SIGNATURE OF CONTRACTOR OR AGENT DATE

Revised 11/84

Submit original to Division of Environmental Management and copy to well owner.

P.O. BOX 27687 – RALEIGH, N.C. 27611, PHONE (919) 733-5083

PZ-3

WELL CONSTRUCTION RECORD

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

DRILLING CONTRACTOR Law Engineering
DRILLER REGISTRATION NUMBER 332

STATE WELL CONSTRUCTION PERMIT NUMBER: ?

WELL LOCATION: (Show sketch of the location below)
Nearest Town: Snow Hill, N.C.
County: Greene County
(Road, Community, or Subdivision and Lot No.)

OWNER Greene County
ADDRESS P.O. Box 5 (Street or Route No.)
Snow Hill (City or Town) N.C. (State) 28580 (Zip Code)

DATE DRILLED Nov 19 81 USE OF WELL Monitoring
TOTAL DEPTH 10.0' CUTTINGS COLLECTED ☐ Yes ☒ No
DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No
STATIC WATER LEVEL: 3 FT. ☐ above ☒ below TOP OF CASING. ground level
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.
YIELD (gpm): – METHOD OF TEST –
WATER ZONES (depth): 6.0' –
CHLORINATION: Type – Amount –

CASING:

	Depth		Diameter	Wall Thickness or Weight/Ft.	Material
From 0	To 5.0	Ft.	2"	40 sch	PVC
From	To	Ft.			
From	To	Ft.			

GROUT:

	Depth		Material	Method
From 0'	To 0	Ft.	Type I	pump
From	To	Ft.		

SCREEN:

	Depth		Diameter	Slot Size	Material
From 5.0	To 10.0	Ft.	2" in.	.010 in.	PVC
From	To	Ft.	in.	in.	
From	To	Ft.	in.	in.	

GRAVEL PACK:

	Depth		Size	Material
From 4.0'	To 10.0	Ft.	20-28	Torpedo sand
From	To	Ft.		

REMARKS

DRILLING LOG

Depth From	To	Formation Description

If additional space is needed use back of form.

LOCATION SKETCH
(Show direction and distance from at least two State Roads, or other map reference points)

attached map

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT DATE

Revised 11/84

Submit original to Division of Environmental Management and copy to well owner.

40-02 W.Q.

Greene Arth

LAW ENGINEERING TESTING COMPANY
geotechnical, environmental & construction materials consultants
3301 WINTON ROAD
P.O. BOX 18288 • RALEIGH, NORTH CAROLINA 27619
(919) 876-0416

RECEIVED
NOV 23 1981
SOLID WASTE MANAGEMENT BRANCH

November 19, 1981

Greene County
Post Office Box 5
Snow Hill, North Carolina 28580

Attention: Mr. George L. Mewborn, Jr.

Subject: Groundwater Monitoring Wells
Proposed Greene County Landfill
Greene County, North Carolina
LETCO Job No. RA-1798

Gentlemen:

As requested and authorized by Mr. William A. Jones, County Commissioner, Law Engineering Testing Company has installed three groundwater monitoring wells at the subject site.

Locations of the wells were staked by Greene Land Surveying and Engineering, P.A. Installation of the wells was accomplished in general accordance with the N. C. Department of Human Resources guidelines.

The wells were drilled with hollow stem augers to depths of 25 ft., 20 ft., and 20 ft. in wells PZ-1, PZ-2, and PZ-3, respectively. Due to the clayey nature of the soils, it was necessary to allow the water level to stabilize prior to installation of the well screens. Below is a summary of the well installations.

	DEPTH BELOW GRADE, FEET		
	PZ-1	PZ-2	PZ-3
Water Level at time of Installation	11	13	6
Bentonite Seal 1 Ft. Thick	7	7	3
Well Screen Bottom, 10 Ft. Long	19	20	10 (Screen 5 Ft. Long

Greene County
November 19, 1981
Page Two

After completion of the wells, locks were placed on the standpipe covers to deter tampering and accidental contamination. Keys to the locks were sent to Mr. Jesse Tyndall.

We appreciate the opportunity to be of service. Please call our office with any questions.

Very truly yours,

LAW ENGINEERING TESTING COMPANY

J. Richard Rhudy, P.E.
Staff Geotechnical Engineer
Registered, N.C. 9070

J. Allan Tice, P.E.
Chief Engineer
Registered, N.C. 6428

JRR/JAT/mr

cc: Mr. Gordan Layton
N. C. Department of Human Resources

WATER QUALITY SAMPLING AND ANALYSIS PLAN

GAI CONSULTANTS

GROUND AND SURFACE WATER SAMPLING AND ANALYSIS PLAN

FOR INCLUSION IN

EXISTING MUNICIPAL SANITARY LANDFILL TRANSITION PLANS
NORTH CAROLINA

FEBRUARY 1994

GROUND AND SURFACE WATER SAMPLING AND ANALYSIS PLAN

INTRODUCTION

The objective of the ground and surface water sampling and analysis plan is to provide clear guidelines and procedures to be followed by field and laboratory personnel when obtaining and testing ground and surface water samples.

The goal of the sampling plan is to obtain the desired sample while neither adding nor subtracting any constituent to or from the sample or the monitoring well. The plan details described below, when followed, are considered adequate to eliminate any cross-contamination or contamination from external sources of the wells sampled. These guidelines are drawn, in part, directly from and are intended to be used in conjunction with the N.C. Water Quality Monitoring Guidance Document for Solid Waste Facilities (Guidance Document), copy enclosed.

The goal of the analysis plan is to test and detect, if present, selected chemical constituents (Appendix I constituents) in the ground and surface water. Testing will be conducted to the desired detection levels with accuracy and precision under controlled testing procedures such that chemical constituents not present are neither added to the water nor detected.

SAMPLING EQUIPMENT

Groundwater samples will be obtained in the field using a dedicated, laboratory-cleaned, stainless steel bailer. Each bailer will be cleaned in a laboratory controlled environment prior to sampling in accordance with the following steps.

1. Completely disassemble bailer.
2. Phosphate-free, laboratory grade, soap and deionized or distilled water wash.
3. Deionized or distilled water rinse.
4. Isopropyl alcohol rinse.
5. Deionized or distilled water rinse.
6. Air dry.
7. Wrap bailer in aluminum foil, shiny side out.
8. Wrap bailer in plastic.

In addition to laboratory cleaned bailers for each well sampled, standard equipment necessary to conduct the sampling includes sample containers, including trip blanks and equipment blanks, wide-mouth container, at least two 600-ft spools of ¼-inch nylon rope, at least two boxes of latex gloves, one box of large plastic bags, temperature indicator, pH indicator, conductivity indicator, water level indicator, storage coolers, and ice. In case

of emergency, supplies to clean bailers as described above may also be brought to the site. If the total depth of all wells to be sampled exceeds 1200 feet, additional spools of rope will be obtained to complete the sampling. If the number of wells to be sampled exceeds one third of the number of pairs of gloves in stock, additional boxes of gloves will be obtained.

The bailers, wrapped in foil and plastic, will be transported between pieces of peaked foam rubber to prevent damage to the wrappings. Other equipment subject to damage and contamination will be transported in sealed, plastic bags. The water level indicator will be cleaned in accordance with Steps 3 through 5 described above prior to placement in a clean plastic bag.

SAMPLE CONTAINERS

Various sample containers are required for a complete sampling and analysis effort. Routine groundwater and surface water monitoring may include the following:

- Volatile organic analysis (VOA),
- Total organic halogens (TOX), and
- Inorganic analysis, such as heavy metals or general chemistry.

Samples will be collected for the various analyses in the containers described below in the order listed.

Samples to be analyzed for VOA and/or TOX will be collected first in two 40-ml glass vials with teflon caps. The sample vials will be completely filled with no air left in the vials.

Samples to be analyzed for inorganic contamination will be collected next in two 1-quart/1-liter plastic containers.

Samples to be analyzed for complete organics, including acid-base neutrals, will be collected in a ½-gallon/2-liter glass jar with aluminum foil or teflon-lined caps.

Samples to be analyzed for radiologic parameters will be collected next in 1-gallon/4-liter plastic containers.

Samples to be analyzed for bacteriological parameters will be collected in one 120-ml plastic vial.

All sample containers will be obtained from an independent laboratory in a sterilized condition. Some of the containers will have a premeasured amount of preservative in them as necessary. In this event, care will be taken not to rinse the container or allow the preservative to wash out during sampling.

GROUNDWATER SAMPLING

Preparation. Sampling a groundwater monitoring well begins with unlocking and opening the locking cap and removing the PVC well cap. The depth to water will be determined using the water level indicator. Before storage and/or reuse, the water level indicator will be cleaned in accordance with Steps 3 through 5 described above and replaced in a clean plastic bag.

The total well depth read from the well tag and the measured depth to water will be used to compute the depth of water in the well. Using the chart in the Guidance Document, the quantity of water in the well will be determined. For example, if a two-inch well is 29 feet deep and has a measured depth to water of 10 feet, there are 19 feet of standing water or 3.3 gallons in the well. Each well will be purged three to five well volumes (quantity of water in the well), or until dry, prior to sampling. In the example, 10 gallons would be adequate. Purged water will be measured in 5-gallon buckets until the desired amount is purged. Care will be taken not to bring the bailer into contact with the bucket during purging.

Based on the number of wells to be sampled and their proximity to each other, all the wells may be purged one after another with sampling to follow. In this manner, if a well is purged dry, it will have time to recharge prior to sampling.

Purging. After the amount of water to be purged from a well is determined, the equipment necessary for purging will be assembled at the well including rope, 5-gallon bucket, bailer, and gloves. With the wrapped bailer maintained in a stable, upright position, the top portion of aluminum foil will be pulled away exposing only the eyelet used for securing the rope to the bailer. After the rope has been secured to the bailer with gloved hands, the bailer will be suspended as the aluminum foil and plastic are removed. The gloved hand used to remove the aluminum foil and plastic will be considered contaminated and may not come into contact with the bailer or rope. The bailer will be lowered slowly into the well using the uncontaminated, gloved hand that suspended the bailer until the bailer contacts the water. The rope will be cut to an adequate length and secured to prevent losing the bailer in the well. The gloves will be discarded and a new pair used during the purging.

In order not to allow the rope to touch the ground during purging, the rope will be gathered when raising the

bailer either by gathering in loops in one hand or by the wind mill method. The wind mill method requires hooking the rope with alternating thumbs as the rope is pulled from the well. When purging deep wells, the ground around the well head may be covered with a clean plastic bag or sheet of plastic with a slit cut to allow the plastic to slide over the well head. The plastic will be placed over the sampler's boots to allow the rope to fall on the plastic without contamination. Alternatively, the rope may be lowered into an open bag placed in a 5-gallon bucket beside the well head. In any case, the rope will not contact anything considered contaminated including ground, boots, dirtied plastic, etc.

If purging and sampling of a well is performed at separate times, the bailer will be left suspended in the well and the rope secured. The remaining rope will be doubled and grasped in a tight loop in one hand. With the free hand, the glove on the hand holding the rope will be removed by pulling away from the hand and over the rope in an inside-out position until rope is encased in the glove. The rope will be transferred to the opposite hand and the procedure repeated to cover any portion of rope remaining uncovered. The glove-encased rope will be set on top of the well head until time to sample. Alternatively, the rope remaining after securing may be gathered in a tight loop and pushed into the 2-inch PVC well pipe and left. If sampling immediately follows purging, new gloves will not be necessary.

Sampling. Prior to sampling the well, the necessary equipment will be assembled at the well, including pH, conductivity, and temperature indicators, sampling jars, a thoroughly cleansed wide mouthed container, and a box of latex gloves. An equipment blank will be prepared prior to sampling each well by rinsing distilled water through the bailer into the equipment blank container.

With gloves on, the bailer will be lowered into the well slowly. To avoid releasing any volatiles from the groundwater, care will be exercised while the bailer is lowered so that it does not splash or smack the water surface. Once full, the bailer will be retrieved and containers filled in the order described above. The containers will be filled by inverting the bailer until water issues from the small holes at the top of the bailer. In addition to collecting the samples, water will be collected in the wide-mouth container for pH, temperature, and conductivity measurements. Following completion of the sampling, the containers, including the equipment blank, will be stored and transported on ice. The used latex gloves and rope will be discarded.

SURFACE WATER SAMPLING

Surface water samples will be obtained from adjacent rivers, streams or brooks upstream and downstream of the landfill at designated surface water sampling sites. Actual collection points for surface water sampling will

be selected with consideration given to minimal turbulence and aeration.

Surface water sample containers will be handled with one hand near the base. The container will be rinsed with the water to be sampled prior to filling the container unless the container contains a premeasured amount of preservative. When collecting surface water samples, sample containers will be dipped at location points with extreme caution in order to avoid contamination at the mouth of the container. The container will be pushed rapidly into the water to a depth of about six inches, mouth down, and tilted towards the stream current to fill. Care will be taken not to let the mouth of the container breech the surface while filling. If there is little current movement, the container will be moved slowly through the water laterally. During times of drought, if the water is not deep enough to allow submersion of the container, a pool may be scooped out of the bottom of the stream to obtain a sample. The pool will be allowed to clear before sampling. The container will be lifted from the water and sealed with the cap, leaving an airspace at the top of about ½ inch. Glass vial containers collected for VOA and TOX analyses will be filled completely as described above. The samples will be stored and transported on ice.

SAMPLE TRANSPORT AND CHAIN-OF-CUSTODY

Sample containers will be clearly labeled as the samples are obtained and stored on ice along with the equipment blanks and trip blanks. Trip blanks will remain in the condition they are received from the laboratory and will not be opened or tampered with during the sampling. A chain-of-custody record will be completed for each day's samples, indicating the date and time, sample location, sample matrix (soil, water, etc.), and laboratory analyses to be conducted. In addition, a field sampling data sheet will be completed indicating the depth to water measured in each well sampled and the pH and temperature of the sample measured in the field. Sample copies of the chain-of-custody record and field sampling data sheet are enclosed.

GROUND AND SURFACE WATER ANALYSIS

Water samples obtained in the field will be maintained in the sample containers on ice and transported to an approved laboratory for analysis. If the individual transporting the samples is different from the individual that did the sampling, the chain of custody forms will be used to document the transfer of custody from the water sampler to the water transporter. When the water samples reach the laboratory, they will be transferred to a sample custodian who will sign the chain of custody documentation for receipt of the samples. Internal control of the water samples in the laboratory will be in accordance with QA/QC procedures for the laboratory. Copies of QA/QC manuals for approved laboratories are on file with the Division of Solid Waste.

Ground and surface water samples will be analyzed for Subtitle D Appendix I constituents. Table 1 contains a list of the Appendix I constituents as well as a list of EPA methods to be utilized in detection of the constituents. References where these test methods are documented are also presented in Table 1. In addition, detection levels for each of the constituents and a list of the equipment that will be used in the laboratory testing are presented in Table 1. QA/QC procedures utilized during the testing will be in conformance with the laboratory QA/QC manual.

TABLE

TABLE 1
GROUND AND SURFACE WATER ANALYSES METHODOLOGY

Inorganic Constituent	Test Method	Equipment	Detection Level, μg/L
Antimony	EPA 7041	GF/AA	2
Arsenic	EPA 7060A	GF/AA	1
Barium	EPA 6010A	ICP	1
Beryllium	EPA 6010A	ICP	1
Cadmium	EPA 7131A	GF/AA	0.2
Chromium	EPA 6010A	ICP	6
Cobalt	EPA 6010A	ICP	5
Copper	EPA 6010A	ICP	3
Lead	EPA 7421	GF/AA	2
Nickel	EPA 6010A	ICP	20
Selenium	EPA 7740	GF/AA	1
Silver	EPA 6010A	ICP	4
Thallium	EPA 7841	GF/AA	1
Vanadium	EPA 6010A	ICP	5
Zinc	EPA 6010A	ICP	2
Organic Constituent			
Acetone	EPA 8240A	GC/MS	100
Acrylonitrile	EPA 8240A	GC/MS	200
Benzene	EPA 8020A	GC/PID	2.00
Bromochloromethane	EPA 8240A	GC/MS	5.00
Bromodichloromethane	EPA 8010A	GC/ELCD	1.00
Bromoform	EPA 8010A	GC/ELCD	2.00
Carbon disulfide	EPA 8240A	GC/MS	100
Carbon tetrachloride	EPA 8010A	GC/ELCD	1.00
Chlorobenzene	EPA 8010A	GC/ELCD	2.00
Chloroethane	EPA 8021	GC/ELCD	1.00
Chloroform	EPA 8010A	GC/ELCD	0.50
Dibromochloromethane	EPA 8010A	GC/ELCD	1.00
1,2-Dibromo-3-chloropropane	EPA 8010A	GC/ELCD	30.0

TABLE 1
(continued)

Organic Constituent	Test Method	Equipment	Detection Level, µg/L
1,2-Dibromoethane	EPA 8021	GC/ELCD	10.0
1,2-Dichlorobenzene	EPA 8021	GC/ELCD	0.50
1,4-Dichlorobenzene	EPA 8240A	GC/MS	5.00
Trans-1,4-dichloro-2-butene	EPA 8240A	GC/MS	100
1,1-Dichloroethane	EPA 8021	GC/ELCD	0.50
1,2-Dichloroethane	EPA 8010A	GC/ELCD	0.50
1,1-Dichloroethylene	EPA 8021	GC/ELCD	0.50
Cis-1,2-dichloroethylene	EPA 8010A	GC/ELCD	0.50
Trans-1,2-dichloroethylene	EPA 8021	GC/ELCD	0.50
1,2-Dichloropropane	EPA 8010A	GC/ELCD	0.50
Cis-1,3-dichloropropene	EPA 8240	GC/MS	10.0
Trans-1,3-dichloropropene	EPA 8010A	GC/ELCD	5.00
Ethylbenzene	EPA 8020A	GC/PID	2.00
2-Hexanone	EPA 8240A	GC/MS	50.0
Methyl bromide	EPA 8021	GC/ELCD	10.0
Methyl chloride	EPA 8021	GC/ELCD	10.0
Methylene bromide	EPA 8240A	GC/MS	10.0
Methylene chloride	EPA 8010A	GC/ELCD	5.00
Methyl ethyl ketone	EPA 8240A	GC/MS	100
Methyl iodide	EPA 8240 A	GC/MS	10.0
4-Methyl-2-pentanone	EPA 8240A	GC/MS	100
Styrene	EPA 8020A	GC/PID	1.00
1,1,1,2-Tetrachloroethane	EPA 8010A	GC/ELCD	0.50
1,1,2,2-Tetrachloroethane	EPA 8010A	GC/ELCD	0.50
Tetrachloroethylene	EPA 8021	GC/ELCD	0.50
Toluene	EPA 8020A	GC/PID	2.00
1,1,1-Trichloroethane	EPA 8240A	GC/MS	5.00
1,1,2-Trichloroethane	EPA 8240A	GC/MS	5.00
Trichloroethylene	EPA 8010A	GC/ELCD	1.00
Trichlorofluoromethane	EPA 8240A	GC/MS	5.00

TABLE 1
(continued)

Organic Constituent	Test Method	Equipment	Detection Level, µg/L
1,2,3-Trichloropropane	EPA 8021	GC/ELCD	5.00
Vinyl acetate	EPA 8240A	GC/MS	50.0
Vinyl chloride	EPA 8240A	GC/MS	10.0
Xylenes	EPA 8020A	GC/PID	5.00

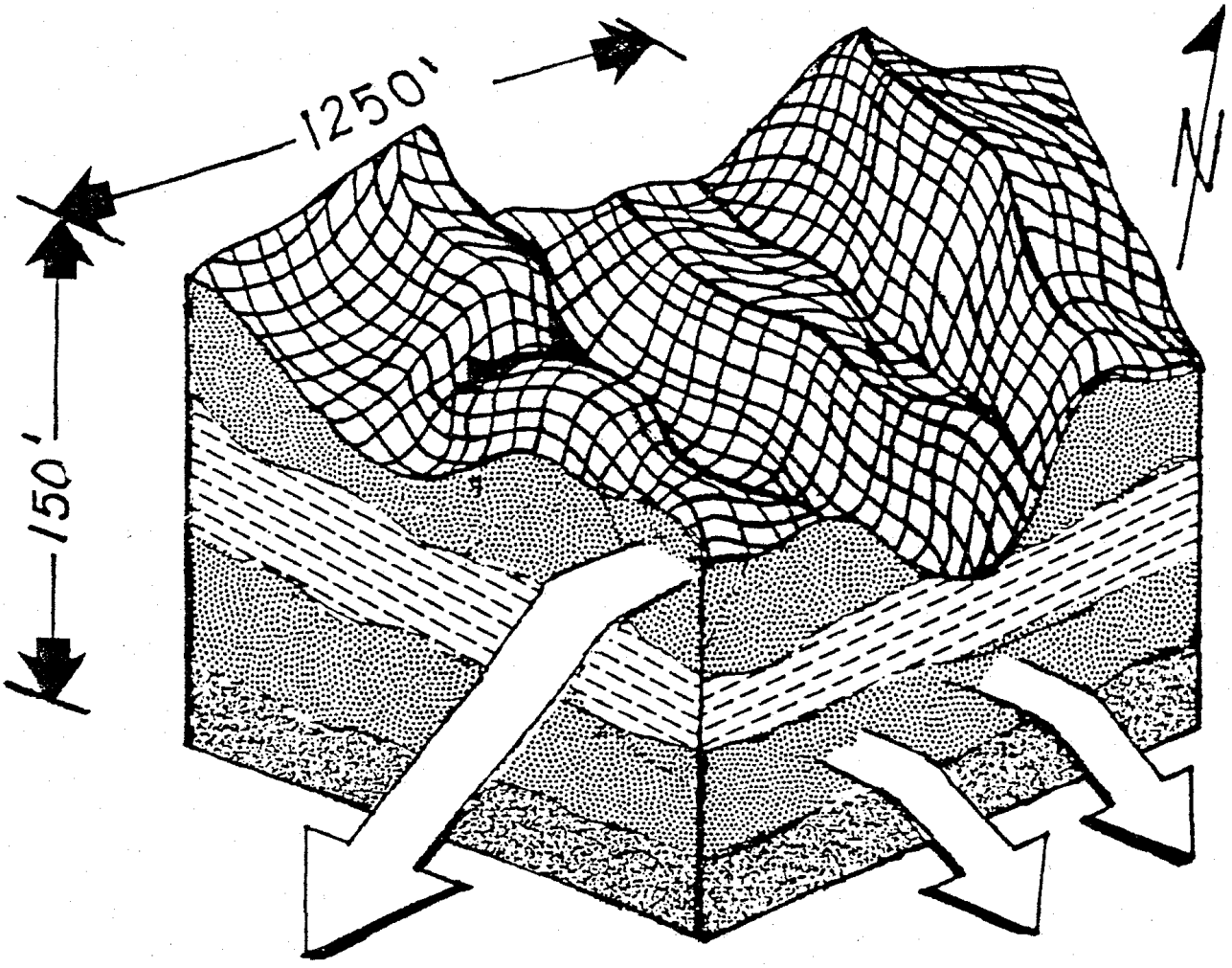
EPA Test Methods from "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," U.S. EPA Publication SW-846, 3rd Edition, September 1986, Amended by Update I, July 1992. Update I methods are designated with the letter "A" on the end of the method numbers. Update I was promulgated by 58 FR, August 31, 1993.

Equipment:

ICP Inductively Coupled Plasma - Atomic Emission Spectrophotometer
GF/AA Graphite Furnace - Atomic Absorption Spectrophotometer
GC/MS Gas Chromatograph - Mass Spectrometer
GC/PID Gas Chromatograph - Photoionization Detector
GC/ELCD Gas Chromatograph - Electrolytic Conductivity Detector

APPENDIX A
N.C. WATER QUALITY MONITORING GUIDANCE DOCUMENT

NORTH CAROLINA WATER QUALITY
MONITORING GUIDANCE DOCUMENT FOR SOLID WASTE FACILITIES



GROUND-WATER FLOW DIRECTION OF UPPER AQUIFER

GROUND-WATER FLOW DIRECTION OF LOWER AQUIFER

Prepared by the
SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH
ENVIRONMENTAL HEALTH SECTION
DIVISION of HEALTH SERVICES
DEPARTMENT of HUMAN RESOURCES
1987
SW-1001-87

NORTH CAROLINA WATER QUALITY
MONITORING GUIDANCE DOCUMENT FOR SOLID WASTE FACILITIES

Prepared by the
SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH
ENVIRONMENTAL HEALTH SECTION
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1987

SW-1001-87

LIST OF FIGURES

FIGURE PAGE

1. Typical Ground-Water Monitoring Well Schematic Diagram 2
2. Graphical Plot of Standing Water Volumes 4
3. Laboratory Analysis Request Sheet 9
4. Chain of Custody Form 10
5. Typical Ground-Water Monitoring Well Nest Schematic 14

TABLE OF CONTENTS

PAGE

ACKNOWLEDGEMENTS i
DEFINITIONS ii
GENERAL INTRODUCTION iii
INTRODUCTION 1
SPECIFIC MONITORING WELL CONSTRUCTION REQUIREMENTS 1
GROUND-WATER MONITORING 5
PORTABLE MONITORING 5
PURGING METHODS 5
SAMPLING METHODS 6
DEDICATED MONITORING 7
EQUIPMENT CLEANING PROCEDURES 7
SAMPLE CONTAINERS 8
TRANSPORT AND STORAGE OF SAMPLES 11
ADMINISTRATIVE PROCEDURES 11
SURFACE WATER MONITORING 12
FRACTURED WATER MONITORING 13
REFERENCES CITED 16

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Michael L. Babuin, 1987

DEFINITIONS

Monitoring Well - any well constructed for the primary or incidental purpose of obtaining subsurface samples of water or other liquids. This definition excludes lysimeters, tensiometers, and other devices used to investigate the characteristics of the unsaturated zone.

Observation Well - any well constructed for the purpose of obtaining ground-water level information only

Permittee - an individual, corporation, company, association, partnership, unit of local government, State agency, Federal agency or other legal entity upon which a permit to operate a sanitary landfill has been issued.

Water Table - the upper limit of the portion of the ground wholly saturated with water.

GENERAL INTRODUCTION

The purpose of this report is to provide a simple, clear and thorough overview of acceptable methods regarding ground and surface-water monitoring at solid waste facilities. The procedures and techniques outlined in this report have been compiled in response to the need for reliable, accurate and consistent data for ground-water and surface-water quality evaluation of sanitary landfills. The standardization of these methods of data collection will undoubtedly clarify proper ground-water monitoring techniques required by the State for all solid waste facilities, and subsequently, minimize much of the subjectivity associated with landfill evaluation. Clearly, it is in the best interests of each facility to utilize these guidelines whereas the probability of contamination is significantly reduced by following the steps outlined in this document.

INTRODUCTION

In order to fully acknowledge the scope and purpose of ground-water monitoring, it is of the utmost importance to fully understand and define the difference between a ground-water monitoring well and a public water supply well. This distinction is very obvious when comparing well construction techniques characteristic of various geologic formations throughout the State. For instance, the western part of North Carolina is dominated by a series of crystalline and metamorfic rocks. Subsequently, water supply wells in these regions typically are constructed by drilling through the saprolite (weathered rock) and into very hard, resistant rock bodies below the true water table. Because of the resistant lithologic character of these units, many well drillers feel that it is unnecessary to case a well characteristic of these type of conditions. This rationale may hold true for drinking water supply wells but is clearly unacceptable for ground-water monitoring purposes due to contamination problems associated with uncased or partially-cased holes and to possible logistic problems. For instance, monitoring equipment may become entangled on the bottom of a well casing which does not span the entire depth of the borehole. Subsequently, this office requires completely cased boreholes in all ground-water monitoring wells.

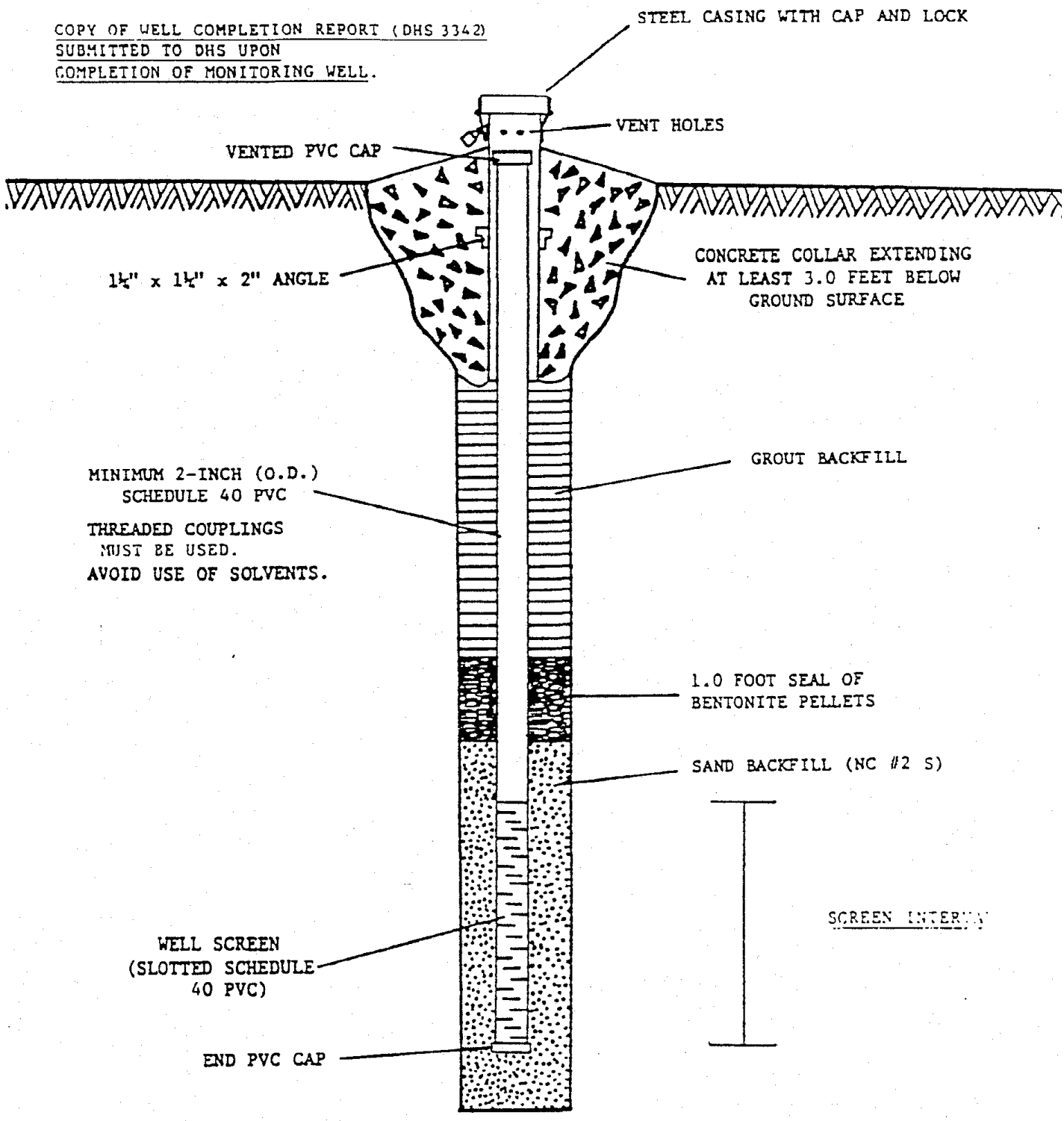
This office strongly urges all contractors and consultants to become familiar with well construction techniques and specifications illustrated on the ground-water monitoring well schematic (Figure 1). Further information regarding construction standards of other types of wells may be found in 15 NCAC 2C "Well Construction Standards: Criteria and Standards Applicable to Water Supply and Certain Other Types of Wells".

A. Specific Monitoring Well Construction Requirements

Because the location of ground-water monitoring wells at the proposed landfill is one of the most crucial phases of site development, the importance of a thorough hydrogeologic evaluation which clearly delineates ground water elevation and flow characteristics is of the highest significance. In order to assure consistent and thorough installation techniques which are in accordance with EPA regulations, all deviations to the following methods, or questions regarding materials, monitoring well locations or other techniques, should be directed to the Solid Waste Hydrogeologist at (919) 733-2178, c/o the Solid and Hazardous Waste Management Branch P.O. Box 2091 Raleigh, North Carolina 27602-2091. Additionally, the Solid and Hazardous Waste Management Branch reserves the right to evaluate in the field, the actual well installation techniques and procedures.

Drilling through the unsaturated soil mantle to the water bearing formation is a standard procedure with most consulting and well-drilling firms. Utmost caution and discretion in minimizing the use of drilling fluids (bentonite-gel mixture), flocculants (mixtures of sodium pyrophosphate) and excessive use of lubricants is highly recommended. If any of these products, or related products, are used in the drilling process the hole should be flushed to remove as much of the contaminants as possible.

Installation of the monitoring well and subsequent placement of the well screen is critical to assure that the ground water sample represents the



Rev. 5/86

Figure 1. Typical ground-water monitoring well schematic diagram.

portion of the aquifer where contaminants may migrate. The minimum length of the screened interval is 10 feet and will be placed at a depth specified as a condition of the permit based upon hydrogeologic data collected during the site investigation. Recommended screen depths will be submitted by the applicant under the heading "proposed comprehensive ground-water monitoring plan" as part of the site plan application as per section .0504 (1)(G)(iv). Well-sorted sand used as a pre-screening of influent ground water should be washed to remove all fines and prevent clogging of the well screen. Finally, in connecting sections of PVC pipe, clamps or threaded pipe fittings are required whereas various types of epoxy cement and other PVC glues have the potential for contaminating the ground-water reservoirs. For these reasons they are not authorized for construction of ground-water monitoring wells.

Various drilling methods and casing sizes are available for installation of monitoring wells. Generally, the most common size bore holes include those which are drilled with an eight inch hollow-stem auger. The casings which are placed in these holes are typically 4" or 2" I.D., and composed of PVC, stainless steel or teflon materials. For reasons which are discussed later under the "Ground-Water Monitoring" heading, this office recommends the use of 2" I.D. casings for wells drilled 100' or less. Ground-water monitoring wells drilled to depths exceeding 100' such as wells designed to monitor water quality through possible fracture patterns, should be cased with a 4" or 6" I.D. casing to readily promote rapid purging via jet pumps. Casings and screens may be composed of PVC or stainless steel. Teflon casings and screens are relatively maleable and may not hold-up under various conditions.

As mentioned above, this office recommends the installation of 2" I.D. cased wells for shallow and semi-shallow ground-water monitoring purposes. The use of 2" I.D. casings readily promotes rapid purging via teflon bailers. For example, a 2" I.D, cased well drilled 20 feet deep may contain up to approximately 3.3 gallons of standing water. Because three to five times the volume must be purged to avoid contamination (EPA, 1977), it is foreseeable that 9.9 to 16.5 gallons of water must be purged prior to sampling (Figure 2) in the above example. Assuming a purging minimum of 9.9 gallons of water, and also assuming that a 3' long bailer (which holds 1-liter of water) will be used for purging of the wells, it will take approximately 40 bails of water to adequately purge this well. Comparatively, a 4" I.D. cased well drilled to an extremely shallow depth of 16' will contain approximately 10.5 gallons of water, and subsequently, require between 31.5 and 52.5 gallons of purged water. Attempts to purge 52.5 gallons of water with a 1-liter bailer will require 210 bails of water-- which will undoubtly displease the field personnel and more importantly, occupy additional hours of expensive and needless labor as well.

An obvious difference shown on the schematic of a typical ground-water monitoring well (Figure 1), compared to other types of wells, is the concrete collar surrounding the stick-up (or outer casing) above the ground surface. This collar should contain small angle-irons attached to the outer casing as outlined on the diagram (Figure 1). The purpose of this set-up is to prevent accidental (or willfull) damage to the well whereas the stick-up could otherwise be pulled loose at the surface without the use of angle-irons to support the collar.

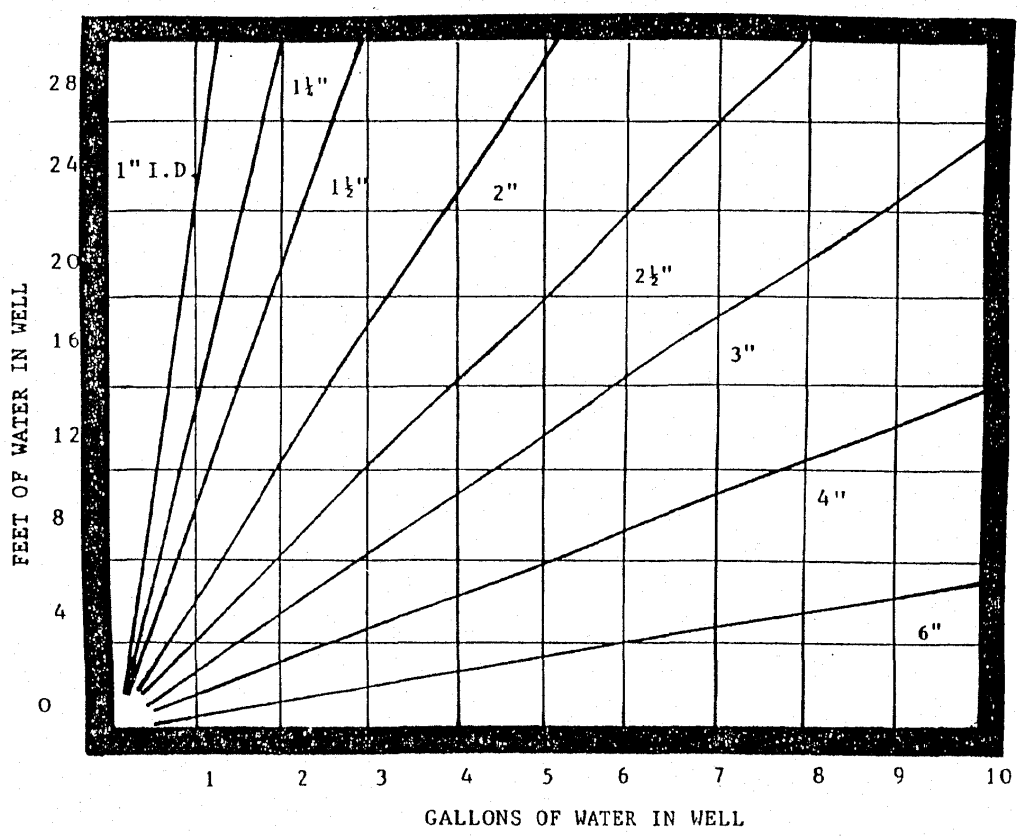


Figure 2. Graphical plot of standing volumes of water.

Because accidental or natural events may influence the status and condition of pre-existing ground-water monitoring wells, an on-going well inspection program is being conducted by personnel of the Solid andHazardous Waste Management Branch. Some of the items which must be regularily maintained by the facility after the wells are installed include: 1) ensuring that all caps are rust-free and locked at all times, 2) ensuring that all inner casings are securely fit with a threaded cap, 3) ensuring that the outer casing is upright and undamaged from equipment or vehicles which may inadvertently back-up into the well, 4) ensuring that a clear unobstructed path, free from dense vegetation exists leading to each well. These maintenance factors are critical to the implementation of proper ground-water monitoring.

B. Ground-Water Monitoring

Because a tremendous liability is associated with water quality data obtained from analytical laboratory results, it is of the utmost importance to ensure the validity and integrity of sampling techniques and methodology. Two distinct monitoring systems exist which may be used to purge and subsequently sample a monitoring well. These systems include the portable monitoring system and the dedicated monitoring system.

Portable Monitoring

The portable monitoring system is by far the most common method of monitoring ground-water quality. This method includes purging the total standing water within the well and subsequent sampling of a representative portion of the aquifer. Purging is required in all instances in order to avoid sampling of stagnant, possibly stratified water above the well screen. In many cases, however, the recharge rate may meet or exceed the purging rate. For these instances three to five times the volume of standing water must be purged prior to sampling. Several methods exist for removing the standing water within a well. Among these methods are various types of automated pumps, compressed air, hand pumps and bailers, each of which has several advantages and disadvantages which will be discussed below.

In some instances dependant upon the hydrogeologic setting, the recharge rate may be exceptionally slow (EPA, 1977), subsequently, sampling may not be possible until the next day when the well is recharged. Generally however, all attempts should be made to purge the wells dry or purge until the necessary three to five times the well volume is extracted. In other settings where the soils are relatively permeable purging and subsequent sampling may be possible in the same day.

1. Purging Methods

Depending upon time constraints and spatial variability of the monitoring wells, the decision whether to purge and sample a facility on the same day must be made by the field personnel performing the monitoring operation. Additional concerns regarding the depth of the well, water volumes, well access and inclement weather are all important in determining which type of device to use in purging the well. For instance, if fully automated, effortless purging is desired and time is not a major concern, the use of an automated pump may be in order. The major disadvantage of

these pumps, however, include slow pumping rates (typically a maximum of 0.5 gallons/minute) and the potential for cross contamination from well to well.

The hand pump is another type of purging device which is available invarious lengths and pumping rates (typically 2.75 gallons/minute). This device has the advantage of easy assembly, low cost and relatively high pumping rates. An obvious disadvantage, however, is the need for a thorough cleaning in the field before purging from one well to the next.

Another popular purging device is the teflon bailer. Teflon is considered to be the preferred material to use for ground water monitoring because of its relatively inert chemical character. Stainless steel is also an acceptable purging/sampling mechanism for similar reasons. Regardless of the composition, bailers are available in various lengths, the most popular being the 3' bailer which holds a volume of water equal to 1 liter or 0.26 gallons.

2. Sampling Methods

Thus far the focus of this discussion has primarily been upon purging techniques, subseqently, a short discussion which addresses sampling procedures is now in order. The use of automated pumps for sampling purposes requires considerable effort to avoid contamination. Many automated pumps are designed to remain on the ground surface while a specified length of flexible tubing is placed into the well. For sampling purposes if this technique is to be used, it is mandatory that the flexible tubing be composed of teflon and adequately cleaned prior to sampling from one well to another. The inevitable question arises, however, whether or not adequate cleaning is possible in the field for these types of automated pumps.

Because laboratory analyses evaluate water quality in terms of parts per million and parts per billion, it is not recommended to clean and prepare sampling devices in the field when a laboratory cleaning will undoubtedly produce a higher quality final product. Other types of automated pumps (called bladder pumps) are designed to fit down the borehole and are typically composed of teflon and stainless steel. One inherent difficulty associated with some bladder pumps in addition to possible sample contamination problems is the inability of many bladder pumps to adequately control and regulate the rate at which the flow of water leaves the flexible tubing. This is critical for samples to be analyzed for volatile organic analysis (VOA) whereas a rapid flow rate will cause aeration which subsequently volatilizes certain chemicals. For these reasons this office urges that the utmost consideration and thought be given to the feasibility of whether or not to utilize traditional automated pumps for sampling purposes.

Hand pumps are useful tools for purging wells in a relatively short period of time but, unfortunately, are highly unsuitable for sampling. The main reason being the likelihood of contamination and the unavailability of teflon or stainless steel hand-pumps in the commercial market. Additionally, no present technology exists for regulating the effluent discharge of water from a hand pump which, as mentioned before, presents a volatilization problem for certain samples.

The overall preferred method of acquiring ground-water samples via portable monitoring is by the use of telfon bailers. In a properly established and equipped laboratory setting, a standardized cleaning and preparation procedure may be followed. The obvious advantage of laboratorycleaning includes minimal generation of contaminants and consistency in preparatory procedures.

Dedicated Monitoring

Thus far the previous discussions have all focused upon techniques and procedures related to portable ground-water monitoring systems. At this time, a short overview of dedicated systems is in order. Dedicated well monitoring differs from portable monitoring primarily by the permanency of the set-up and the higher initial cost. Because portable systems require the use of much of the same equipment from well to well, great care must be exercised in avoiding cross contamination. Dedicated systems, however, require no between-well cleaning procedures. These systems offer permanently affixed down-well and well-head components which are capped after initial set-up.

Because ground water is not in contact with incompatible constituents that otherwise may enter the well from the surface, virtually no contamination is possible from an extrinsic source during times between sampling intervals. As with all sampling methods the competency and integrety of the individual extracting the sample is of the utmost importance. For instance, a great deal of manual dexterity must be exercised in regulating the flow of water leaving the flexible tubing from dedicated systems when collecting VOA samples in order to avoid unnecessary volatilization. In conclusion, dedicated systems have the potential for accurate and reliable ground-water monitoring and are therefore recommended for consideration.

In contrast to this, many individuals are under the false impression that bailers which are initially cleaned in a laboratory and permanently placed in monitoring wells are considered dedicated systems and subsequently are acceptable for ground-water monitoring purposes. Unfortunately, this is not true due to the possibility of extrinsic contamination during sampling intervals, such as decomposition of the bailer line, airborne dirt and dust, or other accidentally induced contaminants. Because the detection limits for the various parameters are measured in terms of parts per million and parts per billion, the utmost discretion is required in selecting sampling procedures which will accomodate these analyses.

1. Equipment Cleaning Procedures

If automatic pumps and flexible tubing are used, a minimum field cleaning procedure will entail using a phosphate-free soap/deionized water solution followed by a deionized water rinse. This method constitutes an absolute minimum field cleaning procedure and should only be used if sampling one G.W. monitoring well. These pumps are not recommended or authorized for sampling more than one well due to probable contamination problems.

Stainless steel bailers require the following minimum cleaning techniques prior to groundwater sample collection:

1. Phosphate-free soap and tap water wash
2. Tap-water rinse
3. Deionized or distilled water rinse
4. Isopropyl alcohol rinse
5. Deionized or distilled water rinse
6. Air dry
7. Wrap bailer to prevent contamination before use (specify the material used for wrapping the bailer, example: aluminum foil shiny side out).

Teflon bailers require the following minimum cleaning techniques prior to ground water sample collection:

1. Phosphate-free soap and tap water wash
2. Tap water rinse
3. 10% nitric or 10% hydrochloric acid rinse
4. Deoinized or distilled water rinse
5. Isopropyl alcohol rinse
6. Deionized or distilled water rinse
7. Air dry
8. Wrap to prevent contamination before use (specify material used for wrapping for wrapping the bailer, example: aluminum foil, shiny side out).

The bailer line which attaches to the teflon or stainless steel bailers should consist of either 1) teflon coated wire, 2) single-strand stainless-steel wire, 3) other monofilament line or 4) nylon rope. In order to avoid contamination, a new segment of one of the above approved types of line should be used at each well. Reusing old line will increase the probability of cross contamination (even if the line is cleaned) and therefore is not approved. Any variation to the above cleaning procedures should be submitted to this office for approval.

Condition

The above cleaning procedures were obtained from EPA Region IV. If changes occur in any procedure specified above, the facility will be notified and be requested to make the necessary ammendments to the sampling and analysis plan.

Sample Containers

Because water samples are analyzed for various parameters, several types of containers are required for a complete sampling scheme. Routine ground-water monitoring should include (in the following order as extracted from the well): 1) VOA samples (for TOX analysis), and 2) heavy metal (inorganic) analysis. If additional analyses are required, the samples should be collected in the order listed below.

For instance, samples which are analyzed for volatile organic analysis (VOA) and/or total organic halogens (TOX) should be collected first in 40 ml glass vials with teflon caps. Two full vials per sample are required.

9

N. C. Department of Human Resources
Division of Health Services

SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Site Number _____ Field Sample Number _____

Name of Site _____ Site Location _____

Collected By _____ ID# _____ Date Collected _____ Time _____

Type of Sample:

Environmental	Concentrate	Comments
____ Groundwater (1)	____ Solid (5)	_____
____ Surface Water (2)	____ Liquid (6)	_____
____ Soil (3)	____ Sludge (7)	_____
____ Other (4)	____ Other (8)	_____

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/1
____ Arsenic	_____	____ Arsenic	_____	____ Silver	_____
____ Barium	_____	____ Barium	_____	____ Sulfates	_____
____ Cadmium	_____	____ Cadmium	_____	____ Zinc	_____
____ Chromium	_____	____ Chloride	_____	____ Ph	_____
____ Lead	_____	____ Chromium	_____	____ Conductivity	_____
____ Mercury	_____	____ Copper	_____	____ TDS	_____
____ Selenium	_____	____ Fluoride	_____	____ TOC	_____
____ Silver	_____	____ Iron	_____	____ _____	_____
____ _____	_____	____ Lead	_____	____ _____	_____
____ _____	_____	____ Manganese	_____	____ _____	_____
____ _____	_____	____ Mercury	_____	____ _____	_____
____ _____	_____	____ Nitrate	_____	____ _____	_____
____ _____	_____	____ Selenium	_____	____ _____	_____

ORGANIC CHEMISTRY

Parameter	Results mg/1	Parameter	Results mg/1	Parameter	Results mg/1
____ P&T:GC/MS	_____	____ EDB	_____	____ Methoxychlor	_____
____ Acid:B/N Ext.	_____	____ PCB's	_____	____ Toxaphene	_____
____ TOX	_____	____ Petroleum	_____	____ 2,4-D	_____
____ _____	_____	____ Endrin	_____	____ 2,4,5-TP (silvex)	_____
____ _____	_____	____ Lindane	_____	____ _____	_____

MICROBIOLOGY	RADIOCHEMISTRY	
Parameter	Parameter	Results PCi/1
____ (MF) Coliform Colonies/100mls	____ Gross Alpha	_____
____ (MPN) Coliform Colonies/100mls	____ Gross Beta	_____
____ _____	____ _____	_____
____ _____	____ _____	_____

Date Received _____ Date Reported _____

Date Extracted _____ Date Analyzed _____

Reported By _____ Lab Number _____

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

Figure 3. Laboratory analysis request sheet.

1C

Chain of Custody Record

Solid & Hazardous Waste Materials

Location of Sampling: _____Generator _____Transporter _____Treatment Facility

_____Storage Facility _____Disposal Facility _____Landfill

_____Other: _____

Company's Name _____ Telephone(_____)_____

Address _____

Collector's Name _____ Telephone(_____)_____
signature

Date Sampled _____ Time Sampled _____

Type of Process Generating Waste _____

Field Information

_____

_____

Field Sample No. _____ _____ _____ _____ _____ _____ _____

_____ _____ _____ _____ _____ _____ _____

Chain of Possession:

1. _____ _____ _____
signature title inclusive dates

2. _____ _____ _____
signature title inclusive dates

3. _____ _____ _____
signature title inclusive dates

Results reported

_____ _____ _____
signature title date

Instuctions: Complete all applicable information including signature, and submit with analysis request forms.

Figure 4. Chain of custody record.

Samples which will be analyzed for inorganic constituents such as heavy metals should be collected following the VOA samples. These samples are collected in small, disposable, 1-quart/1-liter plastic cubes. Two full cubes per sample are required. Depending upon the source of the sample containers, particularly, containers which hold water to be analyzed for heavy metals, some containers may have a pre-measured amount of acid placed in the container to act as a preservative. In these instances do not rinse the sample container prior to use, if uncertain, consult the laboratory where the containers were purchased.

If organic contamination is suspected it may be necessary to undergo a complete organic analysis. In this event, samples which will be analyzed for organics such as an acid-base neutral analysis should be collected in one half gallon/2-liter glass jars with aluminum foil or teflon lined caps. Samples to be tested via acid-base neutral analysis require one full jar of water per sample.

Water samples to be analyzed for radiologic parameters should be collected following acid-base neutral collection. These samples must be collected in the large 1-gallon/4-liter plastic cubes.

Finally, samples which will be analyzed for bacteriological parameters should be collected last in 120ml plastic vials containing a pre-measured amount of sodium thyosulphate. One vial per sample is required to perform the analysis.

Transport and Storage of Samples

Upon completion of water sample collecting all samples will be stored and subsequently transported on ice or in a refrigerated state to the laboratory performing the analyses (APHA, 1985; EPA, 1977). The samples should be stored in such a manner as to inhibit breakage or accidental spills. Unless unusually extraordinary circumstances prevent otherwise, all samples should be delivered to the laboratory on the same day.

Administrative procedures

Samples are to be delivered to a State Certified Drinking Water Laboratory and need to be accompanied by two administrative forms. The first form is a laboratory analysis request sheet (Figure 3). This form stipulates which constituents are to be analyzed for a given sample. The other form is a chain of custody record sheet (Figure 4). This form documents who handled the sample from collection time to lab delivery. These forms (or equivalents) will be submitted to the solid waste hydrogeologist within 15 days of receipt of the analytical results.

Per 10 NCAC 10G section .0601 (a), routine ground-water monitoring shall be the responsibility of the permittee and may be State supervised at the discretion of the Division of Health Services. An exception to this being the initial sampling of newly constructed wells by personnel of the Division of Health Services. Additionally, the State may request "split" or replicate samples from the facility during any of the routine sampling intervals.

Routine ground-water monitoring which encompasses the parameters listed below shall be conducted twice during the first year of operation (for newly-permitted sites) and annually thereafter. Newly-permitted facilities are required to properly install all proposed ground-water monitoring wells and subsequently notify the State within 30 days upon completion, so that the Division of Health Services may schedule a date to initially sample the wells. As mentioned above, subsequent sampling is the responsibility of the facility. All pre-existing (permitted) facilities as of July 1, 1987 are responsible for annual ground-water monitoring activities, and shall forward a copy of the analytical laboratory results within 15 days upon receipt to the solid waste hydrogeologist P.O. Box 2091, Raleigh, North Carolina 27602-2091 c/o the Solid and Hazardous Waste Management Branch.

All facilities (newly-permitted and pre-existing) shall send written notice by July 1, 1987 designating a tentative, annual sampling date for their facility. The purpose of which is to inform State personnel as to a specific date that they may expect the annual water quality results and to accomodate scheduling purposes by State personnel.

The following total inorganic parameters will be included for routine, annual ground-water quality analysis: arsenic, barium, cadmium, chloride,chromium, copper, fluoride, iron, lead, manganese, mercury, nitrate, selenium, silver, sulphates and zinc. The following indicators should be included in all routine, annual ground-water analysis : TOX (total organic halogens), TOC (total organic carbon, TDS (total dissolved solids), BOD (biological oxygen demand), COD (chemical oxygen demand), conductivity and PH. In the event that a contaminant plume is indicated by routine analysis of the monitoring wells, further analysis may be required to adequately assess contaminant migration and extent. Such anaysis may include purge and trap analysis (utilizing the gas chromatograph and mass spectrometer) and acid base-neutral extraction. Finally, a broad level of consistency should be exercised in listing the various quanities of chemical constituents. For instance, units should be PPM (parts per million) or PPB (parts per billion) not both. It is suggested tht parts per million (PPM) be used whenever possible.

C. Surface-Water Monitoring

Sites which contain and/or border small rivers, streams or branches should include within the site plan application, a prospective surface water monitoring plan. This plan will be used to gauge the effect of the landfill upon surficial flow at a given point. A simple procedure for selecting surface-water monitoring sites is to locate a point on the stream where drainage leaves the site. This promulgates detection of contamination through, and possibly downstream, of the site via discharge of surface waters. The sampling points selected should be downstream from any new, old or proposed areas which may be disturbed, including borrow and rubble areas (Babb and Glaser, 1985). An upstream surface water sample should be obtained in order to determine the water quality upstream of the influence of the sanitary landfill.

The following procedure is recommended regarding sample collection of surface water samples. Prior to collecting the sample in the appropriate

container, specific collection points should be determined. Generally, automated or semi-automated samplers or other manual devices accessible from the banks of a stream should be used whenever possible. If logistic or naturally occurring conditions inhibit this method of sample collection, the samples may be obtained manually by wading up-current (and down-stream) of the sample station. The sample should be collected in an area representative of minimal turbulence and aeration (Babb and Glaser, 1985). Because sample containers may be dipped by hand into the stream, extreme caution must be employed in avoiding contamination into the mouth of the container. The following procedures extracted from the "approved RCRA Ground-Water Sampling and Analysis Plan" (Babb and Glaser, 1985) are recommended for extraction and subsequent collection of surface water samples.

1. Hold the bottle near the base with one hand, and with the other, remove the cap.

2. Rinse the sample container with the water to be sampled prior to filling the container. One exception to this is the coliform sample bottle. This bottle may have a pre-measured amount of sodium thyosulphate to neutralize any chlorine present in the water, therefore, this container should not be rinsed prior to sampling.

3. Push the sample container rapidly into the water (mouth down) and tilt-up towards the current to fill. A depth of about six inches is satisfactory. Great care should be taken to avoid breaching the surface while filling the container.

4. During times of little current movement move the container slowly through the water laterally.

5. During times of extreme drought when stream depths are to shallow to allow submersion of the sample container, a pool may be scooped-out of the channel bottom and allowed to clear prior to sampling.

6. Lift the container from the water, and leave one-half inch of air space, and place the uncontaminated cap back-on the container.

7. Place the samples in styrofoam shipping cartons (on ice) for courier transport to the laboratory.

8. A completed Division of Health Services Form 2887 or equivalent (Figure 3) must be submitted along with the samples to the appropriate certified laboratory performing the analysis.

For additional details and further information on how to properly collect, store and transport stream samples, see N.R.C.D. draft on physical and chemical monitoring (in preparation).

D. Fractured Rock Monitoring

Many portions of Western and Central North Carolina are dominated by fractured cystalline rock. These fractures may be expressed on the surface, but more typically, are characteristic of subsurface environments. Areas

14

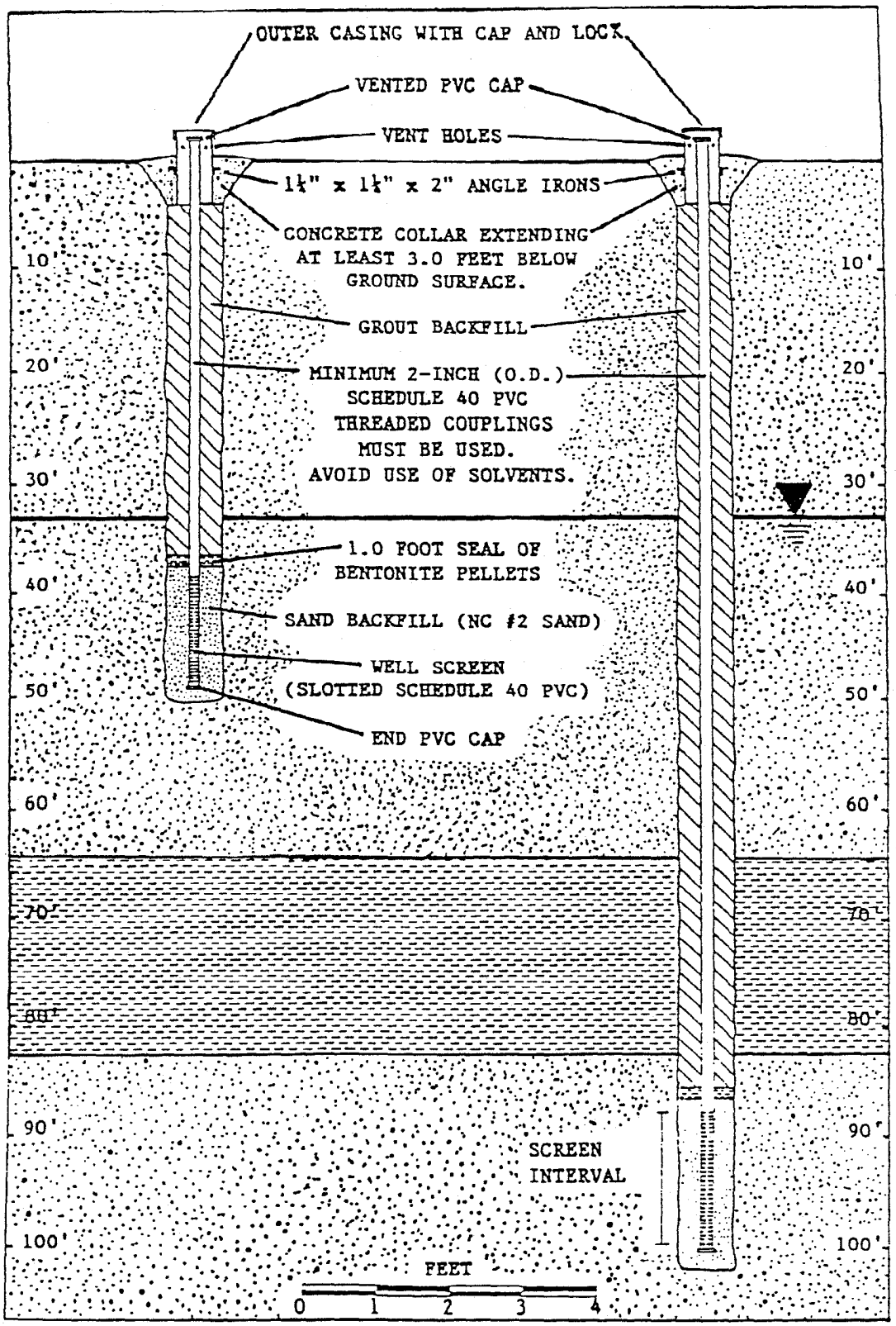


Figure 5. Typical ground-water monitoring well nest schematic.

such as these present inherent technical problems with landfill design and subsequently challenge the effectiveness and integrity of a ground-water monitoring system. The main reason being that fractured rock aquifers offer less predictability and certainty in estimating ground water flow patterns (EPA, 1977).

In order to overcome these difficulties the extent and inclination at depth of these fractures must be ascertained. The most common methods which are available to determine these factors include remote sensing and geophysical surveys. Consultants and engineering firms, may however, specifically utilize and employ these techniques as they see fit in order to adequately address the question of inclination and depth of fracture patterns.

Upon completion of a fracture trace analysis the consulting engineering firm which is responsible for submitting the site plan application will include as part of the proposed ground-water monitoring plan, tentative deep ground-water monitoring well locations at points where fractures intersect and/or at localities characteristic of pronounced lineations which may border or disect the prospective site. As with all proposed well sites, the borehole depths, screen depths and screened intervals will be defined in the report and confirmed with the Division of Health Services prior to drilling. If two aquifers exist beneath a site, a well nest (Figure 5) may be required to adequately assess the migration of potentially contaminanted ground water in both hydrologic regimes..

In most instances, fracture monitoring requires drilling 100 to 200 feet below the surface. This presents a problem for conventional purging methods as described previously in this document. For these wells, a jet pump or equivalent pump which offers a rapid displacement of water will be required for purging. Sampling is performed as described earlier via teflon bailers. A dedicated monitoring system may be used in lui of bailers if depths are not considered a major problem. Consult your industrial representative before purchasing dedicated systems to evaluate the effectiveness of the dedicated device as applied to your specific well requirements.

REFERENCES

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3812-H Tarheel Drive
Raleigh, NC 27609
919/878-4478
FAX 919/878-4032

January 8, 1996

Mr. Wayne Sullivan
Municipal Engineering Services Company, P.A.
Post Office Box 97
Garner, North Carolina 27529

Re: Responses to Review Comments
Greene County Landfill, Permit #40-02
Wootens Crossroads, North Carolina
Project No. 94205.02

Dear Mr. Sullivan:

INTRODUCTION

Responses are made herein to the review comments of Mr. Lutfy of the Division of Solid Waste Management of the Department of Environment, Health, and Natural Resources made in a letter dated November 9, 1995 pertaining to the Transition Plan for the Greene County Landfill, Permit #40-02.

RESPONSES TO COMMENTS

Sampling and Analysis Plan (SAP)

Lutfy Comment: The Revised Sampling And Analysis Plan (SAP) dated April 1995 appears generally okay. At the bottom of page 5, specific conductivity should be reported along with the other field test parameters.

Response: The Sampling and Analysis Plan dated November 1995 submitted herewith requires reporting specific conductivity and is included in the transition plan.

Lutfy Comment: GAI needs to provide a separate copy of the Revised SAP to each County to be included in their copy of the Transition Plan. For the Transition Plans to be retained by the Solid Waste Section, either a sheet referencing the Revised SAP on file should be placed in each County's Transition Plan or a separate copy of the Revised SAP needs to be placed in each of the various Counties Transition Plans.

Response: The Sampling and Analysis Plan dated November 1995 is included in the transition plan.

CLOSURE

This letter responds to review comments of Mr. Bobby Lutfy on the Greene County Landfill pertaining to GAI. Responses to other comments by Mr. Lutfy are considered to be the responsibility of Municipal Engineering Services Company or others.

Respectfully submitted,
GAI Consultants - NC, Inc.

Mujahid H Akram

Mujahid H. Akram, Ph.D.
Senior Engineer

Wendell W. Parker

Wendell W. Parker, Ph.D., P.E.
Vice President