Phase 4 Hydrogeologic and Groundwater Quality Assessment Work Plan Central Carolina Tire Monofill Landfill Phases I/II Harnett County, North Carolina Permit # 43-04

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Prepared by:
Nautilus Geologic Consulting, PLLC License # C-489

Brian S. Boutin, PG
11112 Branding Iron Place
Wendell, NC 27591

Prepared for:
Central Carolina Holdings, LLC
1616 McKoy Town Road
Cameron, NC 28326

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1.0 INTRODUCTION

This document presents a work plan to conduct a Phase 4 Hydrogeologic and Groundwater Quality Assessment at the Central Carolina Tires Phase I/II Monofill landfill facility in Harnett County, North Carolina (**Figures 1 and 2**). The results of a preliminary environmental site assessment conducted at the site in November 2010, which involved sampling and analysis of soil and groundwater samples collected via direct-push techniques, indicated that a relatively narrow, elongated plume of dissolved-phase tetrachloroethene (PCE) originates in the vicinity of the maintenance shelter located approximately 250 feet north of MW-8 and extends to the south-southwest toward MW-8 and the closed Phase I/II monofill landfill. The results further indicated that the source of PCE in groundwater is likely located at or near the maintenance shelter. The maintenance shelter is used to maintain and repair equipment for the landfill, and the interior of the shelter is unpaved. Equipment maintenance and repair includes the use of parts cleaning solutions that contain PCE. Low volume incidental spills of parts cleaning solution onto the ground surface over time are likely the source of PCE in groundwater at the site. The results of the preliminary assessment are presented in the January 2011 *Preliminary Site Assessment Report*.

Based on the results of the preliminary assessment, a Phase 2 Hydrogeologic and Groundwater Quality Assessment was conducted in April and May 2012 to further delineate the horizontal and vertical extent and magnitude of PCE and associated environmental breakdown products in groundwater. The site assessment included installation of 15 groundwater monitoring wells, sampling and analysis of soil and groundwater samples, aquifer testing to assess the hydraulic properties of the surficial aquifer, and a potential receptor survey to identify potable wells and any other receptors within 1,500 feet of the margins of the dissolved-phase PCE plume. The results of the Phase 2 Hydrogeologic and Groundwater Quality Assessment confirmed the presence of an elongated plume of dissolved PCE originating within the shallow surficial aquifer in the vicinity of the facility maintenance shelter and extending to the south toward monitoring well GW-7S and continuing under the closed Phase I/II monofill landfill. The dissolved PCE plume is confined to the shallow surficial aquifer and is not present in the deeper zone of groundwater occurrence monitored by the deep monitoring wells installed as part of the Phase 2 assessment. The results of the preliminary assessment are presented in the June 2012 *Phase 2 Hydrogeologic and Groundwater Quality Assessment*.

Based on the results of the previous assessments, a Phase 3 hydrogeologic and groundwater quality assessment was conducted in March and April 2013 to further

delineate the extent and magnitude of PCE and associated environmental breakdown products in groundwater. The assessment included installation of four additional Type II groundwater monitoring wells, sampling and analysis of groundwater samples collected from all assessment monitoring wells, and aquifer testing of the newly installed wells to further assess the hydraulic properties of the surficial aquifer. The results of the Phase 3 Hydrogeologic and Groundwater Quality Assessment indicate a bow-shaped plume of dissolved PCE originates within the shallow surficial aquifer in the vicinity of the facility maintenance shelter and extends along two distinct axes to the south in the general direction of monitoring well GW-7S and the closed Phase I/II landfill and to the east toward and beyond the location of monitoring well GW-10. Moreover, the dissolved PCE plume is confined to the shallow surficial aquifer and is not present in the deeper zone of groundwater occurrence monitored by the deep monitoring wells. These results further support that the source of dissolved chlorinated ethenes in groundwater is likely located at the maintenance shelter.

The dissolved PCE plume has been adequately delineated up gradient of the source area (north), as well as to the west and south of the source area, by the existing monitoring well network. However, the plume has not been delineated to the east of the maintenance shelter beyond the location of monitoring well MW-10. Inasmuch as the plume extends beneath the closed Phase I/II landfill, delineation of the down gradient extent of the plume will be challenging if not impractical as it would require installation of monitoring wells through the closed landfill. The work plan presented in the following sections is intended to complete delineation of the dissolved PCE plume in the shallow surficial aquifer east of the maintenance shelter.

2.0 BACKGROUND

2.1 History of Site and Operations

The closed Phase I/II of the Central Carolina Tire Monofill is operated in accordance with Solid Waste Permit 43-04. The Phase I Area of the Central Carolina Tire Monofill began operation in 1992 and the Phase II Area of the Central Carolina Tire Monofill began operation in 1997. The combined footprint of the Phase I/II Monofill is a total of 37-acres. The Phase I/II Area reached capacity in the fall of 2008. Closure activities have been completed and approved for 19.5-acres of the Phase I/II Area and a soil closure cap has been installed on the remaining areas.

2.2 Current Conditions

2.2.1 Groundwater Flow

Groundwater levels were gauged in the groundwater monitoring wells installed as part of the Phase 3 assessment in April 2013. Measured depths to groundwater in the shallow Type II monitoring wells at the site ranged from 2.77 feet (MW-8) to 15.20 feet (GW-4S) below grade, which is consistent with the surface topography. The depths to groundwater measured in the Type III wells ranged from 12.39 feet (GW-5D) to 17.67 feet (GW-6D) below grade.

Groundwater within the surficial aquifer at the site occurs under water-table (unconfined) conditions within the interstitial pore spaces of an upper sandy clay and clayey sand unit. A water-table elevation contour map for the shallow surficial aquifer based on the April 2013 groundwater gauging data for the shallow monitoring wells is presented as **Figure 3**. The geometric configuration of the water-table elevation contours presented in **Figure 3** indicate that shallow groundwater flow at the site is generally to the southeast, which is consistent with the overall topography in the assessment area. A groundwater mound appears to encompass the area including the maintenance shelter and monitoring wells GW-2S and GW-10, indicating possible groundwater recharge and radial groundwater flow from this area. However, bulk shallow groundwater flow appears to be toward the southeast. The hydraulic gradient of the water table averages approximately 0.036 ft/ft in the assessment area based on the water-table elevations measured at the shallow monitoring wells in April 2013.

Deeper groundwater at the site is present in a sandy clay unit underlying a sandy clay and clay which functions as a semi-confining to confining unit separating the shallow surficial aquifer from deeper occurrences of groundwater at the site. A groundwater elevation contour map based on the April 2013 groundwater gauging data for the deep

monitoring wells is presented as **Figure 4**. The geometric configuration of the water-table elevation contours presented in **Figure 4** indicate that groundwater flow in the deep water-bearing unit at the site is generally to the southeast, consistent with the flow direction in the shallow aquifer. The hydraulic gradient of the potentiometric surface of the deeper water-bearing zone varies from approximately 0.025 ft/ft in the northeast portion of the assessment area to approximately 0.034 ft/ft in the southwest portion of the assessment area based on the groundwater elevations measured at the deep monitoring wells in April 2013.

2.2.2 Groundwater Quality

Summarized results of laboratory analyses of the groundwater samples collected from the site monitoring wells during the Phase 3 Hydrogeologic and Groundwater Quality Assessment are presented in **Table 1**. The groundwater laboratory analytical results indicate that PCE, trichloroethene (TCE), and cis 1,2-dichloroethene (cis 1,2-DCE) were detected in shallow groundwater samples collected from the site. The latter 2 compounds are environmental transformation products of the sequential anaerobic reductive biotransformation of PCE. Of these compounds, PCE was detected at the most well locations (8) and is the most widespread chlorinated ethene at the site. The concentrations of PCE detected in shallow groundwater ranged from 0.82 µg/L (GW-1S) to 54 µg/L (GW-10) and were all in excess of the 15A NCAC 2L groundwater quality standard (0.7µg/L). The concentrations of cis-1,2-DCE detected in shallow groundwater were all well below the corresponding NCAC 2L groundwater quality standards (60 µg/L). TCE was detected at a concentration of 4.0 µg/L in the groundwater sample collected from shallow monitoring well GW-2S, which exceeds the 15A NCAC 2L groundwater quality standard of 3.0 µg/L. All other concentrations of TCE detected in shallow groundwater at the site were below the 15A NCAC 2L standard. It is noted that chloroform is the only analyte that was detected in groundwater samples collected from the deep monitoring wells, indicating that the Unit 2 clay layer is acting as an effective confining unit between the shallow aquifer and deeper zones of groundwater occurrence. It is further noted that the presence of chloroform in the groundwater samples is attributed to the use of potable water from the municipal water system during drilling, as discussed in the Phase 2 assessment report.

Isoconcentration contour maps of PCE and total chlorinated ethenes (i.e., total concentrations of PCE, TCE and cis-1,2-DCE) in shallow groundwater, based on the April 2013 groundwater analytical data, are presented as **Figures 5** and **6**. The configuration of the isoconcentration contours indicate that the dissolved chlorinated hydrocarbon plume appears to emanate from the general area of the maintenance

shelter and extends along two distinct axes: 1) to the south in the general direction of monitoring well GW-7S and the Phase I/II landfill; and 2) to the east toward and beyond the location of monitoring well GW-10. The general configuration of the plume appears to form a bow shape, extending around the margins of the general area encompassing monitoring wells GW-8D, GW-11 and GW-12, where a considerable thickness of dense clay is present beginning at approximately 6 to 8 feet below grade, thereby providing an impediment to shallow groundwater flow. The arm of the plume extending to the east of the maintenance shelter was not apparent from the results of previous assessment activities conducted at the site.

3.0 GEOLOGY AND HYDROGEOLOGY

The Central Carolina Tire landfill facility is located in the Atlantic Coastal Plain physiographic province in North Carolina (**Figure 3**). The area of the site is underlain by sediments of the Late Creataceous age Middendorf Formation, which are predominantly fluvial-deltaic intercalated, lensing, thick-bedded micaceous quartz sands and clays with local concentrations of clay clast conglomerates.[1] The sediments of the Middendorf Formation are typical of those deposited in a deltaic environment and commonly include cross-bedding, lenses, pinch-outs and facies changes. The Middendorf Formation deposits unconformably overlie sands and clays of the Late Cretaceous age Cape Fear Formation, which outcrop in primary stream valleys in Harnett County. The Cape Fear Formation sediments unconformably overlie crystalline basement rocks, the surface of which occurs at a depth of approximately 200 to 250 feet below grade near the site. Thin, discontinuous Neogene and Quaternary age sediments overlie the Cretaceous age deposits at some locations. Subsurface materials encountered during the preliminary environmental assessment and drilling conducted as part of the Phase 2 and Phase 3 assessments are consistent with descriptions of Middendorf Formation sediments mapped in the area of the site.

Groundwater within the surficial aquifer at the site occurs under unconfined conditions within sandier zones of appreciable thickness of the Middendorf Formation sediments. Laterally extensive and thick clay beds within the Middendorf Formation form confining to semi-confining layers separating the surficial aquifer from deeper occurrences of groundwater. The surficial aquifer, which extends over a large part of the Coastal Plain, discharges water laterally to streams and rivers and provides the bulk of recharge to deeper aquifers. Recharge to the surficial aquifer occurs via rainfall. As discussed above, shallow groundwater flow at the site is generally to the southeast toward unnamed streams and associated wetlands that surround the eastern and southern boundaries of the landfill.

[1] Sohl, Norman F. and James P. Owens, 1991; Cretaceous stratigraphy of the Carolina coastal plain, in *The Geology of the Carolinas*, J. W. Horton, Jr. and V. A. Zullo, eds., The University of Tennessee Press, pp. 191-220.

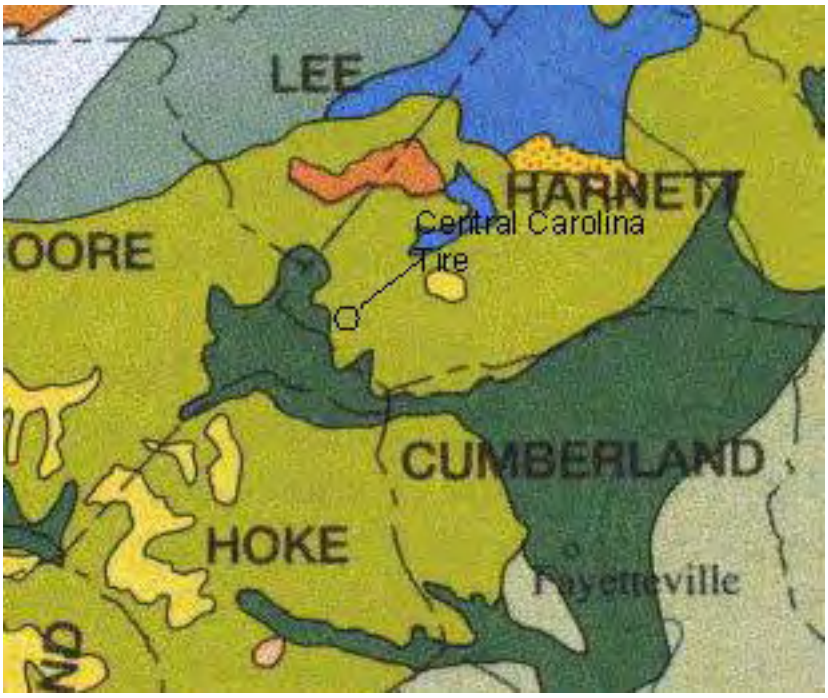


Figure 7. Excerpt from Generalized Geologic Map of North Carolina (1985)

4.0 ASSESSMENT WORK PLAN

4.1 Proposed Groundwater Monitoring Wells

Four additional Type II groundwater monitoring wells are proposed for further delineation of dissolved PCE and associated environmental breakdown products in the shallow surficial aquifer at the site east of the maintenance building. The proposed locations and designations of the monitoring wells are shown in **Figure 8**.

Prior to initiating field work, North Carolina 811 will be contacted to have underground utilities in the areas proposed for drilling appropriately marked. All drilling locations will also be approved by the client prior to drilling.

The proposed Type II monitoring wells will be installed using a hollow-stem auger drilling rig. All Type II wells will be installed to depths of approximately 15 to 25 feet below grade (depending on location) and will be constructed of 2-inch ID Schedule 40 PVC well casing and 10 feet of machine-slotted well screen with 0.010” slots. The wells will be finished with solid PVC risers extending approximately 2 to 3 feet above grade within steel, stickup protective casings with hinged, locking lids. All wells will be installed and constructed in accordance with North Carolina Well Standards. A typical schematic of a Type II monitoring well is presented in **Appendix A**.

Soil samples will be collected at each drilling location for lithologic descriptions using the standard penetration test (SPT) method with a 140-lb sliding hammer and steel split-spoon samplers. Samples will be collected in continuous 2-feet intervals until groundwater is encountered and every five feet thereafter to the completion depth of the boring. The soil retained in each split-spoon sampler will be logged by a geologist with respect to texture composition, color and moisture content. One soil sample will be collected from the saturated zone at each drilling location and submitted for grain size analysis at a geotechnical laboratory to allow for estimating the specific yield of the aquifer sediments.

The augers, drill pipe and drill rig will be decontaminated using a pressure washer prior to drilling at each location. Split-spoon samplers will be decontaminated prior to and following each use with a non-phosphate soap and water wash followed by multiple rinses with distilled water. An area will be set aside in the immediate vicinity of the maintenance shed for decontamination of the drilling equipment. Each well will be developed after installation using a down hole pump or bailer until the discharge water appears to be free of suspended sediments or for a maximum of one hour.

Each well will be surveyed relative to the existing site datum for horizontal position and elevation by a North Carolina licensed surveyor. At each well, elevations will be measured of the ground surface and top of the solid PVC riser. A permanent mark will be made on the top of the PVC riser at the point where the elevation measurement is made for future reference when collecting depth to water data.

4.2 Groundwater Gauging

Prior to well purging and groundwater sampling, and a minimum of one week following completion of drilling, groundwater levels will be measured in the newly installed monitoring wells, as well as the monitoring wells previously installed as part of the Phase 2 assessment and monitoring well MW-8, using an electronic water level meter which will be thoroughly decontaminated before use at each well. The results of the groundwater gauging will be used to refine the conceptual model of groundwater flow in the study area, including groundwater recharge and discharge zones and zones of preferential groundwater flow.

4.4 Groundwater Sampling and Analysis

Groundwater samples will be collected for laboratory analysis from monitoring wells GW-1S/1D through GW-7S/7D, GW-8D, GW-9 through GW-16, and MW-8 using a low flow/low stress sampling technique. Prior to sampling, the wells will be purged of stagnant water and the pH, temperature, specific conductance, turbidity, dissolved oxygen and oxidation-reduction potential (ORP) of the purge water will be measured using a flow-through cell and a multi-parameter meter. With respect to the groundwater chemistry, an adequate purge will be considered to have been achieved when the pH, specific conductance, and temperature of the groundwater have stabilized within 10% for three consecutive readings and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs).

Following purging, groundwater samples will be collected from each well using the low-flow assembly directly into laboratory-prepared containers. All groundwater samples will be analyzed at a DENR-approved laboratory for VOCs by SW 846 Method 8260. This analytical method allows for the detection of PCE and its primary environmental breakdown products.

4.5 Aquifer Characterization

Following groundwater sampling and return of groundwater levels to static conditions, rising-head permeability (“slug”) tests will be conducted in the new monitoring wells. Static water level measurements will be made at each well prior to beginning the slug

tests. The slug tests will be conducted by placing a combined data recorder-pressure transducer (In-Situ Mini Troll™) at the bottom of the well and rapidly removing a volume (slug) of water from the well using a bottom-loading bailer, submersible pump or centrifugal pump (whichever is appropriate given the depth to groundwater and yield) to lower the level of the water table below the level measured at static conditions. The data logger will be used to measure the rate of influx of groundwater until water level equilibrium is reestablished. The measured rate of recovery of the water level is a function of the hydraulic conductivity of the aquifer material in the vicinity of the well. The slug test data will be analyzed using either the HydroSOLVE, Inc. AQTESOLV for Windows™ program according to the Bouwer-Rice procedure.

4.7 Conceptual Site Model

The conceptual site model (CSM) will be refined and updated based on the results of the groundwater gauging, groundwater quality data, information regarding the site geology and hydrogeology available from drilling logs and rising-head permeability test data, as well as all relevant previous work conducted at the site. The CSM is a working hypothesis based on available site data that is a three-dimensional representation of the site hydrogeological framework. The CSM coveys what is known or suspected about contaminant sources, releases and release mechanisms, contaminant fate and transport, exposure pathways, potential receptors, and risks. The CSM is a dynamic model based on what is known about a site at any stage of assessment or remediation and is modified as more information becomes available. The CSM will be used as the basis for developing corrective action strategies for the site, if deemed appropriate.

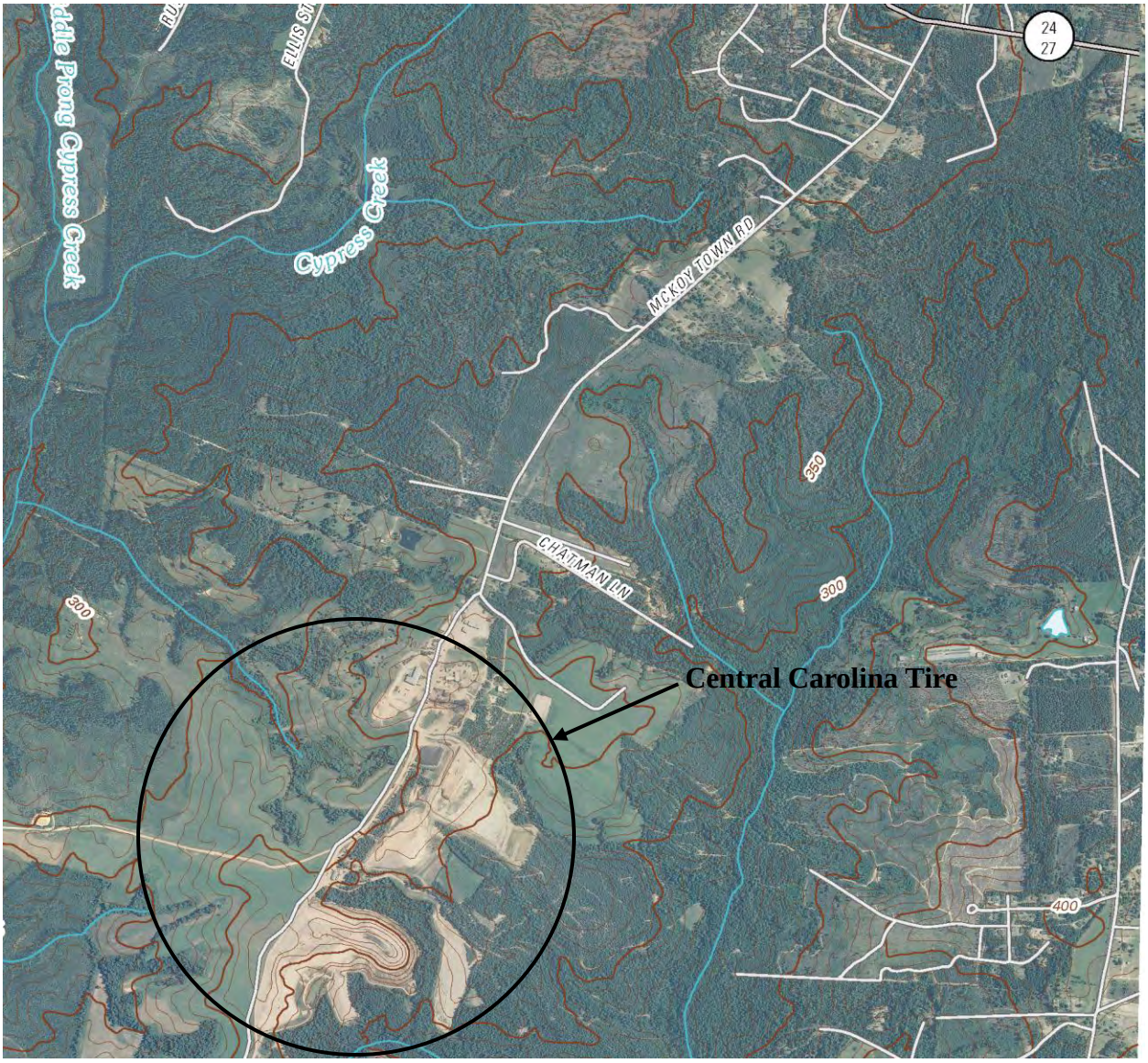
5.0 ASSESSMENT REPORT

A report of results for the Phase 4 Hydrogeologic and Groundwater Quality Assessment will be prepared following completion of all field work and receipt of all laboratory analytical data. The report will present details of the field work performed, the results of laboratory analysis of the groundwater samples, interpretations of the results and recommendations for additional work (if deemed necessary). The report will be sealed by a North Carolina Professional Geologist and/or Engineer.

6.0 PROJECT SCHEDULE

Based on the scope of the assessment work plan presented herein, it is estimated that all field work can be completed and an assessment report forwarded to DENR within 16 weeks following regulatory approval of this work plan.

FIGURES AND TABLES



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Source: USGS 7.5' Topographic Quadrangle Series
Murchisontown, NC 2010

Nautilus Geologic Consulting, PLLC
11112 Branding Iron Place
Wendell, NC 27591
Office: (919) 366-3663
Cell: (919) 995-0363

SITE LOCATION MAP

Central Carolina Tire Monofill Landfill
Harnett County, North Carolina

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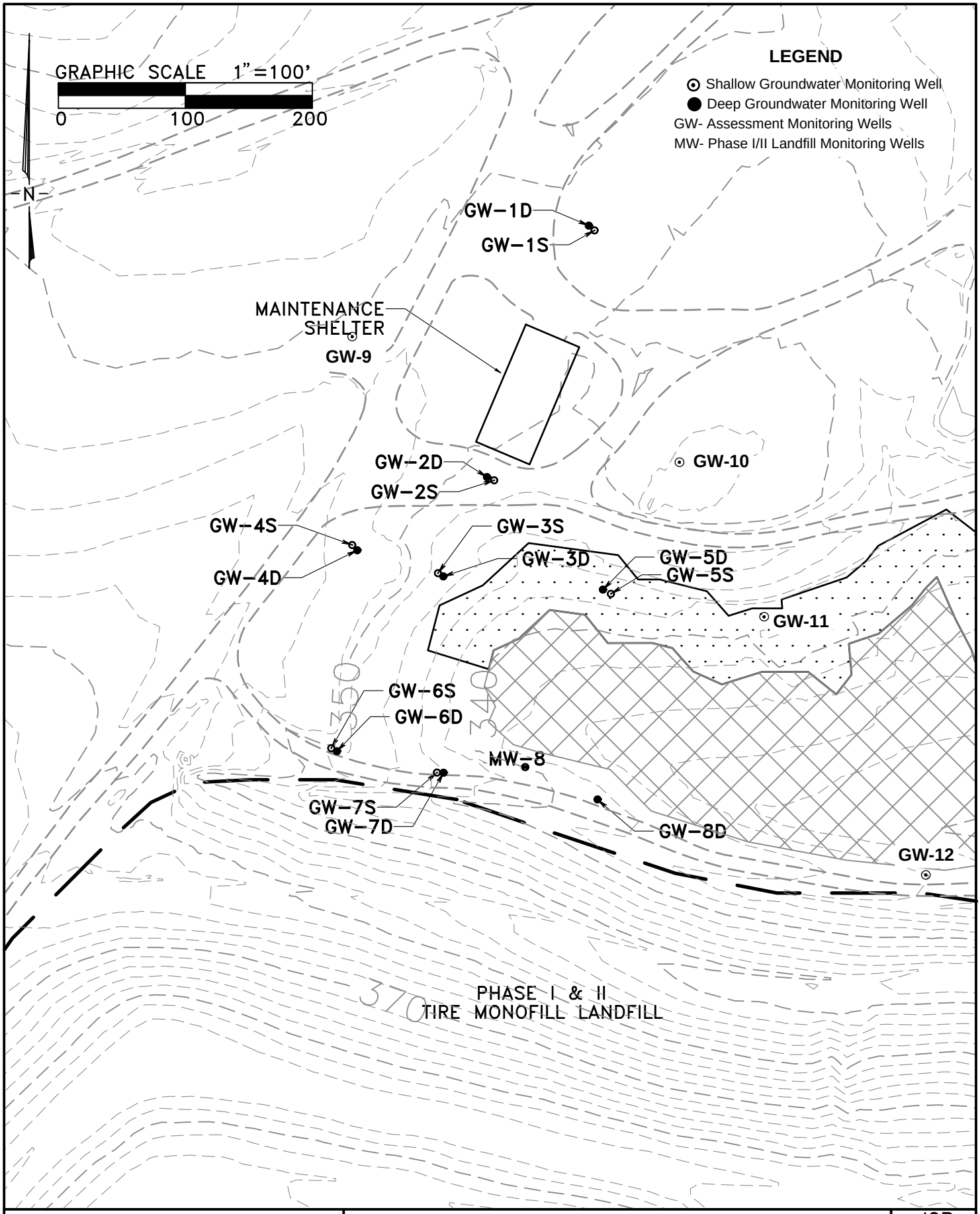
USGS		Scale: 1:24,000	Drawing Date: 05/31/2012	1



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SITE MAP
Central Carolina Tire Monofill Landfill
Harnett County, NC
Permit #43-04

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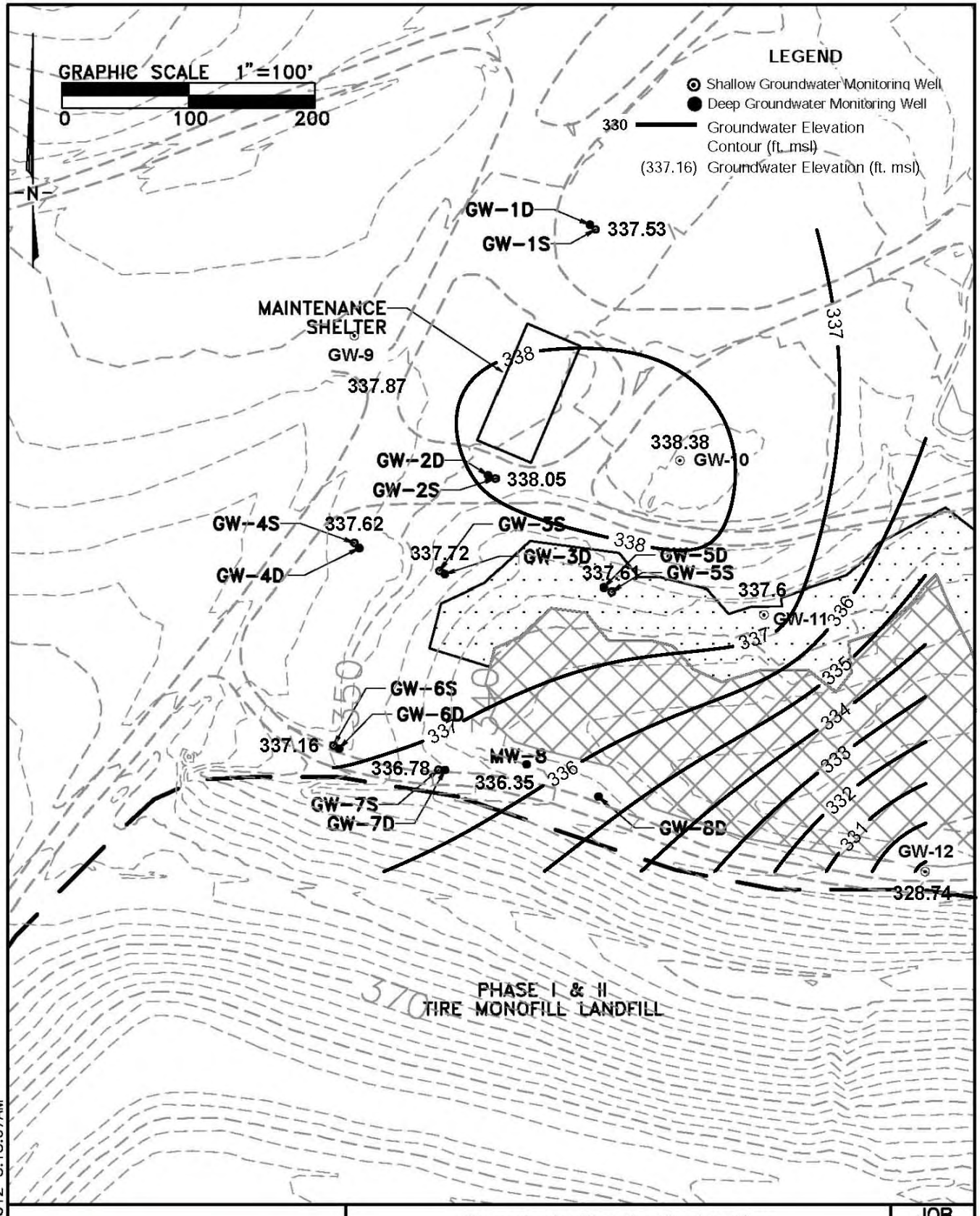

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Groundwater Elevation Contour Map:
Shallow Surficial Aquifer April 2013
Central Carolina Tire Monofill Landfill
Harnett County, NC
Permit #43-04

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FIG
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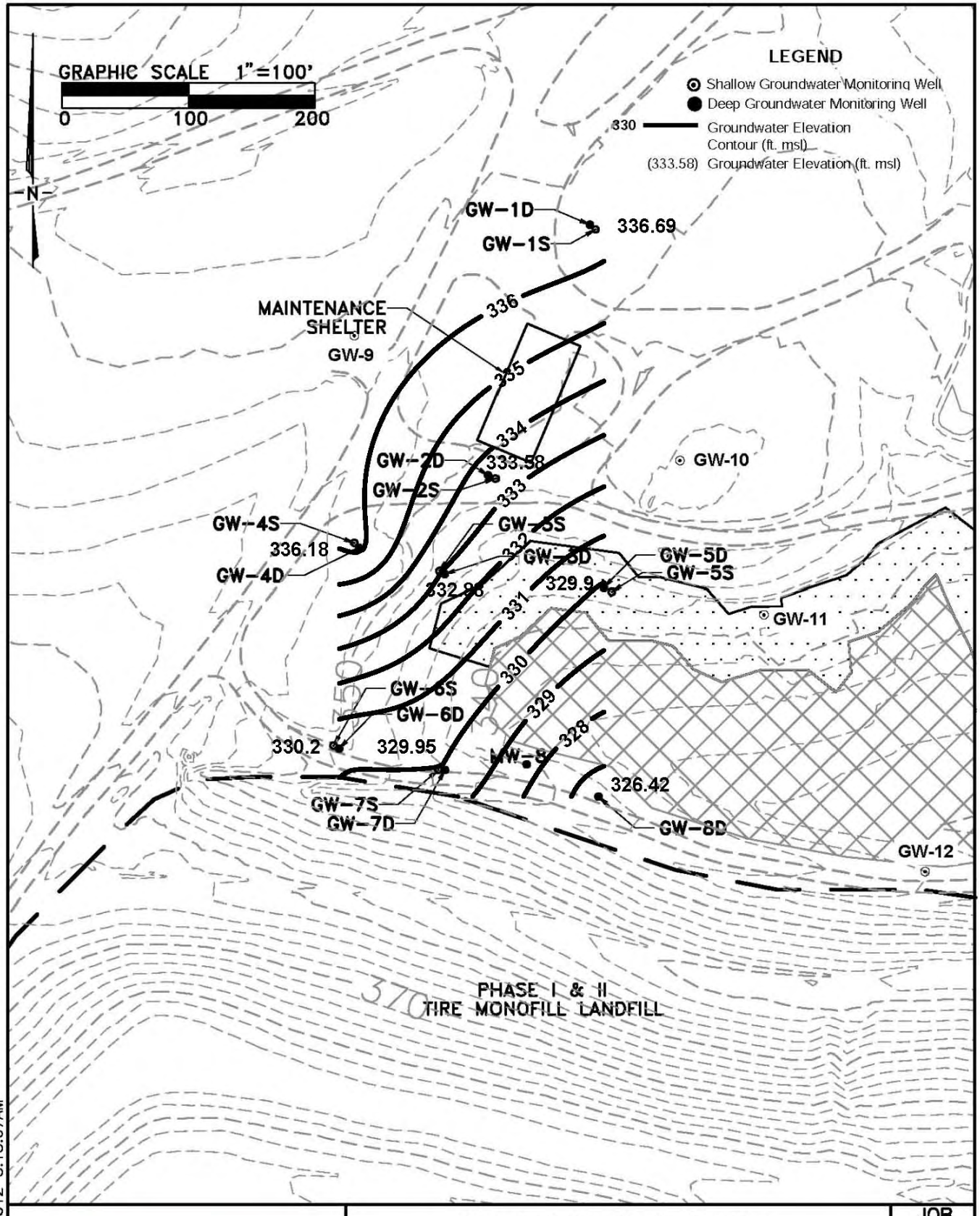

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Groundwater Elevation Contour Map:
Deep Aquifer April 2013
Central Carolina Tire Monofill Landfill
Harnett County, NC
Permit #43-04

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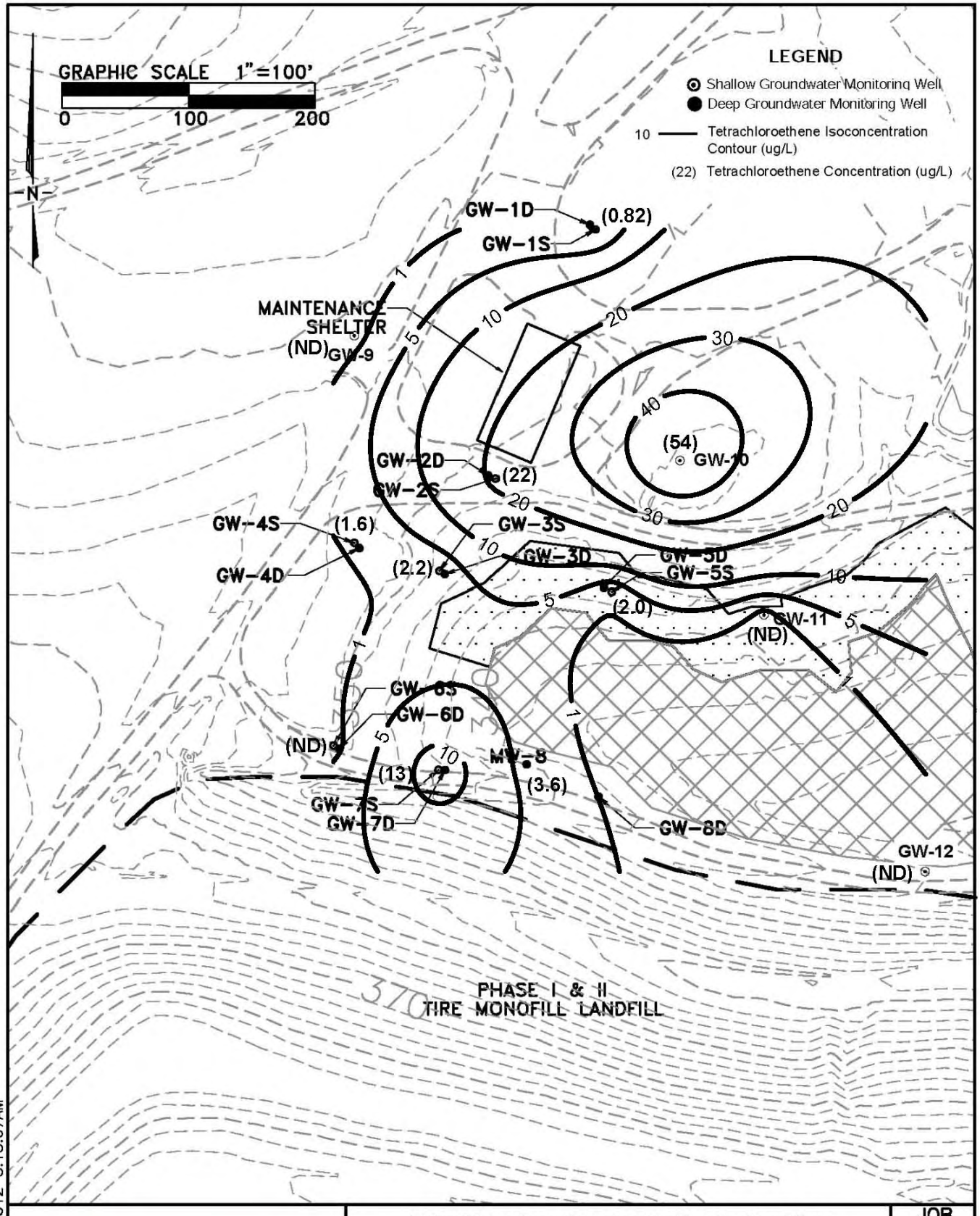

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Tetrachloroethene Isoconcentration Contour Map:
Shallow Surficial Aquifer April 2013
Central Carolina Tire Monofill Landfill
Harnett County, NC
Permit #43-04

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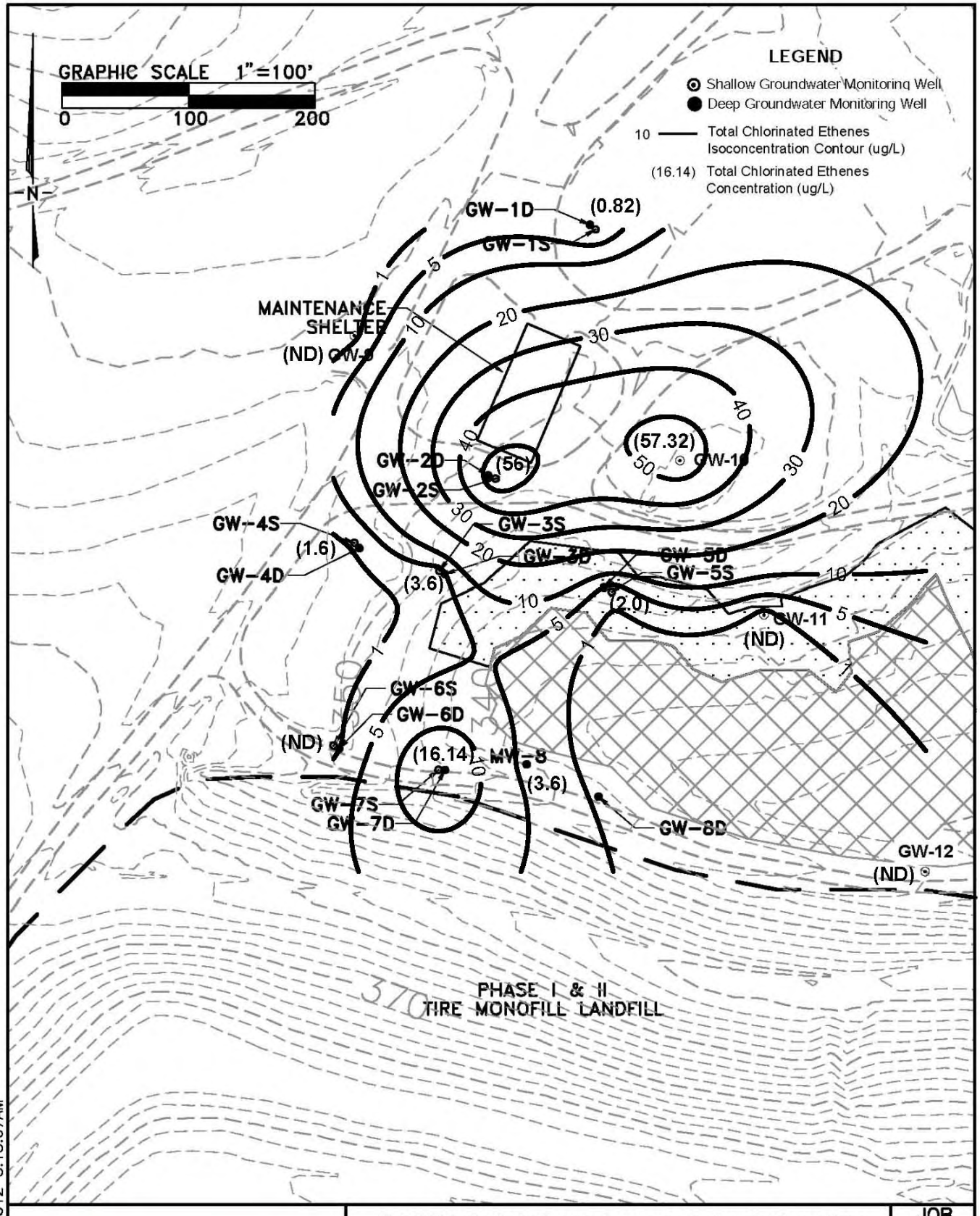

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Total Chlorinated Ethenes Isoconcentration Contour Map:
Shallow Surficial Aquifer April 2013
Central Carolina Tire Monofill Landfill
Harnett County, NC
Permit #43-04

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FIG
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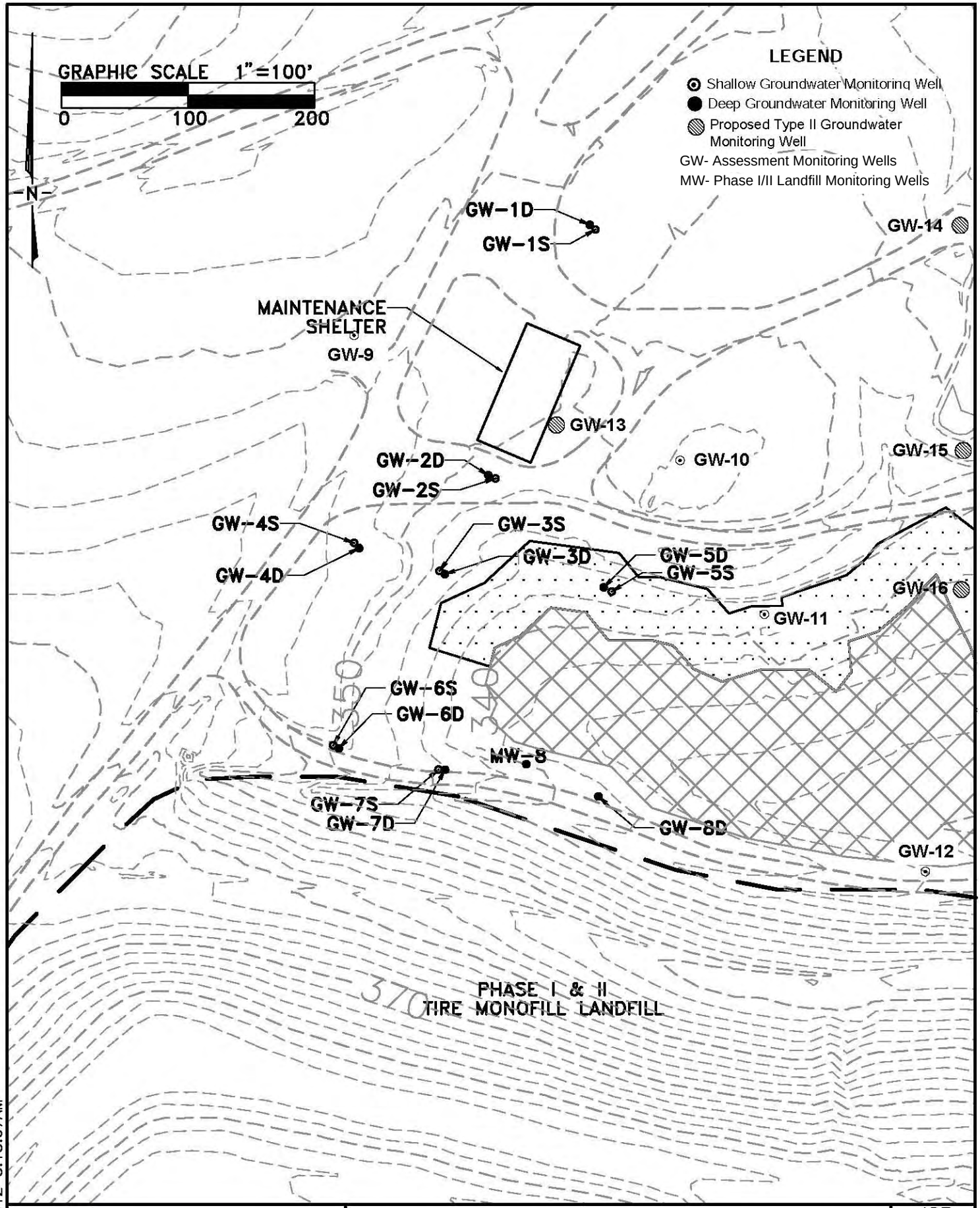

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Proposed Additional Shallow Groundwater Monitoring Wells
Central Carolina Tire Monofill Landfill
Harnett County, NC
Permit #43-04

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Table 1
Summarized Historical Laboratory Analytical Results for Groundwater Samples
Phase 3 Hydrogeologic and Groundwater Quality Assessment
April 2013
Central Carolina Tire Monofill Landfill
Harnett County, North Carolina
Permit # 43-04

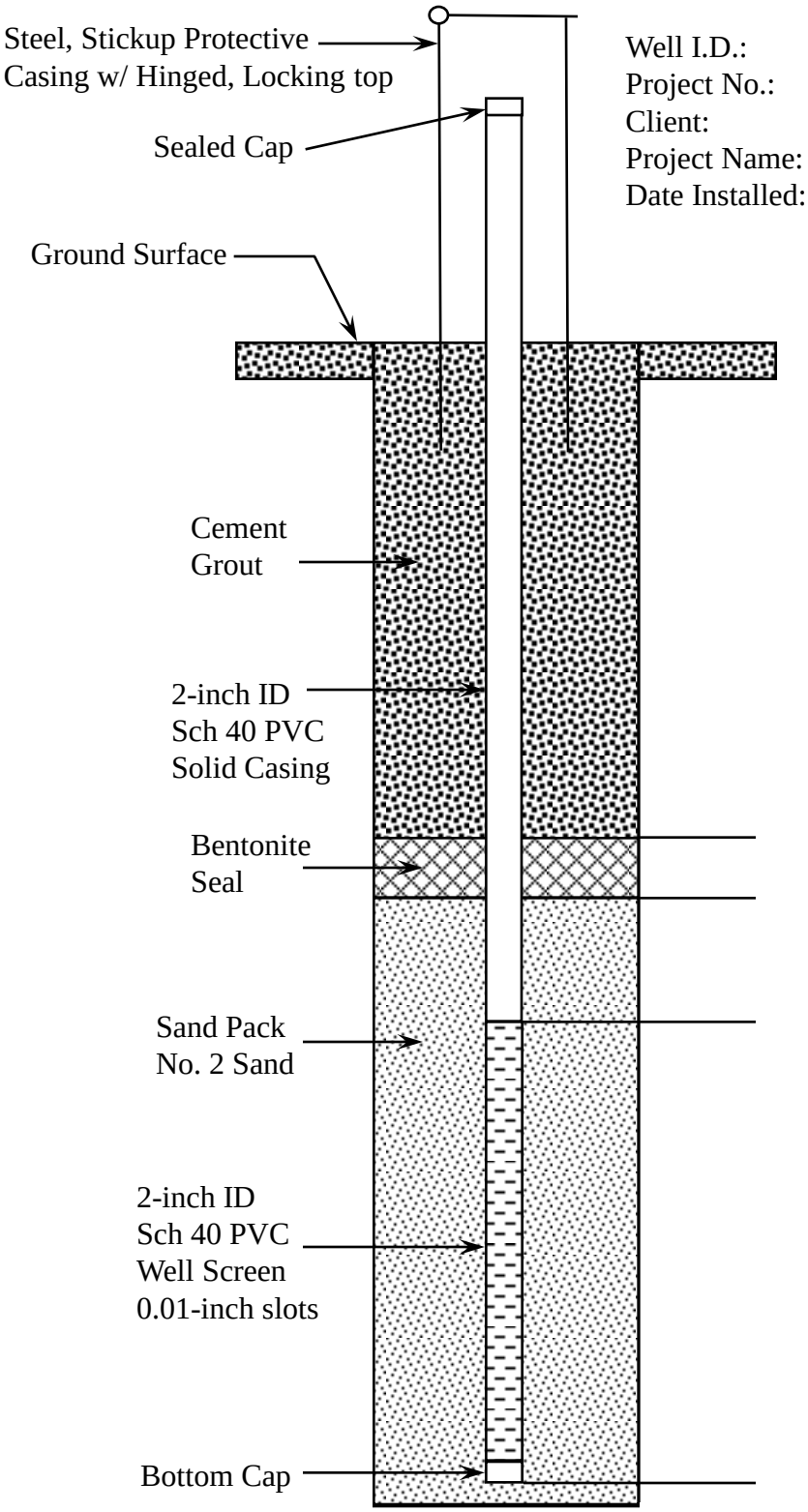
Well ID	Sampling Date	Volatile Organic Compounds by SW 846 8260B (ug/L)											
		Acetone	Benzene	Bromodichloromethane	Bromoform	Carbon Disulfide	Chloroethane	Chloroform	Dibromochloromethane	cis-1,2-Dichloroethene	Tetrachloroethene	Trichloroethene	Trichlorofluoromethane
GW-1S	4/30/2012	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	4/2/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.82**	ND	ND
GW-1D	5/1/2012	5	ND	**0.885**	1.96	0.641	ND	12.9	**6.5**	ND	ND	ND	ND
	4/3/2013	ND	ND	ND	ND	ND	ND	1.7	ND	ND	ND	ND	ND
GW-2S	4/30/2012	ND	ND	ND	ND	ND	ND	ND	ND	8.01	**8.82**	1.33	0.439
	4/2/2013	ND	ND	ND	ND	ND	ND	ND	ND	30	**22**	**4.0**	ND
GW-2D	5/1/2012	4.31	ND	**0.885**	ND	ND	ND	4.79	**0.763**	ND	ND	ND	ND
	4/3/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GW-3S	5/1/2012	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.869 J**	ND	ND
	4/2/2013	ND	ND	ND	ND	ND	ND	ND	ND	1.4	**2.2**	ND	ND
GW-3D	5/1/2012	5.09	ND	**2.04**	1.08	ND	ND	4.61	ND	ND	ND	ND	ND
	4/3/2013	ND	ND	ND	ND	ND	ND	1	ND	ND	ND	ND	ND
GW-4S	4/30/2012	ND	ND	**5.29**	0.831	ND	ND	5.94	**3.94**	ND	**1.7**	ND	ND
	4/2/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	**1.6**	ND	ND
GW-4D	5/1/2012	ND	ND	**1.92**	ND	0.823	ND	4.08	**1.54**	ND	ND	ND	ND
	4/3/2013	ND	ND	ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND
GW-5S	4/30/2012	ND	ND	ND	ND	ND	ND	ND	ND	ND	**3.07**	ND	ND
	4/2/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	**2.0**	ND	ND
GW-5D	5/1/2012	4.36	ND	**6.55**	1.68	0.71	ND	11.5	**5.46**	ND	ND	ND	ND
	4/3/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GW-6S	4/30/2012	ND	ND	**5.9**	0.871	ND	ND	6.09	**4.59**	ND	ND	ND	ND
	4/2/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GW-6D	5/1/2012	3.08	ND	**1.01**	0.937	0.811	ND	2.86	**1.08**	ND	ND	ND	ND
	4/3/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GW-7S	4/30/2012	ND	ND	ND	ND	ND	ND	ND	ND	1.83	**7.37**	0.43	ND
	4/2/2013	ND	ND	ND	ND	ND	ND	ND	ND	2.6	**13**	0.54	ND
GW-7D	5/1/2012	2.59	ND	**3.63**	1.22	ND	ND	7.17	**3.07**	ND	ND	ND	ND
	4/3/2013	ND	ND	ND	ND	ND	ND	1.7	ND	ND	ND	ND	ND
GW-8D	5/1/2012	ND	ND	0.403	ND	ND	ND	0.716	**0.592**	ND	ND	ND	ND
	4/3/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-8	5/1/2012	ND	ND	ND	ND	ND	ND	ND	ND	ND	**3.32**	ND	ND
	4/3/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	**3.6**	ND	ND
GW-9	4/2/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GW-10	4/2/2013	ND	ND	ND	ND	ND	ND	ND	ND	2.4	**54**	0.92	ND
GW-11	4/2/2013	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
GW-12	4/2/2013	ND	**1.9**	ND	ND	ND	1.4	ND	ND	ND	ND	ND	ND
NCAC 2L Std. (ug/L)		**6000**	**1.0**	**0.6**	**4.0**	**700**	**3000**	**70**	**0.4**	**60**	**0.7**	**3.0**	**2000**

Notes:
Values in boldface exceed the corresponding 15A NCAC 2L .0202 groundwater quality standard for Class GA groundwater.
NCAC 2L STD = North Carolina Groundwater Standard established in Title 15A of North Carolina Administrative Code Subchapter 2L
J = Estimated value above laboratory method detection limit.
ND = None detected above laboratory method detection limit.

APPENDIX A

Monitoring Well Schematic

WELL CONSTRUCTION DIAGRAM
Type II Groundwater Monitoring Well



Well I.D.:
Project No.:
Client:
Project Name:
Date Installed:

NOT TO SCALE