SCS ENGINEERS

Design Hydrogeologic Report
A-1 Sandrock C&D Landfill, Phase 2A
Solid Waste Permit 4117-CDLF-2008

Presented to:

A-1 Sandrock, Inc.

A-1 SANDROCK INC.

A-1 Sandrock C&D Landfill
2091 Bishop Road
Greensboro, North Carolina 27406

Presented by:

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May 19, 2015
Revised July 24, 2015
File No. 02214704.00

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August 27, 2015
File No. 02214704.00

Mr. Ed Mussler, PE.
Permitting Branch, Solid Waste Section
NCDENR Division of Waste Management
Green Square, 217 West Jones Street
Raleigh, North Carolina 27603

Subject: Design Hydrogeologic Investigation and Report Revisions
Permit Application for A-1 Sandrock CDLF Phase 2A
Greensboro, North Carolina (Guilford County)
Facility Permit No. 4117-CDLF-2008

Dear Ed:

On behalf of A-1 Sandrock, Inc., SCS Engineers, PC (SCS) has revised the Design Hydrogeologic Report submitted in May 2015. Edits were made to the drawings and text based on comments received from Ms. Christine Ritter in correspondence dated June 12. 2015. All of the comments have been addressed and the issues amicably resolved.

This submittal includes several attachments: 1) revised drawings in 11x17" format, 2) revised individual pages of the report, 3) a written explanation of the changes following this letter, and 4) a revised report with noted changes and revision update (now version 0.1, July 23, 2015). Also included are revised pages for Appendices 7, 8, and 9, i.e., 5) Test Pit documentation and maps for the 6) Ground Water Monitoring Plan, and 7) Landfill Gas Monitoring Plan, respectively. No undocumented changes have been made to the report text or attachments.

We appreciate the Section's cooperation with this project. Please contact me if you have any questions regarding this submittal.

Sincerely,

NORTH CAROLINA PROFESSIONAL SEAL 25482 GEOENGINEER DAVID GARRETT

8/27/2015

G. David Garrett, PG, PE
Project Manager
SCS ENGINEERS

cc: Ronnie Petty, III, A-1 Sandrock, Inc,
Christine Ritter, Solid Waste Section

C:\Users\3921gdg\Documents\Projects\A1 Sandrock\Phase 2 Design Hydro\documents\DH transmittal letter 7-24-2015.doc

Signature page of Applicant

Name of Facility: A-1 Sandrock C&D Landfill

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision, and that the information provided in this application is true, accurate, and complete to the best of my knowledge.

I understand that North Carolina General Statute 130A-22 provides for administrative penalties of up to fifteen thousand dollars ($15,000.00) per day each violation of the Solid Waste Management Rules. I further understand that the Solid Waste Management Rules may be revised or amended in the future and that the facility siting and operations of this solid waste management facility will be required to comply with all such revisions or amendments.

	Ronald E. Petty III	4/2/15
Signature	Print Name	Date

A-1 Sandrock Inc

Business or organization name

Design Hydrogeologic Report
A-1 Sandrock C&D Landfill, Phase 2A
Solid Waste Permit 4117-CDLF-2008

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INTRODUCTION

A-1 Sandrock, Inc., owns and operates a Construction and Demolition debris landfill (CDLF), located at 2091 Bishop Road, near Greensboro, North Carolina, in southeastern Guilford County. The Owner is seeking a Permit to Construct (PTC) and Permit to Operate (PTO) for Phase 2A. This document presents a Design Hydrogeologic Study prepared in accordance with Solid Waste Rules 15A NCAC 13B .0538, with updates to the facility monitoring plan in accordance with Rule 15A NCAC 13B .0544. This work supports a permit amendment application submitted in March 2015, which details the facility plan, engineering plan and operations plan. The PTO was renewed in early 2014, but the new phase was not ready at that time. This report is presented in two sections: **Section 1** excerpts Site Suitability hydrogeology criteria from 2002, specific to Phase 2; **Section 2** presents the Design Hydrogeologic report based on the March 2015 study.

The landfill began operation in 2009 as the reclamation program for an open pit mine (essentially a large borrow pit). The initial Site Suitability Study was performed in 2002, and mining commenced using solid waste buffer criteria ca. 2003. The permitted facility boundary encompasses approximately 75 acres, whereas the footprint is divided into three contiguous phases covering approximately 21 acres. One PTC and three separate PTO's were issued for three cells as completed, identified as Phases 1A, 1B and 1C, located in the northern third of the footprint. Phase 1 straddled a geologic boundary between hard diorite bedrock to the east and deeply weathered granite ("sandrock") to the west, with a north-south oriented diabase dike located near the contact.

Excavation to design base grades in Phase 1 encountered a few rock outliers that required padding with soil to provide the required 4 feet of separation. The diabase dike generally proved to be easier to excavate than was indicated by the "auger refusal" conditions mapped in the Site Suitability investigation. The upper 20-30 feet of diabase in Phase 1C consisted of variable size cobbles and boulders nested in a matrix of clayey soil. A variable rock surface was suspected during the earlier studies, thus when the mining was completed in each cell a second investigation with test pits was performed to confirm the vertical separation, albeit some of the grades were adjusted up or down as conditions dictated. A tally of lost or gained airspace was kept in Phase 1 (and Phase 2A).

Similar excavation conditions were encountered in Phase 2A, whereas the cell is centered on the diabase dike but ground water separation became the controlling factor in the westernmost third of that 4-acre cell. The confirmation test pits in Phase 2A demonstrated sufficient separation to bedrock, but ground water was encountered within the lowest elevations at depths of 2 to 3 feet beneath the prepared base grades evaluated March 18, 2015. Due to the cell geometry and wet conditions over the recent winter, surface water collected in the low elevations and recharged the porous sandrock aquifer. It was not determined whether the water levels observed were "perched" or hydraulically connected to the base flow aquifer, but in the interest of expediting the permit the Owner raised the base grades and had the cell resurveyed on April 4, 2015.

1.1 Map and Literature Review

1.1.1 Geologic and Topo Maps – The site is located in the Piedmont physiographic province. Published geologic mapping [1] places the site in the Charlotte Belt, underlain by metamorphosed igneous plutonic rocks, typically consisting of Precambrian granite and grano-diorite (€Zg) and early Paleozoic intermediate-mafic units, diorite-gabbro (PZzg). These rock units have been altered and jointed during multiple thermo-tectonic events. Localized shearing is evidenced by slickensides and small-scale displacements along joint surfaces. Both units are present on the site but too small to distinguish in **Figure 1**.

Two principle rock types identified on-site include 1) diorite, characterized as very hard, fine-grained, greenish-gray rock comprising olivine-hornblende-plagioclase minerals with accessory chlorite and occasional pyrite; and 2) granite, characterized as moderately hard, coarse-grained, porphyritic, white and black rock consisting chiefly of plagioclase-quartz-biotite with minor potassic feldspar. Both units exhibit high angle jointing spaced 6 to 12 inches apart. Both units exhibit occasional aplite veins, and the granite exhibits quartz "stringers," suggesting some degree of secondary mineralization. Historic gold mines existed within two miles to the northeast and southwest directions.[2]

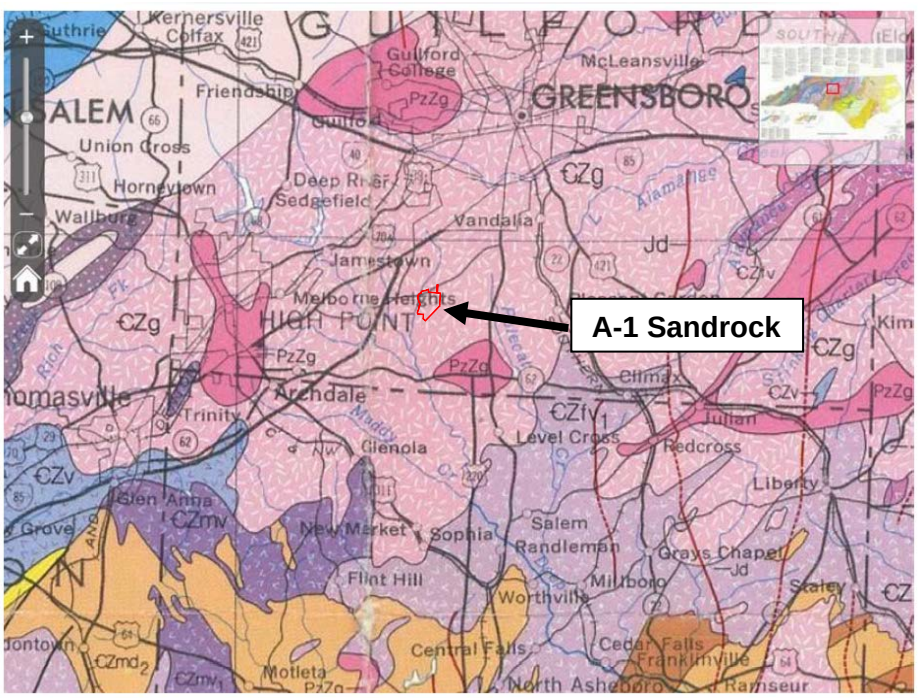


Figure 1 – **Excerpt from the North Carolina Geologic Map (1985)**

[1] North Carolina Geologic Survey at http://www.geology.enr.state.nc.us

[2] Mineral production reported in various Economic Reports, ca. 1900, found in the NCGS archives.

A third significant rock unit, a diabase dike of Triassic-Jurassic age (Jd), was observed along a north-south lineament, just west of the apparent granite-diorite contact. This unit is large enough to be mapped on the regional geologic map but not the state map. The "baked zone" appeared to be approximately 30 to 50 feet wide, but later exposure shows the dike to be approximately 10 feet wide. The upper surface of the diabase is weathered and contains "nests" of hard, rounded, black boulders and cobbles, embedded in a matrix of dark orange, plastic, silty clay. Diabase dikes have generated a lot of interest for solid waste site monitoring. Based on historic data, the diabase is not a significant factor here.

Other mafic rock units were observed as small, disconnected pods, called "xenoliths," of moderately hard, green-gray, foliated gneiss, generally too fine-grained for positive visual mineral identification. Such occurrences are common throughout the region and are believed to represent either old, post-depositional dikes within the granite (not to be confused with the much younger diabase) or diorite inclusions that were assimilated into the granite, now obscured by later thermo-tectonic events. These relatively small rock bodies are too small and isolated to map as individual units, thus they are believed to have no significance for water quality monitoring.

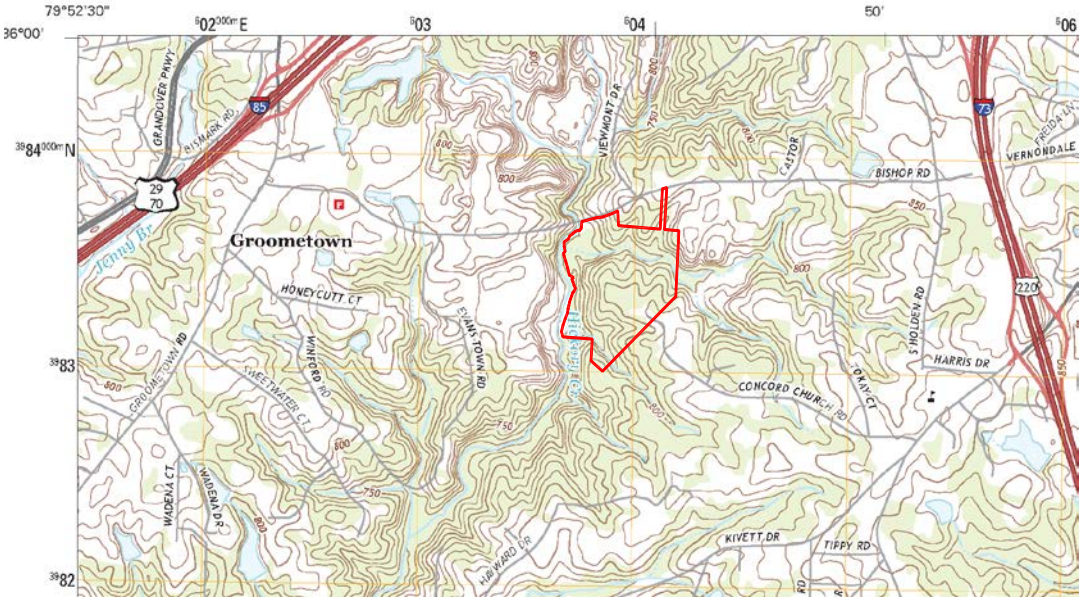


Figure 2 – USGS Pleasant Garden 7.5 minute series topographic quadrangle[3]

Surface topography serves as a guide to the direction of groundwater flow and influences hydraulic gradients. The variable topography observed at the site and throughout the region (**Figure 2**) is largely a manifestation of differential weathering of the bedrock,

[3] http://nationalmap.gov/ustopo

resulting from varying composition (chiefly quartz vs. mica content), upturned foliation, and regional jointing (brittle shear structures) as key factors. Test borings reveal the differential weathering through variations in auger refusal depths and soil composition, yet the soils at the site are relatively deep (typically exceeding 30 feet). Ground water is also relatively deep within the higher elevations and shallower in the lower elevations.

1.1.2 Fracture Trace Analysis – Generalized bedrock fracture trends for a 2 mile study area were acquired during the Site Suitability study by tracing stream alignments on the topo map. The alignment lengths were tallied and grouped according to compass orientation, and a Cumulative Length diagram was presented as a rosette diagram in **Appendix 5**, to show the statistical trends for the length and orientation of major fracture systems. USGS mapped perennial streams were targeted since they represent the predominant regional fracture pattern with minimal background clutter introduced by counting all the drainage features.

Some of the major fracture systems can be traced in the on-site bedrock through outcrop measurements (strike and dip of bedding and jointing), but bedrock exposures at the site are infrequent and highly weathered. The topographic orientations described below are given in coordinates and azimuth directions. Six major orientation groups were identified in the fracture trace analysis. Groupings used here represent 20 degrees of azimuth.

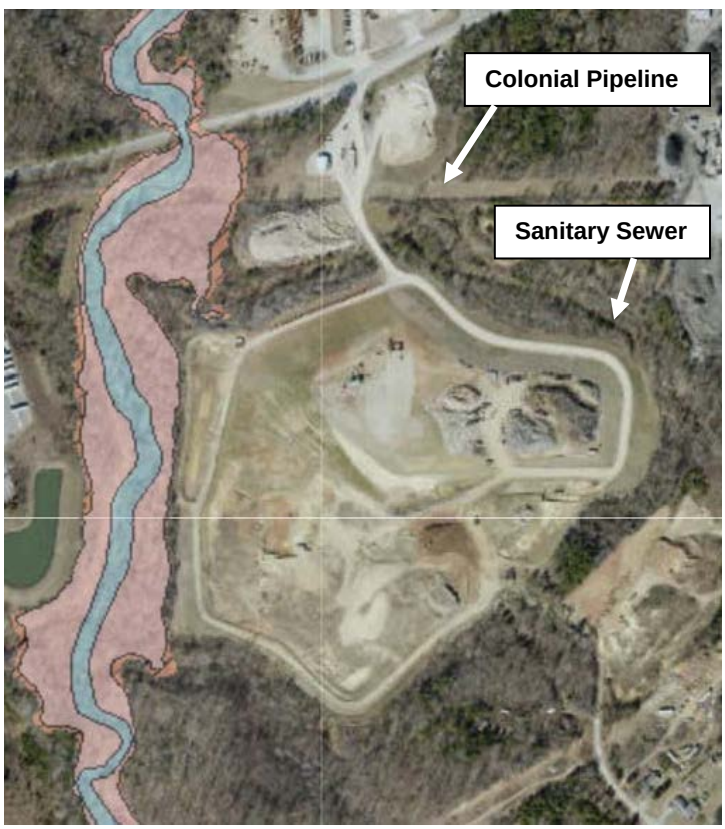
1. N0° to N20°E (Az. 000 to 020) North-south orientation of several larger stream runs, including Hickory Creek, which is believed to represent a significant regional tensional event, akin to the diabase dike intrusion.
2. S84°W to N84°W (Az. 264 to 276) East-west orientation of both unnamed tributaries to Hickory Creek occurring on the site. This is the principal ground water flow direction at the site, based on the potentiometric surface map.
3. N56°W to N49°W (Az. 284 to 311) Northwest orientation of streams leading toward the site from up-gradient areas. Together with Group #4, comprises the predominant fracture pattern in the study area, based on cumulative length of drainage features.
4. N48°W to N48°W (Az. 312 to 338) Northwest orientation of streams leading directly onto the site from up-gradient areas.
5. N045°E to N059°E (Az. 045 to 059) Coincides with the regional NE-SE trend. Together with Group #6, comprises the second-most predominant fracture pattern in the study area, based on cumulative length of drainage features at these orientations. Smaller streams located to the north of the "north" unnamed tributary follow this orientation.
6. N060°E to N073°E (Az. 060 to 073) No drainage features on-site at these orientations, but includes a long run of Hickory Creek south of the site.

Based on the fracture trace analysis, regional ground water flow near the site is directed west toward Hickory Creek, following the trend of Group #2. The potentiometric surface map indicates likely flow directions to the northwest and southwest, divided along an axis

located near the middle of the site that reflects surface topography. A possible flow orientation occurs along the north-south orientation of the diabase dike (Group #1), but this, too, leads to a ground water interceptor stream.

1.1.3 Topographic Setting and Drainage – USGS topographic mapping (**Figure 2**) shows the site situated along the west side of a dissected ridge. Topography consists of a broad, dissected ridge, bordered on three sides by streams. Hickory Creek borders the site to the west. Two unnamed "blue-line" tributaries flow west to Hickory Creek and converge within the site boundary. Drainage is generally northwest, west and southwest. Ground surfaces vary from El. 730 along Hickory Creek to El. 806 near the center and El. 812 at the east facility line. All drainage eventually flows to the Deep River via Hickory Creek, making the site subject to the Randleman Reservoir Watershed buffer rules.

1.1.4 Other Pertinent Features



The unnamed tributaries form deep, steeply sloping valleys that separate the disposal area from its surroundings. A 100-year floodplain is delineated along Hickory Creek. These features restrict access and provide visual screening, as well as limiting ground water and potential subsurface gas movement within predictable limits. Other site features that could influence the monitoring are two easements north of the disposal area, including a cross-country petroleum pipeline (Colonial Pipeline) and a sanitary sewer outfall, shown in aerial photography (**Figure 3**).

Figure 3 – 2013 Photo http://gis.co.guilford.nc.us/Guilfordjs/

1.2 Field Reconnaissance

1.2.1 Bedrock Characteristics – Typical of the Piedmont region, near-surface soils are characterized as saprolite, weathered from the underlying bedrock (saprolite), either diorite or granite on this site, and exhibits a relict texture and mineralogy derived from the parent bedrock. Stratigraphy is based more on the in-situ weathering pattern of the underlying bedrock than actual depositional units. Earlier test borings indicate standard penetration test (SPT) values vary spatially due to localized density variations and the degree of saturation. The on-site soils exhibit SPT values typically in excess of 20 blows per foot and varying with increasing depth to values in excess of 100 blows per foot. These densest soils are known locally as "partially weathered rock," which can be penetrated by power-driven hollow stem augers and transitions to bedrock, defined by "auger refusal." Several borings were cored or advanced into the bedrock with rotary-air drilling methods.

Based on the test boring data, the top of rock exhibits a differential weathering pattern, typical of a transitional boundary between the saprolite and bedrock. No additional test borings were performed for Phase 2A, whereas sufficient coverage (one per acre) was present throughout the footprint at the conclusion of studies that supported the permitting of Phase 1. Site visits made during the excavation of Phases 1 and 2A afforded ample opportunity to observe the soils and rock conditions, documented by numerous photos following this section. The subsurface data were supplemented by 15 test pits excavated on March 17, 2015 and observed with SWS staff on March 18, 2015, to demonstrate the required 4 feet of vertical separation between the base grade and either bedrock or groundwater. **Drawing S1** shows the layout of the investigation.

Within the eastern portions of Phase 2A, the upper soils are stiff to hard, orange-tan (occasionally greenish-gray) sandy silt and clayey silt, extending to depths of 15 to 25 feet below the surface. These soils are variably moist and often exhibit mottling due to past moisture fluctuations, in addition to occasional dark brown iron-manganese staining along joint surfaces. Within the western portion of Phase 2A, the soils are dense to very dense, tan-yellow and white silty sands with occasional pockets of sandy silt, extending from 25 to 50 feet beneath the original ground. The base grade slopes toward the west following the upper bedrock surface. Both the granite and diorite form few outcrops in the uplands, but minor exposures of both are to be found within the excavations, whereas the saprolite exhibits outliers of rock-like materials (not "bedrock") and small veins. The diabase is very conspicuous in the excavations and was visible as a line of boulders prior to grading. However, the diabase was easily excavated with large power equipment, thus final base grades in Phase 2A vary from those estimated using the earlier test borings.

Photo 1 – looking southeast across Phase 2A on May 18, 2015; test pits visible in foreground; dark soils exposed in the south wall (above the excavator) mark the diabase; C&D waste is exposed in the north wall on the left; Phase 2A extends to the base of the large stockpile; the sump is in the right foreground

Photo 2 – looking north across Phase 2A on May 18, 2015; test pits are visible across the bottom; a sliver of Phase 1 waste is exposed to the left on the far wall; lower area was subject to ponding of surface water during the recent winter months; sump is visible along the toe of the perimeter berm on the left side; this berm is residual soil (not structural embankment fill); rocky material to the right is the diabase dike

Photo 3 – close up of the fresh diabase rock, which is hard and chunky but still friable; the exposure is 4 feet high and 8 feet across; subparallel fracture pattern is jointing or exfoliation, not bedding

Photo 4 – diabase exposure in Phase 1C, near the Phase 2A boundary; note the boulders embedded in soil near the surface and the distinctly different soil color; the large boulders piled to the left were excavated mostly from the diabase dike, some from the variably dense "sandrock;" these sizes are large enough to have produced "auger refusal" with a conventional geotechnical drill rig; the contact between granite and diorite is irregular, yielding a mix of soil and rock types within short distances

Photo 5 – exposure of granitic "sandrock" showing exfoliation bands; this material was easily excavated but visible boulders indicate the variable weathering characteristics

Photo 6 – base grade adjustment in the lower elevations of Phase 2A were raised 1 to 2 feet based on ground water measurements made on March 18, 2015, shown here nearing completion

Photo 7 – completed Phase 2A regrade, surveyed April 4, 2015

1.2.2 Rock Depths – Generalized bedrock contours established in 2002 are based on test boring data and available outcrops, shown in **Drawing S4**. The mapped bedrock surface is based on "auger refusal" depths encountered at the test borings, in keeping with NCDENR policy. The rock surface generally reflects the topography, but the actual rock surface is variable due to the differential weathering pattern. "Refusal" can vary based on drilling equipment and technique, in addition to the density, thus "refusal" is not always a reliable indication of the "top of bedrock." A number of borings penetrated into rock using rotary rock coring techniques, which exposed considerable deep weathering along steeply inclined jointing within the upper reaches of bedrock, characteristic of a transitional boundary from saprolite (residual soils) to bedrock.

In Phase 2A the variable weathering became apparent, particularly within the diabase formation, whereas materials existing below the depths of "auger refusal" were excavated relatively easily using conventional earthwork equipment. **Drawing S5** shows maximum potential bedrock contours based on the recent test pit data, whereas the materials encountered in the test pits were rock-like but friable and easy to excavate. It should be noted that the bottoms of the test pits were higher than the "auger refusal" elevations mapped in Drawing S4. Base grades in Phase 2A are generally higher than those presented in the 2002 drawings, but not because of bedrock. Test pit data are summarized on **Table 7** and documented photographically in **Appendix 7**. Current base grades and bedrock separation are shown in **Drawing S6**.

1.2.3 Springs, Seeps and Ground Water Discharge Features – Several streams are located on the property, as indicated on various drawings and figures, though no running streams existed within the footprint. The March 2015 test pits encountered ground water, but no discharge features are present. Down gradient of Phase 2 are a 100-year floodplain and a sediment basin. The basin stays wet much of the year, which might indicate the excavation intersected ground water, though no visible seeps or springs are obvious. The floodplain does not exhibit any ground water discharge features. Base flow discharge occurs along Hickory Creek, but no distinct springs have been identified. The ground water potentiometric maps, **Drawings S2** and **S3**, depict the ground water contours tied to the stream bottoms, consistent with the hydrogeologic model.

1.3 Test Borings/Test Pits

Drawing S1 shows test locations performed in 2002 and test pits excavated in March 2015. Including two previous test borings drilled within Phases 2A, i.e. B-16 and B-29, and 15 test pits, a total of 17 data points exist within the 4.4 acre expansion site. This exceeds the requirement of one boring per acre. In addition, 8 more borings located along the margins are considered relevant: B-7, B-15, B-18, B-12, B-21, B-27, B-19 and B-20. The earlier piezometers have long since been removed, but the data are useful to supplement bedrock information. Two more data points outside the Phase 2A footprint are monitoring wells MW-3 and MW-4, which provide semi-annual water level data.

The test borings were drilled with an all-terrain vehicle-mounted drill rig turning hollow stem augers for a considerable distance into the dense "sandrock" (100+ bpf material). The borings extended to auger refusal depths, which varied from 18 feet at B-7 to 65 feet at B-19. Rock cores were taken at B-12, B-19 and B-27. Some of the variability in auger refusal depths depended on the presence of a relatively narrow (5 to 10 feet wide) diabase dike, a hard linear rock feature oriented north-south in the western side of the site. The upper portion of the dike, just beneath the surface, weathers into hard rounded nodules embedded in soil, transitioning at depth to a friable, chunky material and large boulders at shallower depths than the surrounding sandrock. This feature had influenced bedrock contours used in the 2002 base grades. Later it was found that the material could be excavated easily with conventional earthwork equipment.

This prompted slight changes to the base grades in 2014-2015, which was evaluated with a test pit investigation in March 2015. The investigation started with base grades that were surveyed in March 2015, shown as "initial conditions" in **Drawing S1**, to verify that 4 feet of vertical separation existed below those grades. The test pits were excavated with a CAT 225 track-hoe (or equivalent) on March 17, 2015, observed and documented by an experienced professional geologist. The test pits were inspected with SWS personnel approximately 24 hours later, sufficiently long to achieve stabilized water levels. The test pits were mapped and depths measured by the geologist. Water elevations were calculated by subtracting depths from references on extant surveyor's stakes. Depth of fill required to provide minimum required separation was calculated and additional grading was performed over the next week.

The finished base grade was resurveyed in early April 2015, which is represented in **Drawings S2, S3, S4** and **X1**. These drawings demonstrate that 4 feet of vertical separation, or more, exists between the finished grades and the bedrock or ground water.

A recent monitoring well installation, MW-6, located north of Phase 1C, provides confirmation of subsurface conditions in this portion of the site. Test locations were selected based on topography and other features to demonstrate the vertical separation characteristics within Phase 2A. A summary of relevant test boring data, e.g. elevations of weathered rock, bedrock, termination depths, and piezometer screen intervals, is presented on **Table 1**. A summary of the test pit data is presented on **Table 7**. Test boring records and photographic documentation of the test pits are presented in **Appendices 3** and **7**, respectively.

1.4 Laboratory and Field Testing

1.4.1 Laboratory Analysis – Table 2 presents a summary of laboratory test data for selected samples obtained in 2002. The laboratory test program consists of the following:

Flexible wall permeability – remolded*	D5084	2
Standard Proctor Compaction	D698	2
Grain Size w/Hydrometer	D422, D1140	7
Atterberg Limits	D4318	7
Natural Moisture	D2216	7

*Flexible wall permeability test were performed on relatively undisturbed (Shelby tube) samples.

The soils were classified in the laboratory according the Unified Soil Classification System (USCS). These descriptions were matched to the boring logs to verify the visual soil classifications. Laboratory data is presented in **Appendix 6**. Based on the laboratory data, a majority of the on-site soils classify as silty sands (SM) and sandy silt (SM-ML). Near surface soils exhibited clay contents varying from 6% to 18% by weight, whereas the deeper soils show lower clay contents of 0% to 4%. Silt contents are typically 10% to 40%, whereas sand content was measured from 40% to 85%. The lab reported liquid limits varying from 23 to 41, while the plasticity indices are generally vary from 5 to 13, consistent with sand and silt. Moisture content was reported as less than 10%.

In keeping with Division requirements, the effective porosity was estimated from the grain size distribution analysis using the Textural Classification diagram,[4] originally developed by the US Geological Survey for estimating specific yields in porous aquifers. In an unconfined aquifer, specific yield and effective porosity are close enough to be

[4] Johnson, A.I., Specific Yield – Compilation of Specific Yields for Various Materials, Geological Survey Water Supply Paper 1662, US Department of the Interior, 1967

considered interchangeable. The effective porosities are then utilized in ground water velocity calculations. The ternary diagram (see **Appendix 6**) shows apparent specific yields generally grouped between 12% and 30% – the sandier soils exhibit generally higher values, more silty soils exhibit generally lower values. The effective porosity values were used in the hydraulic conductivity calculations are summarized on **Table 3**.

1.4.2 Formation Descriptions – Relevant test boring logs excerpted from the earlier permitting studies are presented in Appendix 3. The test borings and soil excavations indicate soils derived chiefly from competent diorite and/or granite bedrock, with widely spaced high-angle and sub-horizontal jointing and some thin pegmatite intrusions and quartz-filled veins underlying the site. The rock type observed on-site is consistent with published mapping. The borings encountered no obvious voids, faults, or compressible zones. Aquifers tend to form along highly weathered zones associated with jointing or other fractures (i.e. concoidal fracturing specific to granite) and within the deeper, coarse-grained saprolite that mantles the bedrock. These are secondary porosity features, not typically associated with a given stratigraphy. The aquifers are localized and follow surface topography, associated with regional jointing and coincide with drainage features.

The near surface soils exhibit SPT values ranging from 11 to 100 blows per foot (bpf). Apparent variability in density is due to differential weathering where soils containing hard zones of sandy material (more resistant to weathering) are interlayered with softer, more micaceous material (less resistant to weathering). At locations investigated for this study, the soils become denser (i.e., exhibit higher SPT values) with increasing depth and transition to “partially weathered rock”, defined as very dense saprolite defined by SPT values in excess of 100 bpf, but which can still be penetrated by a hollow stem auger.

The “partially weathered rock” transitions with depth to “bedrock” typically defined by “auger refusal” in NC DENR nomenclature. Auger refusal depths vary in the Phase 2A area from approximately 15 to more than 60 feet. Typically, the granites exhibit deeper weathering depths, hence deeper “auger refusal” conditions. The upper rock surface is transitional, that is, the overlying soils grade into rock at variable depths, partly influenced by textural and mineralogical variations in the diorite, resulting in a differential weathering profile. The soil horizons contain veins of hard materials, termed “stringers,” boulders, or occasional ledges of less weathered rock.

Below auger refusal depths, the rock is generally competent. Three rock cores taken in the nearby borings indicate core run recoveries typically in the 70% to 80% range and rock quality determination (RQD) varying from 0 to 20% for the first 5 to 10 feet below refusal depths. Below these depths, recoveries approach 100% and RQD values increase

to typical values of 60% to 80%. Similar recovery and RQD values were observed at other test boring locations. In terms of hydrologic characteristics, rock with RQD values less than approximately 60% tend to behave as "porous flow media", while in those with RQD values above 60% fracture flow characteristics are likely to predominate.

1.4.3 Field Hydrologic Testing – A summary of conductivity values calculated from falling head slug tests are presented on **Table 3**. Initial static water level measurements were made at the beginning of each slug test. The slug tests were conducted by placing a combined data recorder-pressure transducer (In-Situ Level Troll™) at the bottom of the piezometer, allowing the equipment to come to equilibrium, then inserting a cylindrical fixed volume (slug) to raise the level of water in the well above the static water level. This produced a differential head that caused water to flow out of the well until the head pressure dissipated. The data logger was used to measure the rate of outflow until water level equilibrium was reestablished. The test data were analyzed using the HydroSOLVE, Inc. AQTESOLV for Windows™ program according to the Bouwer-Rice procedure. The test data and permeability calculations are presented in **Appendix 4**.

1.4.4 Hydrogeologic Units – Two principal hydrogeologic units were identified based on the field hydraulic conductivity values: (1) saturated residuum (saprolite), and (2) bedrock. Hydraulic conductivity data is summarized below:

Hydro Unit	Unit Description	Bouwer-Rice Conductivity (cm/sec) Max.	Min.	Avg.
1	Granitic Saprolite	7.14E-6 at B-21	1.20E-5 at B-7	9.60E-6
2	Granite Bedrock	6.00E-6 at B-19		

There is variation within the saprolite, but the general trend is toward increasing density with depth. The unit boundaries are transitional, that is, the units are interconnected and can be considered as one contiguous porous aquifer from the uppermost point of saturation down to the point where the rock is not weathered, below which discrete fracture flow is dominant. In both flow regimes, hydrostatic pressure can lead to artesian conditions, where the static water in the well can be higher than the depth at which a water-bearing seam is encountered.

Hydraulic conductivity test values for the upper, weathered portion of the bedrock are similar to that of the saprolite, which would be expected based on the low recovery and RQD data. The values fall within the range typically observed within the soils and upper bedrock in the Piedmont. It should be noted that slug tests measure hydraulic properties within a relatively narrow zone of influence around the piezometer, and there could be sample bias.

1.4.5 Dispersivity Characteristics – Predicting the movement of contaminants in ground water is of interest in developing an effective monitoring program. Contaminant transport modeling, which is dependent on the properties of both the aquifer and the contaminant of interest, is typically described in the literature by the advection-dispersion equation, where a**dvection** is chemical movement via groundwater flow due to the groundwater hydraulic (i.e. head) gradient, and **dispersion** is defined as, **"**the spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing (due to microscopic variations in velocities within and between pores)." [5]

As water moves through a porous medium, soil grains become obstacles that result in friction between the fluid and solids, resulting in localized variations in groundwater velocity. Solutes and non-soluble fluids that might be released from a waste unit (contaminants of concern) may be introduced as a chronic mass flux over a long period or as a relatively short-term pulse.

Without dispersion, all of the dissolved-phase contaminants would travel in a straight line at the ambient groundwater velocity. With dispersion, some chemical fluids travels faster and some slower than the mean velocity – due in part to inherent aquifer properties and in part to chemical properties of the solute. Dispersion results from both mechanical dispersion and molecular diffusion.

Mechanical dispersion describes the degree of mixing at the microscopic level, due to the velocity variations within randomly oriented, interconnected pore space – an inherent property of both the medium (texture and material type) and each solute (chemical partitioning). **Molecular diffusion** describes variations in solute concentrations within the fluid phase at the microscopic level – inherent to the solubility of each solute. The **dispersion coefficient** is defined as the sum of the coefficients of mechanical dispersion and molecular diffusion in a porous medium (Bear, 1972).[6]

Within aquifers with three-dimension flow, **longitudinal dispersion** describes how some of the water molecules and solute molecules travel more rapidly than the average linear velocity and some travel more slowly, spreading the solute in the direction of the bulk

[5] http://www.fosterwelldrilling.com/glossary.htm

[6] Bear, J., Dynamics of Fluids in Porous Media, Elsevier, New York, 1972

flow, while **transverse dispersion** describes the spreading of the solute in directions perpendicular to the bulk flow (after Freeze and Cherry, 1979).[7]

A key input parameter to advection-dispersion evaluations is a mixing parameter that depends solely to the characteristics of the porous medium, i.e., **dispersivity**, $\alpha = D/\nu$, where D is the dispersion coefficient [L^2/T] and ν is the mean pore-water velocity [L/T]. Recognizing the inherent difficulties in measuring solute dispersion within undisturbed, heterogeneous soils for use in predictive calculations of contaminant transport, whereas most prior lab testing had focused on simple homogeneous soil, Perfect *et al* evaluated a series of laboratory flow tests using six different undisturbed soil types.[8]

That study measured breakthrough concentrations under steady state conditions, from which the bulk dispersive characteristics of each soil were back-calculated to relate linear dispersivity to the soil-type dependent effective porosity. It was determined that lab-scale dispersivity ranged from less than 0.5 cm to more than 20 cm and increased sequentially moving from coarser to finer textural classes. The following table depicts the variation in dispersivity (denoted as "predicted" for comparison to reference values published in an earlier work) and other parameters for the tested soil types.

[7] "The Federal Glossary of Selected Terms: Subsurface-Water Flow and Solute Transport", Department of Interior, U.S. Geological Survey, Office of Water Data Coordination, August 1989. http://or.water.usgs.gov/projs_dir/willgw/glossary.html

[8] Perfect, E., M.C. Sukop, G.R. Haszler, Prediction of Dispersivity for Undisturbed Soil Column from Water Retention Parameters, Journal American Society of Soil Science, 66:696-701, 2002.

Table 6. Dispersivity (predicted using the regression coefficients in Table 5) as a function of soil textural class.†

Textural Class	n	ψ_a	b	α_{pred}
		kPa		10^{-3} m
Sand	14	0.69	2.79	8
Loamy sand	30	0.36	4.26	26
Sandy loam	124	1.41	4.74	34
Loam	103	3.55	5.25	46
Silt loam	394	7.59	5.33	56
Sandy clay loam	104	1.35	6.77	60
Clay loam	147	2.63	8.17	81
Silty clay loam	324	6.17	8.72	96
Sandy clay	16	0.98	10.73	109
Silty clay	43	3.24	10.39	110
Clay	148	4.68	11.55	128

† Mean values of ψ_a and b from Cosby et al. (1984).

Where: n = porosity (not specified; the paper discussed an effective transport porosity, θ_T)

Ψ_a = air-entry pressure, inversely related to the size of the largest pores

b = dimensionless parameter, directly related to the width of the pore distribution

α = dispersity coefficient.

Each unit of the uppermost aquifer consists of slightly to moderately to clayey and silty sand. This classification is analogous to loamy sand, so values presented in the literature might be considered representative. The models, which are often used to evaluate horizontal spacing between monitoring wells, are sensitive to this parameter. However, empirical evidence suggests that dispersivity can be most effectively estimated as a function of contaminant plume length (i.e., the scale of the problem) and not the texture or structure of the medium through which the plume is migrating. A practical rule of thumb is a_x (longitudinal dispersivity) is approximately 0.1 times the scale of the system, and transverse dispersivity equals 0.1 times longitudinal dispersivity.[9]

The use of advection-dispersion modeling can be appropriate for determining well spacing on certain sites (e.g., sedimentary aquifers with relatively flat ground water gradients), where discharge features may not be well defined or the land not controlled to the discharge feature. However, at the subject site discharge features are well-defined (i.e., streams hydraulically isolate the existing and proposed disposal units), and the property (hence groundwater use) is controlled to the known discharge features. Dispersion and dispersivity become less relevant under such conditions.

[9] http://www.epa.gov/athens/learn2model/part-two/onsite/longdisp.htm

1.5 Other Investigative Tools

This report builds upon the data collected during the earlier Site Suitability study and field observation of excavations of Phase 1. Isolated occurrences of rock were discovered, some of which were considered too large to excavate – these were padded with soil to provide the required vertical separation. No ground water was encountered at elevations above the excavated base grades. Whereas the principle investigator visited the site many times over the 5-year operational period, a significant understanding of the in-situ soil characteristics was gained through observation of soil exposures. No other field tests or investigations were deemed necessary.

1.6 Stratigraphic Cross Sections

Drawing X1 presents two generalized subsurface profiles prepared from the test boring, test pit and laboratory data, which indicate the hydrogeologic and lithologic units for this site. There is no clear stratigraphy present (i.e., sedimentary formations). For this discussion, two **hydrogeologic units** were identified based on the relative density of the saturated residuum (saprolite) and underlying bedrock:

- **Unit 1** is defined as the variably dense saprolite existing beneath the water table and above a depth of "auger refusal."
- **Unit 2** is defined by materials that yield auger refusal and require rotary coring and/or air-hammer techniques to penetrate (defined here as bedrock).

These units are characterized by differing degrees of weathering and corresponding ranges of field hydraulic conductivity values (**Section 1.4)**. The soil and rock units exhibit differential weathering, typical of gradational boundaries. The subsurface profiles show irregular unit boundaries that generally conform to the surface topography. Within crystalline rock terrains of the Piedmont, relict jointing carried over from the parent rock typically determines the development of the Unit 1 and Unit 2 aquifers. The spacing and degree of weathering control the location, thickness, and transmissivity of the numerous aquifers that form in the regolith (saprolite). Aquifers formed along the relatively isolated fractures do not necessarily interconnect horizontally.[10]

[10] LeGrand, Sr., H.E., A Master Conceptual Model for Hydrogeological Site Characterization in the Piedmont and Mountain Region of North Carolina, North Carolina Department of Environment and Natural Resources, Division of Water Quality, Groundwater Section, 2004

Unit 1 exhibits porous flow media, characteristic of an unconfined to partially confined "water table" aquifer. The thickness of saprolite is highly variable, but the Unit 1 designation considers the saturated zones only. Groundwater flow within Unit 2 is discrete fracture flow along relatively widely spaced, localized joint sets. This characterization is consistent with observations made of rock cores obtained during drilling for previous field investigations conducted at the site. Due to the hydraulic interconnection, Unit 1 influences pressure in Unit 2, thus these units are considered together for drawing a single potentiometric surface on the cross sections (**Drawing X1**).

1.7 Water Table Information

1.7.1 Short-Term Water Levels – Table 4 presents a summary of short-term ground water levels observed at the end of drilling and stabilized readings obtained after a period of one to fourteen days after completion of the piezometers. These data are relevant for this study in noting that many of the borings were initially dry, with stabilized water levels occurring slowly at elevations higher than the bottoms of the borings.

1.7.2 Long-Term Water Levels – A summary of semi-annual water level observations at the nearby monitoring wells extending back to 2006 is presented on **Table 5**. Groundwater hydrographs for the monitoring wells follow the table. These data can be used to correlate recent water level observations with climatic trends and historic water level observations for estimating the maximum long-term seasonal high water levels at the piezometers.

Historical climatic trends are published using regional climatic data from the National Climatic Data Center.[11] A key parameter of interest is the Palmer Hydrologic Drought Index (PHDI), which is compiled for over 100 years of weather records. The PHDI represents an overall moisture balance within a region, compiled from multiple weather stations for average precipitation, temperature (PET effects), leaf indices (growing season), wind velocities, and solar radiation. Palmer indices provide a more complete description of climatic trends than precipitation data alone, since evapotranspiration effects are factored into the overall moisture balance in the atmosphere and at the ground surface, i.e., the water availability for ground water recharge. Graphic data for the regional PHDI is discussed below in context with ground water fluctuation and presented in **Appendix 10**.

[11] Time Bias Corrected Divisional Temperature-Precipitation-Drought Index, (TD-9640) March 1994, National Oceanic and Atmospheric Administration, periodic updates available at www.ncdc.noaa.gov.

PHDI values can be presented as a hydrograph that shows cyclical trends, both seasonal and over a longer timeframe (decades). Shifts in PHDI indices for a given region reflect local climate changes, as well as changes in land use, e.g., forest cover vs. urban development. Major climate events can influence the regional PHDI; notable events seen across much of North Carolina include hurricanes, e.g., Fran in 1996 and Floyd in 1999, as well as global phenomena, the most recognizable is "El Nino." [12]

Values are either neutral, i.e., "normal" relative to historical statistics, positive indicating a wet spell, or negative indicating drought. The increasing numerical value toward positive or negative represents the degree if wetness or drought, described with adjectives moderate, severe, extreme, and exceptional. The use of Palmer indices provides a more realistic indication of the recharge potential than considering precipitation alone. The NOAA offers on-line interactive graphing capability by states and regions.

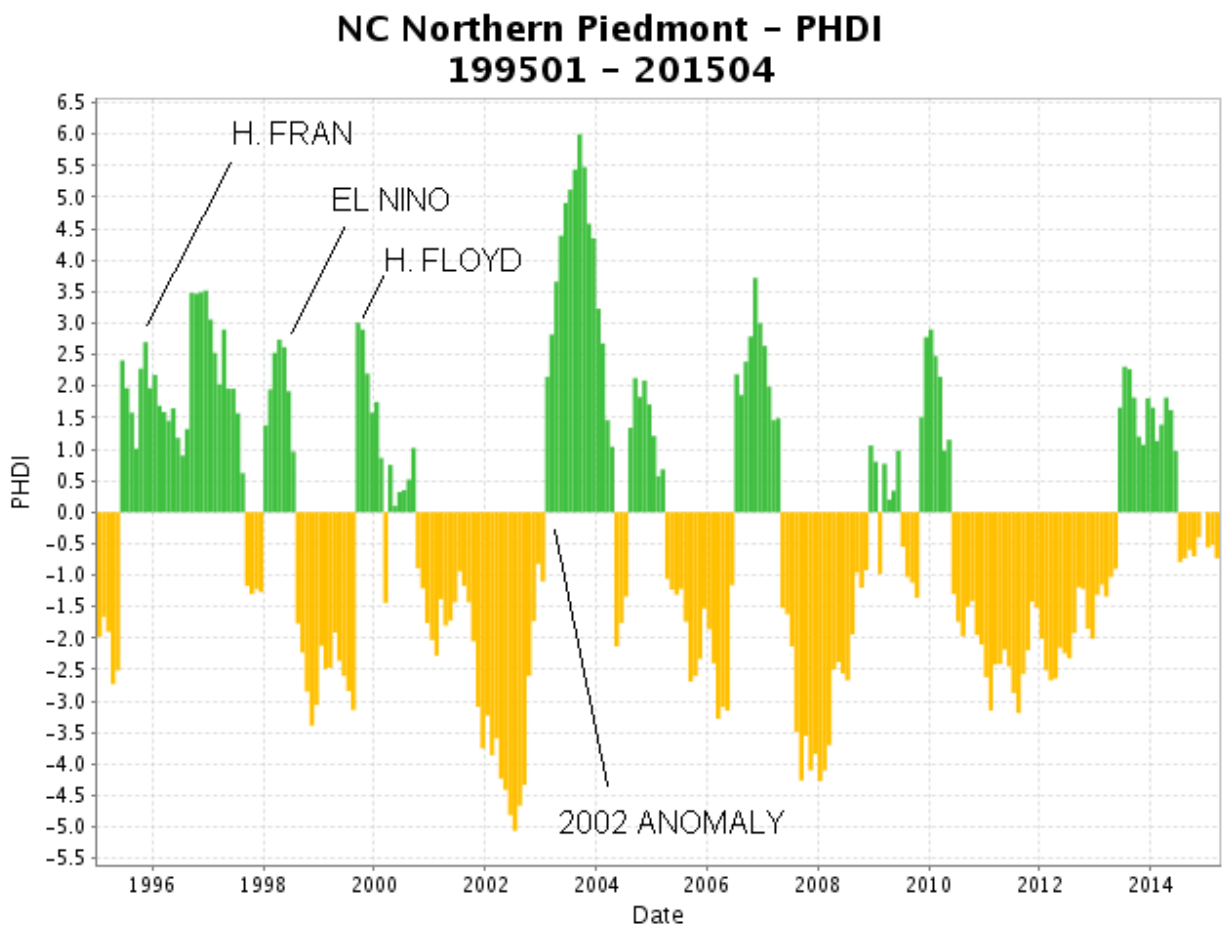


Figure 4

[12] http://www.ncdc.noaa.gov/oa/climate/onlineprod/drought/xmgr.html and http://www.ncdc.noaa.gov/cag/time-series/us

However, the PHDI graphs (**Figures 4** and **5**) do not show that El Nino as especially remarkable in this region. It is interesting to note in the short-term graph (Figure 4) that a drastic reversal of the PHDI in late 2002, in which a peak negative (drought) transitioned to a peak positive (wet spell) within a few weeks, both extreme periods lasting for several months' duration. This event was reflected in ground water monitoring networks throughout the North Carolina piedmont, with several monitored sites experiencing record high ground water levels. This was called an "anomaly" relative to hydrologic investigations then under review by the Solid Waste Section. Similar reversals can be seen throughout the record, just not as pronounced, following the normal seasonality.

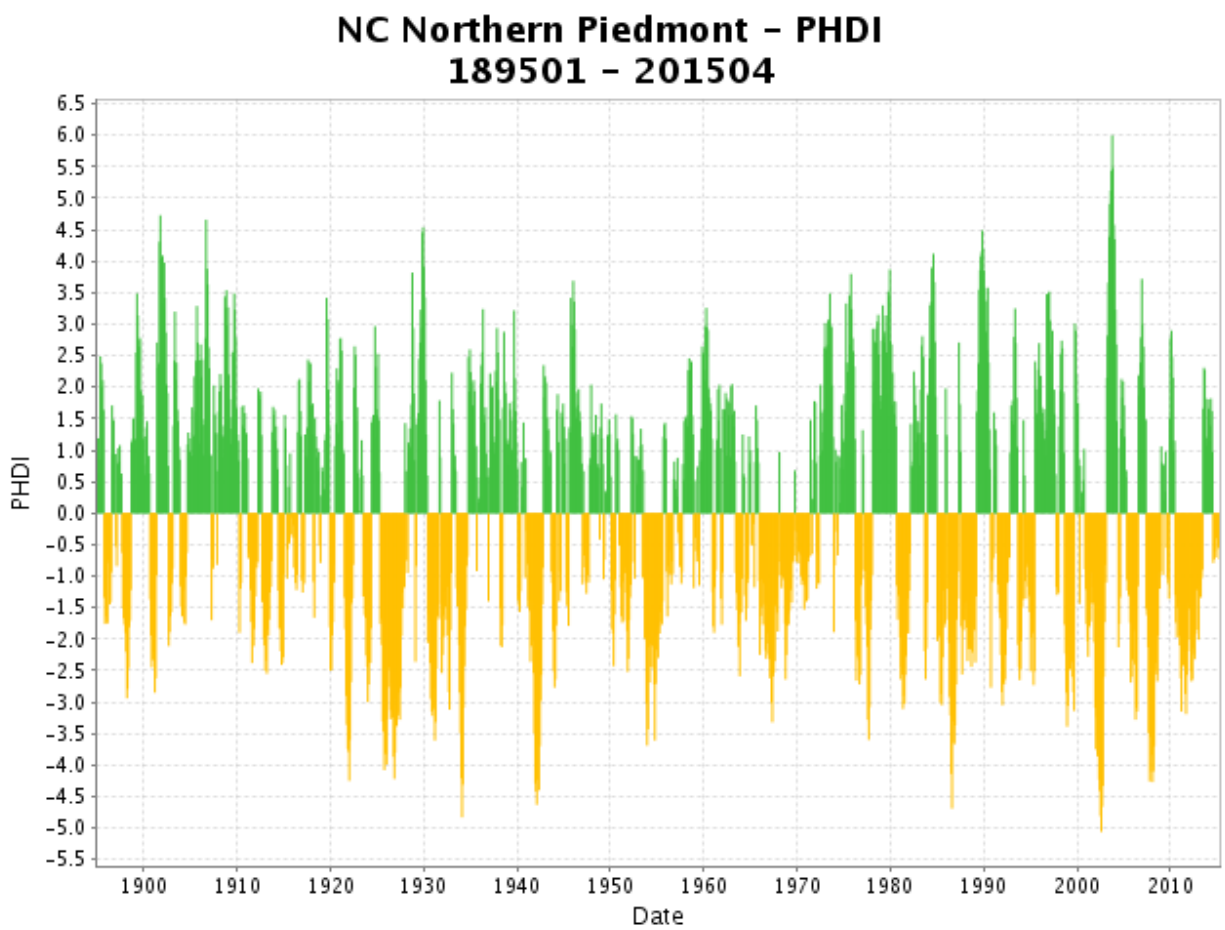


Figure 5

In the long-term PHDI graph (**Figure 5**), the 2002 anomaly stands out as the wettest period on record, albeit short-lived, ironically following the peak drought on record. It should be noted that all the available water does not infiltrate, whereas the PHDI does not consider surface conditions (slope, drainage and vegetative cover) at a given site. Where these data are useful is observing the overall moisture trend for the region during a given time period.

The on-site ground water data dates back only to 2006. The regional climatology since 2006 shows normal seasonal fluctuation, not excessively wet or dry, thus ground water trends during this time are expected to be more or less within a normal range, with highs and lows reflecting seasonal trends.

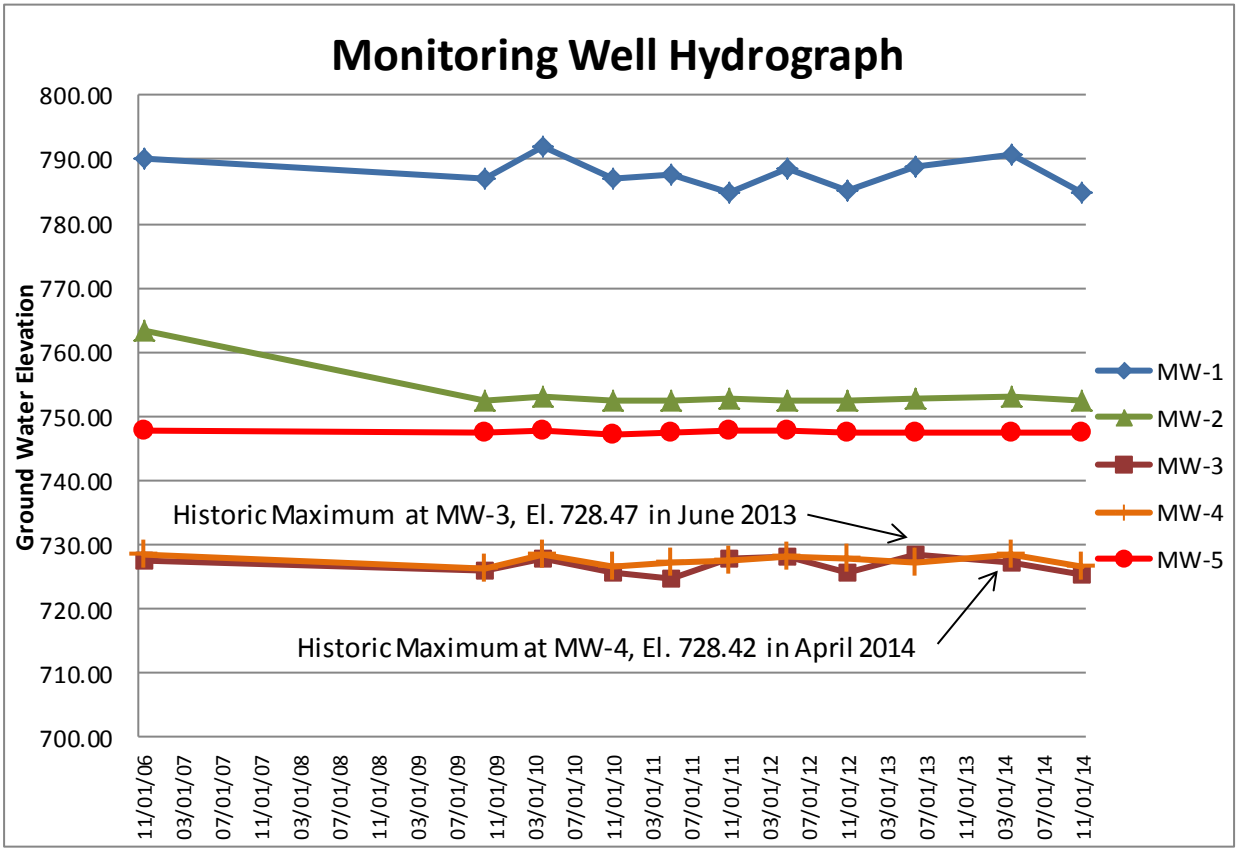


Figure 6

The historic maximum at MW-1, shown in **Figure 6**, the up-gradient background well not subject to changes in surface conditions, occurred in April 2010 with an observed water level of El. 791.96. In April 2014 an observed water level of El. 790.73 reflects the PHDI peak that occurred in the winter of 2009-2010, shown in **Figure 4**. The April 2010 maximum is seen in the other four wells, albeit the difference between the peak and ambient water levels is not as pronounced. This is expected because wells in the higher elevations are prone to more significant fluctuation.

Monitoring wells MW-3 and MW-4 exhibit maximum values in June 2013 (El. 728.47) and April 2014 (El. 728.42), respectively, which not only reflect a wet spell that occurred from 2013 to 2014 (**Figure 4**), but significant changes in surface conditions (mining and

grading of Phase 2A), which actually led to impounded surface water up-gradient of MW-4. It should be noted that the PHDI for both the 2009-10 and 2013-14 peaks were at least as wet as the El Nino winter of 1997-98.

1.7.3 Estimated Seasonal High Water Table – The monitoring well data show a good correlation between climatic trends and historic ground water levels observed in the monitoring well network. However, the mining of Phase 2A resulted in poor drainage, exacerbated by exposure of the surface without vegetation, which has led to maximum infiltration conditions. Ponding surface water observed during 2014-15 winter season, later corrected via pumping, raised ground water levels beneath Phase 2A.

At the time of the test pit investigation in March 2015, subsurface water levels were observed at depths approximately 2 to 4 feet beneath the surface. Based on the conclusion that the stabilized water table would likely be higher than that established during the 2002 studies, but not as high as the bottom of Phase 2A, a conservative estimate was made (in the interest of time) that the March 18, 2015 water levels would represent the maximum seasonal high water table. Additional fill was needed to provide the required 4 feet of vertical separation.

1.7.4 Factors That Influence the Water Table – The topographic ridge to the east of the proposed expansion area results in a large recharge zone, and the location of the creeks in the northeast and southwest portions of the property and along the western border of the property provide on-site discharge zones. Groundwater movement beneath the site appears to have a strong horizontal component; recharge (downward movement) is expected over most of the site, while discharge (upward movement) occurs at the stream banks and beneath the streams. Manmade influences include changing the vegetative cover and soil excavations; the landfill itself is hydraulically isolated and is not expected to significantly influence ground water levels beyond the facility boundary.

1.8 Horizontal and Vertical Flow Dimensions

Ground water movement at the site is through both the unconsolidated aquifer within porous media and the upper bedrock aquifer through widely spaced joints. Generalized ground water trends are represented with a seepage line in **Drawing X1**, with the generalized flow directions depicted. Shallow groundwater appears to move at depths typically greater than 20 feet beneath the surface, along relatively porous zones formed in the saprolite and widely spaced joints within the upper bedrock.

Based on the data, the saprolite aquifer (Unit 1) is inter-connected hydraulically with the upper bedrock aquifer (Unit 2) with no discreet confining layers. Horizontal flow occurs throughout a relatively thick saturated zone, beginning at depths greater than 20 feet beneath the surface. The cross-sections depict areas of recharge (downward groundwater movement) occurring over a majority of the site. Discharge (upward ground water movement) occurs in the lower elevations leading toward the streams. The cross sections indicate a dominant horizontal flow pattern between the recharge and discharge zones.

Vertical Flow: The majority of the site is characterized topographically as upland areas and slopes. Groundwater recharge occurs mainly in these upland areas in the Piedmont, while discharge occurs mainly in lowland areas bordering surface water bodies, marshes, and floodplains. As stated by LeGrand (2004), "Hydraulic head beneath upland areas decreases with depth, resulting in the overall downward movement of groundwater and providing the mechanism for recharge to the aquifer… Hydraulic head beneath lowland areas increases with depth, indicating upward movement of groundwater."[10]

The earlier Site Suitability study or Design Hydrogeologic Investigation did not include piezometer couplets, from which the vertical flow gradients can be calculated. However, the original test boring data at MW-3 and MW-4 indicate stabilized water levels much higher than those observed upon completion of the borings. Both borings encountered moist alluvial soils but relatively dry underlying saprolite, until auger refusal was encountered with wet soil conditions at depths below the adjacent creek bottom. This condition suggests that upward water movement occurs beneath the floodplain and the stream bottom, i.e., these features function as discharge features.

Horizontal Flow: Table 6 presents horizontal groundwater gradient data and velocity calculations for various piezometers at the site. Calculated horizontal groundwater flow velocities are based on field hydraulic conductivity data collected at the various piezometers (**Appendix 4**) and the horizontal gradients are developed from potentiometric contours shown on **Drawing S2**.

Based on the data, the hydraulic conductivity of Unit 1 and the upper reaches of Unit 2, within the depths of the investigation, do not differ significantly, nor do the potentiometric contours, thus both units can be considered together as a shallow, relatively unconfined aquifer at the site. Horizontal gradients were found to very within a range of 0.024 to 0.062. The average horizontal groundwater velocity for the shallow saprolite aquifer follows:

Hydrogeologic Unit	Average Horizontal Velocity ft/day	ft/year
1	0.003	1.1
2 (upper)	0.006	2.2

Based on the foregoing, the average horizontal groundwater velocity beneath Phase 2A is estimated at 1 to 2 feet/year.

1.9 Ground Water Contour Maps

Drawings S2 and **S3** show groundwater potentiometric contours for 2002 and March 2015, respectively. Site-wide, ground water flow is generally to the west with radial flow to the southwest and northwest, toward the surface streams. The potentiometric contours generally reflect a subdued expression of the surface topography – characteristic of the Piedmont province – making a smooth transition to the unnamed tributary. Within Phase 2A, the groundwater flow is westward with a minor southwesterly component.

1.10 Local Well and Water Use Information

No occupied dwellings were identified between the landfill and the nearest ground water discharge points. The nearest well known water supply well is at the scale house, which is within another drainage basin (and localized aquifer) from the landfill footprint. Most of the region is on a municipal water supply system.

1.11 Special Geologic Considerations

No unusual geologic features were observed that would affect groundwater flow or the ability to effectively monitor the site. The diabase dike does not appear to affect ground water flow. Conditions are typical of the North Carolina piedmont.

1.12 Summary Report

Ground water conditions near the subject site consist of multiple short segmented, closed-loop hydrologic systems developed along the drainage features, with recharge occurring over a majority of the site and discharge occurring at adjacent streams and on-site streams. Ground water depths beneath Phase 2A vary from 4 to 10 feet beneath the finished base grades, based on the March 2015 data. Groundwater flow is horizontal beneath Phase 2A, now and continuing after the future cell development, with velocities on the order of 1 to 2 feet/year within the uppermost saprolite (Unit 1).

Historical water levels observed at the on-site monitoring wells show seasonal fluctuation that correlate to climatic variation. The water levels observed beneath Phase 2A are shallower than those originally contoured during the site suitability study, due largely as a result of poor surface drainage during the winter months leading up to this investigation. Base grades have been set based on the March 2015 data, although this approach is conservative; i.e., the shallower water levels observed beneath Phase 2A are temporary and are believed to be artificially induced by the drainage conditions.

Groundwater flow beneath Phase 2A flows generally toward the west and discharges along the streams bordering the site. There are no known groundwater users within 500 feet of the landfill, and those outside this radius are across the major stream bordering the property. No known groundwater users are located down gradient of the landfill; institutional controls will prevent future down gradient groundwater use. The landfill poses no apparent threat to local groundwater supplies.

2.0 Design Hydrogeologic Report – CDLF Phase 2A

Hydrogeological investigations performed during the site suitability study and the design hydrogeologic evaluation, both completed ca. 2002 within and near proximity to the 4.4-acre footprint, plus the 15 test pits performed in 2015, provide an adequate amount of relevant data for characterizing the Phase 2A and designing (or confirming) an effective ground water monitoring program.

2.1 Ground Water Monitoring System Design

2.1.1 Uppermost Aquifer Characteristics – The saprolite (Unit 1) that mantles the bedrock (Unit 2) is ubiquitous and exhibits a transitional boundary. This uppermost unit exhibits porous media characteristics and hydraulic pressures associated with an unconfined to partially confined "water table" aquifer. Multiple aquifers exist within the saprolite along the fracture pattern underlying the drainage features and the topography. Beneath the transitional boundary, the unweathered bedrock (Unit 2) generally exhibits discreet fracture flow characteristics and slow recharge. Due to the widespread distribution and thickness of the saprolite, in addition to the deeper saprolite exhibiting relatively high transmissivity, this unit is the primary focus of the groundwater monitoring program. The saprolite discharges within the facility boundary, which is an ideal condition for effective ground water monitoring.

2.1.2 Relevant Point of Compliance – Selection of monitoring well locations for compliance monitoring of the uppermost aquifer is based on an understanding of hydrogeological conditions presented in this report and the earlier study by others. North Carolina solid waste Rule .1631 (a)(2)(B), pertaining to MSW facilities (extended to CDLFs) makes a provision for the relevant point of compliance to be located no more than 150 feet from the waste boundary (relative to a 200 foot buffer) but at least 50 feet within the facility boundary. The distance from the lower waste boundary to the facility boundary is over 300 feet. Division policy has been to require the compliance wells to be located within approximately 75-100 feet of the waste boundary, or approximately half the distance between the edge of waste and the compliance boundary. Based on the site studies, it appears that the location of existing compliance wells is appropriate.

2.1.3 Monitoring Plan Amendments – The monitoring program will be supplemented with one additional well, designated as MW-6, which is described in detail within the Sampling and Analysis Plan (**Appendix 8**).

2.2 Rock Core Information

Samples of the bedrock were taken in the earlier Site Suitability study. The boring logs (**Appendix 3**) indicate rock cores were collected at three borings relevant to Phase 2A, representative of diorite (B-12), granite (B-19), and probable diabase (B-27). The cores exhibited recovery values typically in excess of 90% and rock quality determination (RQD) values in excess of 80%. Based on these recovery and RQD values, the rock encountered by these borings would classify as fracture flow media. Relevant test boring records (see Appendix 3) present the detailed descriptions of the rock cores. Photos of the cores were presented in the Site Suitability report.

2.3 Estimated Long-Term Seasonal High Water Table

Section 1.7.3 provides a detailed description of historic water level data, including wells pertaining to the CDLF. These data were used to estimate a maximum long-term seasonal high potentiometric surface, presented in **Drawing S2**. The 2015 test pit data were used to amend the potentiometric surface for Phase 2A, presented in **Drawing S3**. It should be noted based on earlier site studies, minimum vertical separation requirements were met in the original Phase 1. Special circumstances led to the water levels observed in Phase 2A.

2.4 Bedrock Contour Map

The top-of-bedrock contours (based on auger refusal) are presented in **Drawing S4**. Nearly all the test borings were extended to auger refusal, thus the data density for the top of rock has high resolution. The 2015 test pit data were used to amend the bedrock contours for Phase 2A, presented in **Drawing S5**. It should be noted that the contours in Phase 2A represent maximum theoretical bedrock elevations in Phase 2A, which were set based on the test pits and first-hand observation as the cell was mined. The contours depict a minimum of 4 feet of vertical separation exists to the as-built base grades.

2.5 Hydrogeologic Cross Sections

Drawing X1 presents two generalized hydrogeologic cross-sections, one parallel to the primary ground water direction, the other perpendicular, which depict the horizontal and vertical extent of the upper most aquifer (Unit 1) and ground water flow characteristics (discharge areas vs. recharge areas). The cross sections show more than the minimum vertical separation requirement for bedrock and/or the maximum long-term seasonal high potentiometric surface and Phase 2A base grades.

2.6 Ground Water Flow Regime

Ground water at this site is isolated from areas beyond the boundary streams. Recharge occurs over a majority of the site and discharge occurs along the stream margins. Principle groundwater flow paths occur within the mantle of saprolite (Unit 1) above the bedrock (Unit 2) and for some distance into the bedrock along fractures. Porous zones are developed beneath drainage features. Highly conductive zones are typically located at the base of the saprolite, with thicknesses ranging on the order of 20 to 60 feet. The porous flow transitions to discrete fracture flow within the deeper crystalline bedrock. Average hydraulic conductivity values on the order of 9.60 x 10^{-6} cm/sec were calculated for the saprolite, and values of 6.00 x 10^{-6} cm/sec were calculated for the bedrock.

Horizontal gradients beneath Phase 2A vary from 0.024 to 0.062 within Unit 1. The horizontal gradients reflect the generally the gently rolling topography and influence the ground water velocities. Calculated horizontal velocities are approximately 0.003 feet/day (1.1 feet/year) within the saprolite, and 0.006 feet/day (2.2 feet/year) in the bedrock. Emphasis has been (and continues to be) placed on the saprolite as the "uppermost" aquifer with respect to ground water protection.

2.7 On-site Soils Report

Sampled materials in Phase 2A generally tested as silty sand (SM). Nearly all the soils exhibit a coarse grain texture (chiefly sand and fine gravel fractions) with variable amounts of silt and clay. The soils are generally non-plastic and exhibit excellent strength characteristics. In-situ, the soils are only moderately permeable. Two bulk samples from within the upper 10 feet beneath the surface exhibited remolded laboratory hydraulic conductivity values of 1.11 x 10^{-5} cm/sec to 3.66 x 10^{-7} cm/sec when compacted to 95% standard Proctor maximum dry density.

2.8 Certification

This is to certify that all borings that intersected the water table at this site have been constructed and maintained as permanent monitoring wells or shall be abandoned in accordance with the provisions of 15A NCAC 02C .0113.

Signed _____

Printed _G. David Garrett, PG, PE_____

Date ___July 15, 2014_____

NORTH CAROLINA PROFESSIONAL SEAL 25482 GEOLOGIST G. DAVID GARRETT

Not valid unless this document bears the seal of the above-named licensed professional.

APPENDIX 1
Design Hydro Tables

Table 1
Test Boring/Piezometer Data
Borings relevant to Phase 2A

Elevation Data				Test Boring Data				Piezometer Construction Data								
Boring Number	**Boring Date**	**PVC Pipe Elev.**	**Ground Elev.**	**Drilling Method**	**Total Depth, ft.**	**PWR Depth, ft.**	**PWR Elev.**	**Auger Refusal**		**Tricone Refusal**		**Top of Screen**		**Bot. of Screen**		**Stickup ft.**
								Depth, ft.	**Elev.**	**Depth, ft.**	**Elev.**	**Depth, ft.**	**Elev.**	**Depth, ft.**	**Elev.**	
B-7	5/21/2002	734.65	732.63	HSA	18.2	5.4	**727.2**	18.2	**714.4**	NA	NA	13.0	**719.6**	18.0	**714.6**	2.02
B-12	5/1/2002	808.12	806.53	HSA/Core	30.0	0.0	**806.5**	19.5	**787.0**	NA	NA	25.0	**781.5**	30.0	**776.5**	1.59
B-15	5/20/2002	771.71	770.94	HSA	35.4	8.7	**762.2**	35.4	**735.5**	NA	NA	30.0	**740.9**	35.0	**735.9**	0.77
B-16	5/16/2002	781.94	779.32	HSA	50.0	9.0	**770.3**	50.0	**729.3**	NA	NA	38.0	**741.3**	48.0	**731.3**	2.62
B-18	5/9/2002	785.39	782.49	HSA	29.0	6.5	**776.0**	29.0	**753.5**	NA	NA	19.0	**763.5**	29.0	**753.5**	2.90
B-19	5/1/2002	776.64	773.50	HSA/Core	65.5	2.0	**771.5**	53.6	**719.9**	54.0	**719.5**	60.0	**713.5**	65.0	**708.5**	3.14
B-20	5/20/2002	782.85	782.40	HSA	35.0	3.0	**779.4**	35.0	**747.4**	NA	NA	30.0	**752.4**	35.0	**747.4**	0.45
B-21	4/30/2002	809.97	807.94	HSA	60.4	2.7	**805.2**	60.4	**747.5**	NA	NA	48.0	**759.9**	58.0	**749.9**	2.03
B-27	5/13/2002	797.21	795.68	Rot/Core	29.0	2.7	**793.0**	14.6	**781.1**	23.0	**772.7**	24.0	**771.7**	29.0	**766.7**	1.53
B-28	8/24/2002	NA	780.0	HSA	18.0	5.2	**774.8**	18.0	**762.0**	NA	NA	NA	NA	NA	NA	NA
B-29	8/24/2002	NA	796.0	HSA	26.0	11.0	**785.0**	26.0	**770.0**	NA	NA	NA	NA	NA	NA	NA
MW-3	8/31/2002	731.82	729.80	HSA	33.0	9.0	**720.8**	33.0	**696.8**	NA	NA	28.0	**701.8**	33.0	**696.8**	2.02
MW-4	8/31/2002	733.17	731.10	HSA	24.0	8.5	**722.6**	24.0	**707.1**	NA	NA	9.0	**722.1**	24.0	**707.1**	2.07
MW-6	4/2/2015	755.89	753.10	HSA	45.0	31.0	**722.1**	45.0	**708.1**	NA	NA	30.0	**723.1**	45.0	**708.1**	2.79

Notes:

1. Piezometers screened in rock at B-10, B-11, B-12, B-17, B-19, B-22, and B-27 (dry)
2. Piezometers screened in saprolite at B-13, B-18, B-12, B-24
3. PWR is defined as saprolite that exhibits standard penetration resistance values in excess of 100 blows per foot (not necessarily a distinct hydrogeological unit)
4. Bedrock is defined as auger refusal material (this is considered a distinct hydogeologic unit where RQD values exceed 50%)
5. Boring B-27 was advanced from surface using rotary wash boring techniques (roller cone) and coring
6. All piezometers are 2" flush-mount PVC with 0.010" screen openings

Table 2
Geotechnical Laboratory Data

Sample Types:
S = Split spoon sample
B = Bulk sample
U = Undisturbed (Shelby tube)

Grain Size Distributution and Soil Classification

Boring Number	Sample Number	Sample Depth, ft.	% >3"	% Gravel	% Sand	% Silt	% Clay	Liquid Limit	Plasticity Limit	Plasticity Index	USCS Class.	Natural Moisture	% Passing	Hydrogeologic Description****
			>75 mm	75 mm>	4.5 mm>	0.075 mm>	0.005 mm>						#200 Sieve	
				> #4	#4 - #200	#200 >						%		
B-21	B2	0.0 -20.0	0	0.0	87.5	6.5	6.0	23	18	5	SM		12.5	Tan Silty Coarse to Fine SAND
B-12	S2	8.5 - 10.0	0	0.0	86.4	9.6	4.0	NP	NP	NP	SM	4.5	13.6	White-Brown Silty F - C SAND
B-19	S3	13.5 - 15.0	0	0.0	83.4	16.6	0.0	NP	NP	NP	SM		16.6	Silty Fine to Medium SAND
B-21	S1	3.5 - 5.0	0	0.0	39.5	43.5	17.0	33	24	9	SM-ML		60.5	Tan Fine Sandy SILT
B-21	S2	8.5 - 10.0	0	0.0	40.7	41.3	18.0	41	28	13	SM-ML		59.3	Fine Sandy SILT
B-21	S3	13.5 - 15.0	0	0.0	55.8	38.2	6.0	28	23	5	SM-ML		44.2	Silty Fine SAND
B-21	S4	18.5 - 20.0	0	0.0	54.0	38.0	8.0	NP	NP	NP	SM-ML		46.0	Silty Fine SAND

Notes to Above:

Moisture Contents are Dry Unit Weight Based

Moisture data for bulk samples acquired from individual jar samples collected with the bulk sample. Samples were oven-dried.
These data are considered representative of in-situ moisture conditions for earth work considerations.

Samples tested by Geotechnologies. Inc., Raleigh, NC

Compaction Data Bulk Samples

Boring Number	Sample Number	Sample Depth, ft.	Max. Dry Density, pcf	Optimum Moisture, %
B-21	B2	0.0-50.0	128.7	9.8%
B-22	B3	0.0-20.0	127.8	11.1%

Hydraulic Conductivity Data Bulk Samples

Boring Number	Sample Number	Sample Depth, ft.	Compaction % MDD	Tested Moisture, %	K cm/sec	Porosity %
B-21	B2	0.0-50.0	99.8%	13.7%	3.66E-07	22.4%
B-22	B3	0.0-20.0	90.2%	15.5%	5.02E-06	31.6%

Table 3
Hydrogeological Properties

Conductivity Values Based on Falling Head Slug Tests, Evaluated by Two Methods: Hvorslev Bouwer-Rice

Piezometer No.	Hydrological Unit	Hydrogeological Description *	Input Aquifer Thickness	Input Screen Length, ft.	Input Height of Water*	Input Static Water Level, ft.**	Effective Porosity	Total Porosity	Conductivity k (cm/sec)	Conductivity k (cm/sec)
B-7	1 - Granite	Fine to Coarse SAND, residual	12	5	9.4	10.65	0.20	22.40%	5.47E-06	1.20E-05
B-18	1 - Granite	mixed with Sandy SILT	10	10	9.8	22.09	0.20		6.10E-07	1.37E-06
B-21	1 - Granite	(SM and SM-ML, Saprolite)	16	21	16	44.03	0.20		2.59E-06	7.14E-06
B-19	2 - Granite		50	5	28.5	39.68	0.17		2.37E-06	6.00E-06
B-12	2 - Diorite		50	5	1.3	30.29	0.15		NA	NA

Effective and total porosity values taken from Groundwater and Wells (Driscoll, 1986), p. 67.

All slug tests were of the falling head variety. Water levels in the diorite stabilized within the screen interval, which renders the slug test invalid (not performed under these conditions)

Bedrock aquifer thickness was assumed to be approximately 50 feet in thickness within the upper more transmissive zone

Saprolite aquifer thickness, including dense soil and partially weathered rock (100+ bpf material), was determined as the vertical distance from the water table to auger refusal\

NOTE: the methods used to analyze the slug test data, Hvorslev and Bouwer-Rice, are not especially sensitive to the aquifer thickness input parameter

* Vertical distance from top of water table to bottom of screen in the piezometer

**Measured from top of piezometer casing

Insufficient water depth in piezometer to run the slug test at B-10, B-11, B-12, B-13, and B-22

Table 4
Short-Term Ground Water Observations
Borings Relevant to Phase 2A

Boring Number	Boring Date	PVC Pipe Elev.	Ground Elev.	e of Boring Levels Depth, ft.	Elev.	Stabilized Levels (24 hr) Depth, ft.	Elev.	Stabilized Levels (7+ day) Depth, ft.	Elev.	Date
B-7	5/21/2002	734.65	732.63	Dry*		8.8	723.9	8.6	724.0	5/28/2002
B-12	5/1/2002	808.12	806.53	27.0	779.5	28.8	777.7	28.7	777.8	5/28/2002
B-15	5/20/2002	771.71	770.94	Dry w/ Piez		Dry		Dry		
B-16	5/16/2002	781.94	779.32	Dry w/ Piez		Dry		Dry		
B-18	5/9/2002	785.39	782.49	17.8	764.7	19.2	763.3	19.2	763.3	5/28/2002
B-19	5/1/2002	776.64	773.50	35.9	737.6	36.6	736.9	36.5	737.0	5/28/2002
B-20	5/20/2002	782.85	782.40	Dry*		Dry		34.9	747.5	5/28/2002
B-21	4/30/2002	809.97	807.94	51.1	756.9	42.1	765.8	42.0	765.9	5/28/2002
B-27	5/13/2002	797.21	795.68	Dry w/ Piez		Dry		Dry		

*No water encountered at auger refusal, time of completion water level after coring is not representative (piezometers were bailed dry after completion)

All cored borings were bailed dry after obtaining 24-hour water levels and again on May 14, 2002 (except B-13)

**B-13 experienced total water loss during coring, piezometer remained dry

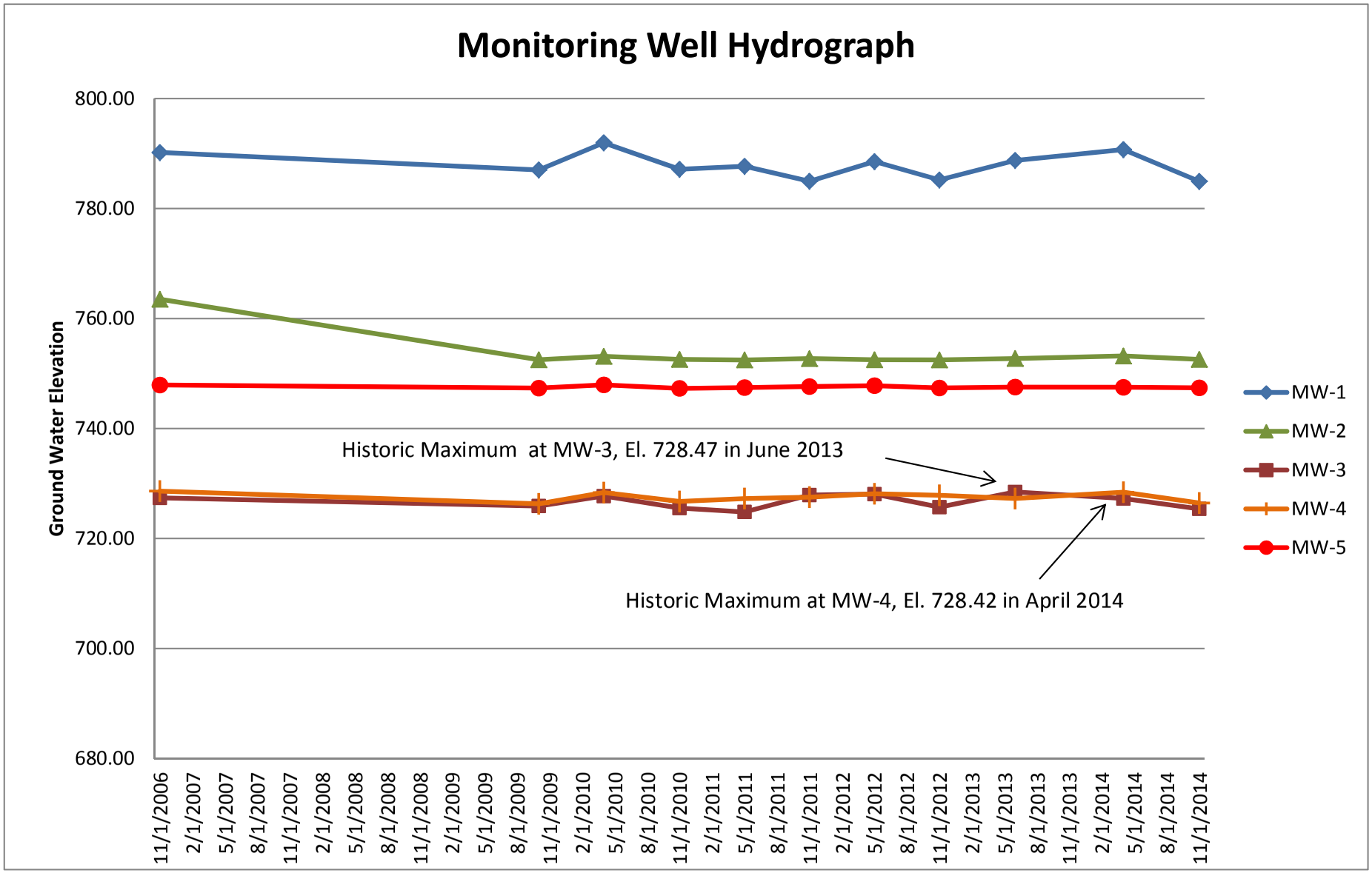
Boring Numbers B-1 through B-5 are reserved for future investigation or monitoring well installation

All water depths shown are referenced from ground surface, bgs (measured from top of piez. casing)

Table 5
Historical Ground Water Levels

Boring Number	11/29/2006 Elev.	10/27/2009 Elev.	4/9/2010 Elev.	11/2/2010 Elev.	5/24/2011 Elev.	11/1/2011 Elev.	5/17/2012 Elev.	11/15/2012 Elev.	6/27/2013 Elev.	4/28/2014 Elev.	11/25/2014 Elev.	Elev.
MW-1	790.20	787.02	791.96	787.14	787.68	784.96	788.55	785.21	788.75	790.73	784.94	
MW-2	763.51	752.51	753.13	752.57	752.47	752.72	752.51	752.49	752.73	753.19	752.57	
MW-3	727.39	725.90	727.72	725.53	724.83	727.91	728.07	725.71	728.47	727.27	725.39	
MW-4	728.62	726.30	728.35	726.73	727.26	727.52	728.13	727.85	727.27	728.42	726.46	
MW-5	747.92	747.35	747.94	747.30	747.45	747.64	747.79	747.38	747.53	747.50	747.39	

*Top of Inner Casing


Monitoring Well Hydrograph
Ground Water Elevation
800.00
780.00
760.00
740.00
720.00
700.00
680.00
11/1/2006
2/1/2007
5/1/2007
8/1/2007
11/1/2007
2/1/2008
5/1/2008
8/1/2008
11/1/2008
2/1/2009
5/1/2009
8/1/2009
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11/1/2012
2/1/2013
5/1/2013
8/1/2013
11/1/2013
2/1/2014
5/1/2014
8/1/2014
11/1/2014
Historic Maximum at MW-3, El. 728.47 in June 2013
Historic Maximum at MW-4, El. 728.42 in April 2014
MW-1
MW-2
MW-3
MW-4
MW-5

Table 6
Horizontal Ground Water Gradient and Velocity Calculations

Based on Bouwer-Rice Solutions (Table 3)

Ground water elevations and reference potentiometric elevations are based on May 2002 observations

Hydr. Unit	Well / Piez. No.	Hydraulic Conductivity (k) cm/sec	Hydraulic Conductivity (k) ft/day	Ground Water El.	Reference Elevation	Vertical Change, ft.	Horizontal Change, ft.	Hydraulic Gradient (I)	Effective Porosity (n)	Ground Water Velocity (V), ft/day
1	B-7	1.20E-05	0.033	724.0	730	6	250	0.024	0.20	0.004
1	B-18	1.37E-06	0.004	763.3	770	6.7	150	0.045	0.20	0.001
1	B-21	7.14E-06	0.020	765.9	770	4.1	125	0.033	0.20	0.003
2	B-19	6.00E-06	0.017	737.0	750	13	210	0.062	0.17	0.006

Notes: Ground Water Velocity Calculated from Equation:

$V=KI/n$ where K = Hydraulic Conductivity in ft/day
I = Hydraulic Gradient in units of ft/ft
n = Effective Porosity is unitless
V = Ground Water Velocity in ft/day

Hydraulic Conductivity Conversion Factor: 1 ft/day = 3.59E-04 cm/sec

Effective Porosity values from published literature (see footnote on Table 3).

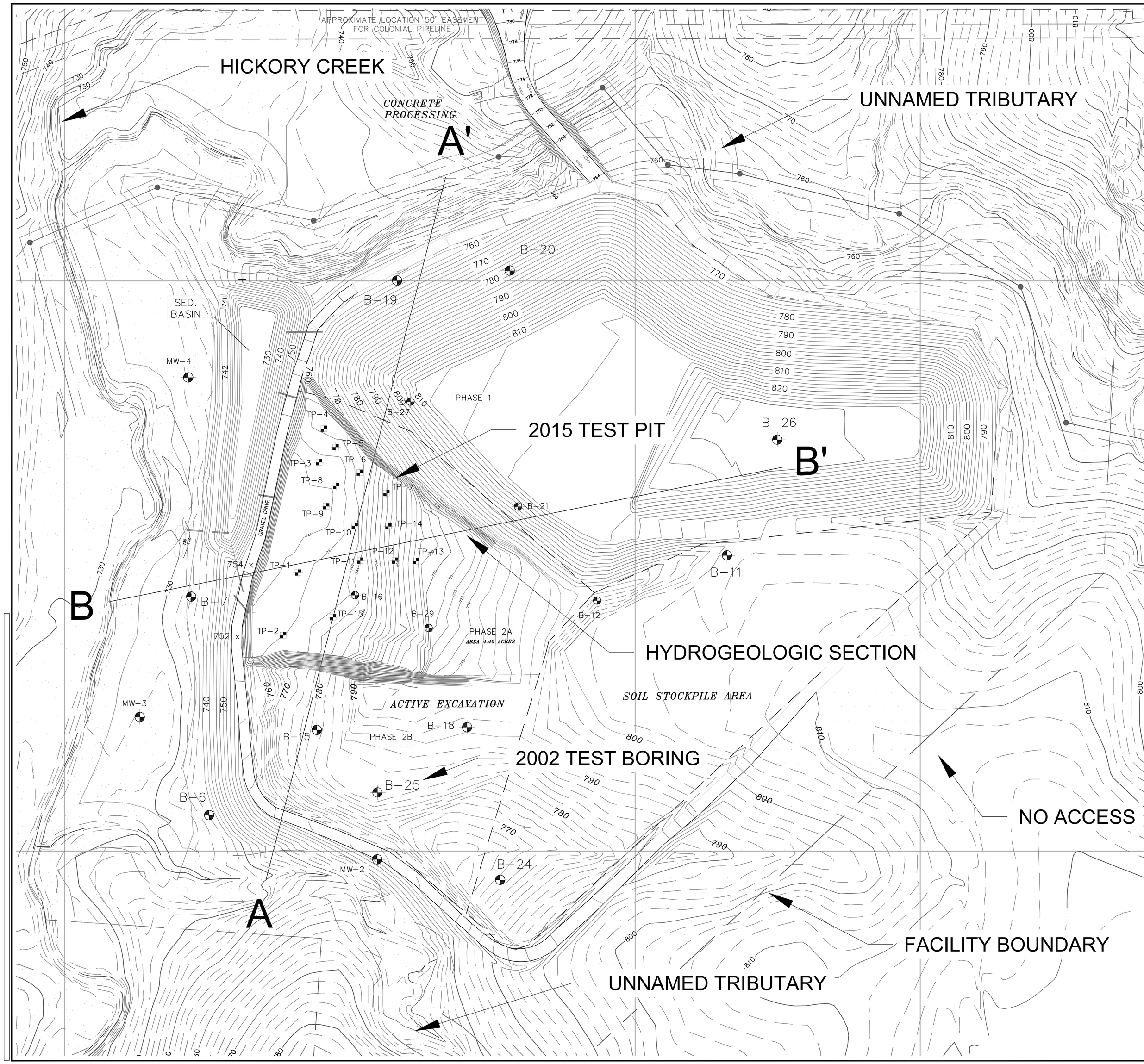
Table 7
Test Pit Observations

Test Pit	Ground Elevation	Excavated Depth	Bottom Excavation*	Water Depth	Water Elevation
1	740.2	6	734.2	3.5	736.7
2	740.2	6	734.2	3.5	736.7
3	741.3	6	735.3	3.0	738.3
4	742.4	6	736.4	5.0	737.4
5	744.1	6	738.1	3.0	741.1
6	743.5	6	737.5	4.0	739.5
7	753.0	4	749.0	dry	NA
8	741.3	6	735.3	2.0	739.3
9	741.3	6	735.3	2.0	739.3
10	743.1	6	737.1	4.0	739.1
11	740.0	5	735.0	dry	NA
12	759.0	5	754.0	dry	NA
13	768.0	4	764.0	dry	NA
14	755.0	4	751.0	dry	NA
15	743.5	4	739.5	3.5	740.0
Sump	740.0	3	737.0	2.0	738.0

Note: Test pits were excavated March 17, 2015 and observed for water on March 18, 2015

*Highest possible rock elevation at this test pit, though none was encountered

APPENDIX 2
Design Hydro Drawings



250 0 250 500 750

Scale 1" = 250'

Bar is 1" on original drawing

LEGEND

PROPOSED

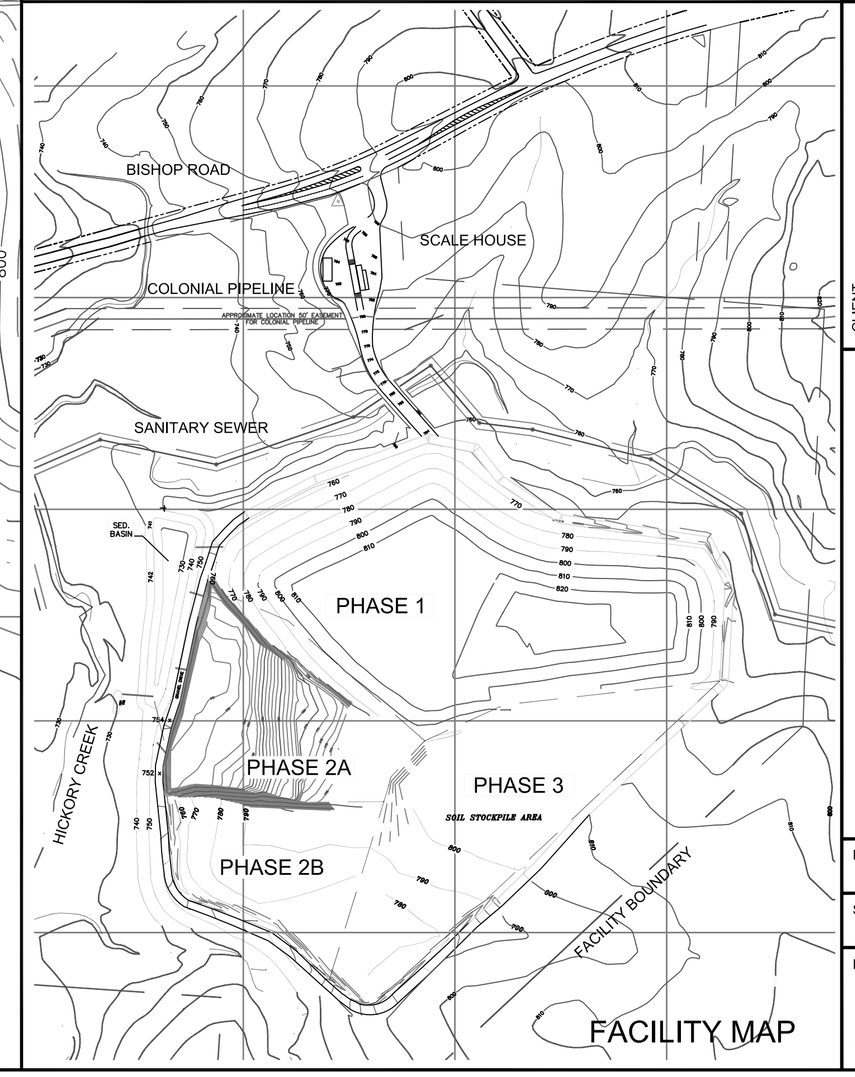
- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (280)
- CELL AND WASTE LIMITS

NOTE:
CONTOURS SHOWN FOR CELLS 1A / 1B, 2A AND 2B REPRESENT FINAL TOP OF WASTE GRADES

EXISTING

- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (280)
- FACILITY BOUNDARY
- SANITARY SEWER
- WATERCOURSE BUFFER ZONE
- PROPERTY BUFFER ZONE
- 100 YR FLOODPLAIN
- WATERCOURSE

BASE GRADE CONTOURS FOR PHASE 2 SHOWN AS SURVEYED IN MARCH 2015



FACILITY MAP

NORTH CAROLINA PROFESSIONAL SEAL 22168 ENGINEER DAVID G. GARRETT
7/28/2015
NC CORP. LICENSE NO. C-1837

NO.	REVISION	DATE
1	REVISED PER REGULATORY REVIEW	7-14-2014

SHEET TITLE: INITIAL CONDITIONS W/ TEST LOCATIONS

PROJECT TITLE: PERMIT RENEWAL APPLICATION PHASE 2 PERMIT TO CONSTRUCT

CLIENT: A-1 SANDROCK, INC. PERMIT NO. 41-17-CDLF-2008 2091 BISHOP ROAD GREENSBORO, NC 27406

SCS ENGINEERS, PC
2520 WHITEHALL PARK DRIVE, SUITE 450
CHARLOTTE, NORTH CAROLINA 28273
PHONE: (704) 504-3107 FAX: (704) 504-3174

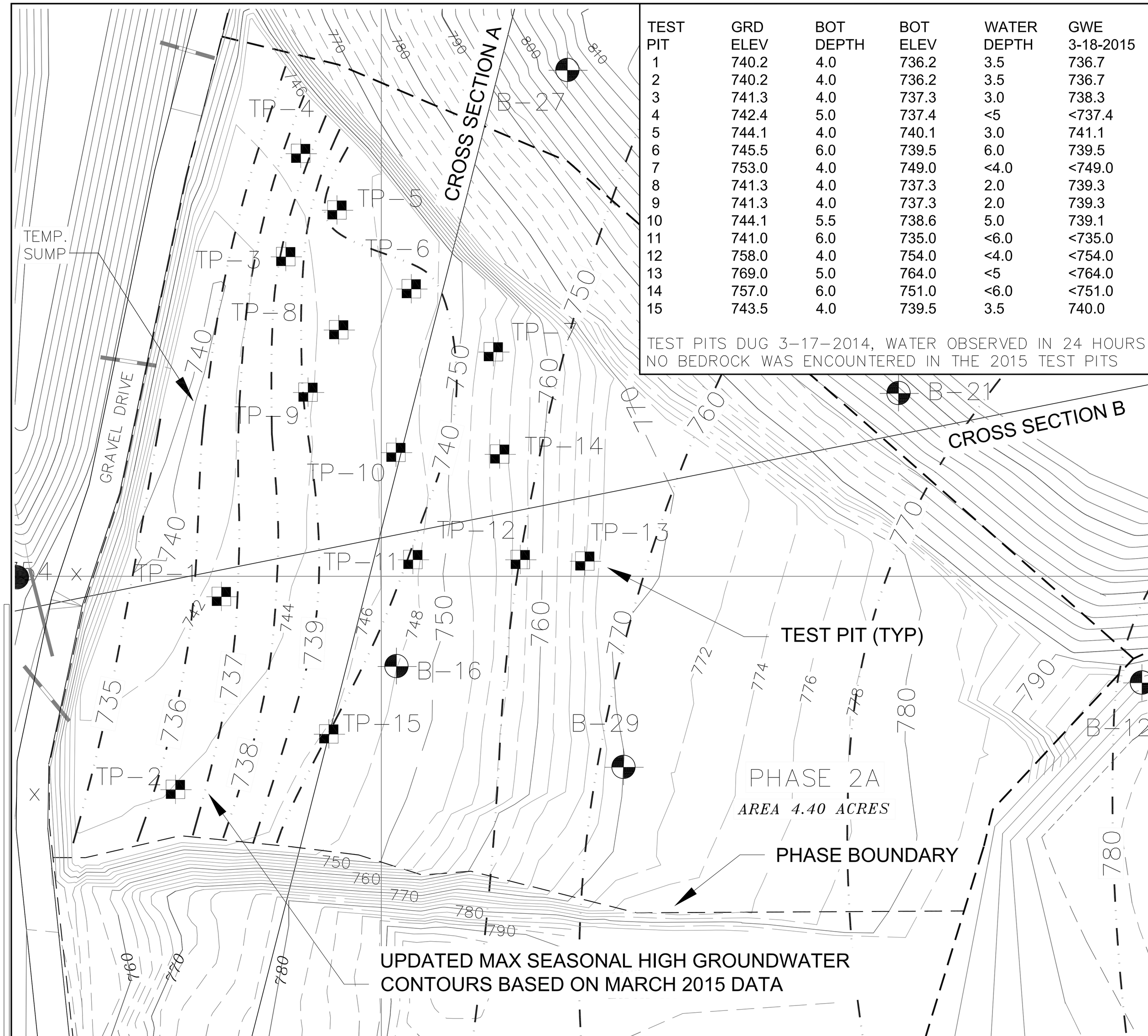
PROJ. NO. 02224704.00 T3 | DSN. BY: GDG | DWN. BY: GDG | CHK. BY: SCL | QA RVW BY: | APP. BY:

DATE: 4/14/2015

SCALE: AS SHOWN

DRAWING NO. S1

Sheet 1 of 6



TEST PIT	GRD ELEV	BOT DEPTH	BOT ELEV	WATER DEPTH	GWE 3-18-2015
1	740.2	4.0	736.2	3.5	736.7
2	740.2	4.0	736.2	3.5	736.7
3	741.3	4.0	737.3	3.0	738.3
4	742.4	5.0	737.4	<5	<737.4
5	744.1	4.0	740.1	3.0	741.1
6	745.5	6.0	739.5	6.0	739.5
7	753.0	4.0	749.0	<4.0	<749.0
8	741.3	4.0	737.3	2.0	739.3
9	741.3	4.0	737.3	2.0	739.3
10	744.1	5.5	738.6	5.0	739.1
11	741.0	6.0	735.0	<6.0	<735.0
12	758.0	4.0	754.0	<4.0	<754.0
13	769.0	5.0	764.0	<5	<764.0
14	757.0	6.0	751.0	<6.0	<751.0
15	743.5	4.0	739.5	3.5	740.0

TEST PITS DUG 3-17-2014, WATER OBSERVED IN 24 HOURS
NO BEDROCK WAS ENCOUNTERED IN THE 2015 TEST PITS

N

80 0 80 120 200

Scale 1" = 80'

Bar is 1" on original drawing

LEGEND

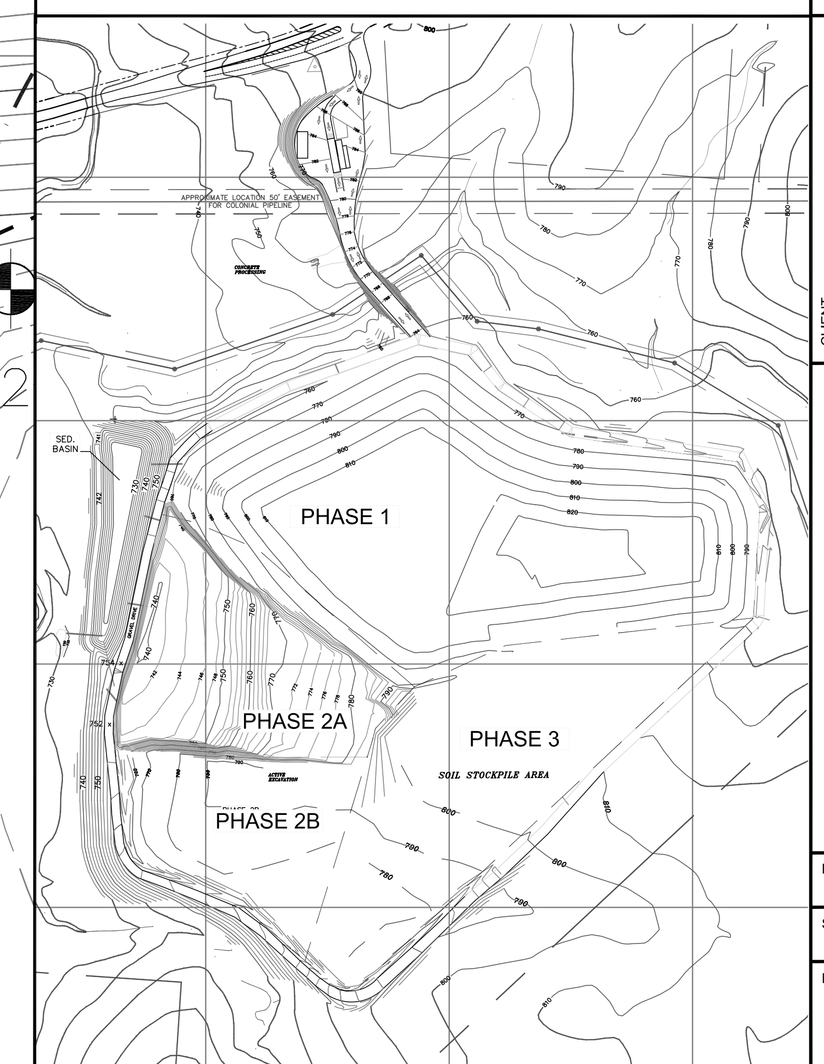
TEST BORING/PIEZOMETER (2002)

TEST PIT EXCAVATED 4-17-2015

EXISTING

- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR
FACILITY BOUNDARY
SANITARY SEWER
WATERCOURSE BUFFER ZONE
PROPERTY BUFFER ZONE
100 YR FLOODPLAIN
GROUONDWATER CONTOUR
PHASE BOUNDARY

BASE GRADE CONTOURS FOR PHASE 2
SHOWN AS SURVEYED IN APRIL 2015



NORTH CAROLINA PROFESSIONAL SEAL 22062 ENGINEER SCOTT L. GARRETT
7/28/2015
NC CORP. LICENSE NO. C-1837

NO.	REVISION	DATE
1	REVISED PER REGULATORY REVIEW	7-14-2014

SHEET TITLE
FINAL GRADES & GROUNDWATER SEPARATION

PROJECT TITLE
PERMIT RENEWAL APPLICATION
PHASE 2 PERMIT TO CONSTRUCT

CLIENT
A-1 SANDROCK, INC.
PERMIT NO. 41-17-CDLF-2008
2091 BISHOP ROAD
GREENSBORO, NC 27406

SCS ENGINEERS, PC
2520 WHITEHALL PARK DRIVE, SUITE 450
CHARLOTTE, NORTH CAROLINA 28273
PHONE: (704) 504-3107 FAX: (704) 504-3174

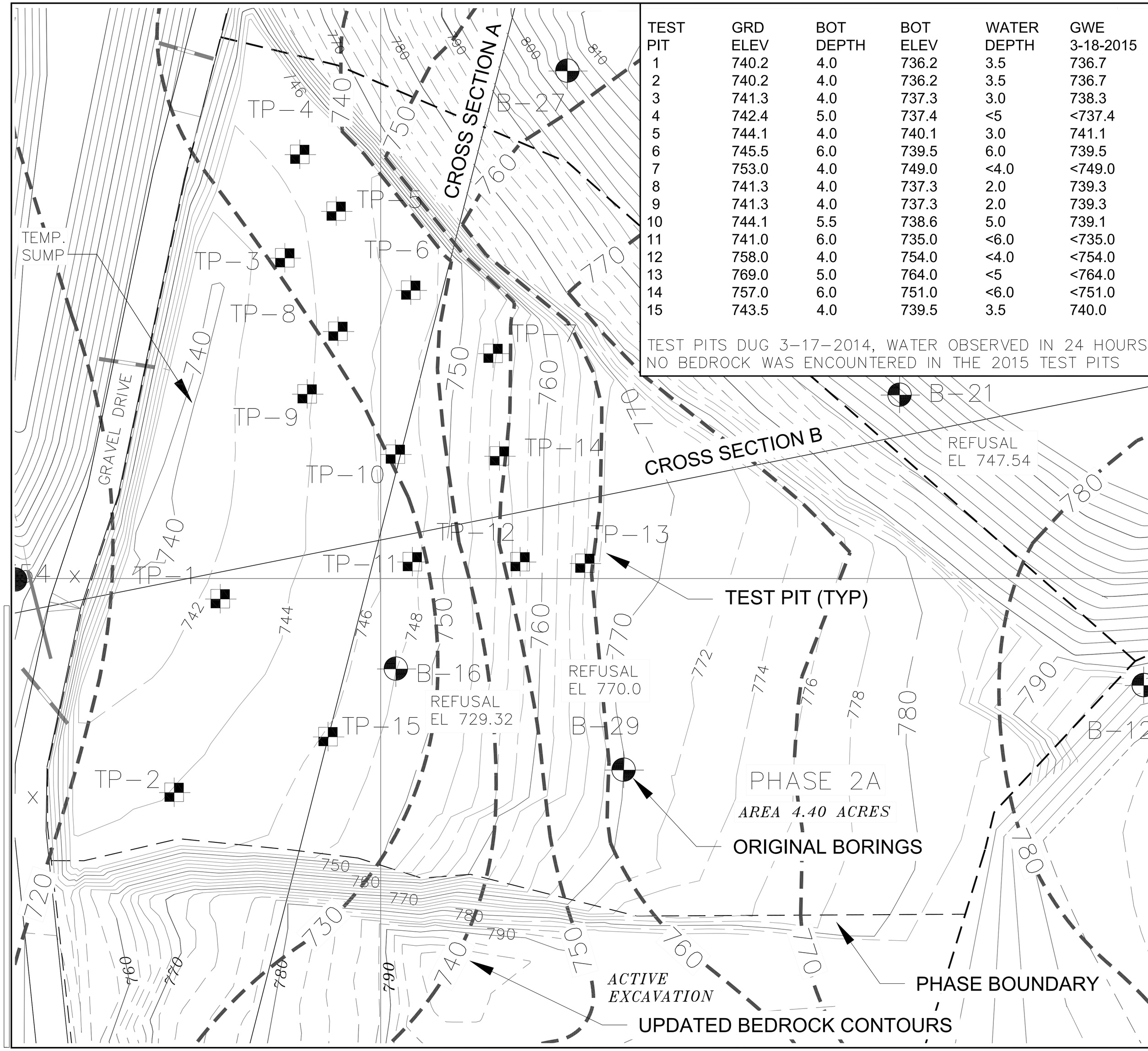
PROJ. NO. 0221417.04.00 T3
DSN. BY: GDG
DWN. BY: GDG
CHK. BY: SCL
QA RVW BY:
APP. BY:

DATE: 4/14/2015

SCALE: AS SHOWN

DRAWING NO. S2

Sheet 2 of 6



TEST PIT	GRD ELEV	BOT DEPTH	BOT ELEV	WATER DEPTH	GWE 3-18-2015
1	740.2	4.0	736.2	3.5	736.7
2	740.2	4.0	736.2	3.5	736.7
3	741.3	4.0	737.3	3.0	738.3
4	742.4	5.0	737.4	<5	<737.4
5	744.1	4.0	740.1	3.0	741.1
6	745.5	6.0	739.5	6.0	739.5
7	753.0	4.0	749.0	<4.0	<749.0
8	741.3	4.0	737.3	2.0	739.3
9	741.3	4.0	737.3	2.0	739.3
10	744.1	5.5	738.6	5.0	739.1
11	741.0	6.0	735.0	<6.0	<735.0
12	758.0	4.0	754.0	<4.0	<754.0
13	769.0	5.0	764.0	<5	<764.0
14	757.0	6.0	751.0	<6.0	<751.0
15	743.5	4.0	739.5	3.5	740.0

TEST PITS DUG 3-17-2014, WATER OBSERVED IN 24 HOURS
NO BEDROCK WAS ENCOUNTERED IN THE 2015 TEST PITS

N

80 0 80 120 200

Scale 1" = 80'

Bar is 1" on original drawing

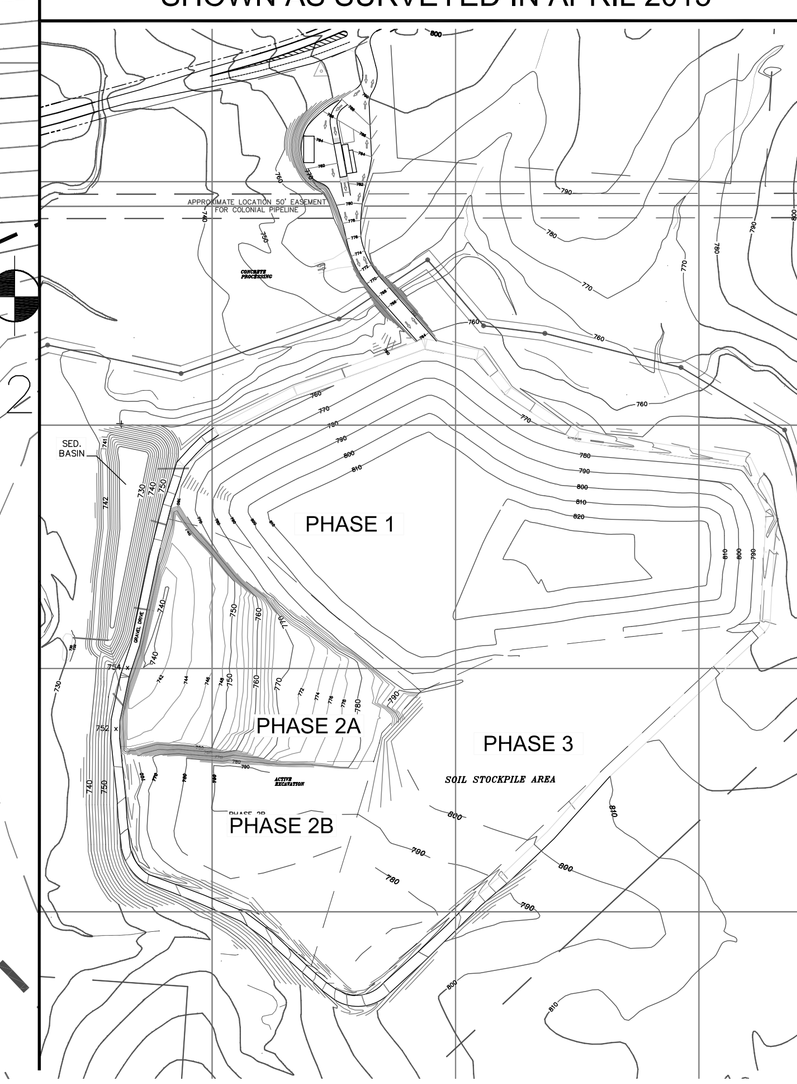
LEGEND

- TEST BORING/PIEZOMETER (2002)
- TEST PIT EXCAVATED 4-17-2015

EXISTING

- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (780)
- FACILITY BOUNDARY
- SANITARY SEWER
- WATERCOURSE BUFFER ZONE
- PROPERTY BUFFER ZONE
- 100 YR FLOODPLAIN
- GROUONDWATER CONTOUR
- PHASE BOUNDARY

BASE GRADE CONTOURS FOR PHASE 2
SHOWN AS SURVEYED IN APRIL 2015



NORTH CAROLINA PROFESSIONAL SEAL 022647 ENGINEER SCOTT L. CARRETT
7/28/2015
NC CORP. LICENSE NO. C-1837

NO.	REVISION	DATE
1	REVISED PER REGULATORY REVIEW	7-14-2014

SHEET TITLE: FINAL GRADES & BEDROCK SEPARATION

PROJECT TITLE: PERMIT RENEWAL APPLICATION PHASE 2 PERMIT TO CONSTRUCT

CLIENT: A-1 SANDROCK, INC.
PERMIT NO. 41-17-CDLF-2008
2091 BISHOP ROAD
GREENSBORO, NC 27406

SCS ENGINEERS, PC
2520 WHITEHALL PARK DRIVE, SUITE 450
CHARLOTTE, NORTH CAROLINA 28273
PHONE: (704) 504-3107 FAX: (704) 504-3174

PROJ. NO. 0224704.00 T3
DSN. BY: GDG
DWN. BY: GDG
CHK. BY: SCL
QA RVW BY:
APP. BY:

DATE: 4/14/2015

SCALE: AS SHOWN

DRAWING NO. S3

PHASE 1

VERTICAL SEPARATION BETWEEN FINAL BASE GRADES AND BEDROCK OR GROUND WATER (MIN. VALUES)

GRAVEL DRIVE

PHASE 2A

AREA 4.40 ACRES

ACTIVE EXCAVATION

PHASE BOUNDARY

Scale 1" = 80'

Bar is 1" on original drawing

LEGEND

PROPOSED

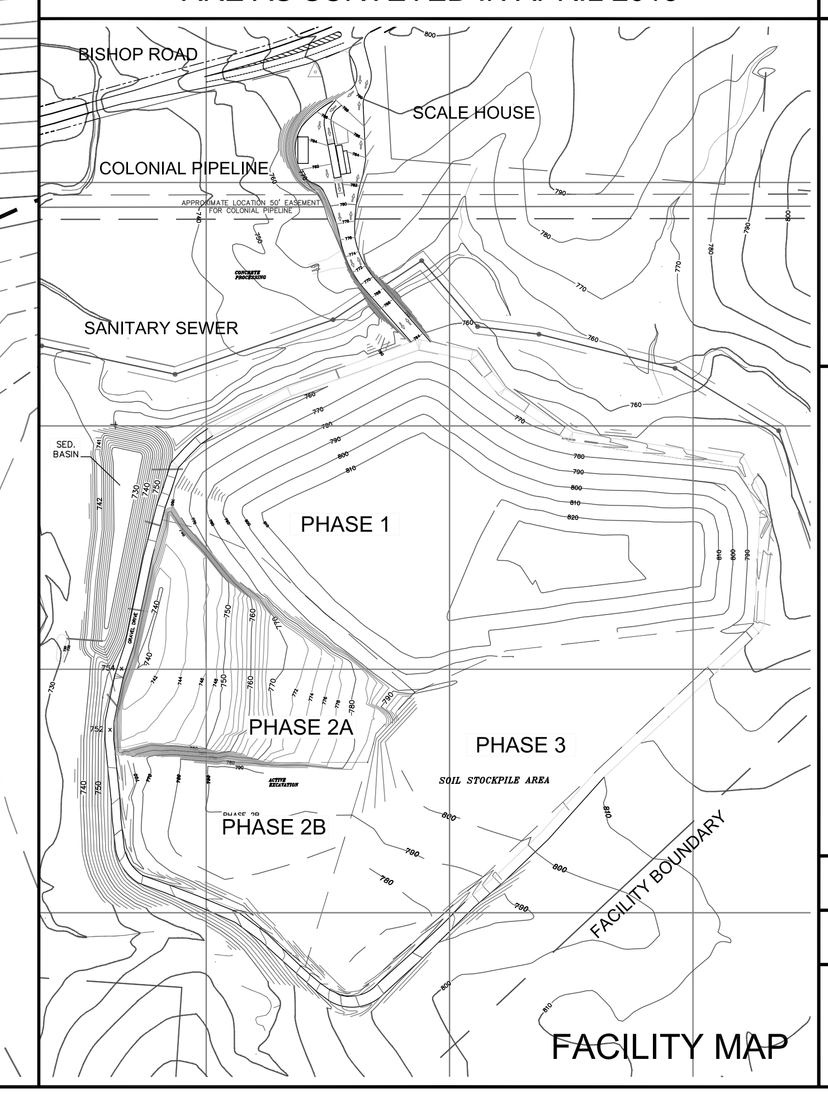
- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (280)
- CELL AND WASTE LIMITS

NOTE:
CONTOURS SHOWN FOR CELLS 1A / 1B, 2A AND 2B REPRESENT FINAL TOP OF WASTE GRADES

EXISTING

- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (280)
- FACILITY BOUNDARY
- SANITARY SEWER
- WATERCOURSE BUFFER ZONE
- PROPERTY BUFFER ZONE
- 100 YR FLOODPLAIN
- WATERCOURSE

BASE GRADE CONTOURS FOR PHASE 2 ARE AS SURVEYED IN APRIL 2015



FACILITY MAP

NORTH CAROLINA PROFESSIONAL SEAL 22068 ENGINEER DAVID G. GARRETT

7/28/2015

NC CORP. LICENSE NO. C-1837

NO.	REVISION	DATE
1	REVISED PER REGULATORY REVIEW	7-14-2014

SHEET TITLE: VERTICAL SEPARATION ISOPACH

PROJECT TITLE: PERMIT RENEWAL APPLICATION PHASE 2 PERMIT TO CONSTRUCT

CLIENT: A-1 SANDROCK, INC. PERMIT NO. 41-17-CDLF-2008 2091 BISHOP ROAD GREENSBORO, NC 27406

SCS ENGINEERS, PC
2520 WHITEHALL PARK DRIVE, SUITE 450
CHARLOTTE, NORTH CAROLINA 28273
PHONE: (704) 504-3174 FAX: (704) 504-3107

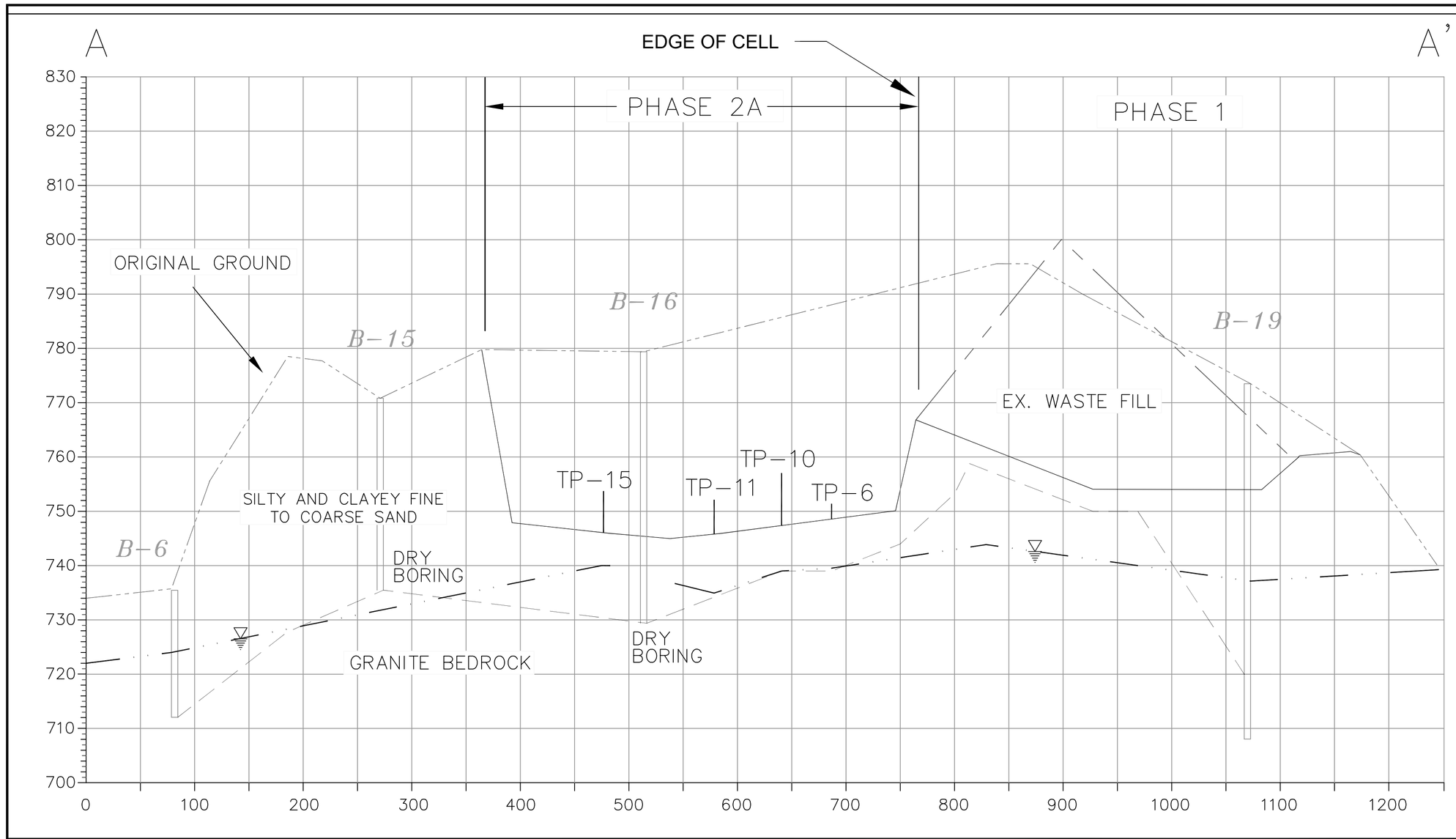
PROJ. NO. 02214704.00 T3 | DSN. BY: GDG | DWN. BY: GDG | CHK. BY: SCL | QA RVW BY: | APP. BY:

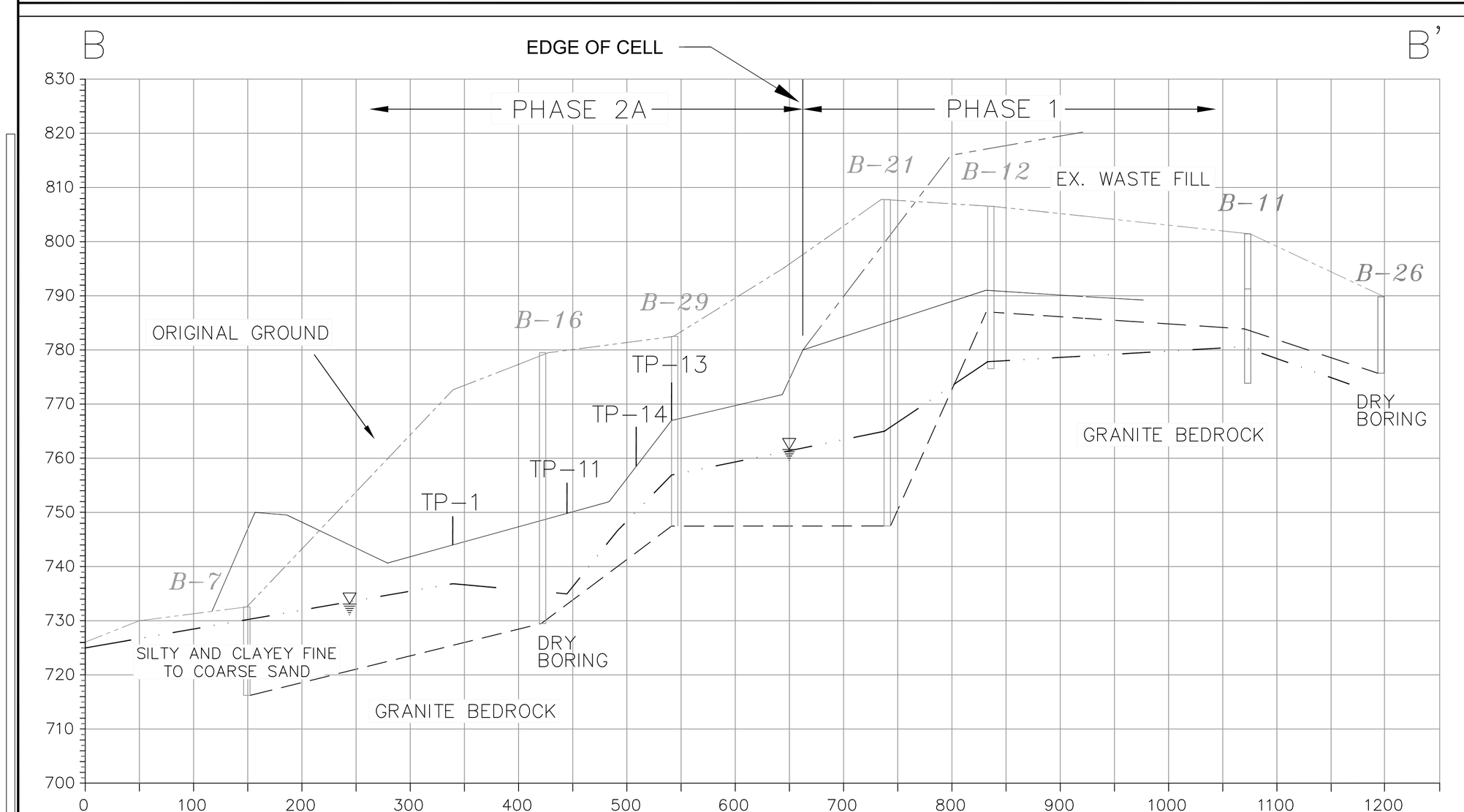
DATE: 4/14/2015

SCALE: AS SHOWN

DRAWING NO. S4

Sheet 4 of 6





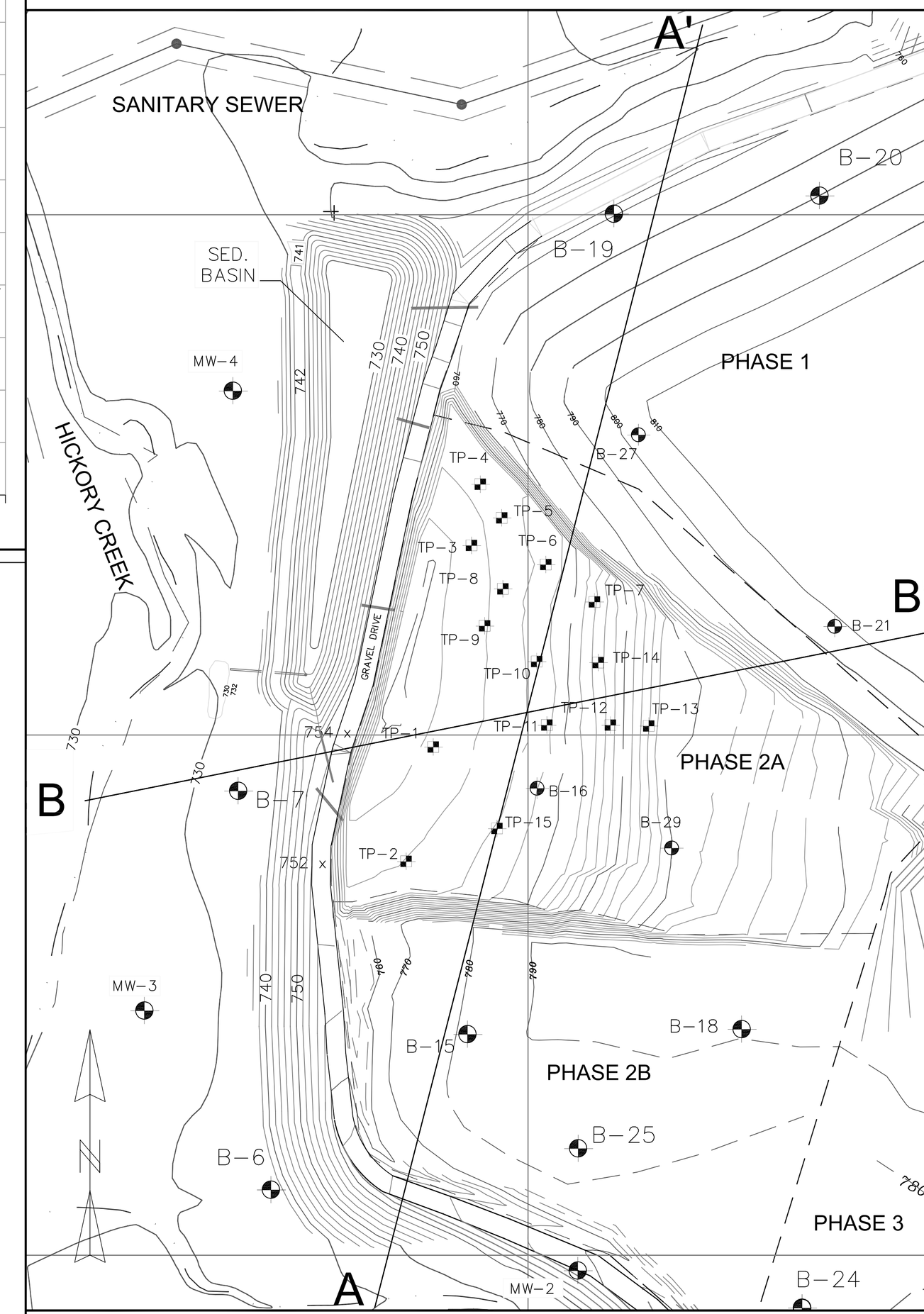
LEGEND

- ORIGINAL GROUND SURFACE
- FINISHED BASE GRADE
- UPDATED MAXIMUM SEASONAL HIGH GROUND WATER
- BEDROCK SURFACE
- EXISTING WASTE SURFACE

BASE GRADE CONTOURS FOR PHASE 2 SHOWN AS SURVEYED IN APRIL 2015

GROUNDWATER AND BEDROCK CONTOURS ARE MODIFIED FROM EARLIER STUDIES USING TEST PIT DATA FROM MARCH 2015

PHASE 1 BASE GRADES FROM AS-BUILT SURVEYS



LOCATION MAP

NORTH CAROLINA PROFESSIONAL SEAL 21062 ENGINEER GARRETT D. GARRETT
7/28/2015
NC CORP. LICENSE NO. C-1837

NO.	REVISION	DATE
1	REVISED PER REGULATORY REVIEW	7-14-2014

SHEET TITLE: HYDROGEOLOGIC CROSS SECTIONS

PROJECT TITLE: PERMIT RENEWAL APPLICATION PHASE 2 PERMIT TO CONSTRUCT

CLIENT: A-1 SANDROCK, INC. PERMIT NO. 41-17-CDLF-2008 2091 BISHOP ROAD GREENSBORO, NC 27406

SCS ENGINEERS, PC
2520 WHITEHALL PARK DRIVE, SUITE 450
CHARLOTTE, NORTH CAROLINA 28273
PHONE: (704) 504-3107 FAX: (704) 504-3174

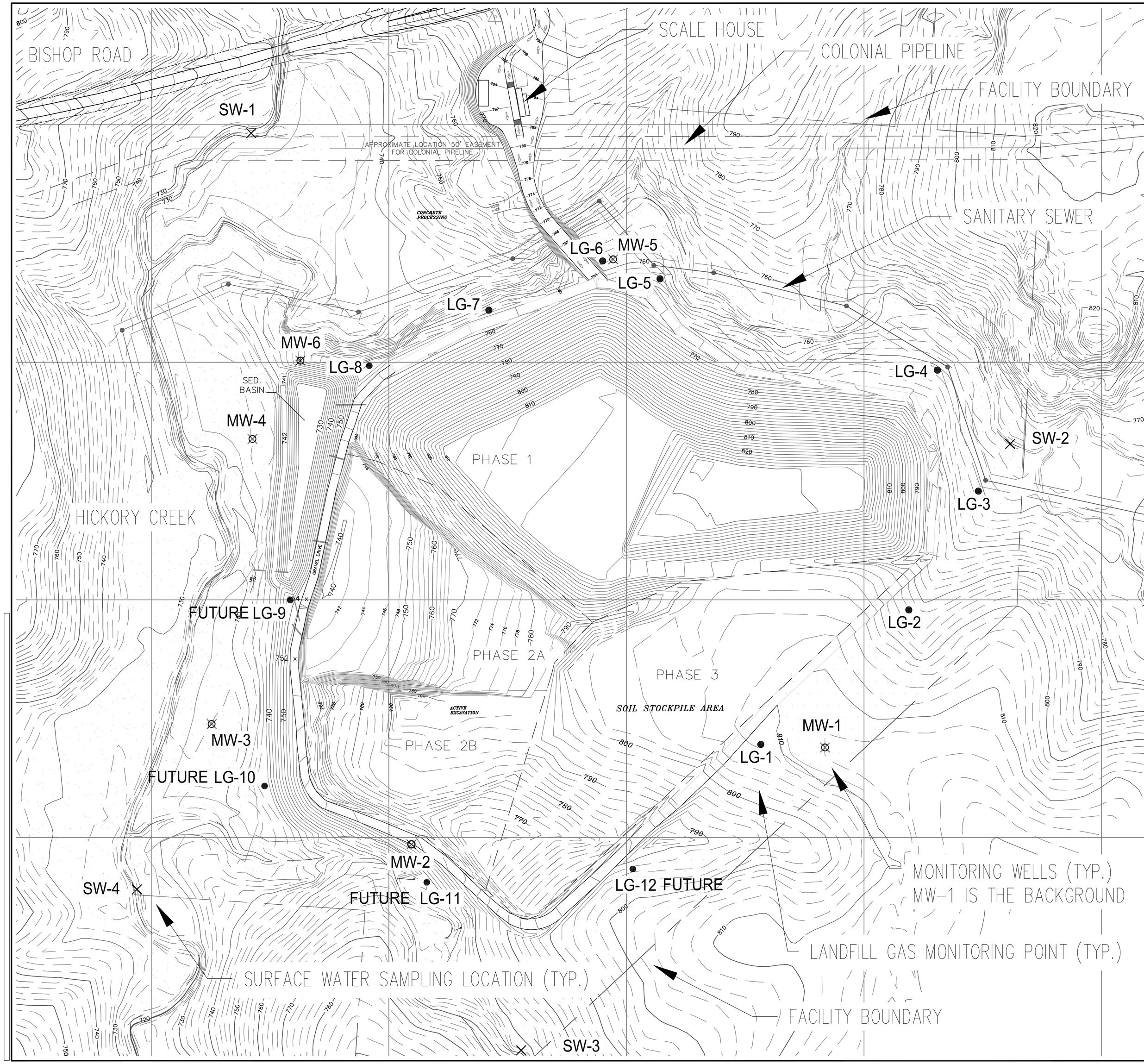
PROJ. NO. 02214704.00 T3 | DSN. BY: GDG | DWN. BY: GDG | CHK. BY: SCL | QA RVW BY: | APP. BY:

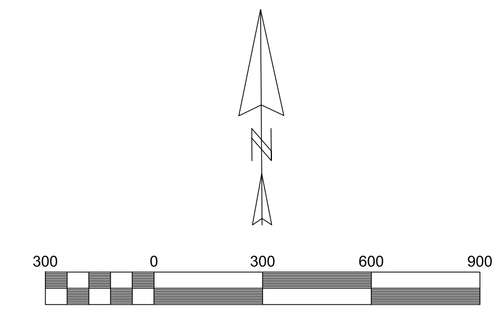
DATE: 4/14/2015

SCALE: AS SHOWN

DRAWING NO. X1

Sheet 5 of 6





Scale 1" = 300'

Bar is 1" on original drawing

LEGEND

PROPOSED

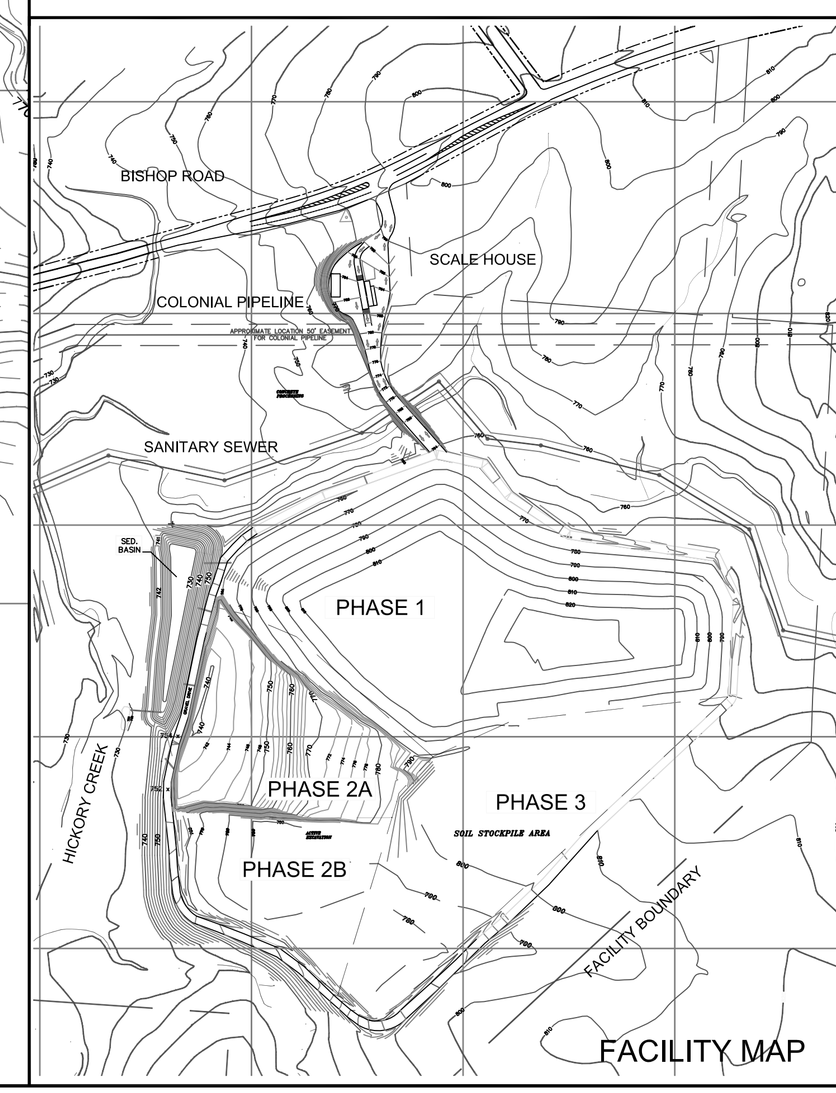
- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (280)
- CELL AND WASTE LIMITS

NOTE:
CONTOURS SHOWN FOR CELLS 1A / 1B, 2A AND 2B REPRESENT FINAL TOP OF WASTE GRADES

EXISTING

- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (280)
- FACILITY BOUNDARY
- SANITARY SEWER
- WATERCOURSE BUFFER ZONE
- PROPERTY BUFFER ZONE
- 100 YR FLOODPLAIN
- WATERCOURSE

BASE GRADE CONTOURS FOR PHASE 2 ARE AS SURVEYED IN APRIL 2015



FACILITY MAP

NORTH CAROLINA PROFESSIONAL SEAL 22068 ENGINEER DAVID G. GARRETT
7/28/2015
NC CORP. LICENSE NO. C-1837

NO.	REVISION	DATE
1	ADDED MW-6 AND REGULATORY REVIEW	7-14-2014
2		
3		
4		
5		
6		

SHEET TITLE: WATER AND GAS MONITORING LOCATIONS

PROJECT TITLE: PERMIT RENEWAL APPLICATION PHASE 2 PERMIT TO CONSTRUCT

CLIENT: A-1 SANDROCK, INC.
PERMIT NO. 41-17-CDLF-2008
2091 BISHOP ROAD
GREENSBORO, NC 27406

SCS ENGINEERS, PC
2520 WHITEHALL PARK DRIVE, SUITE 450
CHARLOTTE, NORTH CAROLINA 28273
PHONE: (704) 504-3107 FAX: (704) 504-3174

PROJ. NO. 0224141704.00 T3
DWN. BY: GDG
CHK. BY: SCL
QA RVW BY:
APP. BY:
DSN. BY: GDG

DATE: 4/30/2015

SCALE: AS SHOWN

DRAWING NO. M1

Sheet 6 of 6

APPENDIX 3
Phase 2A Boring Logs

David Garrett, P.G., P.E.

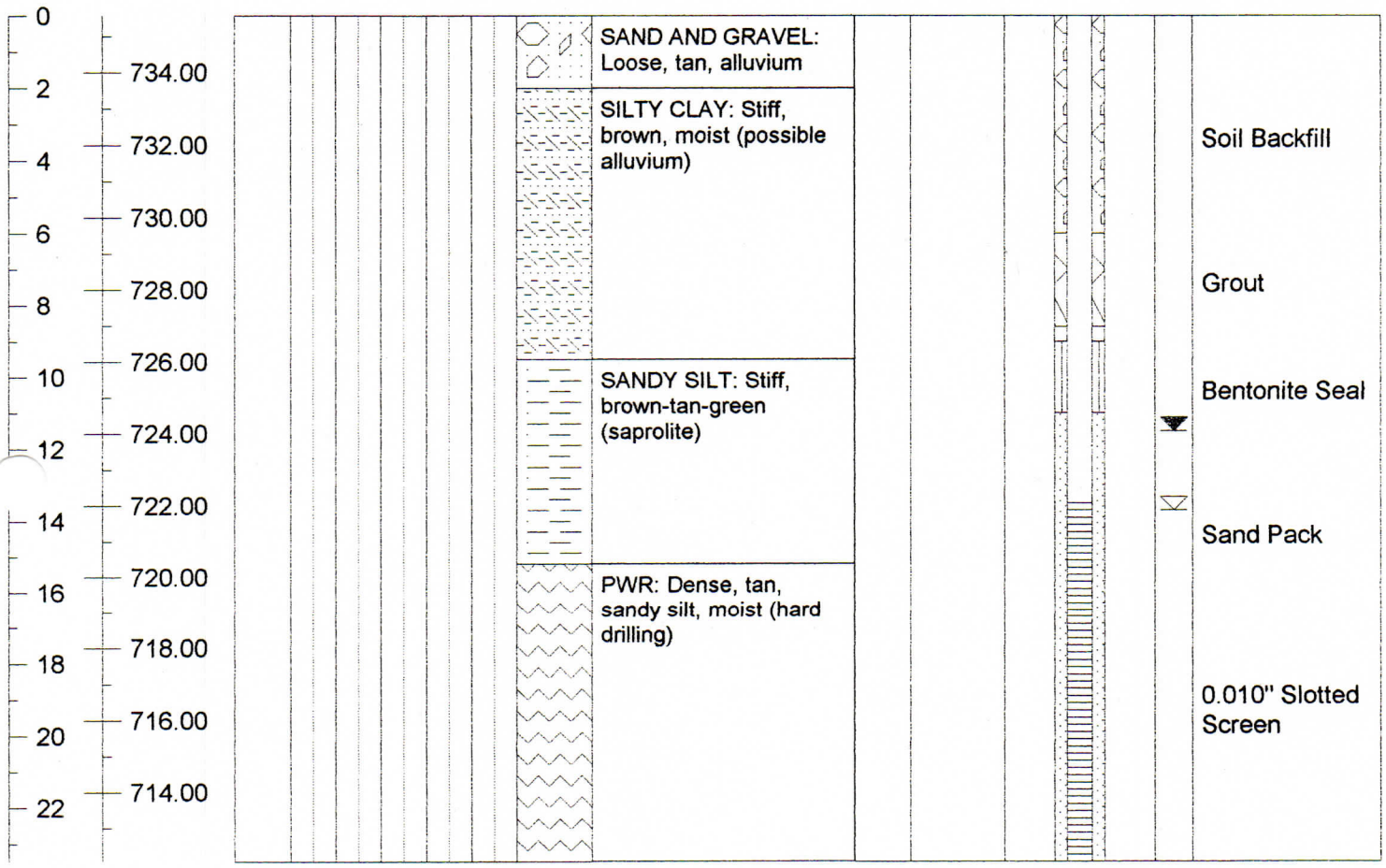
Engineering and Geology

Boring No. B-6

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**735.57**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**13.7**
Date Started	**5/21/02**	Date Ended	**5/21/02**	Water Level, 24 Hr.	**11.7**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**11.5**
Comments	**Cleared access road through woods**	Total Depth	**23.5**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

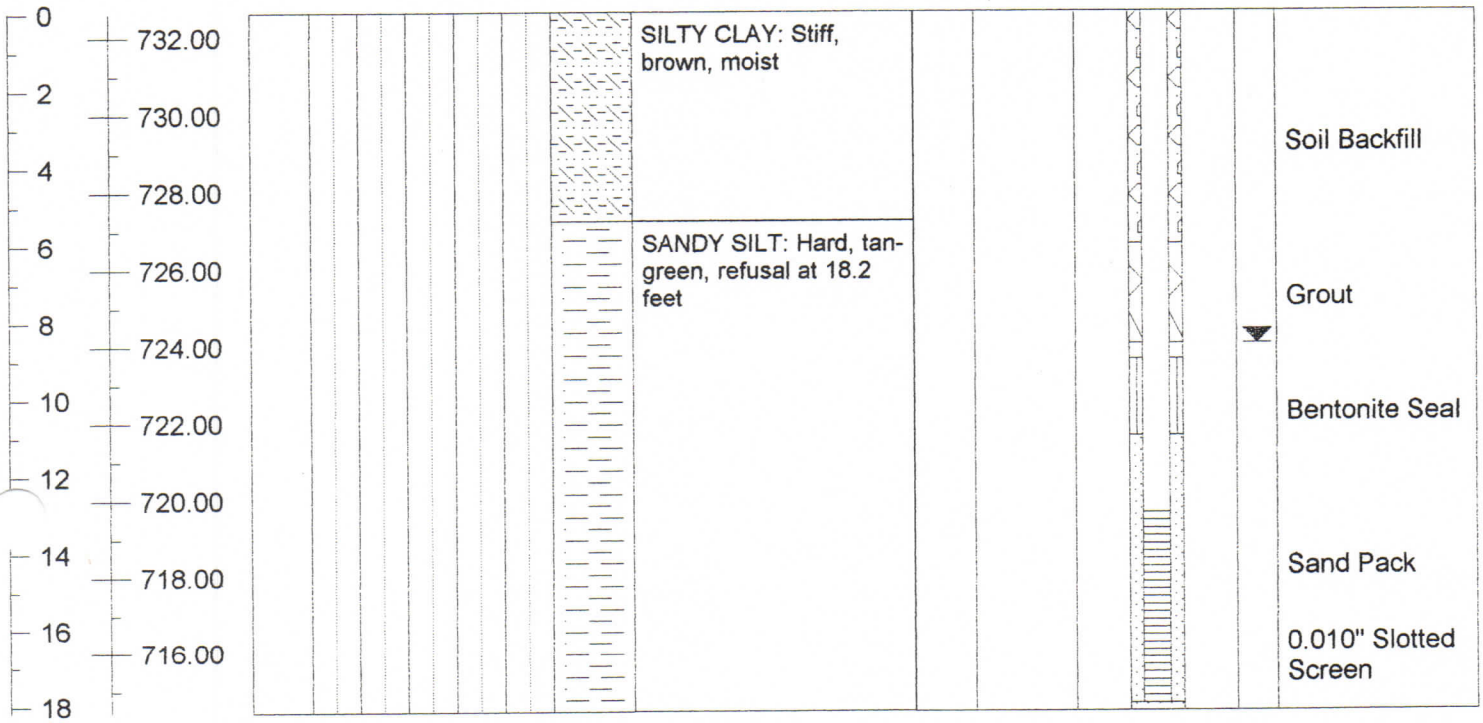
Engineering and Geology

Boring No. B-7

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**732.63**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**Dry**
Date Started	**5/21/02**	Date Ended	**5/21/02**	Water Level, 24 Hr.	**8.8**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**8.6**
Comments	**Cleared access road through woods**	Total Depth	**18.2**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

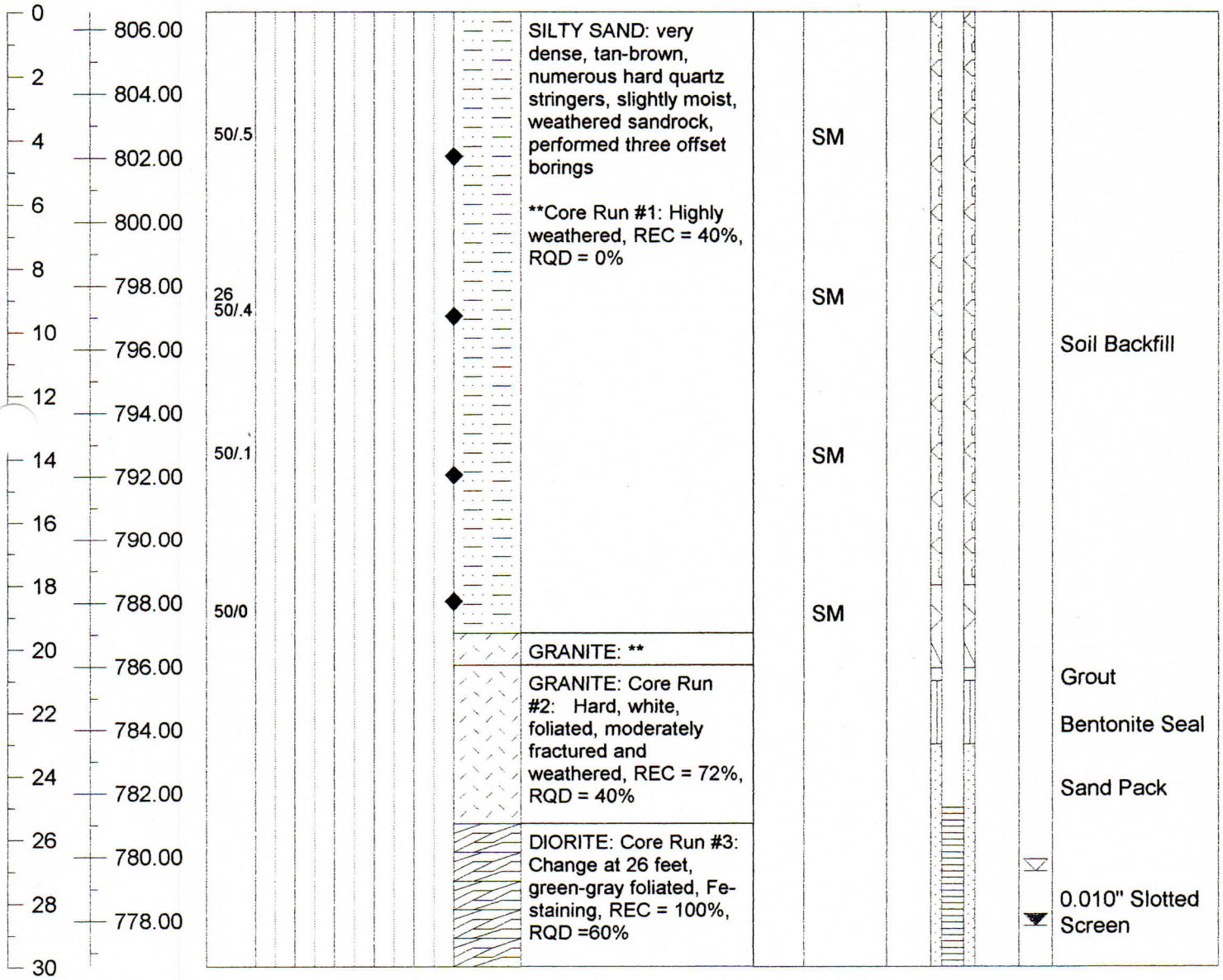
Engineering and Geology

Boring No. B-12

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**806.53**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA/NQWL core**	Water Level, TOB	**27.0**
Date Started	**5/1/02**	Date Ended	**5/1/02**	Water Level, 24 Hr.	**28.8**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**28.7**
Comments	**Cleared access road through woods**	Total Depth	**30.0**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

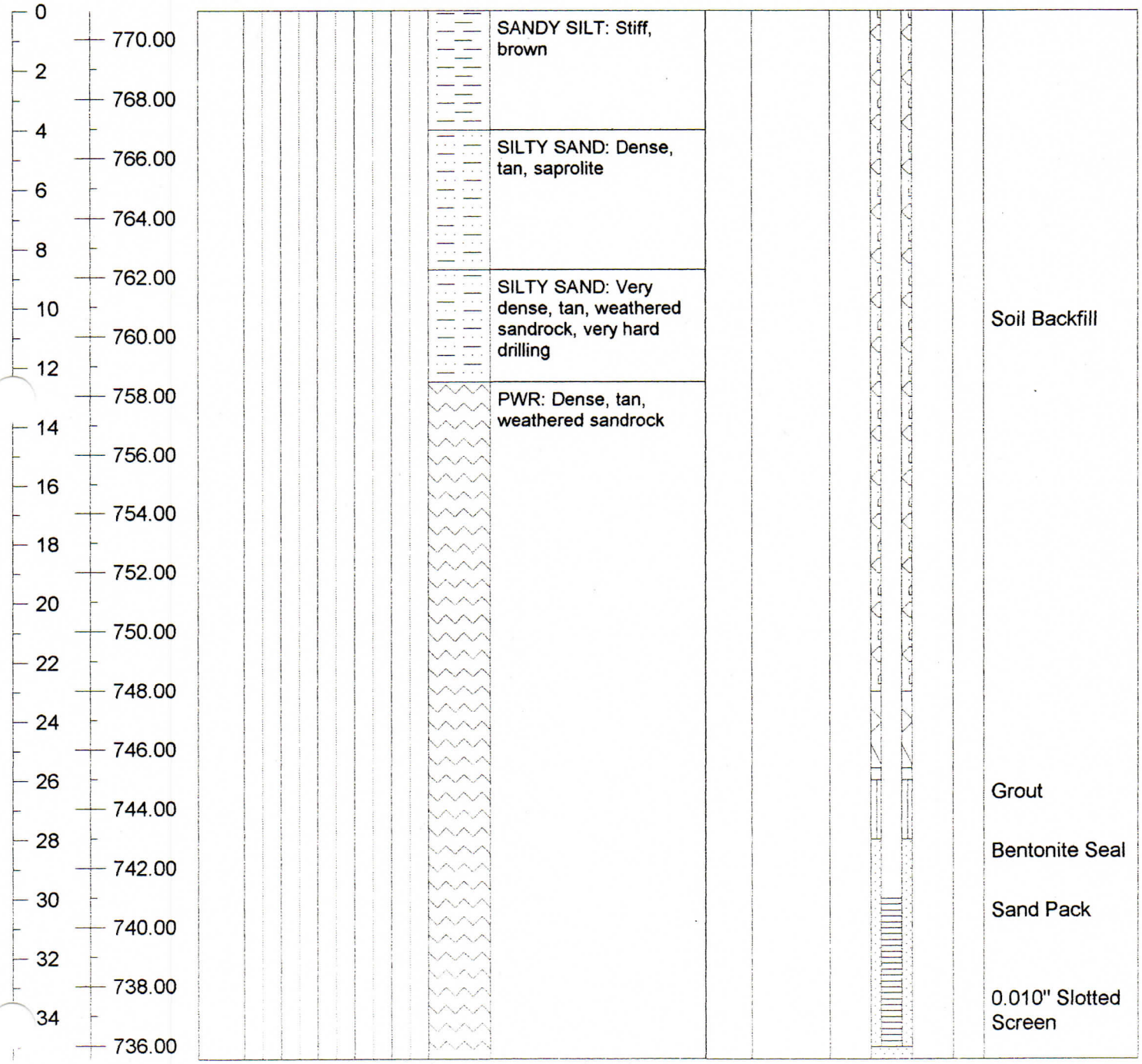
Engineering and Geology

Boring No. B-15

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**770.94**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**Dry**
Date Started	**5/20/02**	Date Ended	**5/20/02**	Water Level, 24 Hr.	**Dry**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**Dry**
Comments	**Cleared access road through woods**	Total Depth	**35.4**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

Engineering and Geology

Boring No. B-16

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**779.32**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**Dry**
Date Started	**5/16/02**	Date Ended	**5/16/02**	Water Level, 24 Hr.	**Dry**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**Dry**
Comments	**Cleared access road through woods**	Total Depth	**50.0**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data
0 / 778.00		SILTY SAND: Dense, tan, scattered hard zone at 9 to 10.5 feet	
2 / 776.00			
4 / 774.00			
6 / 772.00			
8 / 770.00			
10 / 768.00		SILTY SAND: Hard, tan, weathered sandrock	Soil Backfill
12 / 766.00			
14 / 764.00			
16 / 762.00			
18 / 760.00			
20 / 758.00			
22 / 756.00			
24 / 754.00		PWR: Very dense, tan, zones of difficult drilling from 25 to 27 feet	Soil Backfill
26 / 752.00			
28 / 750.00			
30 / 748.00			
32 / 746.00			Grout
34 / 744.00			
36			Bentonite Seal

David Garrett, P.G., P.E.

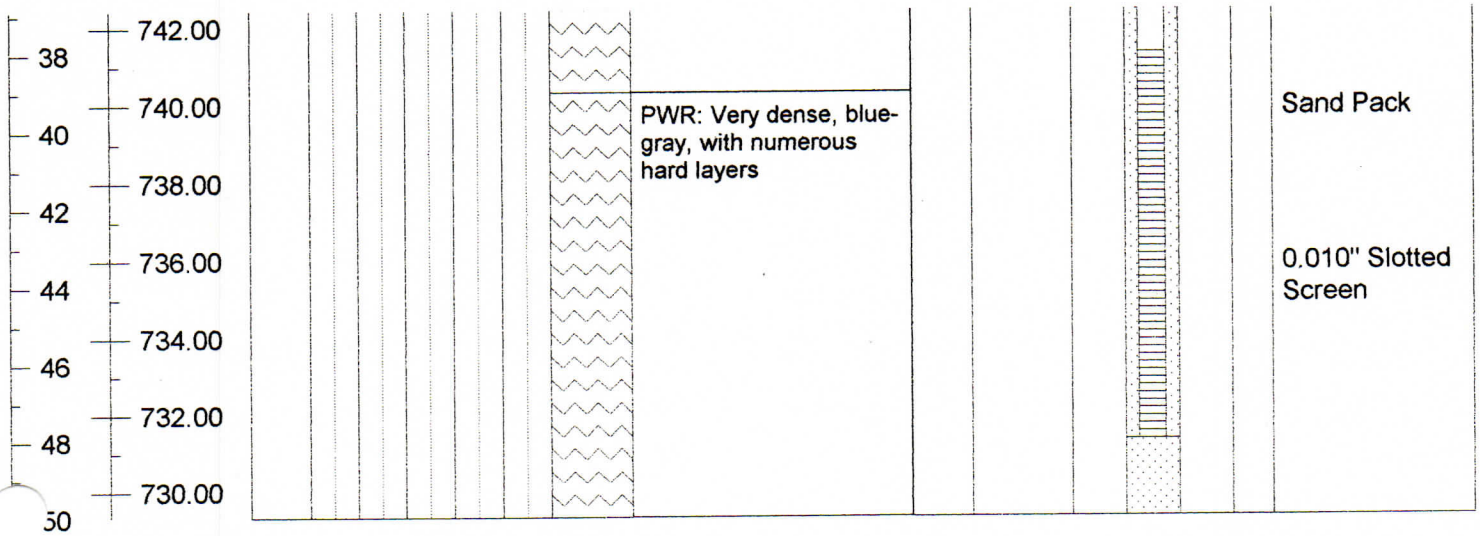
Engineering and Geology

Boring No. B-16

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**779.32**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**Dry**
Date Started	**5/16/02**	Date Ended	**5/16/02**	Water Level, 24 Hr.	**Dry**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**Dry**
Comments	**Cleared access road through woods**	Total Depth	**50.0**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

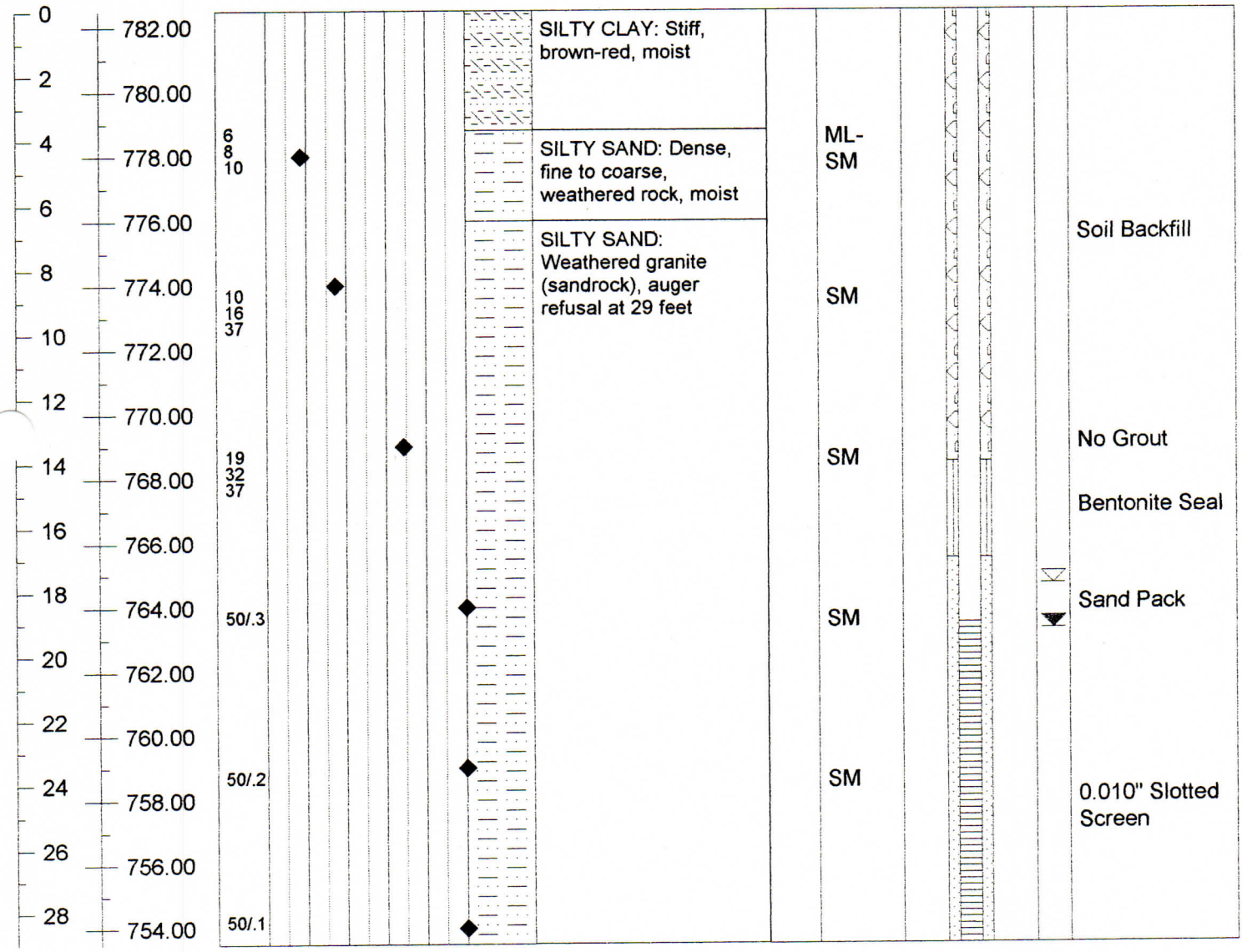
Engineering and Geology

Boring No. B-18

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**782.49**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**17.8**
Date Started	**5/9/02**	Date Ended	**5/9/02**	Water Level, 24 Hr.	**19.2**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**19.2**
Comments	**Cleared access road through woods**	Total Depth	**29.0**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

Engineering and Geology

Boring No. B-19

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**773.50**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA/NQWL core**	Water Level, TOB	**35.9**
Date Started	**5/1/02**	Date Ended	**5/1/02**	Water Level, 24 Hr.	**36.6**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**36.5**
Comments	**Cleared access road through woods**	Total Depth	**65.5**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data
0 / 772.00		SILTY SAND: Very dense, tan-brown, numerous hard quartz stringers, slightly moist, weathered sandrock, cobbles near surface	
2 / 770.00	10 19 25	SM	
4 / 768.00			
6 / 766.00			
8 / 764.00	36 50/.3	SM	
10 / 762.00			
12 / 760.00	42 50/.4	SM	
14 / 758.00			Soil Backfill
16 / 756.00			
18 / 754.00	50/.3	SM	
20 / 752.00			
22 / 750.00	50/.5	SM	
24 / 748.00			
26 / 746.00			
28 / 744.00	50/.3	SM	
30 / 742.00			
32 / 740.00	50/.3	SM	
34 / 738.00			
36			

David Garrett, P.G., P.E.

Engineering and Geology

Boring No. B-19

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**773.50**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA/NQWL core**	Water Level, TOB	**35.9**
Date Started	**5/1/02**	Date Ended	**5/1/02**	Water Level, 24 Hr.	**36.6**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**36.5**
Comments	**Cleared access road through woods**	Total Depth	**65.5**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data
38 / 736.00	50/.2	SM	Soil Backfill
40 / 734.00			
42 / 732.00			
44 / 730.00	50/.2	SM	
46 / 728.00			
48 / 726.00	50/.1	SM	
50 / 724.00		SILT: Hard, blue-gray, sandy, dry, advanced with roller cone from 53.6 to 54.0 feet	Grout
52 / 722.00			
54 / 720.00	50/.1	GNEISS: Core Run #1: Blue-gray, REC = 74%, RQD = 12%	Bentonite Seal
56 / 718.00			
58 / 716.00		GRANITE: Core Run #2: Hard, tan-white, mod. fractured, REC = 100%, RQD = 63%	Sand Pack
60 / 714.00			
62 / 712.00		GRANITE: Core Run #3: Same, fractured, REC = 96%, RQD = 58%	0.010" Slotted Screen
64 / 710.00			
708.00			

David Garrett, P.G., P.E.

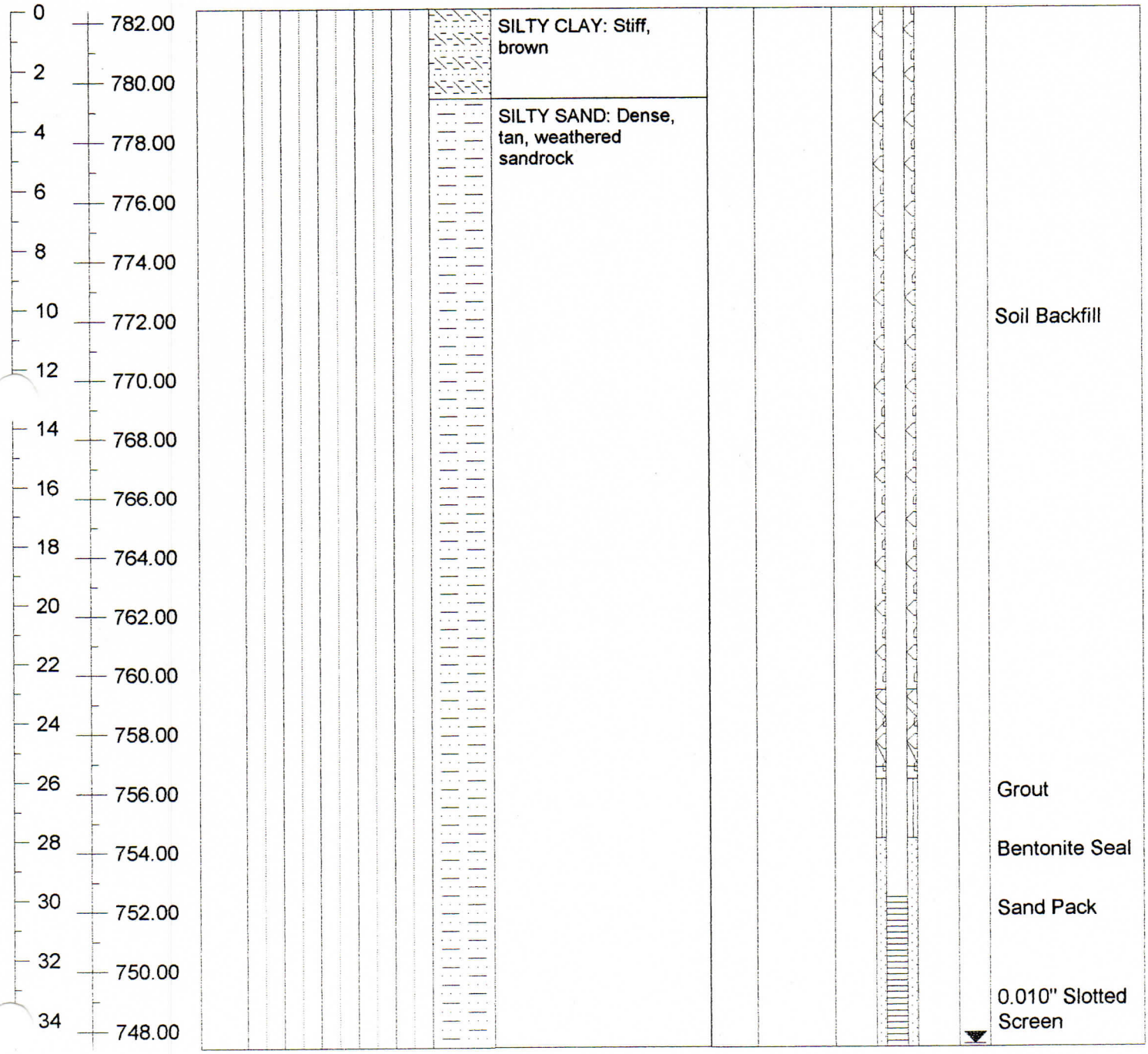
Engineering and Geology

Boring No. B-20

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**782.40**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**Dry**
Date Started	**5/22/02**	Date Ended	**5/22/02**	Water Level, 24 Hr.	**Dry**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**34.9**
Comments	**Cleared access road through woods**	Total Depth	**35.0**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

Engineering and Geology

Boring No. B-21

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**807.94**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**51.1**
Date Started	**4/30/02**	Date Ended	**4/30/02**	Water Level, 24 Hr.	**42.1**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**42.0**
Comments	**Cleared access road through woods**	Total Depth	**60.4**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data
0			
2 — 806.00		SILTY SAND: Very dense, tan-yellow, gravelly	
4 — 804.00	27 41 50/.4	SILT: Hard, tan-yellow, hard "slatey" layers, weathered granite — SM	
6 — 802.00			
8 — 800.00		SM	
10 — 798.00	11 15 25		Soil Backfill
12 — 796.00			
14 — 794.00	50/.4	SM	
16 — 792.00			
18 — 790.00		SM	
20 — 788.00	28 50/.3	SILTY SAND: Dense, tan, fine to coarse, quartz stringers	
22 — 786.00			
24 — 784.00	50/.4	SM	
26 — 782.00			
28 — 780.00	50/.2	SM	
30 — 778.00			Soil Backfill
32 — 776.00			
34 — 774.00	50/.3	PWR: Very dense, weathered granite with numerous hard layers — SM	
36 — 772.00			

David Garrett, P.G., P.E.

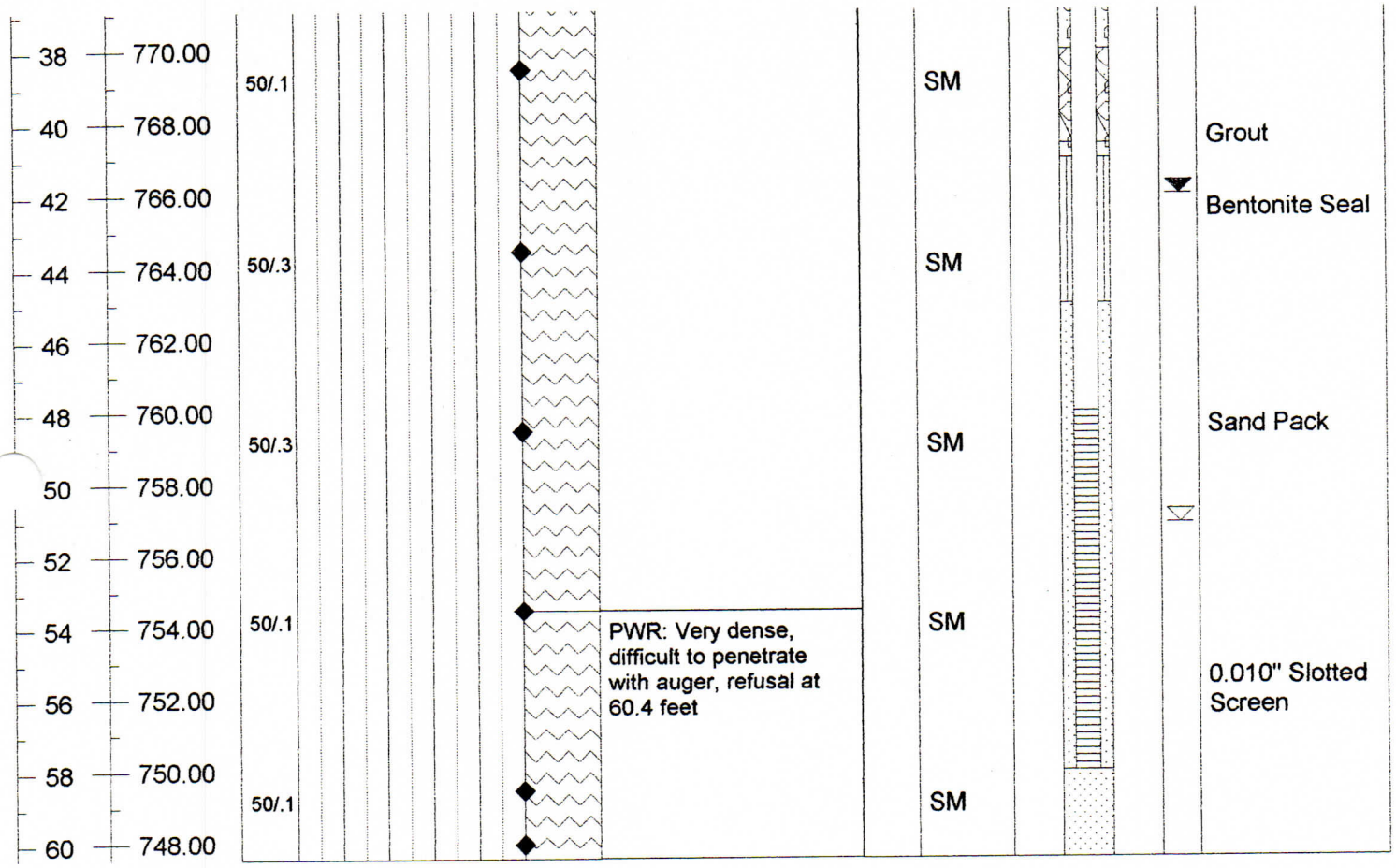
Engineering and Geology

Boring No. B-21

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**807.94**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**51.1**
Date Started	**4/30/02**	Date Ended	**4/30/02**	Water Level, 24 Hr.	**42.1**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**42.0**
Comments	**Cleared access road through woods**	Total Depth	**60.4**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

Engineering and Geology

Boring No. B-27

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**795.68**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA/NQWL core**	Water Level, TOB	**Dry**
Date Started	**5/13/02**	Date Ended	**5/13/02**	Water Level, 24 Hr.	**Dry**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**Dry**
Comments	**Cleared access road through woods**	Total Depth	**29.0**	Date of Observation	**5/28/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data
0		SILTY CLAY: Hard, brown-orange, boulder and cobbles (weathered	
2 / 794.00			
4 / 792.00	28 50/.2	SILT: Hard, sandy, boulders, (advanced with roller bit) — ML-CL	
6 / 790.00			
8 / 788.00	50/.4	Core Run #2: REC = 80%, RQD =0% (see below) — ML	Soil Backfill
10 / 786.00			
12 / 784.00			
14 / 782.00	50/.3	ML	
16 / 780.00		DIABASE: Core Run #1: Gray, fine grained, highly weathered, REC = 22%, RQD = 0%	
18 / 778.00			Grout
20 / 776.00	50/.5	SILT: Hard, weathered rock, advanced with roller bit	Bentonite Seal
22 / 774.00			
24 / 772.00		DIABASE: Core Run #2	
		DIABASE: Core Run #3: less weathered, REC = 92%, RQD = 31%	Sand Pack
26 / 770.00			0.010" Slotted Screen
28 / 768.00			

BORE & CORE, INC.

TEST BORING FIELD RECORD

PROJECT A-1 Sandrock PROJECT NO. _____ DATE 8/28/02

DRILLER Seiler CREW David WEATHER Sunny-Warm

GROUND SURFACE ELEVATION N/A DRILL RIG D-50 BORING NO. 29 El. 796

Soil Strata Depth From	Depth To	Soil Description and Remarks	Sampling / Blow Per Foot No	Depth From	Depth To	1st 6"	2nd 6"	3rd 6"	Rec
		TOP SOIL:							
7.0	11.0	Tan. Dry Sandrock Hard							
11.0	24.0	Bn. Tan Sandrock Some Gravel							
24.0	25.0	Rock ledge							
25.0	B.T	Sandrock to Refusal (Dry)							
		B.T @ 26.0' left open							
		B+28 El. 780							
0.0	0.6	Topsoil							
0.6	5.2	Bn. Tan Dry Sandrock							
5.2	18.0	Green. Sandrock V. hard (DRY)							
		B.T @ 18.0 Auger Ref.							

WATER LEVEL Dry at TOB
WATER LEVEL _____ at _____
WATER LEVEL _____ at 24 Hrs.
CAVE-IN DEPTH _____ at _____

WATER LOSSES,% _____ DEPTH _____

Of Bag Samples _____ # Of Undisturbed Samples _____
Special Tests (Explain) _____

METHOD OF DRILLING (check one)
AUGER ☒ SIZE 6" Solid MUD ___ SIZE _____
AIR ___ SIZE _____ / CORE ___ SIZE _____
TRICONE ___ SIZE _____ / CASING SIZE _____
LENGTH _____

DRILLING TIME (Hrs.):
Layout _____/Moving _____/Standby _____
Hauling Water _____/ Drilling _____

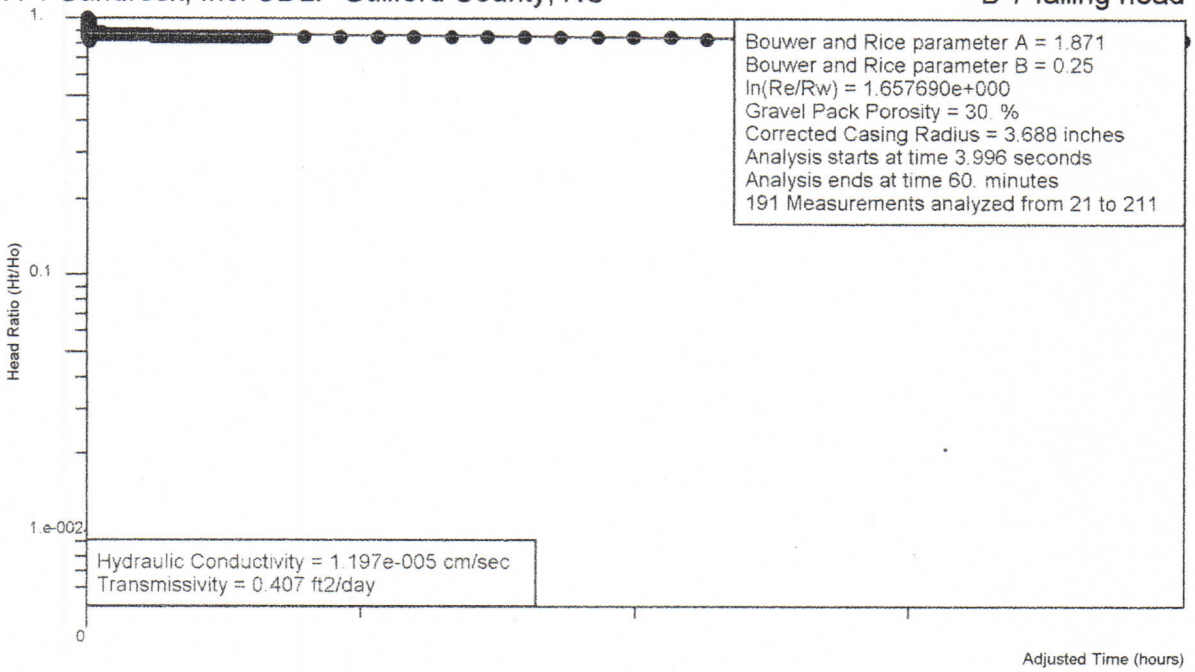
APPENDIX 4
Hydraulic Conductivity Tests

Field Hydraulic Conductivity Test 05/28/02

Bouwer and Rice Graph

A-1 Sandrock, Inc. CDLF Guilford County, NC

B-7 falling head



Ho is 12.81 feet at 3.996 seconds

Project Number Granite saprolite piezometer

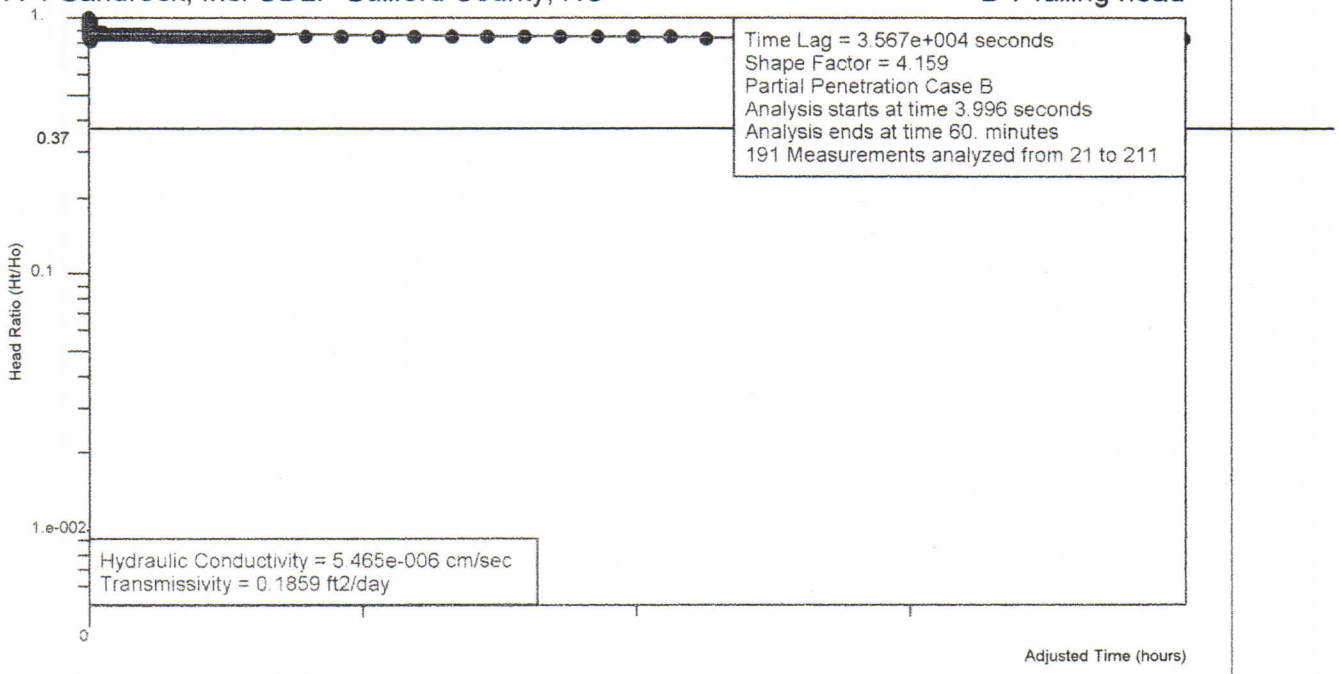
Analysis by Starpoint Software

Field Hydraulic Conductivity Test 05/28/02

Hvorslev Graph

A-1 Sandrock, Inc. CDLF Guilford County, NC

B-7 falling head



Ho is 12.81 feet at 3.996 seconds

Project Number Granite saprolite piezometer

Analysis by Starpoint Software

Field Hydraulic Conductivity Test

Site Name:	A-1 Sandrock, Inc. CDLF
Location:	Guilford County, NC
Test Date:	05/28/02
Project Number:	Granite saprolite piezometer
Import File:	A:\B-7

Well Label:	B-7 falling head
Aquifer Thickness:	12. feet
Screen Length:	5. feet
Casing Radius:	2. inches
Effective Radius:	6. inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	3.688 inches
Static Water Level:	10.65 feet
Water Table to Screen Bottom:	9.4 feet
Anisotropy Ratio:	1.
Time Adjustment:	3.996 Seconds

Test starts with trial 20
There are 211 time and drawdown measurements
Maximum head is 12.81 feet
Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-6.66e-002	0.	10.65	0.8315
2	3.3e-003	-6.33e-002	-6.e-003	10.66	0.832
3	6.6e-003	-6.e-002	-6.e-003	10.66	0.832
4	1.e-002	-5.66e-002	-6.e-003	10.66	0.832
5	1.33e-002	-5.33e-002	-6.e-003	10.66	0.832
6	1.66e-002	-5.e-002	-1.2e-002	10.66	0.8324
7	2.e-002	-4.66e-002	-6.e-003	10.66	0.832
8	2.33e-002	-4.33e-002	-1.2e-002	10.66	0.8324
9	2.66e-002	-4.e-002	-6.e-003	10.66	0.832
10	3.e-002	-3.66e-002	-6.e-003	10.66	0.832
11	3.33e-002	-3.33e-002	-0.765	11.42	0.8912
12	3.66e-002	-3.e-002	-1.267	11.92	0.9304
13	4.e-002	-2.66e-002	-0.771	11.42	0.8917
14	4.33e-002	-2.33e-002	-0.903	11.55	0.902
15	4.66e-002	-2.e-002	-1.486	12.14	0.9475
16	5.e-002	-1.66e-002	-2.007	12.66	0.9882
17	5.33e-002	-1.33e-002	-1.436	12.09	0.9436
18	5.66e-002	-1.e-002	-1.091	11.74	0.9167
19	6.e-002	-6.6e-003	-1.035	11.69	0.9123
20	6.33e-002	-3.3e-003	-1.612	12.26	0.9574
21	6.66e-002	0.	-2.158	12.81	1.
22	7.e-002	3.4e-003	-1.938	12.59	0.9828
23	7.33e-002	6.7e-003	-1.411	12.06	0.9417
24	7.66e-002	1.e-002	-1.21	11.86	0.926
25	8.e-002	1.34e-002	-1.424	12.07	0.9427
26	8.33e-002	1.67e-002	-1.58	12.23	0.9549
27	8.66e-002	2.e-002	-1.191	11.84	0.9245
28	9.e-002	2.34e-002	-0.777	11.43	0.8922
29	9.33e-002	2.67e-002	-1.21	11.86	0.926
30	9.66e-002	3.e-002	-1.505	12.15	0.949
31	0.1	3.34e-002	-1.066	11.72	0.9147
32	0.1033	3.67e-002	-0.959	11.61	0.9064

33	0.1066	4.e-002	-1.285	11.94	0.9318
34	0.11	4.34e-002	-1.411	12.06	0.9417
35	0.1133	4.67e-002	-1.066	11.72	0.9147
36	0.1166	5.e-002	-0.997	11.65	0.9094
37	0.12	5.34e-002	-1.21	11.86	0.926
38	0.1233	5.67e-002	-1.311	11.96	0.9339
39	0.1266	6.e-002	-1.147	11.8	0.9211
40	0.13	6.34e-002	-0.991	11.64	0.9089
41	0.1333	6.67e-002	-1.129	11.78	0.9197
42	0.1366	7.e-002	-1.229	11.88	0.9275
43	0.14	7.34e-002	-1.035	11.69	0.9123
44	0.1433	7.67e-002	-0.815	11.47	0.8951
45	0.1466	8.e-002	-0.878	11.53	0.9001
46	0.15	8.34e-002	-1.053	11.7	0.9137
47	0.1533	8.67e-002	-1.16	11.81	0.9221
48	0.1566	9.e-002	-1.009	11.66	0.9103
49	0.16	9.34e-002	-1.185	11.84	0.924
50	0.1633	9.67e-002	-1.493	12.14	0.9481
51	0.1666	1.e-001	-1.028	11.68	0.9118
52	0.17	0.1034	-0.181	10.83	0.8456
53	0.1733	0.1067	-0.828	11.48	0.8962
54	0.1766	0.11	-1.185	11.84	0.924
55	0.18	0.1134	-1.022	11.67	0.9113
56	0.1833	0.1167	-0.583	11.23	0.877
57	0.1866	0.12	-0.545	11.2	0.8741
58	0.19	0.1234	-1.035	11.69	0.9123
59	0.1933	0.1267	-1.122	11.77	0.9191
60	0.1966	0.13	-0.589	11.24	0.8775
61	0.2	0.1334	0.131	10.52	0.8213
62	0.2033	0.1367	-0.614	11.26	0.8795
63	0.2066	0.14	-1.442	12.09	0.9441
64	0.21	0.1434	-1.725	12.38	0.9662
65	0.2133	0.1467	-1.147	11.8	0.9211
66	0.2166	0.15	-0.275	10.93	0.853
67	0.22	0.1534	-0.445	11.1	0.8663
68	0.2233	0.1567	-0.94	11.59	0.9049
69	0.2266	0.16	-1.091	11.74	0.9167
70	0.23	0.1634	-0.959	11.61	0.9064
71	0.2333	0.1667	-0.683	11.33	0.8848
72	0.2366	0.17	-0.671	11.32	0.8839
73	0.24	0.1734	-0.853	11.5	0.8981
74	0.2433	0.1767	-0.903	11.55	0.902
75	0.2466	0.18	-0.809	11.46	0.8947
76	0.25	0.1834	-0.759	11.41	0.8908
77	0.2533	0.1867	-0.802	11.45	0.8941
78	0.2566	0.19	-0.821	11.47	0.8956
79	0.26	0.1934	-0.796	11.45	0.8937
80	0.2633	0.1967	-0.771	11.42	0.8917
81	0.2666	0.2	-0.784	11.43	0.8927
82	0.27	0.2034	-0.79	11.44	0.8932
83	0.2733	0.2067	-0.777	11.43	0.8922
84	0.2766	0.21	-0.765	11.42	0.8912
85	0.28	0.2134	-0.771	11.42	0.8917
86	0.2833	0.2167	-0.771	11.42	0.8917
87	0.2866	0.22	-0.759	11.41	0.8908
88	0.29	0.2234	-0.752	11.4	0.8902
89	0.2933	0.2267	-0.752	11.4	0.8902

90	0.2966	0.23	-0.752	11.4	0.8902
91	0.3	0.2334	-0.752	11.4	0.8902
92	0.3033	0.2367	-0.727	11.38	0.8883
93	0.3066	0.24	-0.733	11.38	0.8887
94	0.31	0.2434	-0.74	11.39	0.8893
95	0.3133	0.2467	-0.74	11.39	0.8893
96	0.3166	0.25	-0.721	11.37	0.8878
97	0.32	0.2534	-0.721	11.37	0.8878
98	0.3233	0.2567	-0.721	11.37	0.8878
99	0.3266	0.26	-0.715	11.37	0.8873
100	0.33	0.2634	-0.708	11.36	0.8868
101	0.3333	0.2667	-0.708	11.36	0.8868
102	0.35	0.2834	-0.715	11.37	0.8873
103	0.3666	0.3	-0.664	11.31	0.8834
104	0.3833	0.3167	-0.658	11.31	0.8829
105	0.4	0.3334	-0.639	11.29	0.8814
106	0.4166	0.35	-0.633	11.28	0.8809
107	0.4333	0.3667	-0.633	11.28	0.8809
108	0.45	0.3834	-0.627	11.28	0.8805
109	0.4666	0.4	-0.627	11.28	0.8805
110	0.4833	0.4167	-0.62	11.27	0.8799
111	0.5	0.4334	-0.62	11.27	0.8799
112	0.5166	0.45	-0.62	11.27	0.8799
113	0.5333	0.4667	-0.614	11.26	0.8795
114	0.55	0.4834	-0.614	11.26	0.8795
115	0.5666	0.5	-0.614	11.26	0.8795
116	0.5833	0.5167	-0.608	11.26	0.879
117	0.6	0.5334	-0.608	11.26	0.879
118	0.6166	0.55	-0.602	11.25	0.8785
119	0.6333	0.5667	-0.589	11.24	0.8775
120	0.65	0.5834	-0.608	11.26	0.879
121	0.6666	0.6	-0.595	11.25	0.878
122	0.6833	0.6167	-0.595	11.25	0.878
123	0.7	0.6334	-0.595	11.25	0.878
124	0.7166	0.65	-0.595	11.25	0.878
125	0.7333	0.6667	-0.589	11.24	0.8775
126	0.75	0.6834	-0.589	11.24	0.8775
127	0.7666	0.7	-0.583	11.23	0.877
128	0.7833	0.7167	-0.564	11.21	0.8755
129	0.8	0.7334	-0.545	11.2	0.8741
130	0.8166	0.75	-0.583	11.23	0.877
131	0.8333	0.7667	-0.583	11.23	0.877
132	0.85	0.7834	-0.577	11.23	0.8766
133	0.8666	0.8	-0.577	11.23	0.8766
134	0.8833	0.8167	-0.57	11.22	0.876
135	0.9	0.8334	-0.57	11.22	0.876
136	0.9166	0.85	-0.57	11.22	0.876
137	0.9333	0.8667	-0.57	11.22	0.876
138	0.95	0.8834	-0.564	11.21	0.8755
139	0.9666	0.9	-0.564	11.21	0.8755
140	0.9833	0.9167	-0.564	11.21	0.8755
141	1.	0.9334	-0.558	11.21	0.8751
142	1.2	1.133	-0.533	11.18	0.8731
143	1.4	1.333	-0.514	11.16	0.8716
144	1.6	1.533	-0.495	11.15	0.8702
145	1.8	1.733	-0.482	11.13	0.8691
146	2.	1.933	-0.464	11.11	0.8677

147	2.2	2.133	-0.445	11.1	0.8663
148	2.4	2.333	-0.439	11.09	0.8658
149	2.6	2.533	-0.426	11.08	0.8648
150	2.8	2.733	-0.413	11.06	0.8638
151	3.	2.933	-0.401	11.05	0.8628
152	3.2	3.133	-0.388	11.04	0.8618
153	3.4	3.333	-0.376	11.03	0.8609
154	3.6	3.533	-0.363	11.01	0.8599
155	3.8	3.733	-0.351	11.	0.8589
156	4.	3.933	-0.344	10.99	0.8584
157	4.2	4.133	-0.332	10.98	0.8574
158	4.4	4.333	-0.326	10.98	0.857
159	4.6	4.533	-0.319	10.97	0.8564
160	4.8	4.733	-0.307	10.96	0.8555
161	5.	4.933	-0.301	10.95	0.855
162	5.2	5.133	-0.301	10.95	0.855
163	5.4	5.333	-0.301	10.95	0.855
164	5.6	5.533	-0.301	10.95	0.855
165	5.8	5.733	-0.301	10.95	0.855
166	6.	5.933	-0.294	10.94	0.8545
167	6.2	6.133	-0.294	10.94	0.8545
168	6.4	6.333	-0.294	10.94	0.8545
169	6.6	6.533	-0.288	10.94	0.854
170	6.8	6.733	-0.288	10.94	0.854
171	7.	6.933	-0.288	10.94	0.854
172	7.2	7.133	-0.282	10.93	0.8535
173	7.4	7.333	-0.282	10.93	0.8535
174	7.6	7.533	-0.282	10.93	0.8535
175	7.8	7.733	-0.275	10.93	0.853
176	8.	7.933	-0.275	10.93	0.853
177	8.2	8.133	-0.269	10.92	0.8525
178	8.4	8.333	-0.269	10.92	0.8525
179	8.6	8.533	-0.269	10.92	0.8525
180	8.8	8.733	-0.263	10.91	0.852
181	9.	8.933	-0.263	10.91	0.852
182	9.2	9.133	-0.263	10.91	0.852
183	9.4	9.333	-0.263	10.91	0.852
184	9.6	9.533	-0.257	10.91	0.8516
185	9.8	9.733	-0.257	10.91	0.8516
186	10.	9.933	-0.257	10.91	0.8516
187	12.	11.93	-0.238	10.89	0.8501
188	14.	13.93	-0.225	10.88	0.8491
189	16.	15.93	-0.213	10.86	0.8481
190	18.	17.93	-0.206	10.86	0.8476
191	20.	19.93	-0.2	10.85	0.8471
192	22.	21.93	-0.188	10.84	0.8462
193	24.	23.93	-0.181	10.83	0.8456
194	26.	25.93	-0.175	10.83	0.8452
195	28.	27.93	-0.169	10.82	0.8447
196	30.	29.93	-0.163	10.81	0.8442
197	32.	31.93	-0.156	10.81	0.8437
198	34.	33.93	-0.15	10.8	0.8432
199	36.	35.93	-0.15	10.8	0.8432
200	38.	37.93	-0.144	10.79	0.8428
201	40.	39.93	-0.137	10.79	0.8422
202	42.	41.93	-0.131	10.78	0.8417
203	44.	43.93	-0.131	10.78	0.8417

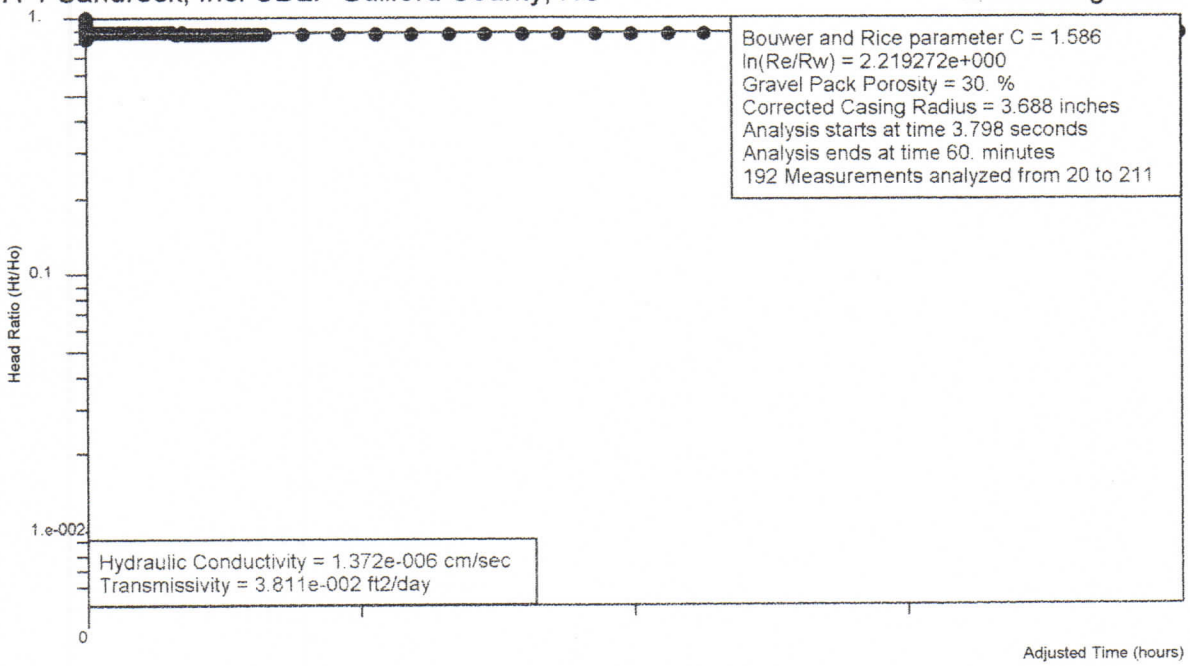
204	46.	45.93	-0.119	10.77	0.8408
205	48.	47.93	-0.112	10.76	0.8403
206	50.	49.93	-0.112	10.76	0.8403
207	52.	51.93	-0.106	10.76	0.8398
208	54.	53.93	-0.1	10.75	0.8393
209	56.	55.93	-9.4e-002	10.74	0.8389
210	58.	57.93	-9.4e-002	10.74	0.8389
211	60.	59.93	-8.7e-002	10.74	0.8383

Field Hydraulic Conductivity Test 05/28/02

Bouwer and Rice Graph

A-1 Sandrock, Inc. CDLF Guilford County, NC

B-18 falling head



Ho is 25.51 feet at 3.798 seconds

Project Number Granite saprolite piezometer

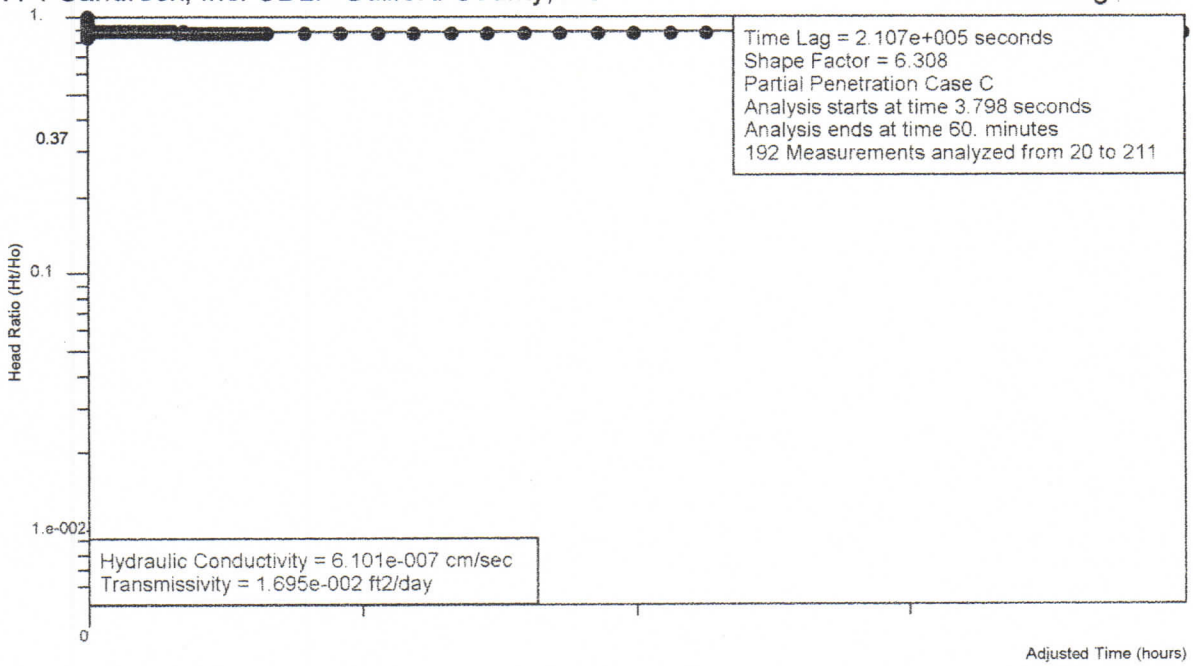
Analysis by Starpoint Software

Field Hydraulic Conductivity Test 05/28/02

A-1 Sandrock, Inc. CDLF Guilford County, NC

Hvorslev Graph

B-18 falling head



Ho is 25.51 feet at 3.798 seconds

Project Number Granite saprolite piezometer

Analysis by Starpoint Software

Field Hydraulic Conductivity Test

Site Name:	A-1 Sandrock, Inc. CDLF
Location:	Guilford County, NC
Test Date:	05/28/02
Project Number:	Granite saprolite piezometer
Import File:	A:\B-18

Well Label:	B-18 falling head
Aquifer Thickness:	9.8 feet
Screen Length:	10. feet
Casing Radius:	2. inches
Effective Radius:	6. inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	3.688 inches
Static Water Level:	22.09 feet
Water Table to Screen Bottom:	9.8 feet
Anisotropy Ratio:	1.
Time Adjustment:	3.798 Seconds

Test starts with trial 19
There are 211 time and drawdown measurements
Maximum head is 25.51 feet
Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-6.33e-002	-1.2e-002	22.1	0.8664
2	3.3e-003	-6.e-002	-1.2e-002	22.1	0.8664
3	6.6e-003	-5.67e-002	-1.8e-002	22.11	0.8667
4	1.e-002	-5.33e-002	-2.5e-002	22.11	0.8669
5	1.33e-002	-5.e-002	-1.8e-002	22.11	0.8667
6	1.66e-002	-4.67e-002	-6.e-003	22.1	0.8662
7	2.e-002	-4.33e-002	-3.1e-002	22.12	0.8672
8	2.33e-002	-4.e-002	-6.e-003	22.1	0.8662
9	2.66e-002	-3.67e-002	0.	22.09	0.866
10	3.e-002	-3.33e-002	-1.2e-002	22.1	0.8664
11	3.33e-002	-3.e-002	-4.3e-002	22.13	0.8677
12	3.66e-002	-2.67e-002	2.5e-002	22.06	0.865
13	4.e-002	-2.33e-002	-3.1e-002	22.12	0.8672
14	4.33e-002	-2.e-002	-1.2e-002	22.1	0.8664
15	4.66e-002	-1.67e-002	-1.2e-002	22.1	0.8664
16	5.e-002	-1.33e-002	-1.8e-002	22.11	0.8667
17	5.33e-002	-1.e-002	-5.6e-002	22.15	0.8682
18	5.66e-002	-6.7e-003	-5.e-002	22.14	0.8679
19	6.e-002	-3.3e-003	-0.978	23.07	0.9043
20	6.33e-002	0.	-3.419	25.51	1.
21	6.66e-002	3.3e-003	-2.835	24.92	0.9771
22	7.e-002	6.7e-003	-1.373	23.46	0.9198
23	7.33e-002	1.e-002	-0.188	22.28	0.8733
24	7.66e-002	1.33e-002	-1.348	23.44	0.9188
25	8.e-002	1.67e-002	-1.856	23.95	0.9387
26	8.33e-002	2.e-002	-1.43	23.52	0.922
27	8.66e-002	2.33e-002	-0.602	22.69	0.8896
28	9.e-002	2.67e-002	-1.097	23.19	0.909
29	9.33e-002	3.e-002	-1.292	23.38	0.9166

30	9.66e-002	3.33e-002	-1.003	23.09	0.9053
31	0.1	3.67e-002	-0.551	22.64	0.8876
32	0.1033	4.e-002	0.852	21.24	0.8326
33	0.1066	4.33e-002	0.137	21.95	0.8606
34	0.11	4.67e-002	-0.972	23.06	0.9041
35	0.1133	5.e-002	-1.122	23.21	0.91
36	0.1166	5.33e-002	7.5e-002	22.02	0.863
37	0.12	5.67e-002	0.52	21.57	0.8456
38	0.1233	6.e-002	-0.602	22.69	0.8896
39	0.1266	6.33e-002	-0.326	22.42	0.8787
40	0.13	6.67e-002	-9.4e-002	22.18	0.8697
41	0.1333	7.e-002	-0.395	22.48	0.8815
42	0.1366	7.33e-002	-0.232	22.32	0.8751
43	0.14	7.67e-002	-0.188	22.28	0.8733
44	0.1433	8.e-002	0.382	21.71	0.851
45	0.1466	8.33e-002	0.42	21.67	0.8495
46	0.15	8.67e-002	-0.52	22.61	0.8864
47	0.1533	9.e-002	-0.878	22.97	0.9004
48	0.1566	9.33e-002	-0.426	22.52	0.8827
49	0.16	9.67e-002	0.	22.09	0.866
50	0.1633	0.1	-0.282	22.37	0.877
51	0.1666	0.1033	-0.326	22.42	0.8787
52	0.17	0.1067	-0.269	22.36	0.8765
53	0.1733	0.11	-0.344	22.43	0.8795
54	0.1766	0.1133	-0.294	22.38	0.8775
55	0.18	0.1167	-0.213	22.3	0.8743
56	0.1833	0.12	-0.294	22.38	0.8775
57	0.1866	0.1233	-0.301	22.39	0.8778
58	0.19	0.1267	-0.269	22.36	0.8765
59	0.1933	0.13	-0.263	22.35	0.8763
60	0.1966	0.1333	-0.294	22.38	0.8775
61	0.2	0.1367	-0.288	22.38	0.8773
62	0.2033	0.14	-0.275	22.36	0.8767
63	0.2066	0.1433	-0.275	22.36	0.8767
64	0.21	0.1467	-0.282	22.37	0.877
65	0.2133	0.15	-0.282	22.37	0.877
66	0.2166	0.1533	-0.275	22.36	0.8767
67	0.22	0.1567	-0.282	22.37	0.877
68	0.2233	0.16	-0.282	22.37	0.877
69	0.2266	0.1633	-0.275	22.36	0.8767
70	0.23	0.1667	-0.282	22.37	0.877
71	0.2333	0.17	-0.288	22.38	0.8773
72	0.2366	0.1733	-0.275	22.36	0.8767
73	0.24	0.1767	-0.282	22.37	0.877
74	0.2433	0.18	-0.282	22.37	0.877
75	0.2466	0.1833	-0.282	22.37	0.877
76	0.25	0.1867	-0.282	22.37	0.877
77	0.2533	0.19	-0.282	22.37	0.877
78	0.2566	0.1933	-0.282	22.37	0.877
79	0.26	0.1967	-0.282	22.37	0.877
80	0.2633	0.2	-0.275	22.36	0.8767
81	0.2666	0.2033	-0.282	22.37	0.877
82	0.27	0.2067	-0.282	22.37	0.877
83	0.2733	0.21	-0.282	22.37	0.877

84	0.2766	0.2133	-0.282	22.37	0.877
85	0.28	0.2167	-0.275	22.36	0.8767
86	0.2833	0.22	-0.275	22.36	0.8767
87	0.2866	0.2233	-0.338	22.43	0.8792
88	0.29	0.2267	-0.595	22.68	0.8893
89	0.2933	0.23	-0.144	22.23	0.8716
90	0.2966	0.2333	8.1e-002	22.01	0.8628
91	0.3	0.2367	-0.413	22.5	0.8822
92	0.3033	0.24	-0.482	22.57	0.8849
93	0.3066	0.2433	-0.163	22.25	0.8724
94	0.31	0.2467	-0.169	22.26	0.8726
95	0.3133	0.25	-0.357	22.45	0.88
96	0.3166	0.2533	-0.344	22.43	0.8795
97	0.32	0.2567	-0.213	22.3	0.8743
98	0.3233	0.26	-0.263	22.35	0.8763
99	0.3266	0.2633	-0.319	22.41	0.8785
100	0.33	0.2667	-0.294	22.38	0.8775
101	0.3333	0.27	-0.257	22.35	0.876
102	0.35	0.2867	-0.282	22.37	0.877
103	0.3666	0.3033	-0.282	22.37	0.877
104	0.3833	0.32	-0.275	22.36	0.8767
105	0.4	0.3367	-0.275	22.36	0.8767
106	0.4166	0.3533	-0.282	22.37	0.877
107	0.4333	0.37	-0.282	22.37	0.877
108	0.45	0.3867	-0.282	22.37	0.877
109	0.4666	0.4033	-0.275	22.36	0.8767
110	0.4833	0.42	-0.275	22.36	0.8767
111	0.5	0.4367	-0.282	22.37	0.877
112	0.5166	0.4533	-0.275	22.36	0.8767
113	0.5333	0.47	-0.275	22.36	0.8767
114	0.55	0.4867	-0.275	22.36	0.8767
115	0.5666	0.5033	-0.282	22.37	0.877
116	0.5833	0.52	-0.282	22.37	0.877
117	0.6	0.5367	-0.275	22.36	0.8767
118	0.6166	0.5533	-0.275	22.36	0.8767
119	0.6333	0.57	-0.282	22.37	0.877
120	0.65	0.5867	-0.282	22.37	0.877
121	0.6666	0.6033	-0.275	22.36	0.8767
122	0.6833	0.62	-0.275	22.36	0.8767
123	0.7	0.6367	-0.275	22.36	0.8767
124	0.7166	0.6533	-0.275	22.36	0.8767
125	0.7333	0.67	-0.263	22.35	0.8763
126	0.75	0.6867	-0.275	22.36	0.8767
127	0.7666	0.7033	-0.275	22.36	0.8767
128	0.7833	0.72	-0.275	22.36	0.8767
129	0.8	0.7367	-0.275	22.36	0.8767
130	0.8166	0.7533	-0.275	22.36	0.8767
131	0.8333	0.77	-0.275	22.36	0.8767
132	0.85	0.7867	-0.275	22.36	0.8767
133	0.8666	0.8033	-0.275	22.36	0.8767
134	0.8833	0.82	-0.275	22.36	0.8767
135	0.9	0.8367	-0.275	22.36	0.8767
136	0.9166	0.8533	-0.275	22.36	0.8767
137	0.9333	0.87	-0.275	22.36	0.8767

138	0.95	0.8867	-0.275	22.36	0.8767
139	0.9666	0.9033	-0.275	22.36	0.8767
140	0.9833	0.92	-0.275	22.36	0.8767
141	1.	0.9367	-0.275	22.36	0.8767
142	1.2	1.137	-0.275	22.36	0.8767
143	1.4	1.337	-0.275	22.36	0.8767
144	1.6	1.537	-0.269	22.36	0.8765
145	1.8	1.737	-0.269	22.36	0.8765
146	2.	1.937	-0.269	22.36	0.8765
147	2.2	2.137	-0.269	22.36	0.8765
148	2.4	2.337	-0.269	22.36	0.8765
149	2.6	2.537	-0.263	22.35	0.8763
150	2.8	2.737	-0.263	22.35	0.8763
151	3.	2.937	-0.263	22.35	0.8763
152	3.2	3.137	-0.263	22.35	0.8763
153	3.4	3.337	-0.263	22.35	0.8763
154	3.6	3.537	-0.263	22.35	0.8763
155	3.8	3.737	-0.257	22.35	0.876
156	4.	3.937	-0.257	22.35	0.876
157	4.2	4.137	-0.257	22.35	0.876
158	4.4	4.337	-0.257	22.35	0.876
159	4.6	4.537	-0.257	22.35	0.876
160	4.8	4.737	-0.257	22.35	0.876
161	5.	4.937	-0.25	22.34	0.8758
162	5.2	5.137	-0.25	22.34	0.8758
163	5.4	5.337	-0.257	22.35	0.876
164	5.6	5.537	-0.25	22.34	0.8758
165	5.8	5.737	-0.25	22.34	0.8758
166	6.	5.937	-0.25	22.34	0.8758
167	6.2	6.137	-0.25	22.34	0.8758
168	6.4	6.337	-0.25	22.34	0.8758
169	6.6	6.537	-0.244	22.33	0.8755
170	6.8	6.737	-0.244	22.33	0.8755
171	7.	6.937	-0.244	22.33	0.8755
172	7.2	7.137	-0.244	22.33	0.8755
173	7.4	7.337	-0.244	22.33	0.8755
174	7.6	7.537	-0.244	22.33	0.8755
175	7.8	7.737	-0.244	22.33	0.8755
176	8.	7.937	-0.244	22.33	0.8755
177	8.2	8.137	-0.244	22.33	0.8755
178	8.4	8.337	-0.238	22.33	0.8753
179	8.6	8.537	-0.238	22.33	0.8753
180	8.8	8.737	-0.238	22.33	0.8753
181	9.	8.937	-0.238	22.33	0.8753
182	9.2	9.137	-0.238	22.33	0.8753
183	9.4	9.337	-0.232	22.32	0.8751
184	9.6	9.537	-0.232	22.32	0.8751
185	9.8	9.737	-0.232	22.32	0.8751
186	10.	9.937	-0.232	22.32	0.8751
187	12.	11.94	-0.219	22.31	0.8746
188	14.	13.94	-0.213	22.3	0.8743
189	16.	15.94	-0.206	22.3	0.874
190	18.	17.94	-0.2	22.29	0.8738
191	20.	19.94	-0.194	22.28	0.8736

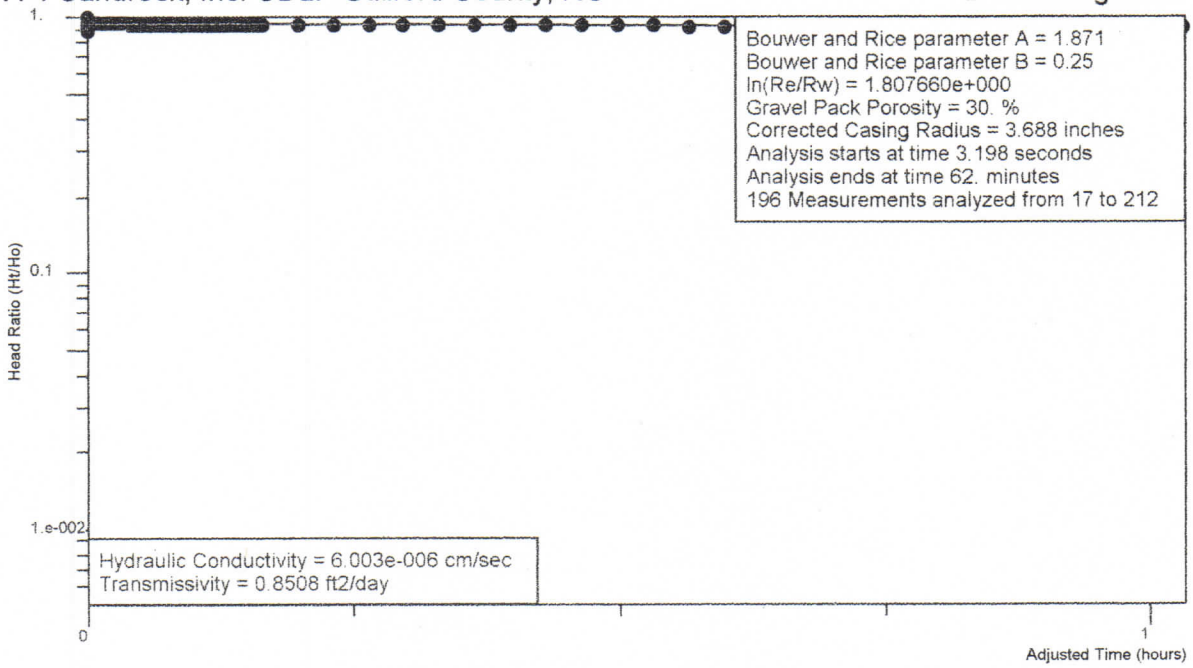
192	22.	21.94	-0.188	22.28	0.8733
193	24.	23.94	-0.181	22.27	0.8731
194	26.	25.94	-0.175	22.26	0.8728
195	28.	27.94	-0.169	22.26	0.8726
196	30.	29.94	-0.175	22.26	0.8728
197	32.	31.94	-0.163	22.25	0.8724
198	34.	33.94	-0.156	22.25	0.8721
199	36.	35.94	-0.15	22.24	0.8718
200	38.	37.94	-0.144	22.23	0.8716
201	40.	39.94	-0.144	22.23	0.8716
202	42.	41.94	-0.144	22.23	0.8716
203	44.	43.94	-0.144	22.23	0.8716
204	46.	45.94	-0.131	22.22	0.8711
205	48.	47.94	-0.125	22.21	0.8709
206	50.	49.94	-0.119	22.21	0.8706
207	52.	51.94	-0.119	22.21	0.8706
208	54.	53.94	-0.112	22.2	0.8704
209	56.	55.94	-0.112	22.2	0.8704
210	58.	57.94	-0.106	22.2	0.8701
211	60.	59.94	-0.112	22.2	0.8704

Field Hydraulic Conductivity Test 05/28/02

Bouwer and Rice Graph

A-1 Sandrock, Inc. CDLF Guilford County, NC

B-19 falling head



Project Number Granite bedrock piezometer

Analysis by Starpoint Software

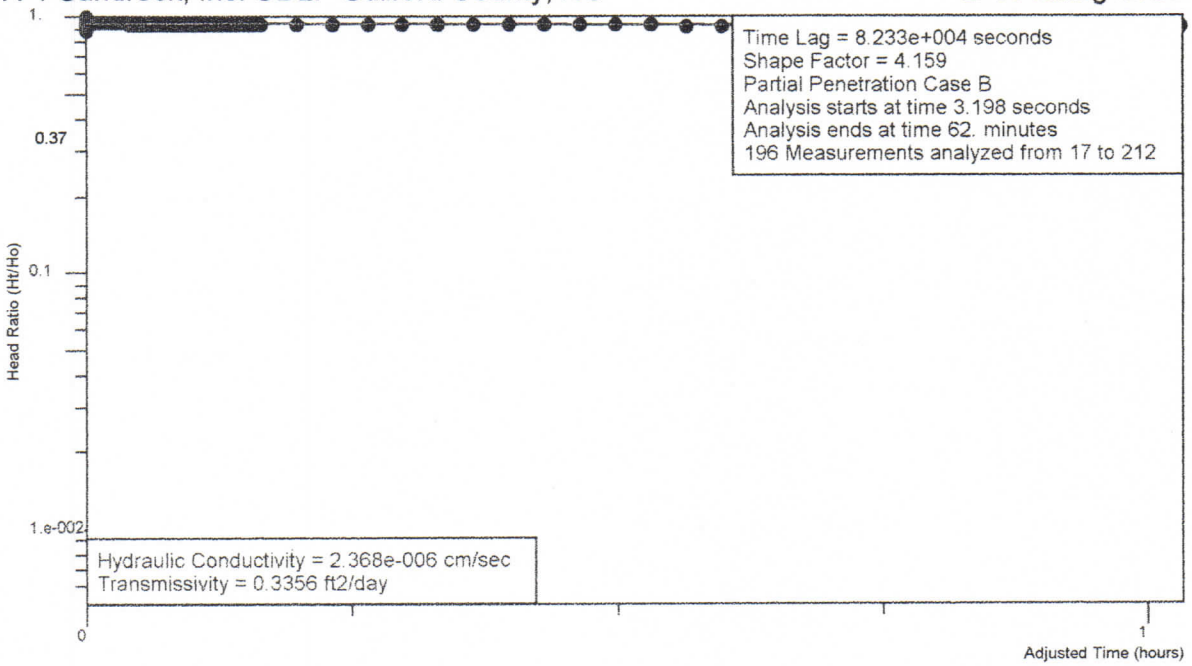
Ho is 43.94 feet at 3.198 seconds

Field Hydraulic Conductivity Test 05/28/02

Hvorslev Graph

A-1 Sandrock, Inc. CDLF Guilford County, NC

B-19 falling head



Ho is 43.94 feet at 3.198 seconds

Project Number Granite bedrock piezometer

Analysis by Starpoint Software

Field Hydraulic Conductivity Test

Site Name:	A-1 Sandrock, Inc. CDLF
Location:	Guilford County, NC
Test Date:	05/28/02
Project Number:	Granite bedrock piezometer
Import File:	A:\B-19

Well Label:	B-19 falling head
Aquifer Thickness:	50. feet
Screen Length:	5. feet
Casing Radius:	2. inches
Effective Radius:	6. inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	3.688 inches
Static Water Level:	39.68 feet
Water Table to Screen Bottom:	28.5 feet
Anisotropy Ratio:	1.
Time Adjustment:	3.198 Seconds

Test starts with trial 16
There are 212 time and drawdown measurements
Maximum head is 43.94 feet
Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-5.33e-002	0.	39.68	0.9031
2	3.3e-003	-5.e-002	0.	39.68	0.9031
3	6.6e-003	-4.67e-002	-6.e-003	39.69	0.9032
4	1.e-002	-4.33e-002	-6.e-003	39.69	0.9032
5	1.33e-002	-4.e-002	6.e-003	39.67	0.9029
6	1.66e-002	-3.67e-002	-6.e-003	39.69	0.9032
7	2.e-002	-3.33e-002	-6.e-003	39.69	0.9032
8	2.33e-002	-3.e-002	0.	39.68	0.9031
9	2.66e-002	-2.67e-002	-1.2e-002	39.69	0.9033
10	3.e-002	-2.33e-002	6.e-003	39.67	0.9029
11	3.33e-002	-2.e-002	-1.2e-002	39.69	0.9033
12	3.66e-002	-1.67e-002	-2.5e-002	39.7	0.9036
13	4.e-002	-1.33e-002	1.2e-002	39.67	0.9028
14	4.33e-002	-1.e-002	-3.1e-002	39.71	0.9038
15	4.66e-002	-6.7e-003	-6.2e-002	39.74	0.9045
16	5.e-002	-3.3e-003	0.	39.68	0.9031
17	5.33e-002	0.	-4.259	43.94	1.
18	5.66e-002	3.3e-003	-1.117	40.8	0.9285
19	6.e-002	6.7e-003	0.646	39.03	0.8884
20	6.33e-002	1.e-002	-3.298	42.98	0.9781
21	6.66e-002	1.33e-002	-2.87	42.55	0.9684
22	7.e-002	1.67e-002	-3.046	42.73	0.9724
23	7.33e-002	2.e-002	-2.996	42.68	0.9713
24	7.66e-002	2.33e-002	-2.594	42.27	0.9621
25	8.e-002	2.67e-002	-2.996	42.68	0.9713
26	8.33e-002	3.e-002	-3.128	42.81	0.9743
27	8.66e-002	3.33e-002	-2.895	42.58	0.969
28	9.e-002	3.67e-002	-2.958	42.64	0.9704
29	9.33e-002	4.e-002	-2.883	42.56	0.9687

30	9.66e-002	4.33e-002	-2.33	42.01	0.9561
31	0.1	4.67e-002	-2.732	42.41	0.9652
32	0.1033	5.e-002	-2.173	41.85	0.9525
33	0.1066	5.33e-002	-2.198	41.88	0.9531
34	0.11	5.67e-002	-2.236	41.92	0.954
35	0.1133	6.e-002	-2.38	42.06	0.9572
36	0.1166	6.33e-002	-1.771	41.45	0.9434
37	0.12	6.67e-002	-1.903	41.58	0.9464
38	0.1233	7.e-002	-2.883	42.56	0.9687
39	0.1266	7.33e-002	-2.87	42.55	0.9684
40	0.13	7.67e-002	-2.977	42.66	0.9708
41	0.1333	8.e-002	-3.059	42.74	0.9727
42	0.1366	8.33e-002	-2.895	42.58	0.969
43	0.14	8.67e-002	-2.217	41.9	0.9535
44	0.1433	9.e-002	-2.21	41.89	0.9534
45	0.1466	9.33e-002	-1.048	40.73	0.9269
46	0.15	9.67e-002	-1.4	41.08	0.9349
47	0.1533	1.e-001	-2.474	42.15	0.9594
48	0.1566	0.1033	-2.701	42.38	0.9645
49	0.16	0.1067	-2.286	41.97	0.9551
50	0.1633	0.11	-1.852	41.53	0.9452
51	0.1666	0.1133	-1.846	41.53	0.9451
52	0.17	0.1167	-2.097	41.78	0.9508
53	0.1733	0.12	-2.267	41.95	0.9547
54	0.1766	0.1233	-2.16	41.84	0.9522
55	0.18	0.1267	-2.066	41.75	0.9501
56	0.1833	0.13	-2.066	41.75	0.9501
57	0.1866	0.1333	-2.104	41.78	0.951
58	0.19	0.1367	-2.104	41.78	0.951
59	0.1933	0.14	-2.097	41.78	0.9508
60	0.1966	0.1433	-2.097	41.78	0.9508
61	0.2	0.1467	-2.097	41.78	0.9508
62	0.2033	0.15	-2.097	41.78	0.9508
63	0.2066	0.1533	-2.097	41.78	0.9508
64	0.21	0.1567	-2.097	41.78	0.9508
65	0.2133	0.16	-2.104	41.78	0.951
66	0.2166	0.1633	-2.097	41.78	0.9508
67	0.22	0.1667	-2.091	41.77	0.9507
68	0.2233	0.17	-2.097	41.78	0.9508
69	0.2266	0.1733	-2.091	41.77	0.9507
70	0.23	0.1767	-2.091	41.77	0.9507
71	0.2333	0.18	-2.091	41.77	0.9507
72	0.2366	0.1833	-2.091	41.77	0.9507
73	0.24	0.1867	-2.091	41.77	0.9507
74	0.2433	0.19	-2.091	41.77	0.9507
75	0.2466	0.1933	-2.091	41.77	0.9507
76	0.25	0.1967	-2.085	41.77	0.9505
77	0.2533	0.2	-2.085	41.77	0.9505
78	0.2566	0.2033	-2.091	41.77	0.9507
79	0.26	0.2067	-2.091	41.77	0.9507
80	0.2633	0.21	-2.085	41.77	0.9505
81	0.2666	0.2133	-2.085	41.77	0.9505
82	0.27	0.2167	-2.079	41.76	0.9504
83	0.2733	0.22	-2.085	41.77	0.9505

84	0.2766	0.2233	-2.079	41.76	0.9504
85	0.28	0.2267	-2.085	41.77	0.9505
86	0.2833	0.23	-2.085	41.77	0.9505
87	0.2866	0.2333	-2.072	41.75	0.9502
88	0.29	0.2367	-2.079	41.76	0.9504
89	0.2933	0.24	-2.079	41.76	0.9504
90	0.2966	0.2433	-2.072	41.75	0.9502
91	0.3	0.2467	-2.072	41.75	0.9502
92	0.3033	0.25	-2.072	41.75	0.9502
93	0.3066	0.2533	-2.072	41.75	0.9502
94	0.31	0.2567	-2.072	41.75	0.9502
95	0.3133	0.26	-2.072	41.75	0.9502
96	0.3166	0.2633	-2.072	41.75	0.9502
97	0.32	0.2667	-2.072	41.75	0.9502
98	0.3233	0.27	-2.066	41.75	0.9501
99	0.3266	0.2733	-2.066	41.75	0.9501
100	0.33	0.2767	-2.066	41.75	0.9501
101	0.3333	0.28	-2.066	41.75	0.9501
102	0.35	0.2967	-2.06	41.74	0.95
103	0.3666	0.3133	-2.06	41.74	0.95
104	0.3833	0.33	-2.053	41.73	0.9498
105	0.4	0.3467	-2.053	41.73	0.9498
106	0.4166	0.3633	-2.047	41.73	0.9497
107	0.4333	0.38	-2.047	41.73	0.9497
108	0.45	0.3967	-2.041	41.72	0.9495
109	0.4666	0.4133	-2.041	41.72	0.9495
110	0.4833	0.43	-2.041	41.72	0.9495
111	0.5	0.4467	-2.035	41.72	0.9494
112	0.5166	0.4633	-2.035	41.72	0.9494
113	0.5333	0.48	-2.035	41.72	0.9494
114	0.55	0.4967	-2.028	41.71	0.9492
115	0.5666	0.5133	-2.047	41.73	0.9497
116	0.5833	0.53	-2.022	41.7	0.9491
117	0.6	0.5467	-2.022	41.7	0.9491
118	0.6166	0.5633	-2.016	41.7	0.949
119	0.6333	0.58	-2.016	41.7	0.949
120	0.65	0.5967	-2.016	41.7	0.949
121	0.6666	0.6133	-2.009	41.69	0.9488
122	0.6833	0.63	-2.009	41.69	0.9488
123	0.7	0.6467	-2.009	41.69	0.9488
124	0.7166	0.6633	-2.003	41.68	0.9487
125	0.7333	0.68	-2.003	41.68	0.9487
126	0.75	0.6967	-2.003	41.68	0.9487
127	0.7666	0.7133	-1.997	41.68	0.9485
128	0.7833	0.73	-1.997	41.68	0.9485
129	0.8	0.7467	-1.997	41.68	0.9485
130	0.8166	0.7633	-1.991	41.67	0.9484
131	0.8333	0.78	-1.997	41.68	0.9485
132	0.85	0.7967	-1.991	41.67	0.9484
133	0.8666	0.8133	-1.991	41.67	0.9484
134	0.8833	0.83	-1.984	41.66	0.9482
135	0.9	0.8467	-1.984	41.66	0.9482
136	0.9166	0.8633	-1.978	41.66	0.9481
137	0.9333	0.88	-1.978	41.66	0.9481

138	0.95	0.8967	-1.978	41.66	0.9481
139	0.9666	0.9133	-1.972	41.65	0.948
140	0.9833	0.93	-1.972	41.65	0.948
141	1.	0.9467	-1.972	41.65	0.948
142	1.2	1.147	-1.947	41.63	0.9474
143	1.4	1.347	-1.921	41.6	0.9468
144	1.6	1.547	-1.903	41.58	0.9464
145	1.8	1.747	-1.89	41.57	0.9461
146	2.	1.947	-1.877	41.56	0.9458
147	2.2	2.147	-1.859	41.54	0.9454
148	2.4	2.347	-1.846	41.53	0.9451
149	2.6	2.547	-1.834	41.51	0.9448
150	2.8	2.747	-1.821	41.5	0.9445
151	3.	2.947	-1.808	41.49	0.9442
152	3.2	3.147	-1.796	41.48	0.9439
153	3.4	3.347	-1.79	41.47	0.9438
154	3.6	3.547	-1.777	41.46	0.9435
155	3.8	3.747	-1.764	41.44	0.9432
156	4.	3.947	-1.752	41.43	0.9429
157	4.2	4.147	-1.746	41.43	0.9428
158	4.4	4.347	-1.733	41.41	0.9425
159	4.6	4.547	-1.727	41.41	0.9424
160	4.8	4.747	-1.72	41.4	0.9422
161	5.	4.947	-1.708	41.39	0.9419
162	5.2	5.147	-1.702	41.38	0.9418
163	5.4	5.347	-1.689	41.37	0.9415
164	5.6	5.547	-1.683	41.36	0.9414
165	5.8	5.747	-1.676	41.36	0.9412
166	6.	5.947	-1.67	41.35	0.9411
167	6.2	6.147	-1.664	41.34	0.9409
168	6.4	6.347	-1.658	41.34	0.9408
169	6.6	6.547	-1.645	41.32	0.9405
170	6.8	6.747	-1.639	41.32	0.9404
171	7.	6.947	-1.632	41.31	0.9402
172	7.2	7.147	-1.626	41.31	0.9401
173	7.4	7.347	-1.62	41.3	0.9399
174	7.6	7.547	-1.614	41.29	0.9398
175	7.8	7.747	-1.607	41.29	0.9396
176	8.	7.947	-1.595	41.27	0.9394
177	8.2	8.147	-1.595	41.27	0.9394
178	8.4	8.347	-1.589	41.27	0.9392
179	8.6	8.547	-1.582	41.26	0.9391
180	8.8	8.747	-1.57	41.25	0.9388
181	9.	8.947	-1.57	41.25	0.9388
182	9.2	9.147	-1.563	41.24	0.9386
183	9.4	9.347	-1.557	41.24	0.9385
184	9.6	9.547	-1.551	41.23	0.9384
185	9.8	9.747	-1.545	41.23	0.9382
186	10.	9.947	-1.538	41.22	0.9381
187	12.	11.95	-1.475	41.16	0.9366
188	14.	13.95	-1.425	41.1	0.9355
189	16.	15.95	-1.381	41.06	0.9345
190	18.	17.95	-1.331	41.01	0.9334
191	20.	19.95	-1.293	40.97	0.9325

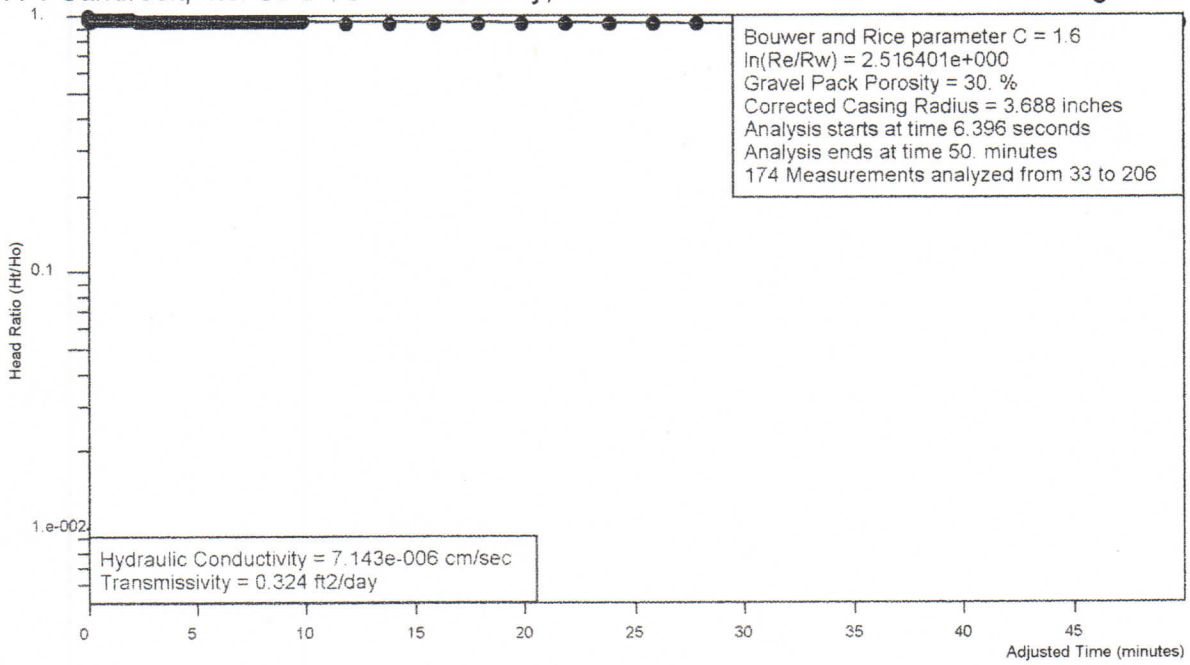
192	22.	21.95	-1.249	40.93	0.9315
193	24.	23.95	-1.212	40.89	0.9307
194	26.	25.95	-1.174	40.85	0.9298
195	28.	27.95	-1.136	40.82	0.9289
196	30.	29.95	-1.105	40.78	0.9282
197	32.	31.95	-1.073	40.75	0.9275
198	34.	33.95	-1.042	40.72	0.9268
199	36.	35.95	-1.011	40.69	0.9261
200	38.	37.95	-0.979	40.66	0.9254
201	40.	39.95	-0.954	40.63	0.9248
202	42.	41.95	-0.923	40.6	0.9241
203	44.	43.95	-0.898	40.58	0.9235
204	46.	45.95	-0.872	40.55	0.9229
205	48.	47.95	-0.841	40.52	0.9222
206	50.	49.95	-0.822	40.5	0.9218
207	52.	51.95	-0.797	40.48	0.9212
208	54.	53.95	-0.772	40.45	0.9206
209	56.	55.95	-0.753	40.43	0.9202
210	58.	57.95	-0.728	40.41	0.9196
211	60.	59.95	-0.709	40.39	0.9192
212	62.	61.95	-0.69	40.37	0.9188

Field Hydraulic Conductivity Test 05/28/02

Bouwer and Rice Graph

A-1 Sandrock, Inc. CDLF Guilford County, NC

B-21 falling head



Project Number Granite saprolite piezometer

Analysis by Starpoint Software

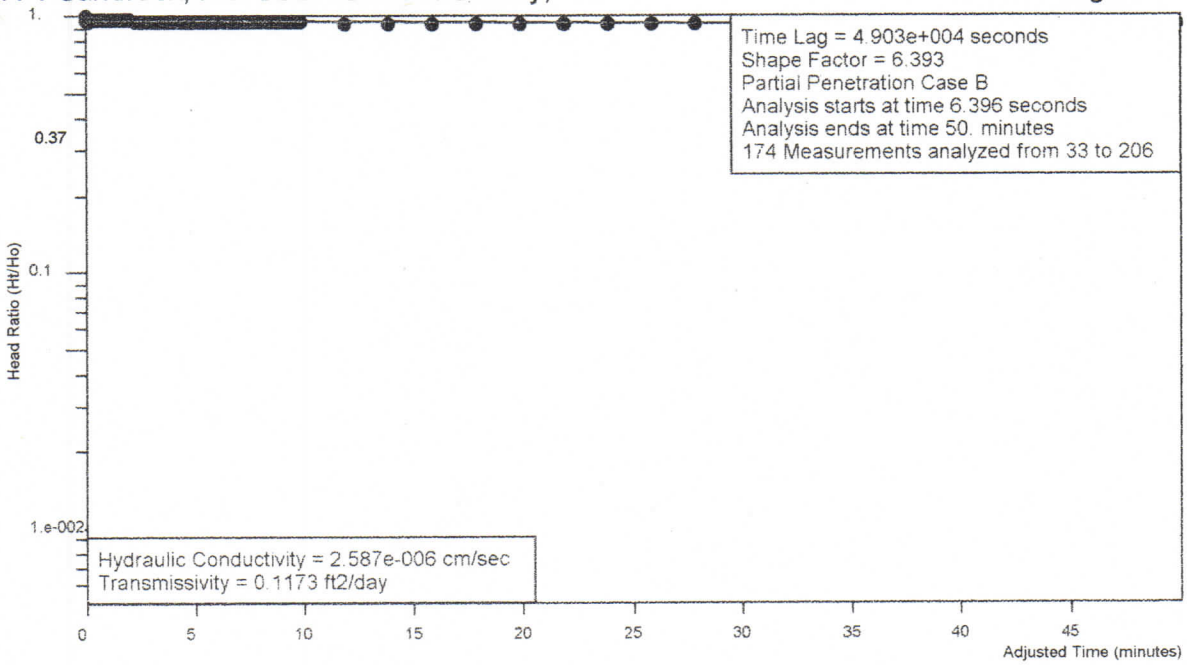
Ho is 47.14 feet at 6.396 seconds

Field Hydraulic Conductivity Test 05/28/02

A-1 Sandrock, Inc. CDLF Guilford County, NC

Hvorslev Graph

B-21 falling head



Project Number Granite saprolite piezometer

Analysis by Starpoint Software

Ho is 47.14 feet at 6.396 seconds

Field Hydraulic Conductivity Test

Site Name:	A-1 Sandrock, Inc. CDLF
Location:	Guilford County, NC
Test Date:	05/28/02
Project Number:	Granite saprolite piezometer
Import File:	A:\B-21fh

Well Label:	B-21 falling head
Aquifer Thickness:	16. feet
Screen Length:	10. feet
Casing Radius:	2. inches
Effective Radius:	6. inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	3.688 inches
Static Water Level:	44.03 feet
Water Table to Screen Bottom:	16. feet
Anisotropy Ratio:	1.
Time Adjustment:	6.396 Seconds

Test starts with trial 32
There are 206 time and drawdown measurements
Maximum head is 47.14 feet
Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-0.1066	0.	44.03	0.934
2	3.3e-003	-0.1033	-6.e-003	44.04	0.9342
3	6.6e-003	-0.1	-1.2e-002	44.04	0.9343
4	1.e-002	-9.66e-002	-1.8e-002	44.05	0.9344
5	1.33e-002	-9.33e-002	-1.2e-002	44.04	0.9343
6	1.66e-002	-9.e-002	-6.e-003	44.04	0.9342
7	2.e-002	-8.66e-002	-1.2e-002	44.04	0.9343
8	2.33e-002	-8.33e-002	-1.8e-002	44.05	0.9344
9	2.66e-002	-8.e-002	-1.8e-002	44.05	0.9344
10	3.e-002	-7.66e-002	-6.e-003	44.04	0.9342
11	3.33e-002	-7.33e-002	-1.2e-002	44.04	0.9343
12	3.66e-002	-7.e-002	-1.2e-002	44.04	0.9343
13	4.e-002	-6.66e-002	-1.2e-002	44.04	0.9343
14	4.33e-002	-6.33e-002	-6.e-003	44.04	0.9342
15	4.66e-002	-6.e-002	-6.e-003	44.04	0.9342
16	5.e-002	-5.66e-002	-1.2e-002	44.04	0.9343
17	5.33e-002	-5.33e-002	-1.2e-002	44.04	0.9343
18	5.66e-002	-5.e-002	-1.023	45.05	0.9557
19	6.e-002	-4.66e-002	-1.733	45.76	0.9708
20	6.33e-002	-4.33e-002	-1.733	45.76	0.9708
21	6.66e-002	-4.e-002	-1.08	45.11	0.957
22	7.e-002	-3.66e-002	-1.394	45.42	0.9636
23	7.33e-002	-3.33e-002	-2.374	46.4	0.9844
24	7.66e-002	-3.e-002	-3.027	47.06	0.9983
25	8.e-002	-2.66e-002	-2.449	46.48	0.986
26	8.33e-002	-2.33e-002	-2.154	46.18	0.9797
27	8.66e-002	-2.e-002	-2.374	46.4	0.9844
28	9.e-002	-1.66e-002	-2.889	46.92	0.9953
29	9.33e-002	-1.33e-002	-2.914	46.94	0.9959

30	9.66e-002	-1.e-002	-2.336	46.37	0.9836
31	0.1	-6.6e-003	-2.286	46.32	0.9825
32	0.1033	-3.3e-003	-2.694	46.72	0.9912
33	0.1066	0.	-3.109	47.14	1.
34	0.11	3.4e-003	-2.939	46.97	0.9964
35	0.1133	6.7e-003	-2.518	46.55	0.9875
36	0.1166	1.e-002	-1.953	45.98	0.9755
37	0.12	1.34e-002	-2.192	46.22	0.9805
38	0.1233	1.67e-002	-2.543	46.57	0.988
39	0.1266	2.e-002	-2.826	46.86	0.994
40	0.13	2.34e-002	-2.248	46.28	0.9817
41	0.1333	2.67e-002	-1.947	45.98	0.9753
42	0.1366	3.e-002	-2.229	46.26	0.9813
43	0.14	3.34e-002	-2.6	46.63	0.9892
44	0.1433	3.67e-002	-2.613	46.64	0.9895
45	0.1466	4.e-002	-2.443	46.47	0.9859
46	0.15	4.34e-002	-2.298	46.33	0.9828
47	0.1533	4.67e-002	-2.148	46.18	0.9796
48	0.1566	5.e-002	-2.066	46.1	0.9779
49	0.16	5.34e-002	-2.041	46.07	0.9773
50	0.1633	5.67e-002	-1.84	45.87	0.9731
51	0.1666	6.e-002	-1.915	45.95	0.9747
52	0.17	6.34e-002	-2.179	46.21	0.9803
53	0.1733	6.67e-002	-2.091	46.12	0.9784
54	0.1766	7.e-002	-1.827	45.86	0.9728
55	0.18	7.34e-002	-1.984	46.01	0.9761
56	0.1833	7.67e-002	-2.16	46.19	0.9799
57	0.1866	8.e-002	-2.198	46.23	0.9807
58	0.19	8.34e-002	-1.978	46.01	0.976
59	0.1933	8.67e-002	-1.576	45.61	0.9675
60	0.1966	9.e-002	-1.607	45.64	0.9681
61	0.2	9.34e-002	-1.815	45.84	0.9725
62	0.2033	9.67e-002	-2.091	46.12	0.9784
63	0.2066	0.1	-2.11	46.14	0.9788
64	0.21	0.1034	-1.94	45.97	0.9752
65	0.2133	0.1067	-1.965	45.99	0.9757
66	0.2166	0.11	-2.179	46.21	0.9803
67	0.22	0.1134	-2.38	46.41	0.9845
68	0.2233	0.1167	-2.298	46.33	0.9828
69	0.2266	0.12	-1.84	45.87	0.9731
70	0.23	0.1234	-1.312	45.34	0.9619
71	0.2333	0.1267	-1.507	45.54	0.966
72	0.2366	0.13	-1.934	45.96	0.9751
73	0.24	0.1334	-2.236	46.27	0.9815
74	0.2433	0.1367	-2.129	46.16	0.9792
75	0.2466	0.14	-1.815	45.84	0.9725
76	0.25	0.1434	-1.683	45.71	0.9697
77	0.2533	0.1467	-1.821	45.85	0.9727
78	0.2566	0.15	-1.626	45.66	0.9685
79	0.26	0.1534	-1.827	45.86	0.9728
80	0.2633	0.1567	-1.752	45.78	0.9712
81	0.2666	0.16	-1.89	45.92	0.9741
82	0.27	0.1634	-2.11	46.14	0.9788
83	0.2733	0.1667	-2.336	46.37	0.9836

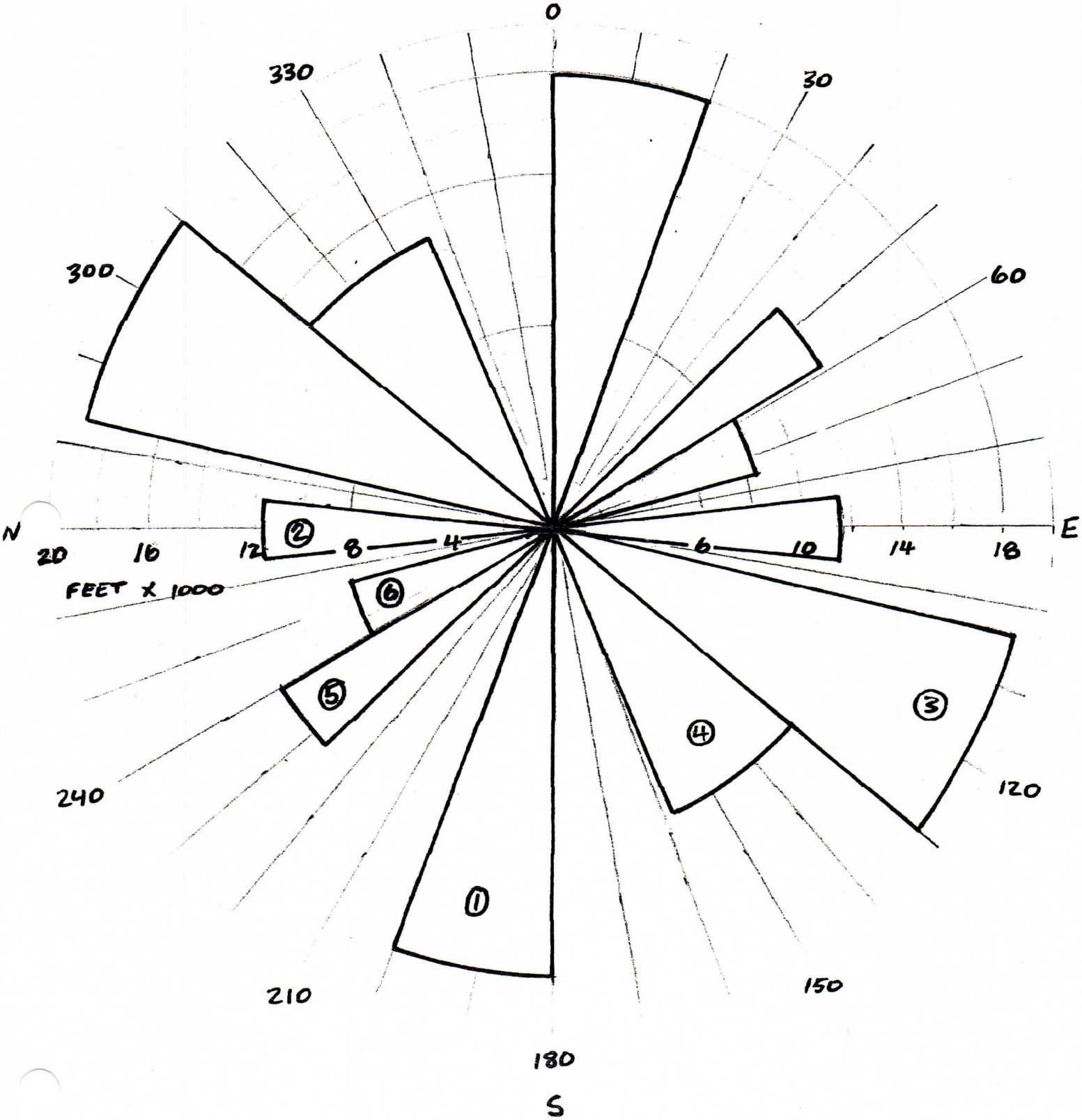
84	0.2766	0.17	-2.11	46.14	0.9788
85	0.28	0.1734	-1.676	45.71	0.9696
86	0.2833	0.1767	-1.532	45.56	0.9665
87	0.2866	0.18	-1.802	45.83	0.9723
88	0.29	0.1834	-2.085	46.12	0.9783
89	0.2933	0.1867	-2.122	46.15	0.9791
90	0.2966	0.19	-1.928	45.96	0.9749
91	0.3	0.1934	-1.764	45.79	0.9715
92	0.3033	0.1967	-1.802	45.83	0.9723
93	0.3066	0.2	-1.921	45.95	0.9748
94	0.31	0.2034	-1.965	45.99	0.9757
95	0.3133	0.2067	-1.921	45.95	0.9748
96	0.3166	0.21	-1.859	45.89	0.9735
97	0.32	0.2134	-1.859	45.89	0.9735
98	0.3233	0.2167	-1.896	45.93	0.9743
99	0.3266	0.22	-1.915	45.95	0.9747
100	0.33	0.2234	-1.896	45.93	0.9743
101	0.3333	0.2267	-1.871	45.9	0.9737
102	0.35	0.2434	-1.871	45.9	0.9737
103	0.3666	0.26	-1.871	45.9	0.9737
104	0.3833	0.2767	-1.865	45.89	0.9736
105	0.4	0.2934	-1.903	45.93	0.9744
106	0.4166	0.31	-1.884	45.91	0.974
107	0.4333	0.3267	-1.884	45.91	0.974
108	0.45	0.3434	-1.865	45.89	0.9736
109	0.4666	0.36	-1.846	45.88	0.9732
110	0.4833	0.3767	-1.84	45.87	0.9731
111	0.5	0.3934	-1.827	45.86	0.9728
112	0.5166	0.41	-1.827	45.86	0.9728
113	0.5333	0.4267	-1.821	45.85	0.9727
114	0.55	0.4434	-1.815	45.84	0.9725
115	0.5666	0.46	-1.808	45.84	0.9724
116	0.5833	0.4767	-1.802	45.83	0.9723
117	0.6	0.4934	-1.796	45.83	0.9721
118	0.6166	0.51	-1.79	45.82	0.972
119	0.6333	0.5267	-1.783	45.81	0.9719
120	0.65	0.5434	-1.783	45.81	0.9719
121	0.6666	0.56	-1.777	45.81	0.9717
122	0.6833	0.5767	-1.771	45.8	0.9716
123	0.7	0.5934	-1.764	45.79	0.9715
124	0.7166	0.61	-1.764	45.79	0.9715
125	0.7333	0.6267	-1.752	45.78	0.9712
126	0.75	0.6434	-1.752	45.78	0.9712
127	0.7666	0.66	-1.746	45.78	0.9711
128	0.7833	0.6767	-1.739	45.77	0.9709
129	0.8	0.6934	-1.733	45.76	0.9708
130	0.8166	0.71	-1.727	45.76	0.9707
131	0.8333	0.7267	-1.758	45.79	0.9713
132	0.85	0.7434	-1.727	45.76	0.9707
133	0.8666	0.76	-1.714	45.74	0.9704
134	0.8833	0.7767	-1.708	45.74	0.9703
135	0.9	0.7934	-1.708	45.74	0.9703
136	0.9166	0.81	-1.702	45.73	0.9702
137	0.9333	0.8267	-1.695	45.72	0.97

138	0.95	0.8434	-1.689	45.72	0.9699
139	0.9666	0.86	-1.683	45.71	0.9697
140	0.9833	0.8767	-1.683	45.71	0.9697
141	1.	0.8934	-1.676	45.71	0.9696
142	1.2	1.093	-1.607	45.64	0.9681
143	1.4	1.293	-1.557	45.59	0.9671
144	1.6	1.493	-1.507	45.54	0.966
145	1.8	1.693	-1.463	45.49	0.9651
146	2.	1.893	-1.419	45.45	0.9641
147	2.2	2.093	-1.375	45.4	0.9632
148	2.4	2.293	-1.337	45.37	0.9624
149	2.6	2.493	-1.293	45.32	0.9615
150	2.8	2.693	-1.262	45.29	0.9608
151	3.	2.893	-1.224	45.25	0.96
152	3.2	3.093	-1.193	45.22	0.9594
153	3.4	3.293	-1.155	45.19	0.9585
154	3.6	3.493	-1.124	45.15	0.9579
155	3.8	3.693	-1.092	45.12	0.9572
156	4.	3.893	-1.067	45.1	0.9567
157	4.2	4.093	-1.036	45.07	0.956
158	4.4	4.293	-1.011	45.04	0.9555
159	4.6	4.493	-0.985	45.02	0.9549
160	4.8	4.693	-0.96	44.99	0.9544
161	5.	4.893	-0.935	44.97	0.9539
162	5.2	5.093	-0.91	44.94	0.9534
163	5.4	5.293	-0.885	44.91	0.9528
164	5.6	5.493	-0.866	44.9	0.9524
165	5.8	5.693	-0.841	44.87	0.9519
166	6.	5.893	-0.822	44.85	0.9515
167	6.2	6.093	-0.803	44.83	0.9511
168	6.4	6.293	-0.778	44.81	0.9506
169	6.6	6.493	-0.759	44.79	0.9501
170	6.8	6.693	-0.747	44.78	0.9499
171	7.	6.893	-0.728	44.76	0.9495
172	7.2	7.093	-0.709	44.74	0.9491
173	7.4	7.293	-0.69	44.72	0.9487
174	7.6	7.493	-0.678	44.71	0.9484
175	7.8	7.693	-0.659	44.69	0.948
176	8.	7.893	-0.646	44.68	0.9478
177	8.2	8.093	-0.634	44.66	0.9475
178	8.4	8.293	-0.615	44.64	0.9471
179	8.6	8.493	-0.602	44.63	0.9468
180	8.8	8.693	-0.59	44.62	0.9466
181	9.	8.893	-0.577	44.61	0.9463
182	9.2	9.093	-0.565	44.59	0.946
183	9.4	9.293	-0.552	44.58	0.9458
184	9.6	9.493	-0.54	44.57	0.9455
185	9.8	9.693	-0.527	44.56	0.9452
186	10.	9.893	-0.514	44.54	0.945
187	12.	11.89	-0.408	44.44	0.9427
188	14.	13.89	-0.345	44.38	0.9414
189	16.	15.89	-0.282	44.31	0.94
190	18.	17.89	-0.238	44.27	0.9391
191	20.	19.89	-0.201	44.23	0.9383

192	22.	21.89	-0.175	44.2	0.9378
193	24.	23.89	-0.157	44.19	0.9374
194	26.	25.89	-0.144	44.17	0.9371
195	28.	27.89	-0.125	44.16	0.9367
196	30.	29.89	-0.113	44.14	0.9364
197	32.	31.89	-0.106	44.14	0.9363
198	34.	33.89	-0.1	44.13	0.9362
199	36.	35.89	-0.1	44.13	0.9362
200	38.	37.89	-8.7e-002	44.12	0.9359
201	40.	39.89	-8.1e-002	44.11	0.9358
202	42.	41.89	-8.1e-002	44.11	0.9358
203	44.	43.89	-7.5e-002	44.1	0.9356
204	46.	45.89	-8.1e-002	44.11	0.9358
205	48.	47.89	-6.9e-002	44.1	0.9355
206	50.	49.89	-6.9e-002	44.1	0.9355

APPENDIX 5
Fracture Trace Analysis

CUMALATIVE LENGTH "ROSETTE" DIAGRAM
FOR MAJOR DRAINAGE FEATURES (>1000')
WITHIN ONE-MILE RADIUS



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 950 ft Scale: 1 : 24,000 Detail: 13-0 Datum: WGS84

NORTH-SOUTH			EAST-WEST		
3	5000'	002	5	1800'	272
* 9	3500'	005	*11	1400	090(270)
20	1000'	017	*12	1500	276
21	1000'	019	14	1400	084(264)
26	1800'	010	17	1000	276
28	1300	009	23	2900	089(269)
31	3000	008	30	1500	090(270)
34	1500	015			

① 000 - 020 18,100

② 264 - 276 11,500

* OCCURS ON-SITE

NORTHWEST

1	1500	294
2	1600	314
4	1600	284
7	2000	327
8	1700	306
* 10	3300	314
* 13	2500	313
15	1500	309
16	1500	335
* 24	1500	301
25	1300	287
32	3200	338
35	1600	305
36	4600	318
39	1500	300

3) 284 - 311 12,600

4) 312 - 338 19,100

NORTHEAST

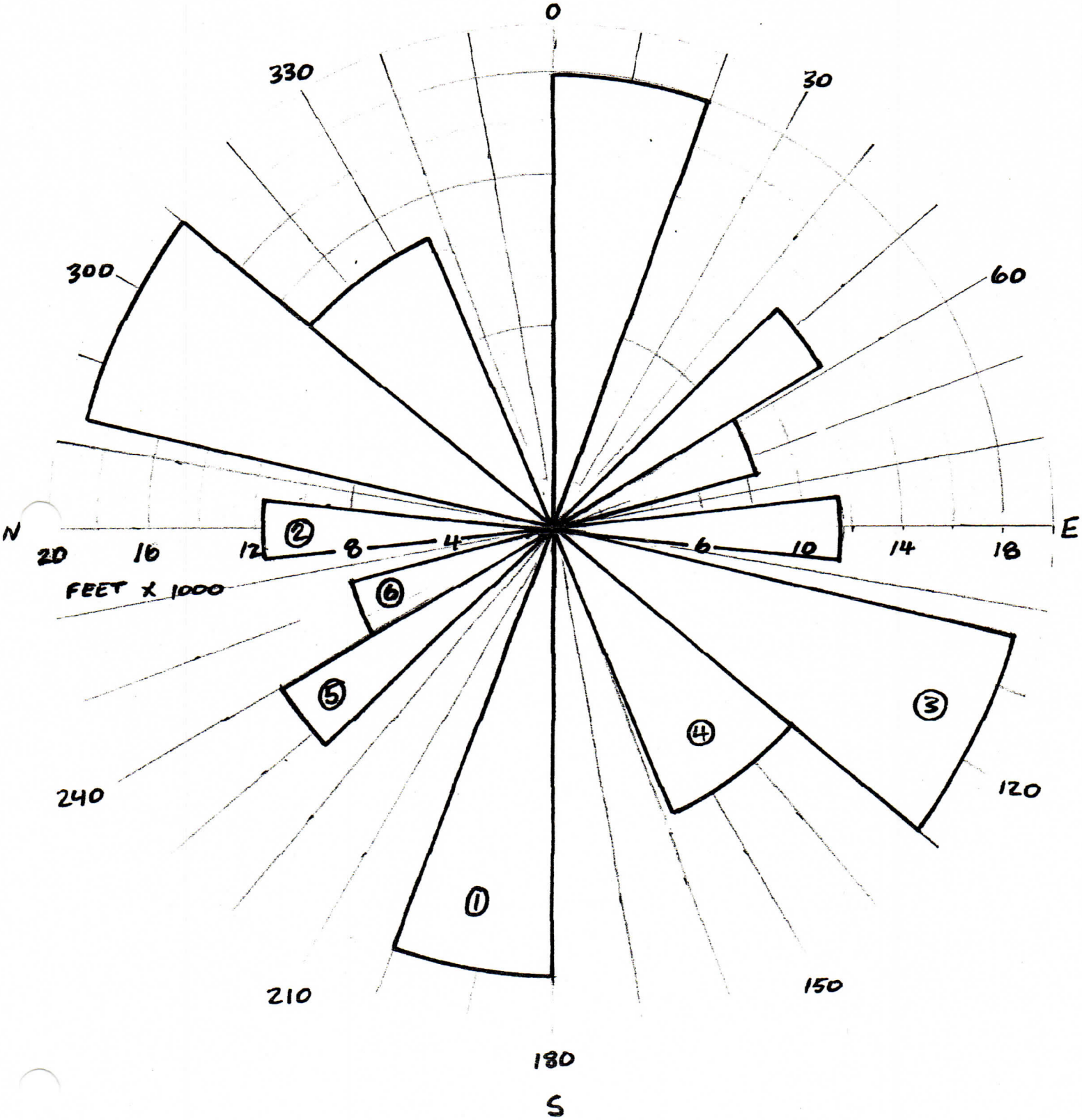
6	3200	045
18	1100	057
19	2000	060
~~20~~		
22	1500	052
~~26~~		
27	1600	041
29	1500	051
33	1500	049
37	1500	073
38	2000	040
40	5000	067

5) 045 - 059 12,600

6) 060 - 073 8,500

* OCCURS ON-SITE

CUMALATIVE LENGTH "ROSETTE" DIAGRAM
FOR MAJOR DRAINAGE FEATURES (>1000')
WITHIN ONE-MILE RADIUS



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 950 ft Scale: 1 : 24,000 Detail: 13-0 Datum: WGS84

NORTH-SOUTH			EAST-WEST		
3	5000'	002	5	1800'	272
* 9	3500'	005	*11	1400	090(270)
20	1000'	017	*12	1500	276
21	1000'	019	14	1400	084(264)
26	1800'	010	17	1000	276
28	1300	009	23	2900	089(269)
31	3000	008	30	1500	090(270)
34	1500	015			

① 000 - 020 18,100

② 264 - 276 11,500

* OCCURS ON-SITE

APPENDIX 6
Geotechnical Lab Data

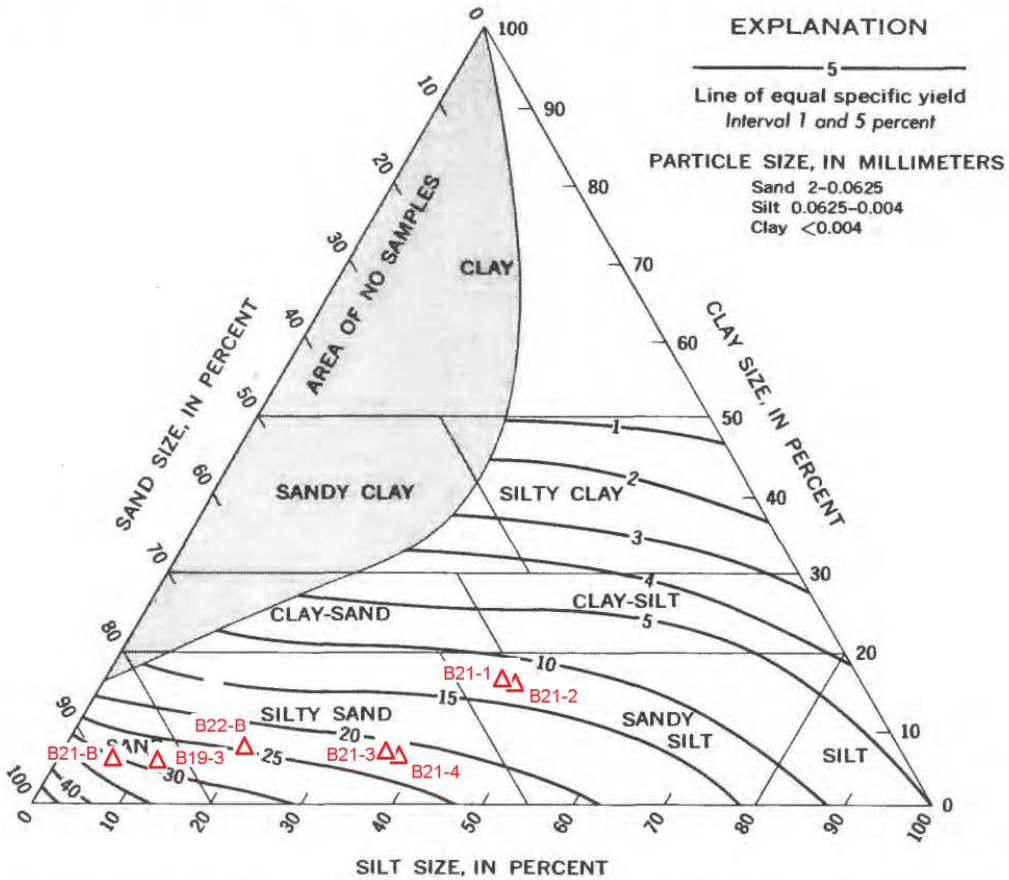
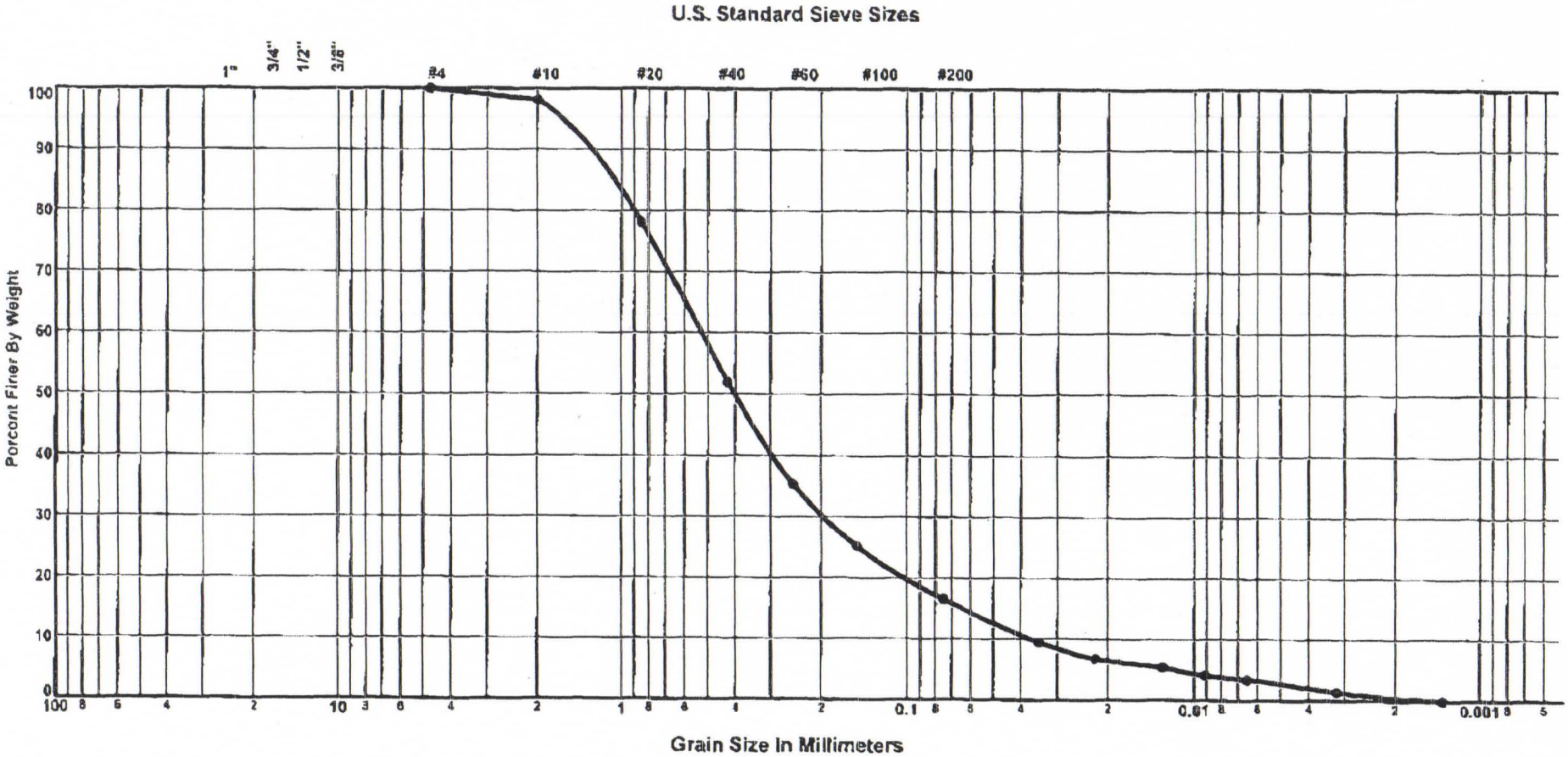


FIGURE 1.—Soil-classification triangle showing relation between particle size and specific yield.

Johnson, A.I., Compilation of Specific Yields for Various Materials, USGS Water Supply Paper 1662-2, 1967

The concept of moisture equivalent was introduced by Briggs and McLane (1907) by determinations made on more than 100 soils of the moisture retained under a centrifugal force 3,000 times the force of gravity. Stearns (1927) pointed out that the moisture-equivalent method is based on the theory of applying a centrifugal force great enough to reduce the capillary fringe enough that it can be ignored without introducing much error, even in small samples, and yet not so great as to withdraw a large proportion of the water that is held more securely above the capillary fringe. Stearns noted that if a material will lift water 100 inches by capillarity acting against gravity, the material will theoretically be able to hold the water only 0.1 inch against a centrifugal force that is 1,000 times greater than the force of gravity. Prill (1961) discussed this relation in more detail and pointed out that water retention after centrifuging is comparable to that obtained by gravity drainage of long columns.

Briggs and McLane (1907) made their early determinations under a centrifugal force of 3,000 times gravity, but in a later publication Briggs (1910) suggested that a force 1,000 times gravity could be used.



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-19 3	13.5-15'		NP	NP	NP	Sandy SILT (ML)

Project:

A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

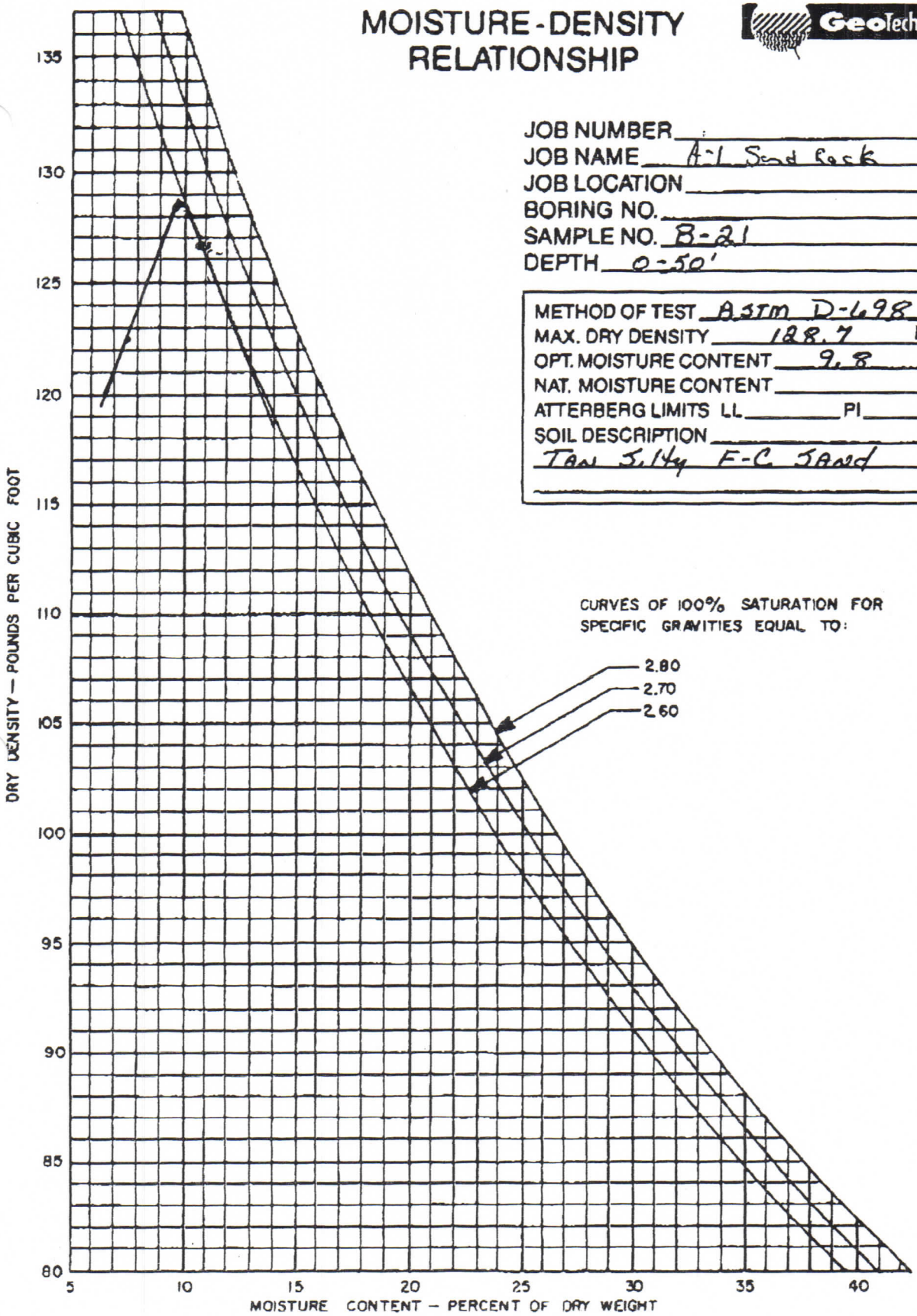
GeoTechnologies, Inc.

MOISTURE-DENSITY RELATIONSHIP

GeoTechnologies, Inc.

JOB NUMBER
JOB NAME A-1 Sand Rock
JOB LOCATION
BORING NO.
SAMPLE NO. B-21
DEPTH 0-50'

METHOD OF TEST ASTM D-698
MAX. DRY DENSITY 128.7 PCF
OPT. MOISTURE CONTENT 9.8 %
NAT. MOISTURE CONTENT %
ATTERBERG LIMITS LL PI
SOIL DESCRIPTION
Tan Silty F-C Sand

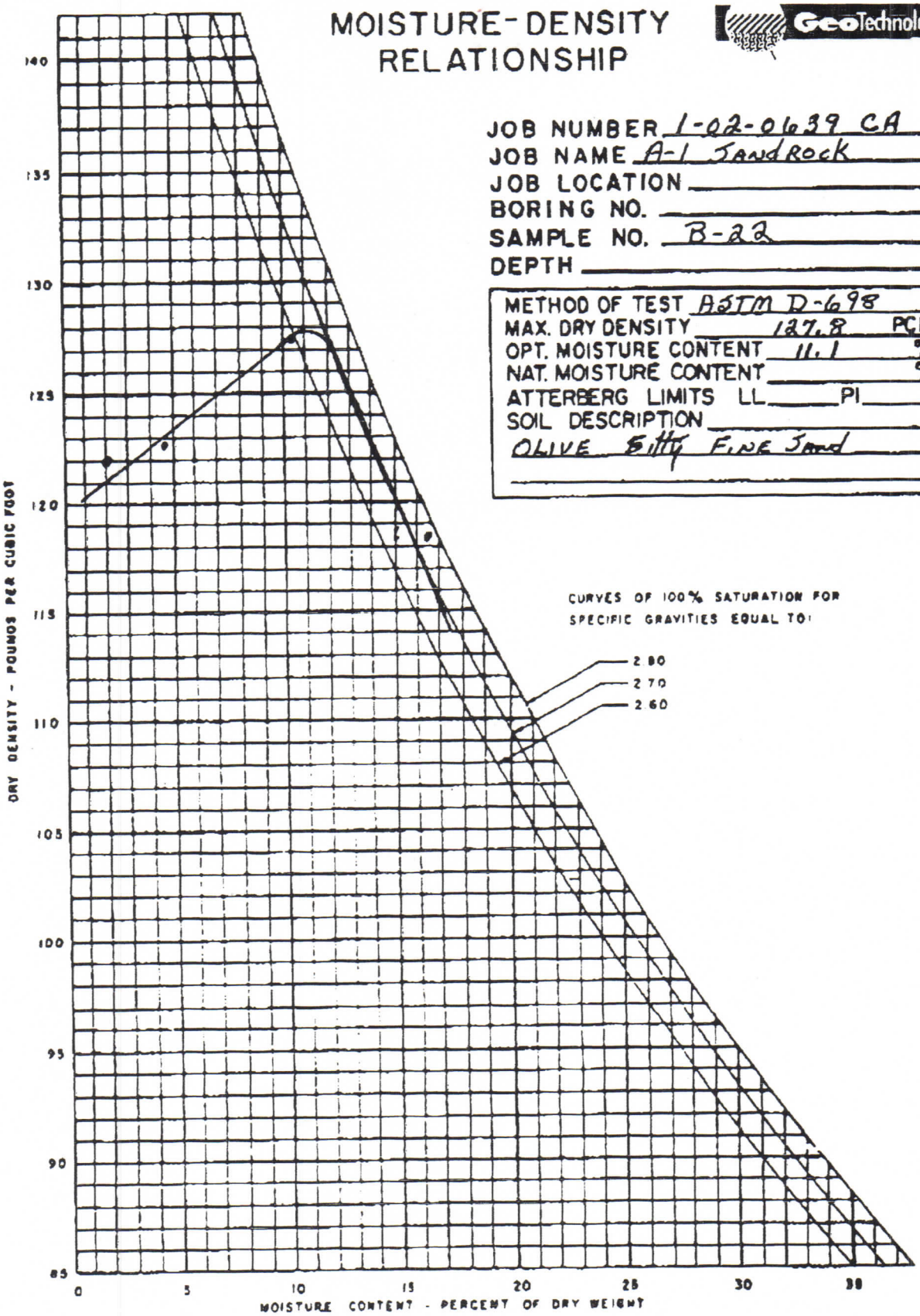


MOISTURE-DENSITY RELATIONSHIP

GeoTechnologies, Inc.

JOB NUMBER 1-02-0639 CA
JOB NAME A-1 Sandrock
JOB LOCATION
BORING NO.
SAMPLE NO. B-22
DEPTH

METHOD OF TEST ASTM D-698
MAX. DRY DENSITY 127.8 PCF
OPT. MOISTURE CONTENT 11.1 %
NAT. MOISTURE CONTENT %
ATTERBERG LIMITS LL PI
SOIL DESCRIPTION
OLIVE Silty Fine Sand



169A

GeoTechnologies, Inc.

PERMEABILITY TEST

Job Number:		**Job Name:**	A-1 Sandrock		
Date:	31-May-02	**Sample I.D.**	B-21	**Depth:**	0 - 50'

Soil Description: Tan Silty Coarse to Fine SAND

SAMPLE DATA

Type		Standard Proctor (ASTM D-698)		
Remolded	(X)	Maximum Dry Density	**128.7**	lbs/cu.ft.
Undisturbed	()	Opt. Moisture Content	**9.8**	%
		Compaction	**99.8**	%

	Inches	cm.				
				Actual Moisture Content	**13.7**	%
				Wet Density	**146.0**	lbs./cu.ft.
Length	**2.930**	**7.442**		Dry Density	**128.4**	lbs./cu.ft.
Diameter	**2.829**	**7.186**		Initial Saturation	**126.0**	%
Area	**6.286**	**40.553**		Final Saturation	**100.0**	%
Volume	**18.417**	**301.804**		Initial Void Ratio	**0.29**	
Wet Mass	**1.556**	**705.93**	grams	Porosity	**22.4**	%
Dry Mass	**1.3688**	**620.9**	grams	Specific Gravity	**2.65**	apparent

TEST DATA

	L =	7.44 cm.	length of sample
hi = inflow burette	A =	40.553 sq.cm.	area of sample
ho = outflow burette	a =	0.852 sq.cm.	area of burettes
t = time	h1 =	head loss across specimen at t1	
	h2 =	head loss across specimen at t2	

t1	t2	ho1	hi1	h1	ho2	hi2	h2
0	**8580**	80.9	14	**66.9**	79.5	15.3	**64.2**
0	**14400**	85.3	9.7	**75.6**	83.2	11.7	**71.5**
0	**12420**	83.2	11.7	**71.5**	80.9	14	**66.9**

ASTM D 5084

k = ((aaL/(At(a+a)))*ln(h1/h2)

				Percent Deviation
NOTE:	1	k =	3.75E-07	2.68%
5 PSI Confining Pressure	2	k =	3.03E-07	17.19%
1 PSI Driving Head	3	k =	4.19E-07	14.51%

Average k= 3.66E-07 cm/sec

GeoTechnologies, Inc.

PERMEABILITY TEST

Job Number:	1-02-0639 CA	Job Name:		A-1 Sandrock	
Date:	12-Jun-02	Sample I.D.	B-22	Depth:	0 - 20'

Soil Description: Gray Slightly Silty Fine - Medium Sand

SAMPLE DATA

Type	
Remolded	(X)
Undisturbed	()

Standard Proctor (ASTM D-698)		
Maximum Dry Density	127.8	lbs/cu.ft.
Opt. Moisture Content	11.1	%
Compaction	90.2	%

	Inches	cm.	
Length	3.108	7.894	
Diameter	2.875	7.303	
Area	6.492	41.883	
Volume	20.177	330.634	
Wet Mass	1.555	705.28	grams
Dry Mass	1.3462	610.6	grams

Actual Moisture Content	15.5	%
Wet Density	133.2	lbs./cu.ft.
Dry Density	115.3	lbs./cu.ft.
Initial Saturation	90.6	%
Final Saturation	100.0	%
Initial Void Ratio	0.46	
Porosity	31.6	%
Specific Gravity	2.7	apparent

TEST DATA

hi = inflow burette
ho = outflow burette
t = time

L =	7.89 cm.	length of sample
A =	41.883 sq.cm.	area of sample
a =	0.852 sq.cm.	area of burettes

h1 = head loss across specimen at t1
h2 = head loss across specimen at t2

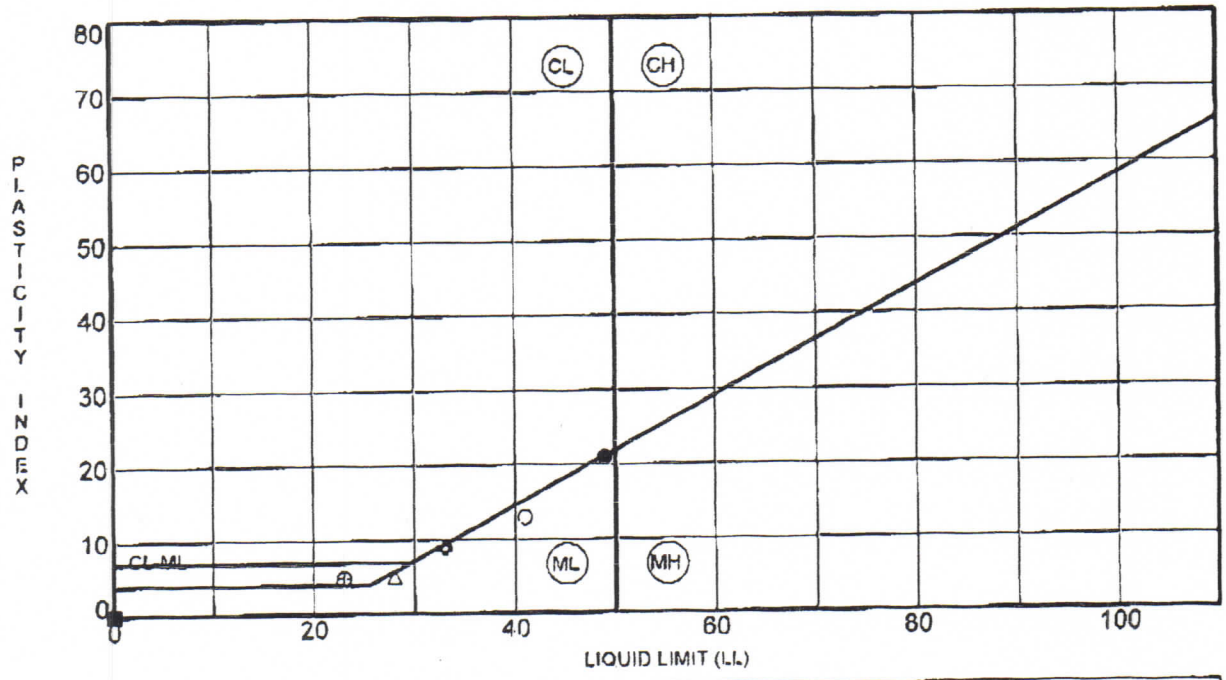
t1	t2	ho1	hi1	h1	ho2	hi2	h2
0	1860	109	7.7	101.3	100.9	15	85.9
0	2460	100.9	15	85.9	91.6	23.7	67.9
0	44880	115.3	1	114.3	107	8.9	98.1
0				0			0

ASTM D 5084

k = ((aaL/(At(a+a)))*ln(h1/h2)

				Percent Deviation
NOTE:	1	k =	7.12E-06	41.74%
5 PSI Confining Pressure	2	k =	7.68E-06	52.82%
1 PSI Driving Head	3	k =	2.73E-07	94.56%

Average k= **5.02E-06** cm/sec



Specimen Identification			LL	PL	PI	Fines	Classification
● B-11	1	3.5-5'	49	28	21	89.9	Orange Silty CLAY (CL-ML)
⊠ B-11	3	13.5-15'	NP	NP	NP	32.0	Gray Tan Silty Fine to Medium SAND (SM)
▶ B-12	2	8.5-10'	NP	NP	NP	13.6	White & Brown Fine to Coarse SAND (SM)
★ B-13	Bulk		NP	NP	NP	29.0	Gray Sandy SILT (ML)
✕ B-19	3	13.5-15'	NP	NP	NP	16.6	Sandy SILT (ML)
◇ B-21	1	3.5-5'	33	24	9	60.5	Tan Silty SAND (SM)
○ B-21	2	8.5-10'	41	28	13	59.3	Silty SAND (SM)
△ B-21	3	13.5-15'	28	23	5	44.2	SILT (ML)
⊗ B-21	4	18.5-20'	NP	NP	NP	46.0	SILT (ML)
⊕ B-21	Bulk	0-5'	23	18	5	12.5	Tan Silty Coarse to Fine SAND (SM)
□ B-22	Bulk		NP	NP	NP	24.3	Olive Silty Fine SAND (SM)

PROJECT A-1 Sandrock - Greensboro, North Carolina

JOB NO. 1-02-0639-CA
DATE 6/18/02

ATTERBERG LIMITS' RESULTS

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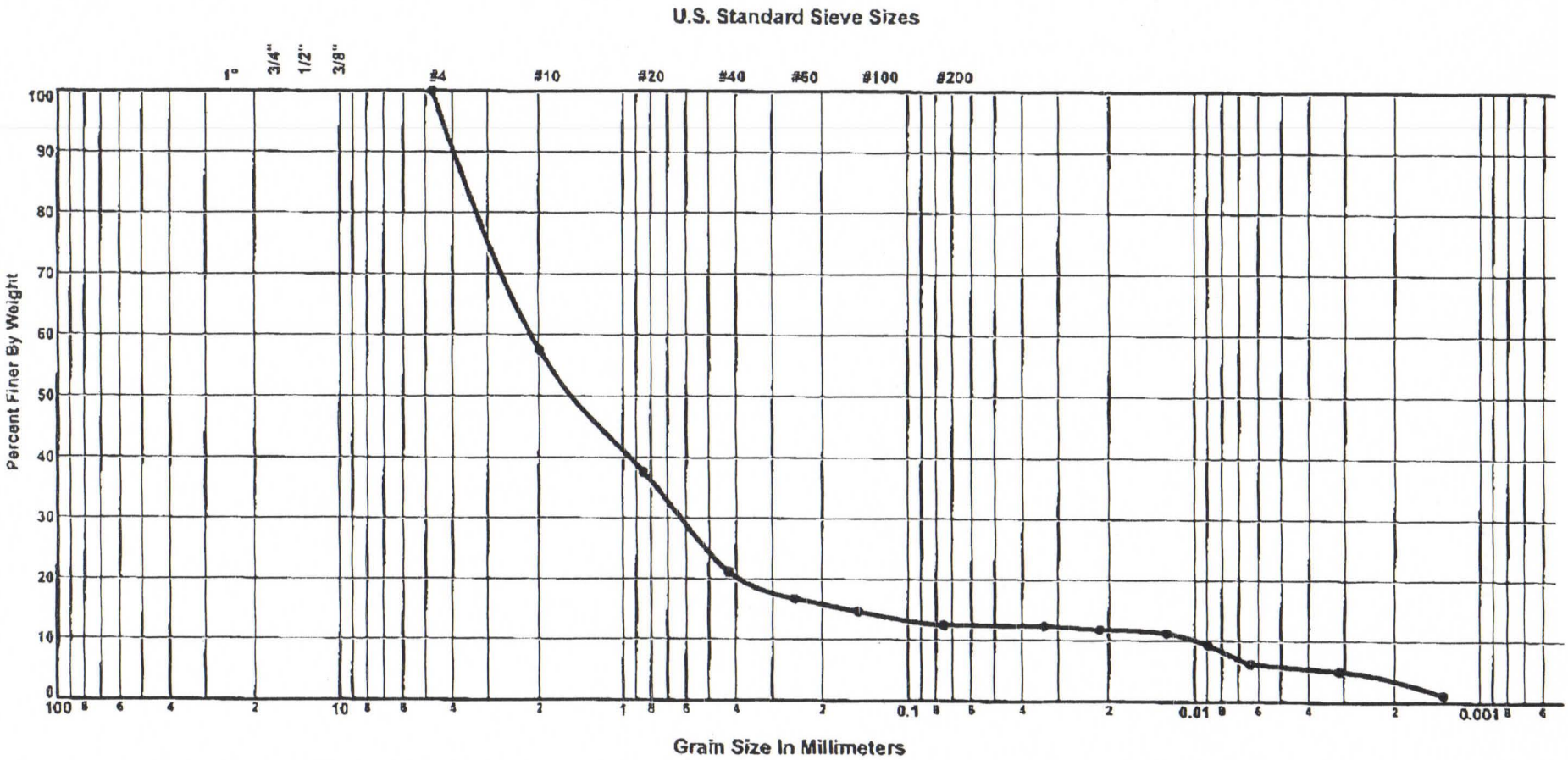

GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-21 Bulk	0-5'		23.0	18.0	5.0	Tan Silty Coarse to Fine SAND (SM)

Project:

A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

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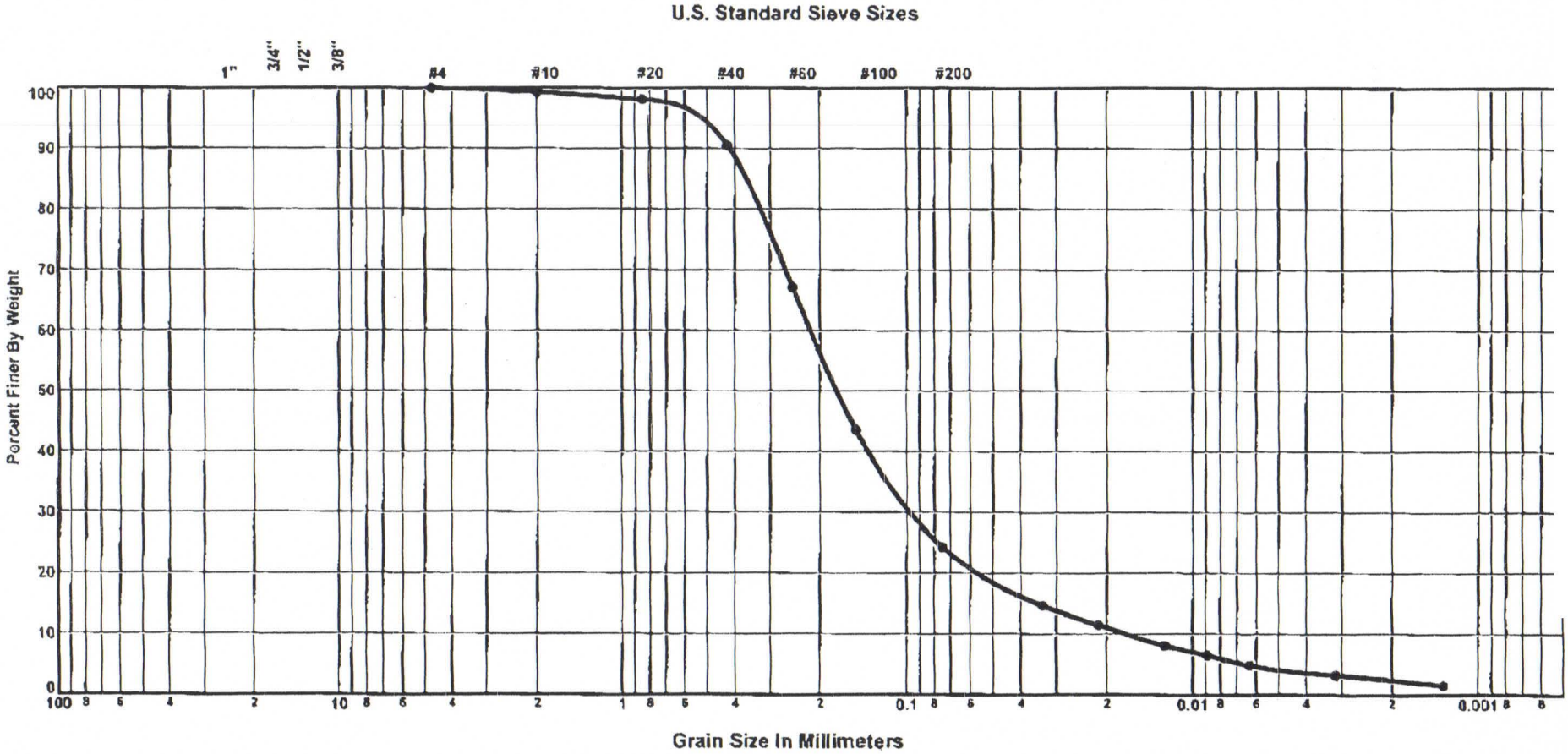

GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-22 Bulk		2.3	NP	NP	NP	Olive Silty Fine SAND (SM)

Project:

A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

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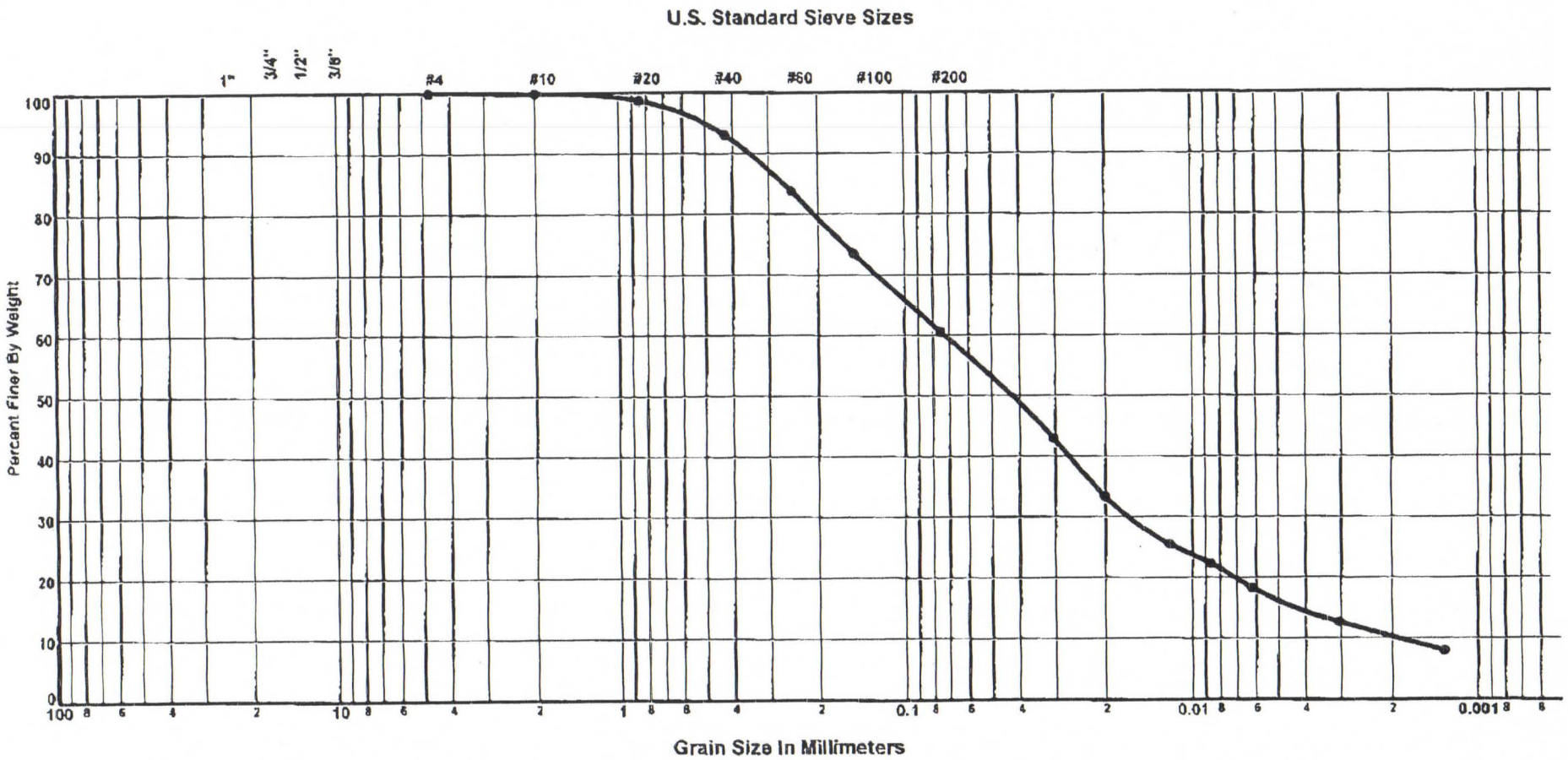

GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-21 1	3.5-5'		33.0	24.0	9.0	Tan Silty SAND (SM)

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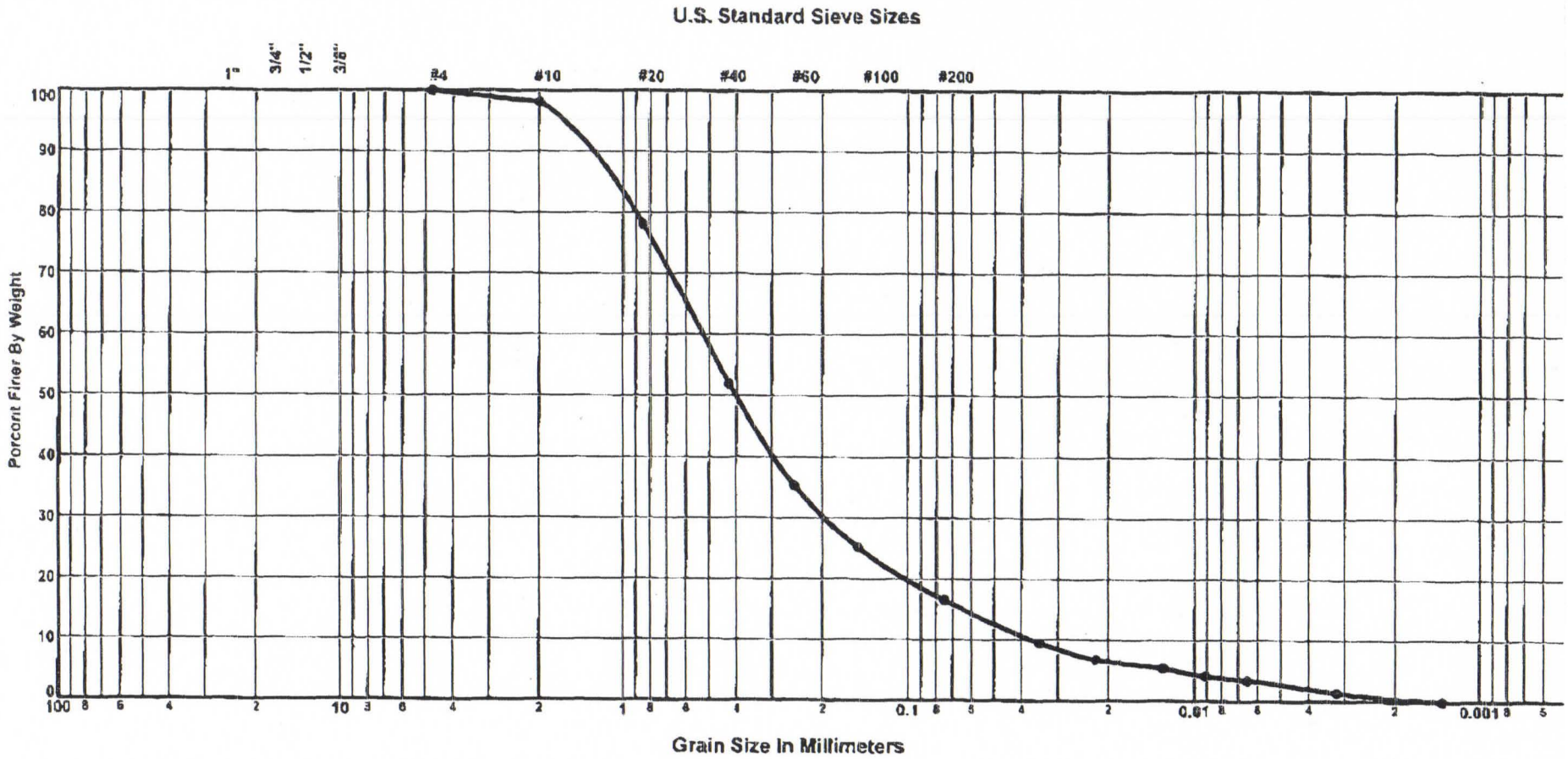

GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-19 3	13.5-15'		NP	NP	NP	Sandy SILT (ML)

Project:

A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

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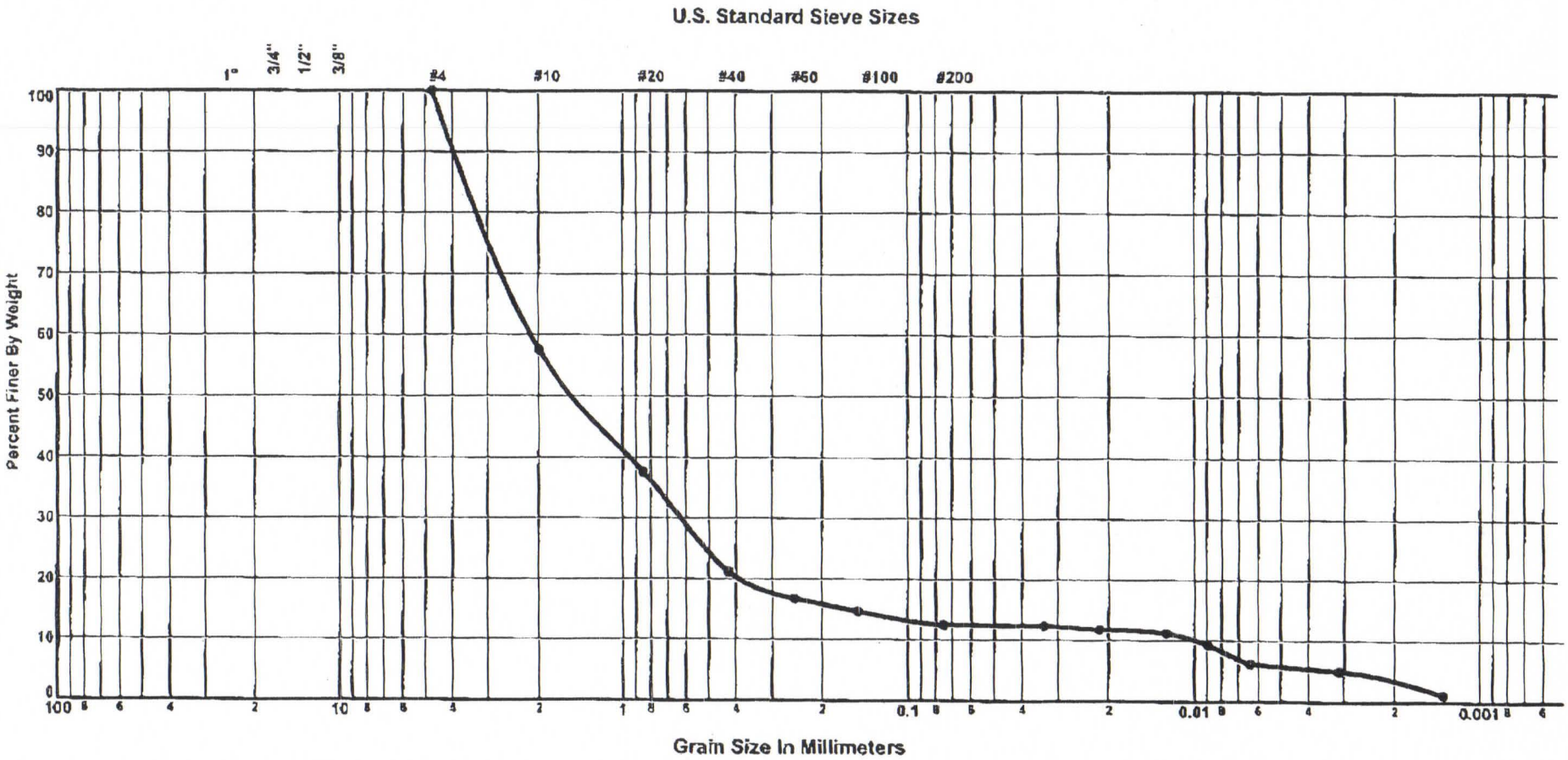

GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-21 Bulk	0-5'		23.0	18.0	5.0	Tan Silty Coarse to Fine SAND (SM)

Project:

A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

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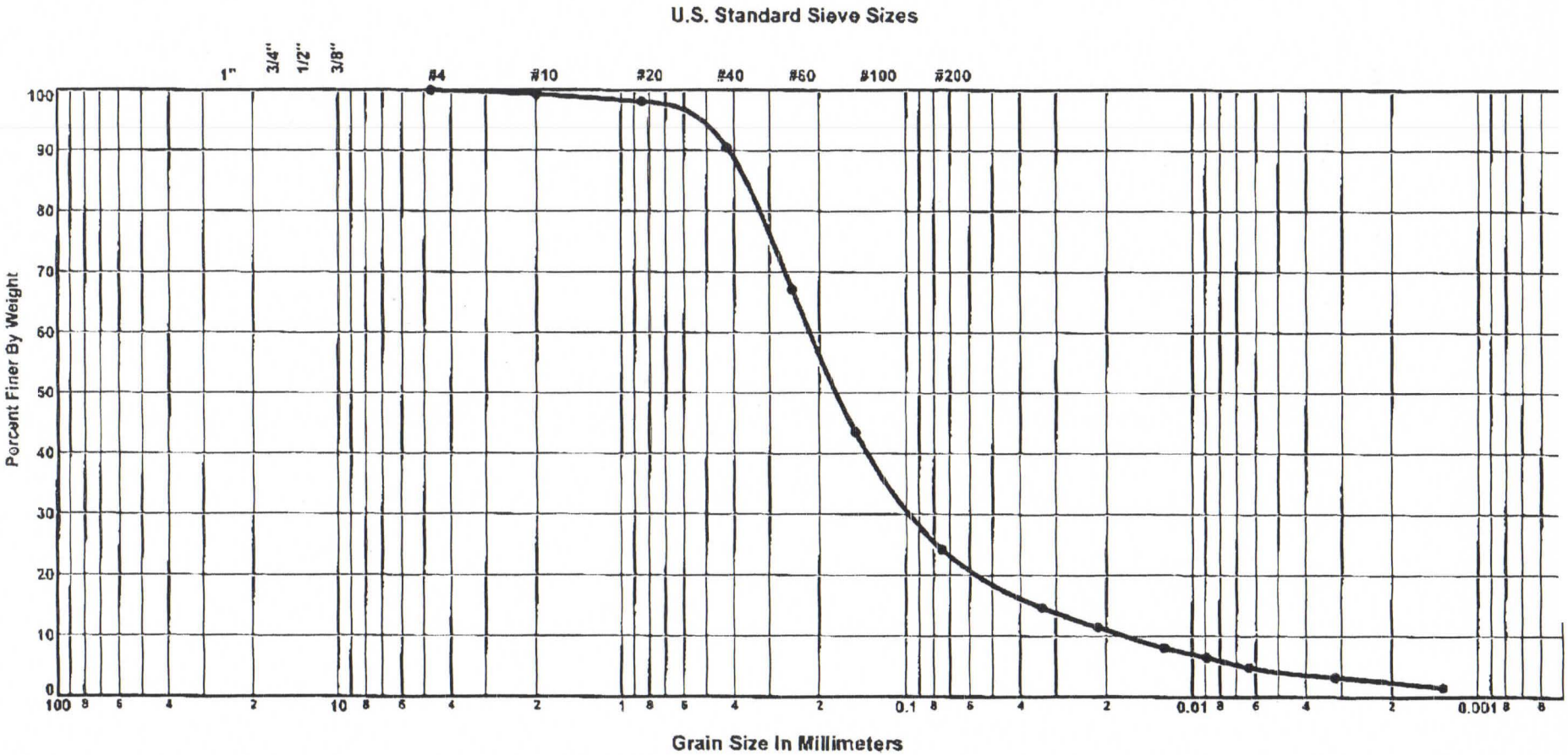


GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-22 Bulk		2.3	NP	NP	NP	Olive Silty Fine SAND (SM)

Project:

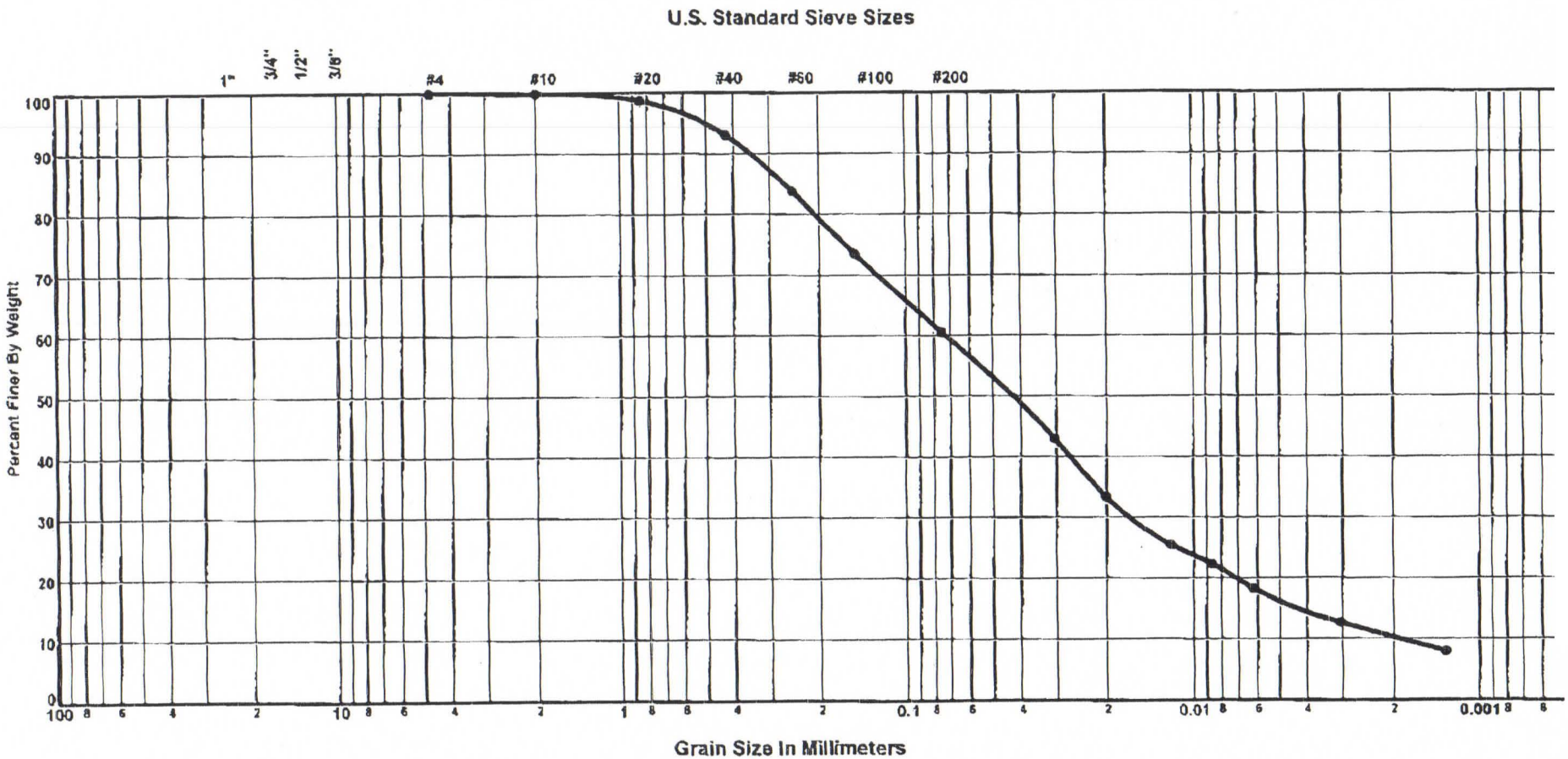
A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-21 1	3.5-5'		33.0	24.0	9.0	Tan Silty SAND (SM)

Project:

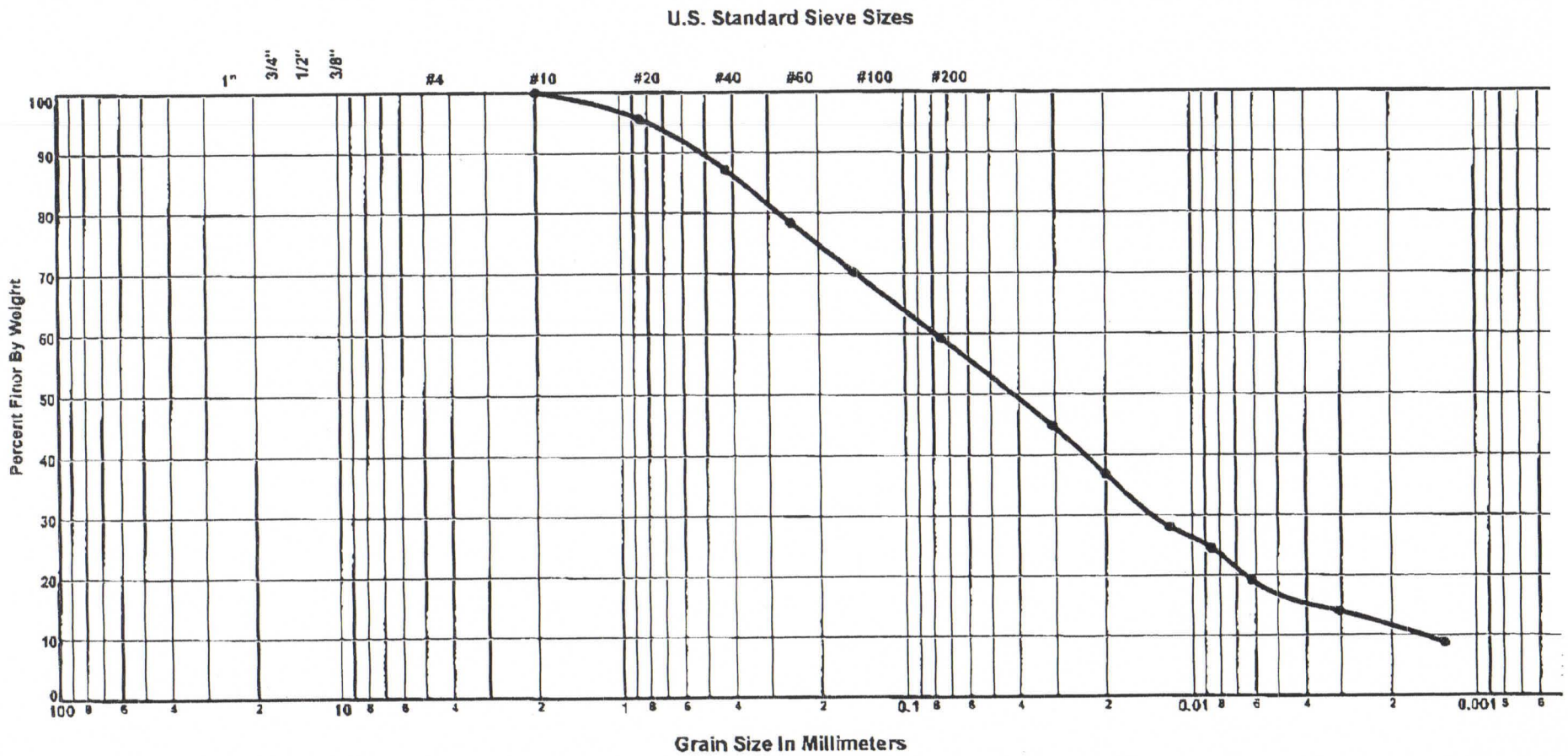
A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-21 2	8.5-10'		41.0	28.0	13.0	Silty SAND (SM)

Project:

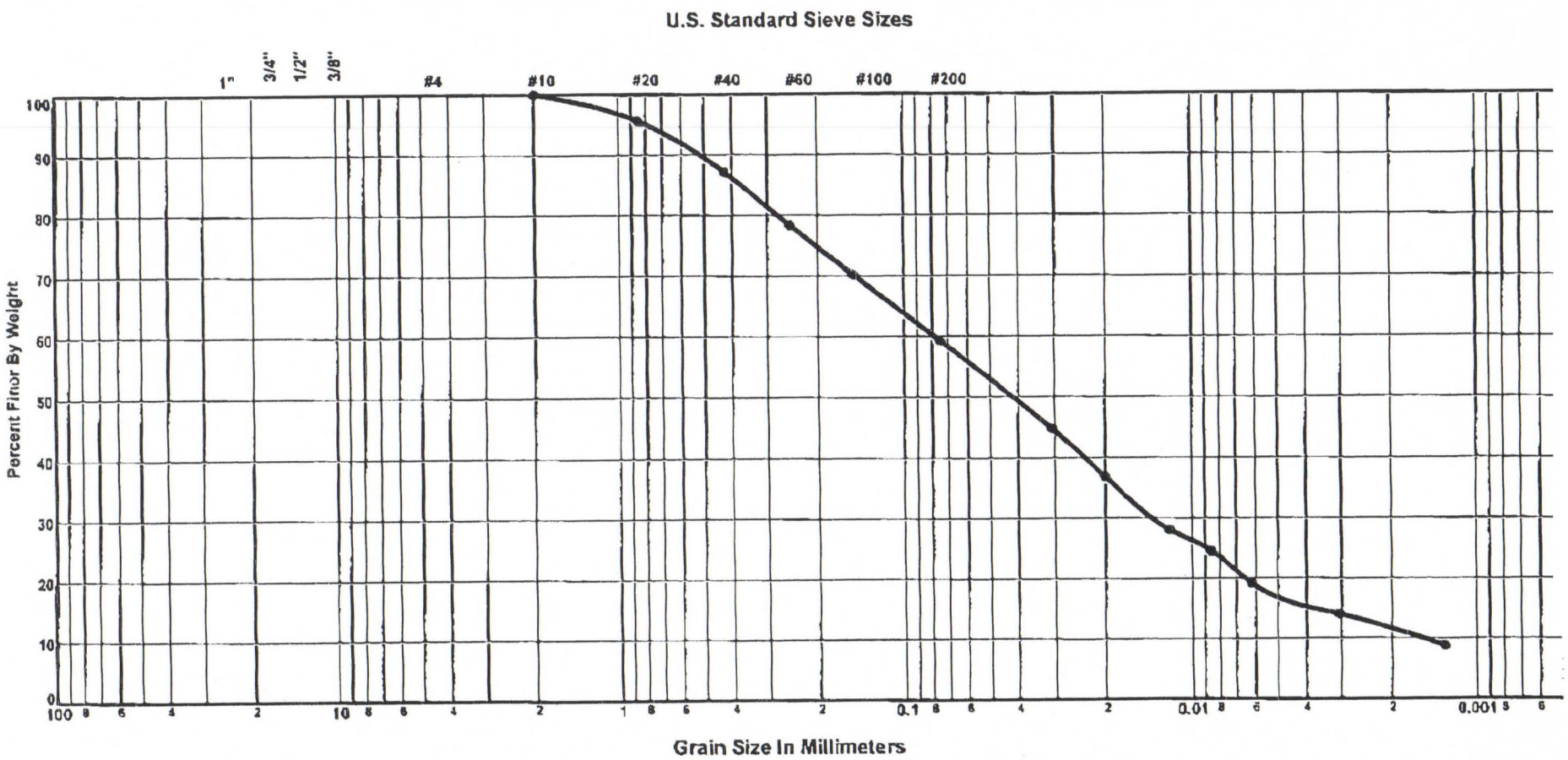
A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-21 2	8.5-10'		41.0	28.0	13.0	Silty SAND (SM)

Project:

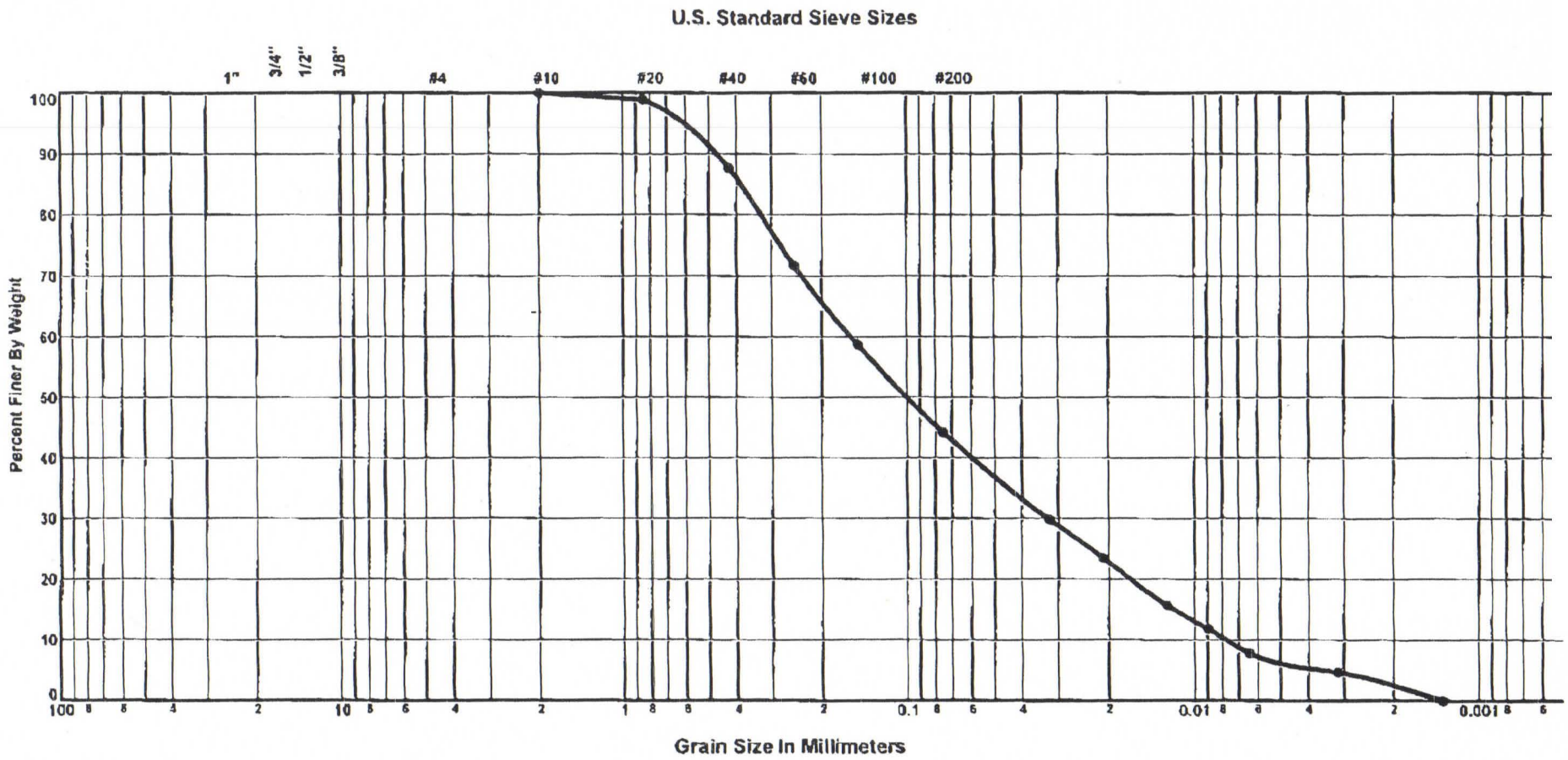
A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-21 3	13.5-15'		28.0	23.0	5.0	SILT (ML)

Project:

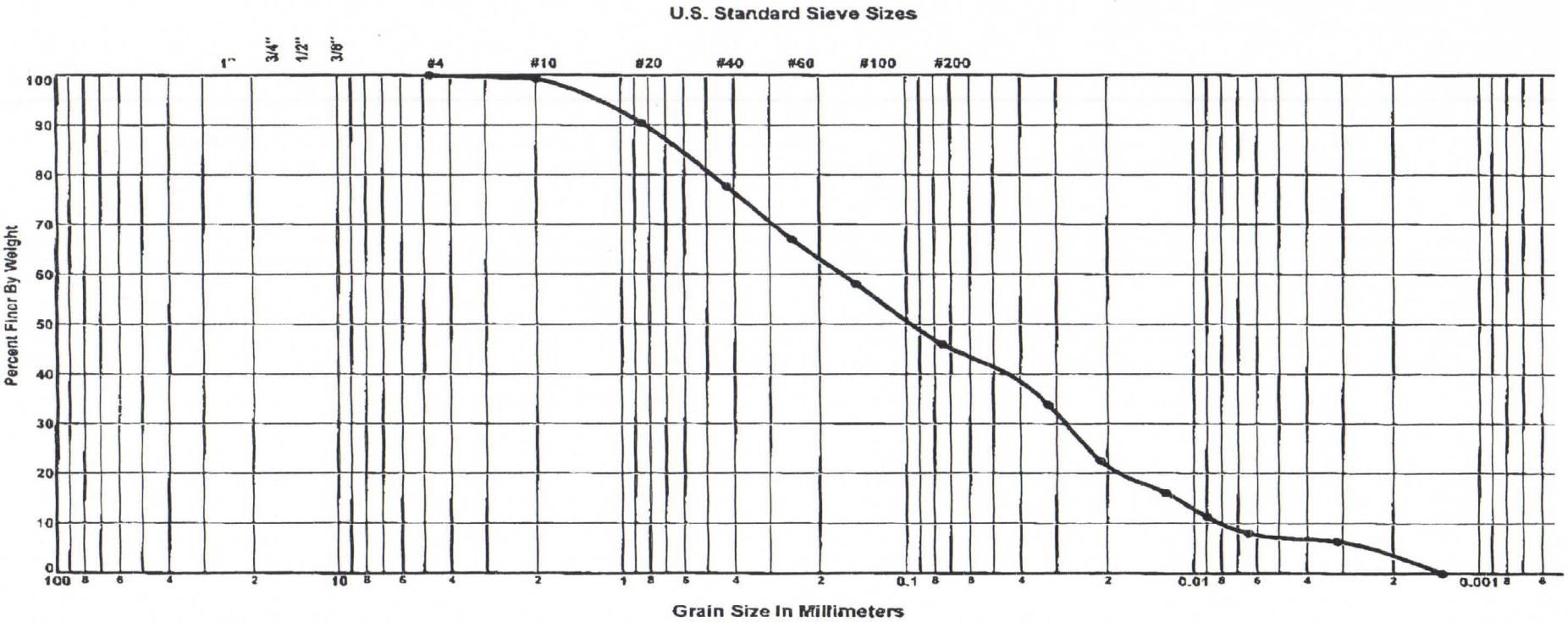
A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

Boring No.	Elev./Depth	Nat. W.C.	L.L.	P.L.	P.I.	Soil Description or Classification
B-21 4	18.5-20'		NP	NP	NP	SILT (ML)

Project:

A-1 Sandrock
Greensboro, North Carolina

Job No.: 1-02-0639-CA

Date: 6/18/02

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.

JOB NAME: A 1 Sandrock	JOB NO.

Boring	B-21	Sample	Bulk	Depth		Date	6/7/02

Total Weight of Air Dried Sample		167.38
Weight Retained on #10 Sieve		70.94
Dry Wt. of Total Sample		165.46
Dry Wt. of Weight Passing #10 Sieve		70.13
Weight Passing #10 Sieve		96.44
Weight of Air Dried Hydrometer Sample		81.51
Dry Wt. of Hydrometer Sample		80.58

% Passing #10 Sieve	57.62

Hygroscopic Moisture	
Tare #	22
Tare Wt.	22.22
Wet Wt.	36.17
Dry Wt.	36.01
% Moisture	1.16

SAMPLE DESCRIPTION:

TAN Silty COARSE - FINE SAND

Spec.Grav.	2.75
Calc. a:	1

TIME (min.)	TEMP, C	HYD. READING	COMP. CORR.	CORRECT. READING	SOIL REMAINING %	K	L	DIAMETER (mm)
2	21.2	18.0	8.0	10.0	12.4	0.01306	13.3	0.03368
5	21.2	17.0	7.5	9.5	11.8	0.01306	13.5	0.02146
15	21.3	15.0	6.0	9.0	11.2	0.01305	13.8	0.01251
30	21.3	13.0	5.5	7.5	9.3	0.01305	14.2	0.00897
60	21.1	12.0	7.0	5.0	6.2	0.01308	14.3	0.00638
250	22.2	10.0	6.0	4.0	5.0	0.01291	14.7	0.00313
1440	20.5	8.0	7.0	1.0	1.2	0.01317	15.0	0.00134

Sieve	Wt. Retained	% Passing
3/4"	0.00	100.0
1/2"	0.00	100.0
3/8"	0.00	100.0
4	0.00	100.0
10	70.94	57.6
20	28.00	37.6
40	50.95	21.2
60	57.11	16.8
100	59.95	14.7
200	63.10	12.5

REMARKS:

Grain Size Wt.: 80.58

GeoTechnologies, Inc.

LF-6

ATTERBERG LIMITS DATA SHEET

ASTM D-4318

JOB NAME: A-1 Sandrock JOB NO.: _____

PERFORMED BY: TN DATE: 5-9-02

BORING: B-21 SAMPLE NO.: Bulk DEPTH: _____

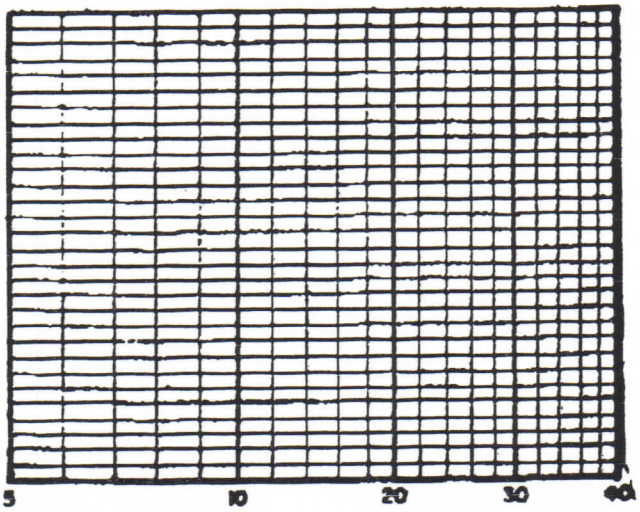
SAMPLE DESCRIPTION: Tan silty Coarse - Fine Sand

LIQUID LIMIT					
TEST #	1	2	3	4	5
CAN #	Z-21				
CAN WEIGHT	23.90				
WET SOIL + CAN	38.28				
DRY SOIL + CAN	35.59				
WEIGHT WATER	2.69				
WEIGHT DRY SOIL	11.69				
MOISTURE CONTENT	23.0				
NO. OF BLOWS	29				
LL = W_c X FACTOR	23.4				

One-Point Liquid Limit Factors			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.978	27	1.009
22	0.985	28	1.014
23	0.99	29	1.018
24	0.995	30	1.022
25	1		

Note: Two moisture trials are required for One-Point Liquid Limit.

Moisture Content



PLASTIC LIMIT		
TEST #	1	2
CAN #	70	Z-30
CAN WEIGHT	24.58	24.54
WET SOIL + CAN	35.78	33.42
DRY SOIL + CAN	34.02	32.05
WEIGHT WATER	1.76	1.37
WEIGHT DRY SOIL	9.44	7.51
MOISTURE, %	18.6	18.2
AVERAGE PL	18.4	

LL = 23

PL = 18

PI = 5

CLASS SYMBOL = _____

HYDROMETER WORKSHEET

JOB NAME: A-1 Sandrock	JOB NO. 1-02-639 CA

Boring	B-22	Sample	Bulk	Depth		Date	6/12/02

Total Weight of Air Dried Sample	142.08
Weight Retained on #10 Sieve	1.01
Dry Wt. of Total Sample	141.82
Dry Wt. of Weight Passing #10 Sieve	1.01
Weight Passing #10 Sieve	141.07
Weight of Air Dried Hydrometer Sample	61.52
Dry Wt. of Hydrometer Sample	61.41

Hygroscopic Moisture	
Tare #	10
Tare Wt.	24.79
Wet Wt.	41.44
Dry Wt.	41.41
% Moisture	0.18

% Passing #10 Sieve	99.29

Spec.Grav.	2.75
Calc. a:	1

SAMPLE DESCRIPTION:

TIME (min.)	TEMP, C	HYD. READING	COMP. CORR.	CORRECT. READING	SOIL REMAINING %	K	L	DIAMETER (mm)
2	23.7	14.0	5.0	9.0	14.7	0.01269	14.0	0.03356
5	23.7	12.0	5.0	7.0	11.4	0.01269	14.3	0.02145
15	23.6	11.0	6.0	5.0	8.1	0.01270	14.5	0.01249
30	23.5	10.0	6.0	4.0	6.5	0.01272	14.7	0.00890
60	23.0	9.0	6.0	3.0	4.9	0.01279	14.8	0.00635
250	22.1	8.0	6.0	2.0	3.3	0.01293	15.0	0.00317
1440	22.0	7.0	6.0	1.0	1.6	0.01294	15.2	0.00133

Sieve	Wt. Retained	% Passing
3/4"	0.00	100.0
1/2"	0.00	100.0
3/8"	0.00	100.0
4	0.00	100.0
10	1.01	99.3
20	0.76	98.1
40	5.41	90.5
60	19.91	67.1
100	34.53	43.5
200	46.35	24.3

REMARKS:

Grain Size Wt.: 61.41

GeoTechnologies, Inc.

LF-6

ATTERBERG LIMITS DATA SHEET

ASTM D-4318

JOB NAME: A-1 Sandrock JOB NO.: 1-02-639 CA

PERFORMED BY: MLN DATE: 5-23-02

BORING: B-22 SAMPLE NO.: Bulk DEPTH:

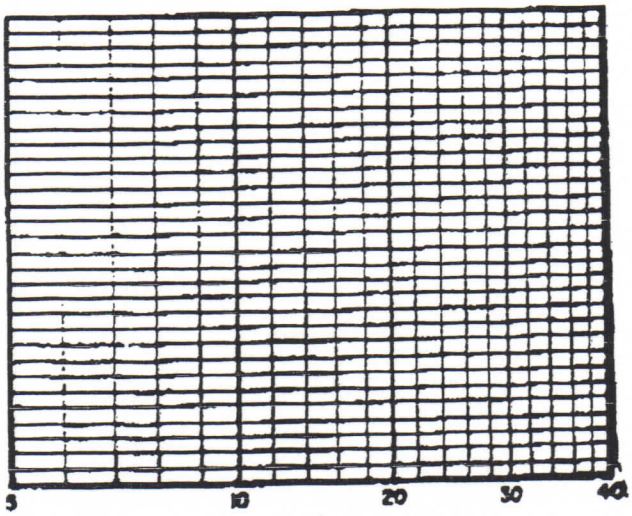
SAMPLE DESCRIPTION: Gray slightly silty F-M Sand

LIQUID LIMIT					
TEST #	1	2	3	4	5
CAN #					
CAN WEIGHT					
WET SOIL + CAN					
DRY SOIL + CAN					
WEIGHT WATER					
WEIGHT DRY SOIL					
MOISTURE CONTENT					
NO. OF BLOWS					
LL = W_c X FACTOR					

One-Point Liquid Limit Factors			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.978	27	1.009
22	0.985	28	1.014
23	0.99	29	1.018
24	0.995	30	1.022
25	1		

Note: Two moisture trials are required for One-Point Liquid Limit.

Moisture Content



PLASTIC LIMIT		
TEST #	1	2
CAN #		
CAN WEIGHT		
WET SOIL + CAN		
DRY SOIL + CAN		
WEIGHT WATER		
WEIGHT DRY SOIL		
MOISTURE, %		
AVERAGE PL		

LL =

PL =

PI =

CLASS SYMBOL =

JOB NAME: A 1 Sandrock	JOB NO.

Boring	B-21	Sample	1	Depth		Date	6/7/02

Total Weight of Air Dried Sample		184.60
Weight Retained on #10 Sieve		0.10
Dry Wt. of Total Sample		176.00
Dry Wt. of Weight Passing #10 Sieve		0.10
Weight Passing #10 Sieve		184.50
Weight of Air Dried Hydrometer Sample		65.85
Dry Wt. of Hydrometer Sample		62.78

Hygroscopic Moisture	
Tare #	4
Tare Wt.	22.47
Wet Wt.	52.53
Dry Wt.	51.13
% Moisture	4.88

% Passing #10 Sieve	99.95

Spec.Grav.	2.75
Calc. a:	1

SAMPLE DESCRIPTION:

Tan silty sand

TIME (min.)	TEMP. C	HYD. READING	COMP. CORR.	CORRECT. READING	SOIL REMAINING %	K	L	DIAMETER (mm)
2	21.1	33.0	6.0	27.0	43.0	0.01308	10.9	0.03052
5	21.1	27.0	6.0	21.0	33.4	0.01308	11.9	0.02017
15	21.1	22.0	6.0	16.0	25.5	0.01308	12.7	0.01203
30	21.1	20.0	6.0	14.0	22.3	0.01308	13.0	0.00861
60	21.1	17.0	5.5	11.5	18.3	0.01308	13.5	0.00620
250	21.7	14.0	6.0	8.0	12.7	0.01299	14.0	0.00307
1440	20.5	12.0	7.0	5.0	8.0	0.01317	14.3	0.00131

Sieve	Wt. Retained	% Passing
3/4"	0.00	100.0
1/2"	0.00	100.0
3/8"	0.00	100.0
4	0.00	100.0
10	0.10	99.9
20	0.80	98.7
40	4.36	93.0
60	10.16	83.8
100	16.63	73.5
200	24.81	60.5

REMARKS:

Grain Size Wt.: 62.78

GeoTechnologies, Inc.

LF-6

ATTERBERG LIMITS DATA SHEET

ASTM D-4318

JOB NAME: A-1 Sandrock JOB NO.:

ERFORMED BY: TN DATE: 5-9-02

BORING: B-21 SAMPLE NO.: 1 DEPTH:

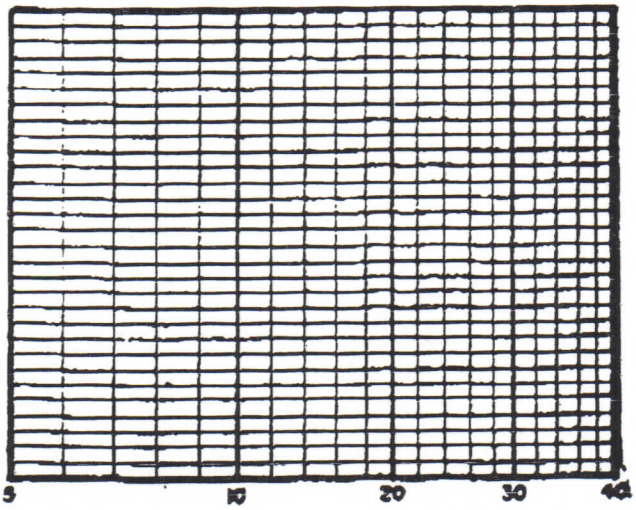
SAMPLE DESCRIPTION:

LIQUID LIMIT					
TEST #	1	2	3	4	5
CAN #	Z-50				
CAN WEIGHT	23.64				
WET SOIL + CAN	37.63				
DRY SOIL + CAN	34.13				
WEIGHT WATER	3.5				
WEIGHT DRY SOIL	10.49				
MOISTURE CONTENT	33.4				
NO. OF BLOWS	22				
LL = W_C X FACTOR	32.9				

One-Point Liquid Limit Factors			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.978	27	1.009
22	0.985	28	1.014
23	0.99	29	1.018
24	0.995	30	1.022
25	1		

Note: Two moisture trials are required for One-Point Liquid Limit.

Moisture Content



PLASTIC LIMIT		
TEST #	1	2
CAN #	Z-4	Z-86
CAN WEIGHT	25.38	24.49
WET SOIL + CAN	35.34	34.21
DRY SOIL + CAN	33.41	32.31
WEIGHT WATER	1.93	1.90
WEIGHT DRY SOIL	8.03	7.88
MOISTURE %	24.0	24.1
AVERAGE PL	24.1	

LL = 33

PL = 24

PI = 9

CLASS SYMBOL =

HYDROMETER WORK SHEET

JOB NAME: A 1 Sandrock	JOB NO.

Boring	B-21	Sample	2	Depth		Date	6/7/02

Total Weight of Air Dried Sample		207.26
Weight Retained on #10 Sieve		0.00
Dry Wt. of Total Sample		194.39
Dry Wt. of Weight Passing #10 Sieve		0.00
Weight Passing #10 Sieve		207.26
Weight of Air Dried Hydrometer Sample		60.63
Dry Wt. of Hydrometer Sample		56.86

% Passing #10 Sieve	100.00

Hygroscopic Moisture	
Tare #	18
Tare Wt.	22.63
Wet Wt.	51.61
Dry Wt.	49.81
% Moisture	6.62

SAMPLE DESCRIPTION:

Silty Sand

Spec.Grav.	2.75
Calc. a:	1

TIME (min.)	TEMP, C	HYD. READING	COMP. CORR.	CORRECT. READING	SOIL REMAINING %	K	L	DIAMETER (mm)
2	21.3	31.5	6.0	25.5	44.8	0.01305	11.2	0.03080
5	21.3	27.0	6.0	21.0	36.9	0.01305	11.9	0.02012
15	21.3	22.0	6.0	16.0	28.1	0.01305	12.7	0.01200
30	21.3	20.0	6.0	14.0	24.6	0.01305	13.0	0.00859
60	21.4	16.5	5.5	11.0	19.3	0.01303	13.6	0.00620
250	21.8	14.0	6.0	8.0	14.1	0.01297	14.0	0.00307
1440	20.5	12.0	7.0	5.0	8.8	0.01317	14.3	0.00131

Sieve	Wt. Retained	% Passing
3/4"	0.00	100.0
1/2"	0.00	100.0
3/8"	0.00	100.0
4	0.00	100.0
10	0.00	100.0
20	2.48	95.6
40	7.32	87.1
60	12.33	78.3
100	17.01	70.1
200	23.15	59.3

REMARKS:

Grain Size Wt.: 56.86

GeoTechnologies, Inc.

LF-6

ATTERBERG LIMITS DATA SHEET

ASTM D-4318

JOB NAME: A-1 Sandrock JOB NO.: _____

PERFORMED BY: JN DATE: 5-9-02

BORING: B-21 SAMPLE NO.: 2 DEPTH: _____

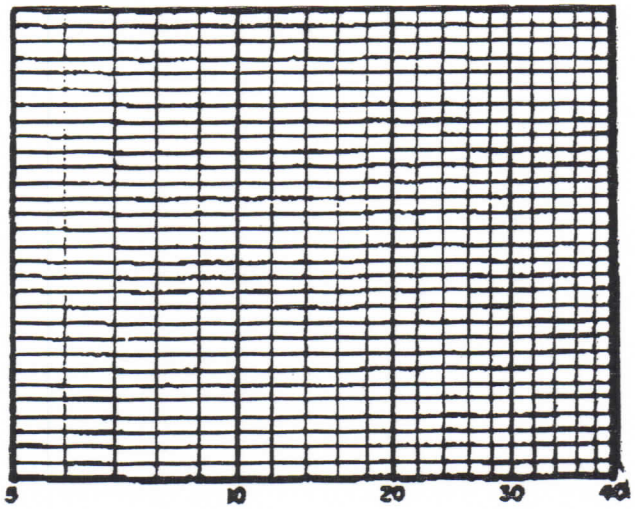
SAMPLE DESCRIPTION: _____

LIQUID LIMIT					
TEST #	1	2	3	4	5
CAN #	Z-19				
CAN WEIGHT	25.30				
WET SOIL + CAN	40.06				
DRY SOIL + CAN	35.77				
WEIGHT WATER	4.29				
WEIGHT DRY SOIL	10.47				
MOISTURE CONTENT	41.0				
NO. OF BLOWS	26				
LL = W_C X FACTOR	41.2				

One-Point Liquid Limit Factors			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.978	27	1.009
22	0.985	28	1.014
23	0.99	29	1.018
24	0.995	30	1.022
25	1		

Note: Two moisture trials are required for One-Point Liquid Limit.

Moisture Content



PLASTIC LIMIT		
TEST #	1	2
CAN #	Z-38	Z-33
CAN WEIGHT	25.10	24.50
WET SOIL + CAN	36.67	36.19
DRY SOIL + CAN	34.13	33.60
WEIGHT WATER	2.54	2.59
WEIGHT DRY SOIL	9.03	9.10
MOISTURE %	28.1	28.5
AVERAGE PL	28.3	

LL = 41.0

PL = 28

PI = 13

CLASS SYMBOL = _____

JOB NAME: A 1 Sandrock	JOB NO.

Boring	B-21	Sample	3	Depth		Date	6/7/02

Total Weight of Air Dried Sample		229.71
Weight Retained on #10 Sieve		0.00
Dry Wt. of Total Sample		222.50
Dry Wt. of Weight Passing #10 Sieve		0.00
Weight Passing #10 Sieve		229.71
Weight of Air Dried Hydrometer Sample		65.78
Dry Wt. of Hydrometer Sample		63.72

Hygroscopic Moisture	
Tare #	32
Tare Wt.	22.28
Wet Wt.	50.95
Dry Wt.	50.05
% Moisture	3.24

% Passing #10 Sieve	100.00

Spec.Grav.	2.75
Calc. a:	1

SAMPLE DESCRIPTION:

S, lt

TIME (min.)	TEMP, C	HYD. READING	COMP. CORR.	CORRECT. READING	SOIL REMAINING %	K	L	DIAMETER (mm)
2	21.2	25.0	6.0	19.0	29.8	0.01306	12.2	0.03226
5	21.3	21.0	6.0	15.0	23.5	0.01305	12.9	0.02095
15	21.3	16.0	6.0	10.0	15.7	0.01305	13.7	0.01247
30	21.4	13.0	5.5	7.5	11.8	0.01303	14.2	0.00896
60	21.1	11.0	6.0	5.0	7.8	0.01308	14.5	0.00643
250	22.0	9.0	6.0	3.0	4.7	0.01294	14.8	0.00315
1440	20.5	7.0	7.0	0.0	0.0	0.01317	15.2	0.00135

Sieve	Wt. Retained	% Passing
3/4"	0.00	100.0
1/2"	0.00	100.0
3/8"	0.00	100.0
4	0.00	100.0
10	0.00	100.0
20	0.70	98.9
40	7.92	87.6
60	18.02	71.7
100	26.29	58.7
200	35.53	44.2

REMARKS:

Grain Size Wt.: 63.72

GeoTechnologies, Inc.

LF-6

ATTERBERG LIMITS DATA SHEET

ASTM D-4318

JOB NAME: A-1 Sandrock JOB NO.:

PERFORMED BY: TN DATE: 5-9-02

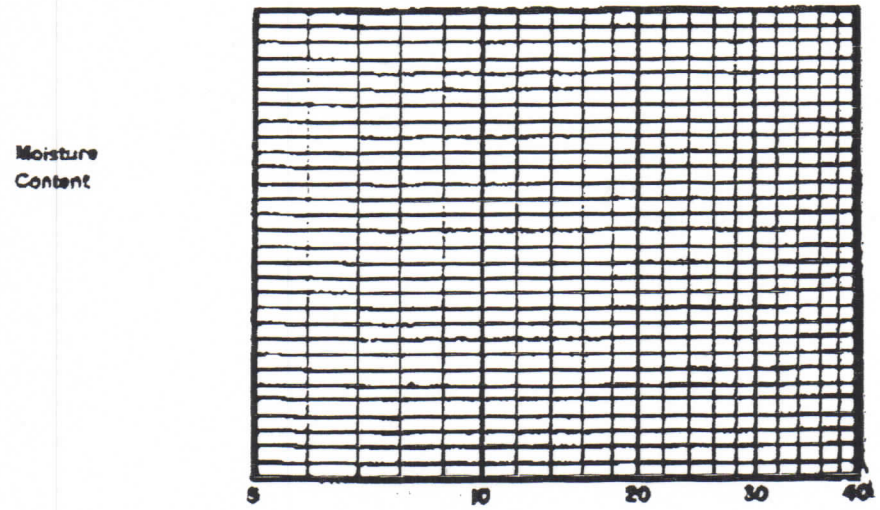
BORING: B-21 SAMPLE NO.: #3 DEPTH:

SAMPLE DESCRIPTION:

LIQUID LIMIT					
TEST #	1	2	3	4	5
CAN #	Z-28				
CAN WEIGHT	26.33				
WET SOIL + CAN	39.62				
DRY SOIL + CAN	36.63				
WEIGHT WATER	2.99				
WEIGHT DRY SOIL	10.30				
MOISTURE CONTENT	29.0				
NO. OF BLOWS	21				
LL = W_C X FACTOR	28.4				

One-Point Liquid Limit Factors			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.978	27	1.009
22	0.985	28	1.014
23	0.99	29	1.018
24	0.995	30	1.022
25	1		

Note: Two moisture trials are required for One-Point Liquid Limit.



PLASTIC LIMIT		
TEST #	1	2
CAN #	Z-14	Z-20
CAN WEIGHT	26.49	24.72
WET SOIL + CAN	37.56	37.19
DRY SOIL + CAN	35.50	34.87
WEIGHT WATER	2.06	2.32
WEIGHT DRY SOIL	9.01	10.15
MOISTURE, %	22.9	22.9
AVERAGE PL	22.9	

LL = 28

PL = 23

PI = 5

CLASS SYMBOL =

JOB NAME: A 1 Sandrock	JOB NO.

Boring	B-21	Sample	4	Depth		Date	6/7/02

Total Weight of Air Dried Sample	207.73
Weight Retained on #10 Sieve	1.39
Dry Wt. of Total Sample	205.29
Dry Wt. of Weight Passing #10 Sieve	1.37
Weight Passing #10 Sieve	206.34
Weight of Air Dried Hydrometer Sample	62.87
Dry Wt. of Hydrometer Sample	62.13

Hygroscopic Moisture	
Tare #	20
Tare Wt.	22.4
Wet Wt.	50.47
Dry Wt.	50.14
% Moisture	1.19

% Passing #10 Sieve	99.33

SAMPLE DESCRIPTION:
S.lt

Spec.Grav.	2.75
Calc. a:	1

TIME (min.)	TEMP, C	HYD. READING	COMP. CORR.	CORRECT. READING	SOIL REMAINING %	K	L	DIAMETER (mm)
2	20.8	27.0	6.0	21.0	33.8	0.01312	11.9	0.03201
5	20.8	20.0	6.0	14.0	22.5	0.01312	13.0	0.02116
15	20.8	16.0	6.0	10.0	16.1	0.01312	13.7	0.01254
30	21.0	12.5	5.5	7.0	11.3	0.01309	14.3	0.00902
60	21.1	11.0	6.0	5.0	8.0	0.01308	14.5	0.00643
250	22.0	10.0	6.0	4.0	6.4	0.01294	14.7	0.00314
1440	20.5	7.0	7.0	0.0	0.0	0.01317	15.2	0.00135

Sieve	Wt. Retained	% Passing
3/4"	0.00	100.0
1/2"	0.00	100.0
3/8"	0.00	100.0
4	0.00	100.0
10	1.39	99.3
20	5.56	90.4
40	13.82	77.6
60	20.21	67.0
100	25.79	58.1
200	33.33	46.0

REMARKS:

Grain Size Wt.: 62.13

GeoTechnologies, Inc.

LF-6

ATTERBERG LIMITS DATA SHEET

ASTM D-4318

JOB NAME: A-1 Sandrock JOB NO.:

PERFORMED BY: TN DATE: 5-9-02

BORING: B-21 SAMPLE NO.: #4 DEPTH:

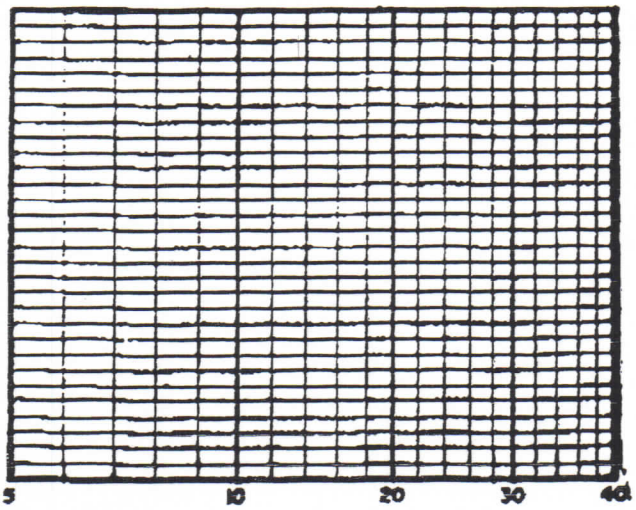
SAMPLE DESCRIPTION:

LIQUID LIMIT					
TEST #	1	2	3	4	5
CAN #					
CAN WEIGHT					
WET SOIL + CAN	N/P			0	
DRY SOIL + CAN				W	
WEIGHT WATER					
WEIGHT DRY SOIL	31.P3				
MOISTURE CONTENT					
NO. OF BLOWS			Cup		
LL = W_C X FACTOR					

One-Point Liquid Limit Factors			
N	Factor	N	Factor
20	0.974	26	1.005
21	0.978	27	1.009
22	0.985	28	1.014
23	0.99	29	1.018
24	0.995	30	1.022
25	1		

Note: Two moisture trials are required for One-Point Liquid Limit.

Moisture Content



PLASTIC LIMIT		
TEST #	1	2
CAN #	[redacted]	
CAN WEIGHT	[redacted]	
WET SOIL + CAN		
DRY SOIL + CAN		
WEIGHT WATER		
WEIGHT DRY SOIL		
MOISTURE, %		
AVERAGE PL		

LL =

PL =

PI =

CLASS SYMBOL =

APPENDIX 7
Phase 2A Test Pits

Test Pit Log for A-1 Sandrock Phase 2A

See Drawing S1 for locations

Supervision and documentation performed by David Garrett, PG, PE

Refer to accompanying photos, taken 3/18/2015 before final grading

Test Pit 1

Encountered tan-yellow very silty sand, field classified as SM

Depth of excavation is 4 feet

Water stabilized at 3’6” after 24 hours

Test Pit 2

Encountered tan-yellow very silty sand, some clay smears, relict texture,

Field classified as SM-ML

Depth of excavation is 4 feet

Water stabilized at 3’6” after 24 hours

Test Pit 3

Encountered red-brown slightly sandy clayey silt, field classified as ML-CL

Depth of excavation is 4 feet

Water stabilized at 3’0” after 24 hours

Test Pit 4

Encountered tan-yellow very silty sand, field classified as SM-ML

Depth of excavation is 5 feet

Water stabilized at >5’ after 24 hours, capillary zone starts at 4’0”

Test Pit 5

Encountered tan-red very silty sand, field classified as SM-ML

Depth of excavation is 4 feet

Water stabilized at 3’0” after 24 hours, capillary zone starts at 3’6”

Test Pit 6

Encountered tan-yellow very silty sand, field classified as SM

Depth of excavation is 6 feet

Water stabilized at 6’0” after 24 hours, capillary zone starts at 5’0”

Test Pit 7

Encountered red-gray clayey silt, diabase nodules, field classified as ML

Depth of excavation is 4 feet

Dry at 4’ after 24 hours

Test Pit 8

Encountered red-gray very silty sand, field classified as SM-ML

Depth of excavation is 4 feet

Water stabilized at 2’0” after 24 hours

Test Pit 9

Encountered red-gray very silty sand, field classified as SM, small rock fragments

Depth of excavation is 4 feet

Water stabilized at 2’0” after 24 hours

Test Pit 10

Encountered tan-yellow very silty sand, field classified as SM

Depth of excavation is 5.5 feet

Water stabilized at 5.0” after 24 hours, capillary zone starts at 4’6”

Test Pit 11

Encountered tan-gray clayey silt, abundant diabase nodules, field classified as ML

Depth of excavation is 6 feet

Dry at 6’ after 24 hours

Test Pit 12

Encountered tan-red clayey silt, diabase nodules, field classified as ML

Depth of excavation is 4 feet

Dry at 4’ after 24 hours

Test Pit 13

Encountered tan-brown very silty sand, field classified as SM-ML, layered rock fragments

Depth of excavation is 5 feet

Dry at 5’ after 24 hours

Test Pit 14

Encountered tan-brown very silty sand, field classified as SM-ML, scattered rock fragments

Depth of excavation is 6 feet

Dry at 6’ after 24 hours

Test Pit 15

Encountered tan-brown very silty sand, very silty sand, some clay smears, relict texture,

Field classified as SM-ML

Depth of excavation is 4 feet

Water at 3.5’ after 24 hours, capillary zone starts at 3’6”

Notes:

Test pits excavated with a CAT 225 track-hoe (or equivalent) on 3/17/2015

Observations with SWS personnel conducted on 3/18/2015

Later that day, pits were surveyed and measured, documented on the field map

Water elevations calculated by subtracting depths from references on extant surveyors stakes

Depth of fill required to provide minimum required separation was calculated

Additional grading was performed over the next week

The finished base grade was resurveyed in early April 2015, which is represented in Drawings S2, S3, and S4

Test Pit 1

Test Pit 2

Test Pit 3

Test Pit 4

Test Pit 5

Test Pit 6

Test Pit 7

Test Pit 8

Test Pit 9

Test Pit 10

Test Pit 11

Test Pit 12

Test Pit 13

Test Pit 14

Test Pit 15

APPENDIX 8
Water Quality Monitoring Plan

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2.0 Sampling Schedule and Term 2

3.0 Record Keeping and Reporting 2
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1 Monitoring Well Construction Data

2 Required Analytical Parameters

Figures

1 Type 3 Monitoring Well Schematic (Lower Aquifer)

2 Type 2 Monitoring Well Schematic (Upper Aquifer)

Attachments

1 Drawing M1 Monitoring Locations

2 Solid Waste Section Guidelines for Groundwater, Soil, and Surface Water Sampling, State Of North Carolina Department Of Environment And Natural Resources Division Of Waste Management Solid Waste Section, Rev 4-08*

3 New Guidelines for the Submittal of Environmental Monitoring Data, Solid Waste Section Memorandum, October 27, 2006

4 Environmental Monitoring Data Form

5 February 23, 2007 Addendum to the October 27, 2006 Memorandum

6 October 16, 2007 Memorandum

7 November 5, 2014 Memorandum

8 Monitoring well construction logs

*available online at http://www.wastenotnc.org/swhome/EnvMonitoring/SolidWasteSamplingGuidance.pdf

Revisions

0 Water Quality Monitoring Plan, A-1 Sandrock CDLF (South Facility)
September 2002

1 Water Quality Monitoring Plan Amendment, A-1 Sandrock CDLF (Permit 41-17)
February 2009

2 Corrections to February 2009 plan text, September 2013

3 Amendment to support Phase 2 PTC/PTO (Added MW-6)

Upon approval by NC DENR-Division of Waste Management, this plan will supersede all previous versions for the detection-phase monitoring of the CDLF.

1.0 Introduction

1.1 Background

Water quality monitoring for the A-1 Sandrock, Inc., construction and demolition debris landfill (CDLF) is scheduled to commence with the opening of Phase 1. The facility is located at 2091 Bishop Road, south of Greensboro, North Carolina. Ground water is the principal source for the local potable water supply, but no downgradient water supply wells are present. The site is within the Randleman Reservoir Watershed, but not in the critical area. The current monitoring well network consists of six wells – MW-1 is the facility background well – and four surface sampling locations (see **Drawing M1**). The monitoring network is based on site studies performed in 2002 and 2015. The original Water Quality Monitoring Plan was approved by the NC DENR Solid Waste Section (SWS) in 2004 with the issuance of the Permit to Construct for Phase 1.

Detection stage water quality monitoring is required by 15A NCAC 13B .0544 (b)(5)(B). This Water Quality Monitoring Plan (WQMP) – also known as a Sampling and Analysis Plan (SAP) – is an update of the original plan that reflects the current monitoring network and current sampling and analysis protocols. These changes include the reporting of "Solid Waste Section Limits" and the electronic data reporting format. The facility is required to undergo semi-annual sampling for Appendix I constituents and specific parameters unique to C&D Landfills (see Tables).

North Carolina solid waste regulations require monitoring of the "uppermost" aquifer – typically consisting of saturated saprolite (variably dense soil derived from the weathering of bedrock) in Piedmont environments, but which can include the upper reaches of bedrock. Earlier hydrogeologic investigations determined that sampling the relatively thick saturated saprolite – which is several ten's of feet thick – is sufficient to adequately monitor the site. Ground water movement is from the higher elevations of the site from east to west, toward the surface streams. The background well is isolated upgradient of the landfill; compliance wells are located downgradient between the landfill and the streams. Stream sampling will be performed with Appendix I parameters.

This Sampling and Analysis Plan (SAP) has been prepared to meet North Carolina's monitoring requirements and describes the detection-stage monitoring program, prepared in accordance with the following applicable rules, which are incorporated by reference:

- 15A NCAC 13B .0544 (Solid Waste Construction and Demolition Rules)
- 15A NCAC 2C (Well Construction Rules)
- 15A NCAC 2L (Ground Water Classifications and Standards)
- 15A NCAC 27 (Well Contractor Certification Rules)
- 15A NCAC 2H (Water Quality Laboratory Certification Rules)

1.2 Monitoring Location Criteria

The compliance well network consists of the five existing wells (MW-1 through MW-5), plus a new well (MW-6), each located to monitor the saprolite aquifer (Unit 1) and/or the transitional zone within the bedrock (Unit 2), plus surface water sampling at four locations. The monitoring locations are shown on **Drawing M1.** Wells currently surround the entire CDLF footprint, but the well spacing is subject to review per the 5-year permitting cycle. A new well was added near the northwest corner, just north of the sediment basin, to provide coverage of that area. The wells are located near the regulatory review boundary, approximately 150 feet from the waste boundary, and no closer than 50 feet inside the facility boundary. These well locations were selected based on topographic relationships, variable depths to bedrock, and a fracture trace analysis apparent from the local topography and reflected in the drilling data.

Refer to **Table 1** following this text for a summary of the well construction details. Monitoring well construction logs are presented in the appendices.

2.0 Sampling Schedule and Term

Sampling shall be conducted on a semi-annual basis, specifically once in the spring and once in the fall. Monitoring shall be conducted for the duration of operations and for a minimum of 30 years following final closure.

3.0 Record Keeping and Reporting

3.1 Sampling Reports

Copies of all laboratory analytical data shall be forwarded to the SWS semi-annually upon completion of the report and in accordance with the schedule outlined in the facility permit and regulations. In addition to the sampling results being submitted in Table format with a written report, the laboratory analytical data shall also be submitted electronically on the Solid Waste Section's Electronic Data Template.

Refer to **Table 2** of this report for a list of the required constituents and reporting limits. These lists were updated in the October 27, 2006, memorandum and February 23, 2007, addendum from the Solid Waste Section. If limits are modified by the DWM, the most current ones will be used for reporting purposes. Reports will be submitted on a cd-rom with analytical data submitted in the required format, and be accompanied by the required Environmental Monitoring Form (see **Attachment 3**), which shall be signed and sealed by a licensed geologist in the State of North Carolina.

The submittal shall specify the date of sample collection, the sampling point identification, a map of the sampling locations, comparisons to applicable ground water and surface water standards. Should significant concentrations of contaminants be detected in groundwater and/or surface water during monitoring (per North Carolina Solid Waste Rules or Ground Water Quality Standards), the owner/operator shall notify the SWS and shall place a notice in the landfill records as to which constituents were detected. Analytical data, calculations, and other relevant ground water monitoring records shall be kept throughout the active life of the facility and the post-closure care period, including notices and reports of any North Carolina 2L Standard exceedance, re-sampling notifications, and re-sampling results.

3.2 Well Abandonment/Rehabilitation

Should wells become irreversibly damaged or require rehabilitation, the SWS shall be notified. If monitoring wells and/or piezometers within unconsolidated formations are damaged irreversibly they shall be abandoned by over-drilling and/or pulling the well casing and plugging the well with an impermeable, chemically-inert sealant such as neat cement grout and/or bentonite clay. For bedrock wells the abandonment shall consist of plugging the interior well riser and screen with an impermeable neat cement grout and/or bentonite clay sealant. Piezometers in the waste footprint shall be abandoned by over drilling the boring and backfilling with a bentonite-cement grout. All well repairs or abandonment shall be certified by a NC-licensed geologist or engineer.

Samples withdrawn from the facility's monitoring wells should be free of clay and silt; therefore, existing wells may require re-development from time to time based upon observed turbidity levels during sampling activities. If re-development of an existing monitoring well is required, it will be performed in a manner similar to that used for a new well as described below.

3.3 Additional Well Installations

All additional monitoring wells (new or replacement) shall be installed under the supervision of a qualified geologist or engineer who is registered in North Carolina and who shall certify to the SWS that the installation complies with the North Carolina Regulations. Upon installation of future wells, the documentation for the construction of each well shall be submitted by the registered geologist or engineer after well construction, as specified in the permit to operate, once issued.

Newly constructed wells will be developed to remove particulates that are present in the well due to construction activities, and to interconnect the well with the aquifer. Development of new monitoring wells will be performed no sooner than 24 hours after

well construction. Wells may be developed with disposable bailers, a mechanical well developer, or other approved method.

A surge block may be used as a means of assessing the integrity of the well screen and riser. In the event a pump is employed, the design of the pump will be such that any ground water that has come into contact with air is not allowed to drain back into the well. In general, each well will be developed until sediment-free water with stabilized field parameters (i.e., temperature, pH, and specific conductance) is obtained.

Well development equipment (bailers, pumps, surge blocks) and any additional equipment that contacts subsurface formations will be decontaminated prior to on-site use, between consecutive on-site uses, and/or between consecutive well installations. The purge water will be disposed of on the ground surface at least 10 feet downgradient of the monitoring well being purged, unless field characteristics suggest the water will need to be disposed of otherwise. If field characteristics suggest, the purge water will be containerized and disposed of by other approved disposal means.

3.3 Well Maintenance

The existing monitoring wells will be used and maintained in accordance with design specifications throughout the life of the monitoring program. Routine well maintenance will include inspection and correction/repair of, as necessary, identification labels, concrete aprons, locking caps and locks, and access to the wells.

Should it be determined that background or compliance monitoring wells no longer provide samples representative of the quality of ground water passing the relevant point of compliance, the SWS shall be notified. The owner shall re-evaluate the monitoring network and provide a plan to the SWS for modifying, rehabilitating, decommissioning, or installing replacement wells or additional monitoring wells, as appropriate.

3.5 Implementation Schedule

The Ground Water Quality Monitoring Program shall be implemented upon approval and issuance of the facility permit. Analyses shall be performed on a semi-annual basis.

3.6 Modifications and Revisions

At some future time it may be appropriate to modify this plan, e.g. add or delete sampling locations or analytical parameters. Such changes may require approval from SWS. Also, this plan will be reviewed as new phases are developed and amended as needed. Refer to the revision section for the latest edition.

4.0 Certification

This water quality monitoring plan has been prepared by a qualified geologist who is licensed to practice in the State of North Carolina. The plan was prepared based on first-hand knowledge of site conditions and familiarity with North Carolina solid waste rules and industry standard protocol. In accordance with North Carolina Solid Waste Regulations, this Water Quality Monitoring Plan amendment should provide early detection of any release of hazardous constituents to the uppermost aquifer, so as to be protective of public health and the environment. No other warranties, expressed or implied, are made.

Signed _____

Printed G. David Garrett

Date March 31, 2015

Not valid unless this document bears the seal of the above-named licensed professional.

Tables

TABLE 1A
Monitoring Well and Surface Sampling Location Data

Location and Elevation Data					Lithologic Data						
Boring Number	Northing Coordinate[1]	Easting Coordinate[1]	PVC Pipe Elevation[2]	Ground Elevation[2]	Drilling Method	Total Depth, ft.	Bottom Elev.	PWR		Bedrock	
								Depth, ft.	Elev.	Depth, ft.	Elev.
MW-1[3]	815,671.56	1,749,908.65	816.05	813.40	HSA/Core	44.0	769.40	13	800.40	19	794.40
MW-2	815,438.94	1,749,056.29	761.92	759.90	HSA/Core	33.0	726.90	8	751.90	13	746.90
MW-3	815,693.01	1,748,698.85	731.82	729.80	HSA	33.0	696.80	9	720.80	33	696.80
MW-4	816,281.49	1,748,723.33	733.17	731.10	HSA	24.0	707.10	11	720.10	24	707.10
MW-5	816,702.88	1,749,461.06	762.88	761.10	HSA/Core	28.5	732.60	4	757.10	8	753.10
MW-6	816,499.93	1,748,826.85	755.89	753.10	HSA	45.00	708.10	31.00	722.10	45.00	708.10

Well Construction Data								Stabilized Water Level at 24 Hours		Monitored Hydrogeologic Unit
Boring Number	PVC Pipe Elevation[2]	Ground Elevation[2]	Stickup ft.	Top of Screen		Bot. of Screen				
				Depth, ft.	Elev.	Depth, ft.	Elev.	Depth, ft.	Elev.	
MW-1[3]	816.05	813.40	2.6	34.0	779.4	44.0	769.4	34.0	779.4	Bedrock
MW-2	761.92	759.90	2.0	23.0	736.9	33.0	726.9	13.6	746.3	Bedrock
MW-3	731.82	729.80	2.0	28.0	701.8	33.0	696.8	8.0	721.8	PWR
MW-4	733.17	731.10	2.1	9.0	722.1	24.0	707.1	13.0	718.1	PWR
MW-5	762.88	761.10	1.8	28.5	732.6	28.5	732.6	17.2	743.9	Bedrock
MW-6	755.89	753.10	2.8	30.00	723.1	45.00	708.1	39.00	716.9	PWR

TABLE 1B
Existing Surface Sampling Locations

Monitoring Location	Description of Monitoring Location
SW-1[3]	Background on Hickory Creek (at Colonial Pipeline crossing)
SW-2 [3, 4]	Background on “north” unnamed tributary (at property line)
SW-3 [4]	Background on “south” unnamed tributary (at property line)
SW-4	Down gradient on Hickory Creek (below stream convergence)

Notes:
1. NAD83 (2007)
2. NGVD29
3. Background monitoring location
4. These streams can go dry during late summer, sample subject to flow conditions

PWR = Partially Weathered Rock, or 100+ bpf material

Survey by Allied Associates, P.A., April 7, 2009 except MW-6, surveyed April 8, 2015

Table 2

Ground and Surface Water Analysis Methodology
For Semi-Annual Detection Monitoring

Inorganic Constituent	**Required Solid Waste Section Limit (ug/l)***	**North Carolina 2L** Ground Water Standard**	
Antimony	6	1.4	***
Arsenic	10	50	
Barium	100	2000	
Beryllium	1	4	***
Cadmium	1	1.75	
Chromium	10	50	
Cobalt	10	70	***
Copper	10	1000	
Lead	10	15	
Nickel	50	100	
Selenium	10	50	
Silver	10	17.5	
Thallium	5.5	0.28	***
Vanadium	25	3.5	***
Zinc	10	1050	
Mercury	0.2	1.05	
Chloride	NE	250,000	
Manganese	50	50	
Sulfate	250,000	250,000	
Iron	300	300	
Alkalinity	NE	NE	
Total Dissolved Solids	NE	500,000	
Specific Conductivity (field)			
pH (field)			
Temperature (field)			

Table 2 (continued)

Ground and Surface Water Analysis Methodology

Organic Constituent	Required Solid Waste Section Limit (ug/l)*	North Carolina Ground Water Standard	
1,1,1,2-Tetrachloroethane	5	1.3	***
1,1,1-Trichloroethane	1	200	
1,1,2,2-Tetrachloroethane	3	0.18	***
1,1,2-Trichloroethane	1	0.6	***
1,1-Dichloroethane	5	70	
1,1-Dichloroethylene	5	7	
1,2,3-Trichloropropane	1	0.005	
1,2-Dibromo-3-chloropropane	13	0.025	
1,2-Dibromoethane	1	0.0004	
1,2-Dichlorobenzene	5	24	
1,2-Dichloroethane	1	0.38	
1,2-Dichloropropane	1	0.51	
1,4-Dichlorobenzene	1	1.4	
2-Butanone	100	4200	
2-Hexanone	50	280	
4-Methyl-2-pentanone	100	560	***
Acetone	100	700	
Acrylonitrile	200	NE	
Benzene	1	1	
Bromochloromethane	3	0.6	***
Bromodichloromethane	1	0.56	
Bromoform	4	4.43	
Bromomethane	10	NE	
Carbon Disulfide	100	700	
Carbon Tetrachloride	1	0.269	
Chlorobenzene	3	50	
Chloroethane	10	2800	
Chloroform	5	70	
Chloromethane	1	2.6	
Cis-1,2-dichloroethylene	5	70	
Cis-1,3-dichloropropene	1	0.19	
Dibromochloromethane	3	0.41	
Dibromomethane	10	NE	
Ethylbenzene	1	550	
Iodomethane	10	NE	
Methylene chloride	1	4.6	
Styrene	1	100	
Tetrachloroethylene	1	0.7	
Toluene	1	1000	
Trans-1,2-dichloroethylene	5	100	

Table 2 (continued)

Ground and Surface Water Analysis Methodology

Organic Constituent	Required Solid Waste Section Limit (ug/l)*	North Carolina Ground Water Standard
Trans-1,3-dichloropropene	1	0.19
Trans-1,4-dichloro-2-butene	100	NE
Trichloroethylene	1	2.8
Trichloroflouromethane	1	2100
Vinyl acetate	50	7000 ***
Vinyl chloride	1	0.015
Xylene (total)	5	530
Tetrahydrofuran	1	NE

Notes:
All samples shall be unfiltered.
NE = not established

* Per North Carolina DENR Division of Waste Management guidelines, eff. 2006, equivalent to the PQL. Only SW-846 methodologies that are approved by the NC DENR Solid Waste Section shall be used for laboratory analyses. The laboratory must be certified by NC DENR for the specific lab methods per SW-846.

** 15A NCAC 2L Standard for Class GA Ground Water – this applies unless otherwise noted (see below)

***North Carolina DWM Ground Water Protection Standard (quoted from website)
Groundwater standards and Solid Waste Section Limits are subject to change; the most current standards and limits will be used.

Figures

Figure 1 – Type 3 Monitoring Well Construction Schematic (Lower Aquifer)

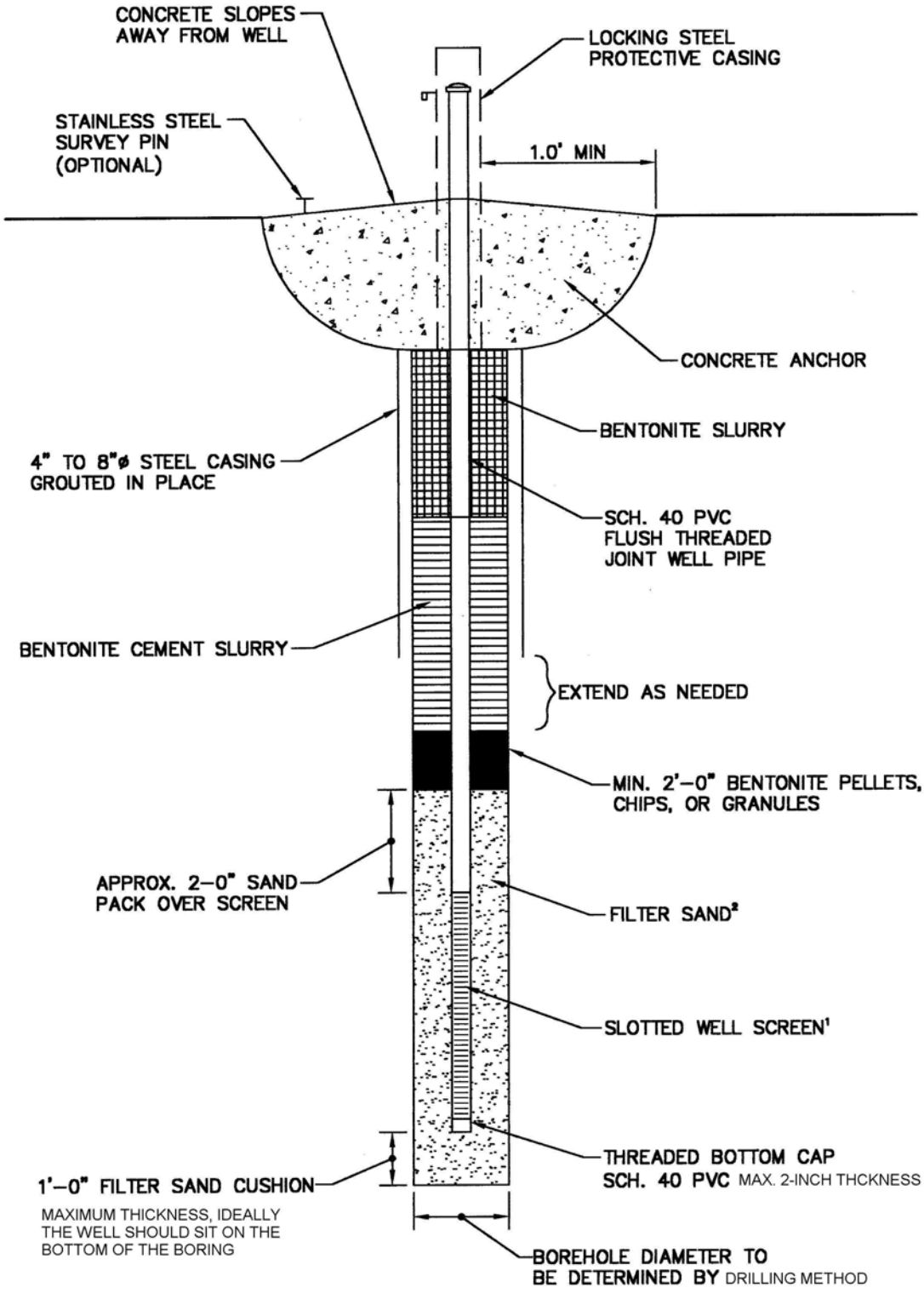
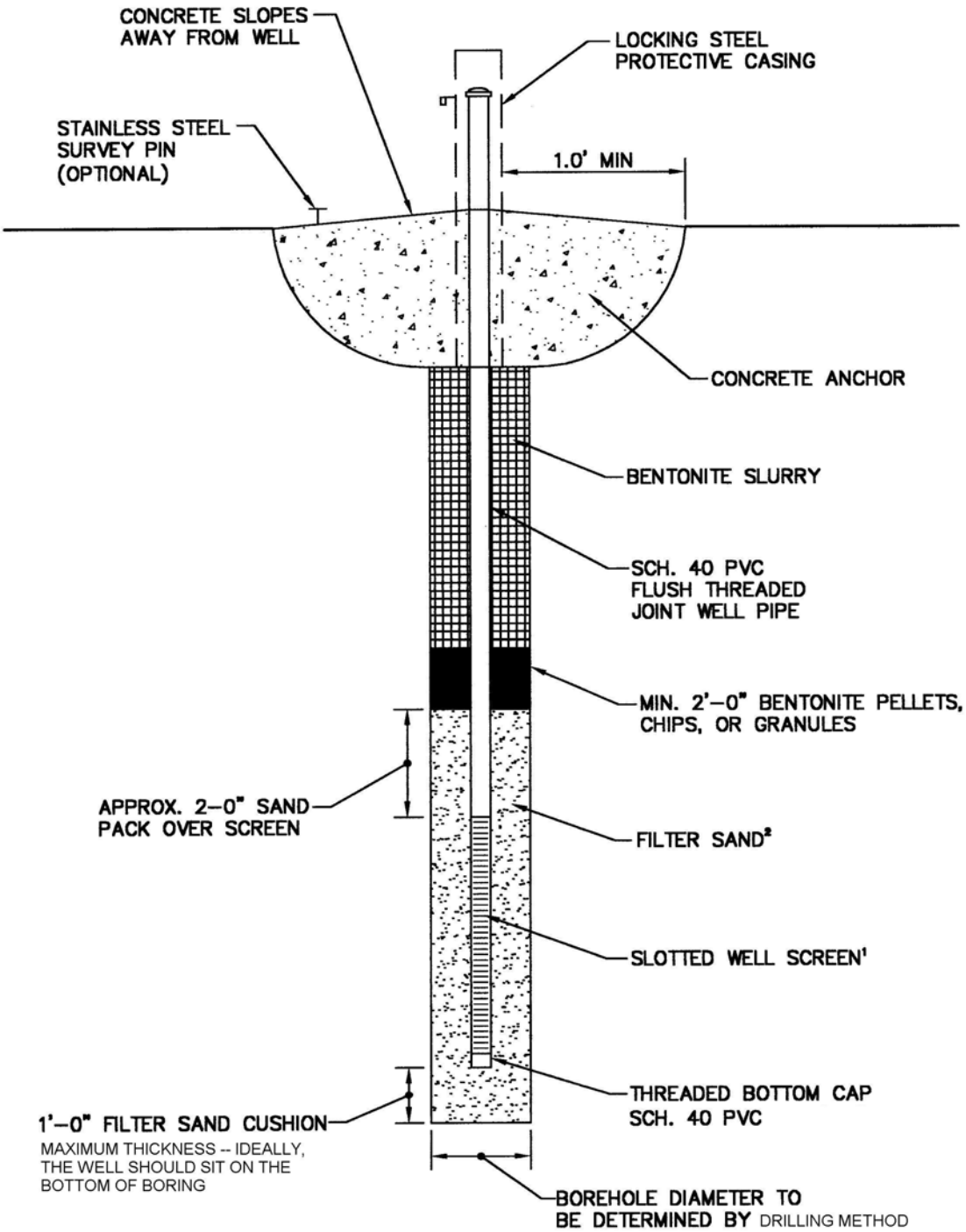
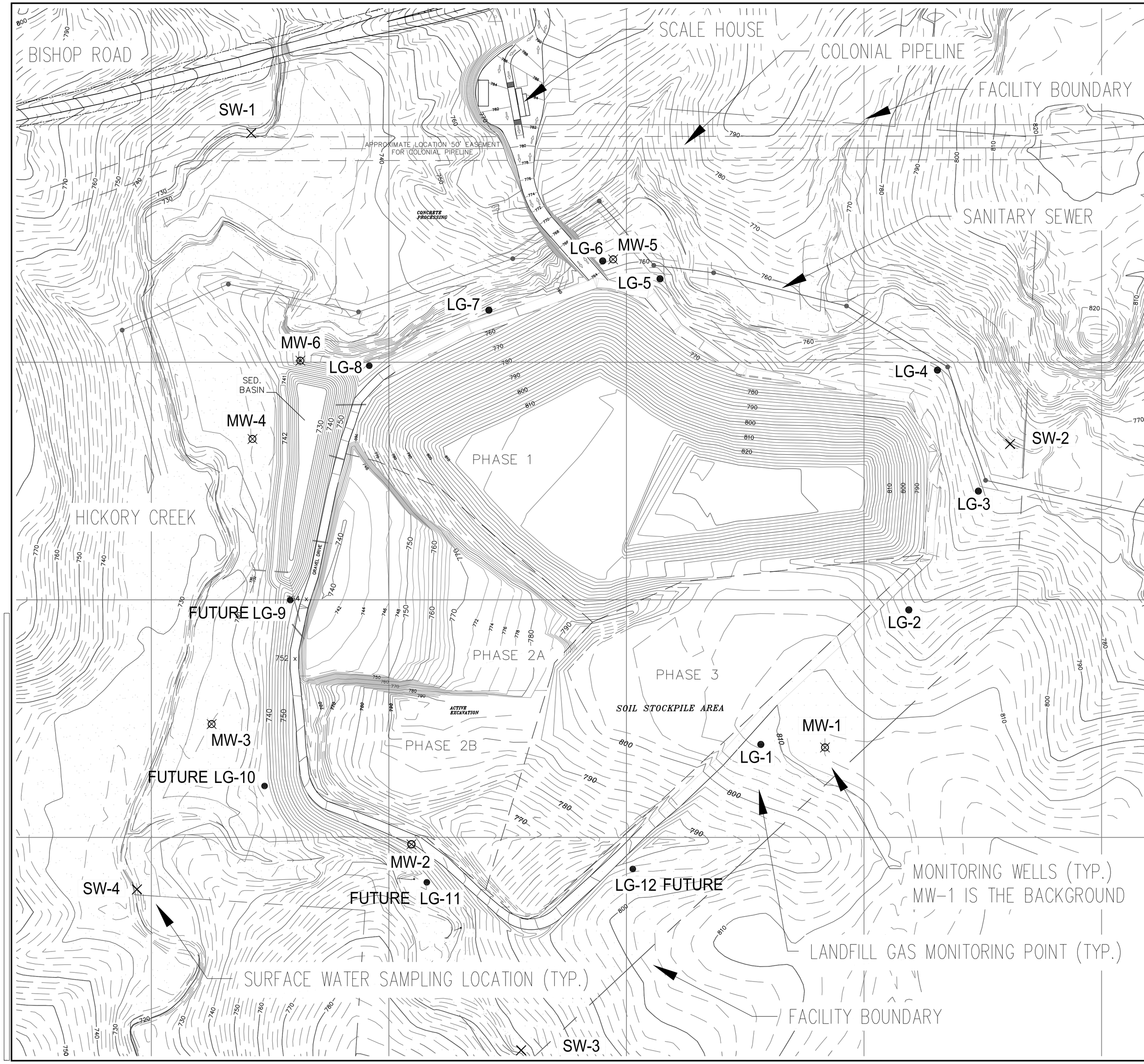


Figure 2 – Type 2 Monitoring Well Construction Schematic (Upper Aquifer)



Attachment 1
Monitoring Locations



300 0 300 600 900

Scale 1" = 300'

Bar is 1" on original drawing

LEGEND

PROPOSED

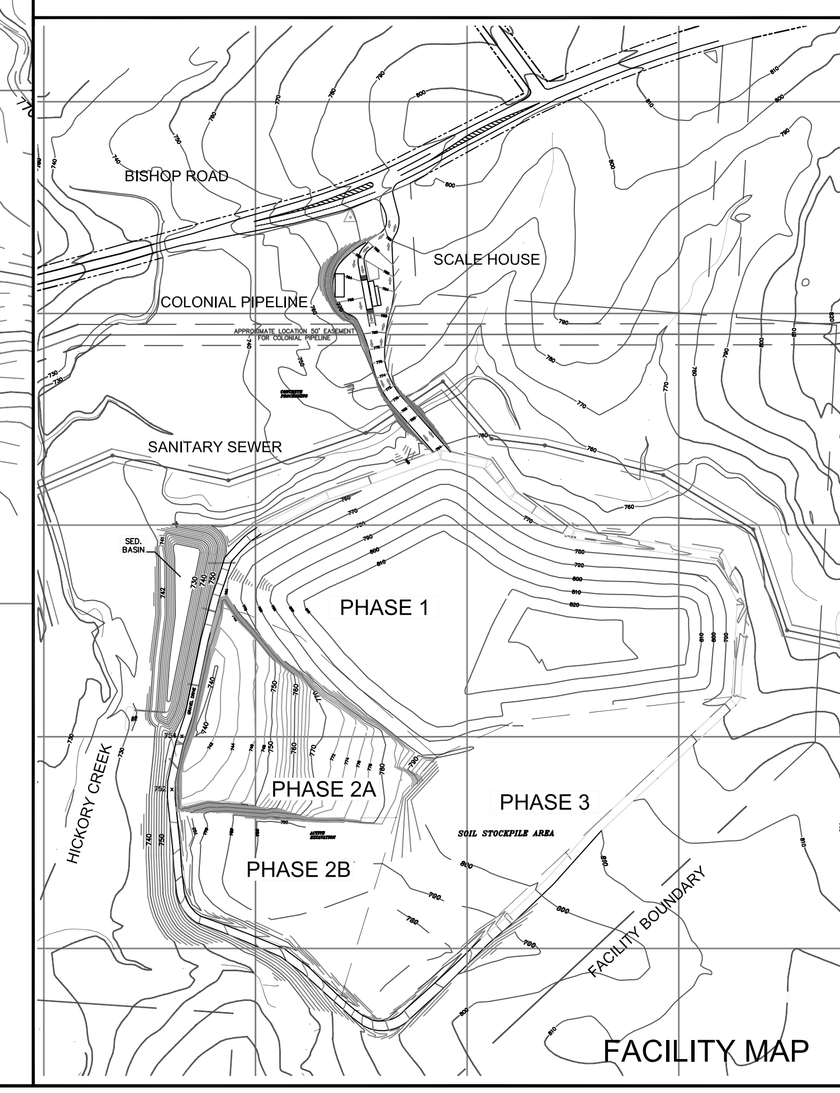
- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (280)
- CELL AND WASTE LIMITS

NOTE:
CONTOURS SHOWN FOR CELLS 1A / 1B, 2A AND 2B REPRESENT FINAL TOP OF WASTE GRADES

EXISTING

- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (280)
- FACILITY BOUNDARY
- SANITARY SEWER
- WATERCOURSE BUFFER ZONE
- PROPERTY BUFFER ZONE
- 100 YR FLOODPLAIN
- WATERCOURSE

BASE GRADE CONTOURS FOR PHASE 2 ARE AS SURVEYED IN APRIL 2015



FACILITY MAP

NORTH CAROLINA PROFESSIONAL SEAL 22068 ENGINEER DAVID G. GARRETT

7/28/2015

NC CORP. LICENSE NO. C-1837

NO.	REVISION	DATE
1	ADDED MW-6 AND REGULATORY REVIEW	7-14-2014
2		
3		
4		
5		
6		

SHEET TITLE: WATER AND GAS MONITORING LOCATIONS

PROJECT TITLE: PERMIT RENEWAL APPLICATION PHASE 2 PERMIT TO CONSTRUCT

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Sheet 6 of 6

Attachment 2
Solid Waste Section Guidelines for Groundwater, Soil and Surface Water Sampling

North Carolina Department of
Environment and Natural Resources
Division of Waste Management
Solid Waste Section

Solid Waste Section
Guidelines for Groundwater, Soil, and Surface Water Sampling

STATE OF NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF WASTE MANAGEMENT
SOLID WASTE SECTION

General Sampling Procedures

The following guidance is provided to insure a consistent sampling approach so that sample collection activities at solid waste management facilities provide reliable data. Sampling must begin with an evaluation of facility information, historical environmental data and site geologic and hydrogeologic conditions. General sampling procedures are described in this document.

Planning

Begin sampling activities with planning and coordination. The party contracting with the laboratory is responsible for effectively communicating reporting requirements and evaluating data reliability as it relates to specific monitoring activities.

Sample Collection

<u>Contamination Prevention</u>

a.) Take special effort to prevent cross contamination or environmental contamination when collecting samples.
    1. If possible, collect samples from the least contaminated sampling location (or background sampling location, if applicable) to the most contaminated sampling location.
    2. Collect the ambient or background samples first, and store them in separate ice chests or separate shipping containers within the same ice chest (e.g. untreated plastic bags).
    3. Collect samples in flowing water at designated locations from upstream to downstream.

b.) Do not store or ship highly contaminated samples (concentrated wastes, free product, etc.) or samples suspect of containing high concentrations of contaminants in the same ice chest or shipping containers with other environmental samples.
    1. Isolate these sample containers by sealing them in separate, untreated plastic bags immediately after collecting, preserving, labeling, etc.
    2. Use a clean, untreated plastic bag to line the ice chest or shipping container.

c.) All sampling equipment should be thoroughly decontaminated and transported in a manner that does not allow it to become contaminated. Arrangements should be made ahead of time to decontaminate any sampling or measuring equipment that will be reused when taking samples from more than one well. Field decontamination of

sampling equipment will be necessary before sampling each well to minimize the risk of cross contamination. Decontamination procedures should be included in reports as necessary. Certified pre-cleaned sampling equipment and containers may be used. When collecting aqueous samples, rinse the sample collection equipment with a portion of the sample water before taking the actual sample. Sample containers do not need to be rinsed. In the case of petroleum hydrocarbons, oil and grease, or containers with pre-measured preservatives, the sample containers cannot be rinsed.

d.) Place all fuel-powered equipment away from, and downwind of, any site activities (e.g., purging, sampling, decontamination).

1. If field conditions preclude such placement (i.e., the wind is from the upstream direction in a boat), place the fuel source(s) as far away as possible from the sampling activities and describe the conditions in the field notes.
2. Handle fuel (i.e., filling vehicles and equipment) prior to the sampling day. If such activities must be performed during sampling, the personnel must wear disposable gloves.
3. Dispense all fuels downwind. Dispose of gloves well away from the sampling activities.

<u>Filling Out Sample Labels</u>

Fill out label, adhere to vial and collect sample. Print legibly with indelible ink. At a minimum, the label or tag should identify the sample with the following information:

1. Sample location and/or well number
2. Sample identification number
3. Date and time of collection
4. Analysis required/requested
5. Sampler's initials
6. Preservative(s) used, if any [i.e., HCl, $Na_2S_2O_3$, NO_3, ice, etc.]
7. Any other pertinent information for sample identification

<u>Sample Collection Order</u>

Unless field conditions justify other sampling regimens, collect samples in the following order:

1. Volatile Organics and Volatile Inorganics
2. Extractable Organics, Petroleum Hydrocarbons, Aggregate Organics and Oil and Grease
3. Total Metals
4. Inorganic Nonmetallics, Physical and Aggregate Properties, and Biologicals
5. Microbiological

NOTE: *If the pump used to collect groundwater samples cannot be used to collect volatile or extractable organics then collect all other parameters and withdraw the pump and tubing. Then collect the volatile and extractable organics.*

Health and Safety

Implement all local, state, and federal requirements relating to health and safety. Follow all local, state and federal requirements pertaining to the storage and disposal of any hazardous or investigation derived wastes.

a.) The Solid Waste Section recommends wearing protective gloves when conducting all sampling activities.

1. Gloves serve to protect the sample collector from potential exposure to sample constituents, minimize accidental contamination of samples by the collector, and preserve accurate tare weights on preweighed sample containers.
2. Do not let gloves come into contact with the sample or with the interior or lip of the sample container. Use clean, new, unpowdered and disposable gloves. Various types of gloves may be used as long as the construction materials do not contaminate the sample or if internal safety protocols require greater protection.
3. Note that certain materials that may potentially be present in concentrated effluent can pass through certain glove types and be absorbed in the skin. Many vendor catalogs provide information about the permeability of different gloves and the circumstances under which the glove material might be applicable. The powder in powdered gloves can contribute significant contamination. Powdered gloves are not recommended unless it can be demonstrated that the powder does not interfere with the sample analysis.
4. Change gloves after preliminary activities, after collecting all the samples at a single sampling point, if torn or used to handle extremely dirty or highly contaminated surfaces. Properly dispose of all used gloves as investigation derived wastes.

b.) Properly manage all investigation derived waste (IDW).

5. To prevent contamination into previously uncontaminated areas, properly manage all IDW. This includes all water, soil, drilling mud, decontamination wastes, discarded personal protective equipment (PPE), etc. from site investigations, exploratory borings, piezometer and monitoring well installation, refurbishment, abandonment, and other investigative activities. Manage all IDW that is determined to be RCRA-regulated hazardous waste according to the local, state and federal requirements.
6. Properly dispose of IDW that is not a RCRA-regulated hazardous waste but is contaminated above the Department's Soil Cleanup Target Levels or the state standards and/or minimum criteria for ground water quality. If the drill cuttings/mud orpurged well water is contaminated with hazardous waste, contact the DWM Hazardous Waste Section (919-508-8400) for disposal options. Maintain all containers holding IDW in good condition. Periodically inspect the containers for damage and ensure that all required labeling (DOT, RCRA, etc.) are clearly visible.

Sample Storage and Transport

Store samples for transport carefully. Pack samples to prevent from breaking and to maintain a temperature of approximately 4 degrees Celsius (°C), adding ice if necessary. Transport samples to a North Carolina-certified laboratory as soon as possible. Avoid unnecessary handling of sample containers. Avoid heating (room temperature or above, including exposure to sunlight) or freezing of the sample containers. Reduce the time between sample collection and delivery to a laboratory whenever possible and be sure that the analytical holding times of your samples can be met by the laboratory.

a.) A complete chain-of-custody (COC) form must be maintained to document all transfers and receipts of the samples. Be sure that the sample containers are labeled with the sample location and/or well number, sample identification, the date and time of collection, the analysis to be performed, the preservative added (if any), the sampler's initials, and any other pertinent information for sample identification. The labels should contain a unique identifier (i.e., unique well numbers) that can be traced to the COC form. The details of sample collection must be documented on the COC. The COC must include the following:

1. Description of each sample (including QA/QC samples) and the number of containers (sample location and identification)
2. Signature of the sampler
3. Date and time of sample collection
4. Analytical method to be performed
5. Sample type (i.e., water or soil)
6. Regulatory agency (i.e., NCDENR/DWM – SW Section)
7. Signatures of all persons relinquishing and receiving custody of the samples
8. Dates and times of custody transfers

b.) Pack samples so that they are segregated by site, sampling location or by sample analysis type. When COC samples are involved, segregate samples in coolers by site. If samples from multiple sites will fit in one cooler, they may be packed in the same cooler with the associated field sheets and a single COC form for all. Coolers should not exceed a maximum weight of 50 lbs. Use additional coolers as necessary. All sample containers should be placed in plastic bags (segregated by analysis and location) and completely surrounded by ice.

1. Prepare and place trip blanks in an ice filled cooler before leaving for the field.
2. Segregate samples by analysis and place in sealable plastic bags.
3. Pack samples carefully in the cooler placing ice around the samples.
4. Review the COC. The COC form must accompany the samples to the laboratory. The trip blank(s) must also be recorded on the COC form.
5. Place completed COC form in a waterproof bag, sealed and taped under the lid of the cooler.
6. Secure shipping containers with strapping tape to avoid accidental opening.
7. For COC samples, a tamper-proof seal may also be placed over the cooler lid or over a bag or container containing the samples inside the shipping cooler.

8. "COC" or "EMERG" should be written in indelible ink on the cooler seal to alert sample receipt technicians to priority or special handling samples.
9. The date and sample handler's signature must also be written on the COC seal.
10. Deliver the samples to the laboratory or ship by commercial courier.
    NOTE*: If transport time to the laboratory is not long enough to allow samples to be cooled to 4° C, a temperature reading of the sample source must be documented as the field temperature on the COC form. A downward trend in temperature will be adequate even if cooling to 4° C is not achieved. The field temperature should always be documented if there is any question as to whether samples will have time to cool to 4° C during shipment. Thermometers must be calibrated annually against an NIST traceable thermometer and documentation must be retained.*

Appendix A - Decontamination of Field Equipment

Decontamination of personnel, sampling equipment, and containers - before and after sampling - must be used to ensure collection of representative samples and to prevent the potential spread of contamination. Decontamination of personnel prevents ingestion and absorption of contaminants. It must be done with a soap and water wash and deionized or distilled water rinse. Certified pre-cleaned sampling equipment and containers may also be used.

All previously used sampling equipment must be properly decontaminated before sampling and between sampling locations. This prevents the introduction of contamination into uncontaminated samples and avoids cross-contamination of samples. Cross-contamination can be a significant problem when attempting to characterize extremely low concentrations of organic compounds or when working with soils that are highly contaminated.

Clean, solvent-resistant gloves and appropriate protective equipment must be worn by persons decontaminating tools and equipment.

Cleaning Reagents

Recommendations for the types and grades of various cleaning supplies are outlined below. The recommended reagent types or grades were selected to ensure that the cleaned equipment is free from any detectable contamination.

a.) Detergents: Use Liqui-Nox (or a non-phosphate equivalent) or Alconox (or equivalent). Liqui-Nox (or equivalent) is recommended by EPA, although Alconox (or equivalent) may be substituted if the sampling equipment will not be used to collect phosphorus or phosphorus containing compounds.

b.) Solvents: Use pesticide grade isopropanol as the rinse solvent in routine equipment cleaning procedures. This grade of alcohol must be purchased from a laboratory supply vendor. Rubbing alcohol or other commonly available sources of isopropanol **are not acceptable**. Other solvents, such as acetone or methanol, may be used as the final rinse solvent if they are pesticide grade. However, methanol is more toxic to the environment and acetone may be an analyte of interest for volatile organics.

1. **Do not** use acetone if volatile organics are of interest
2. Containerize all methanol wastes (including rinses) and dispose as a hazardous waste.

Pre-clean equipment that is heavily contaminated with organic analytes. Use reagent grade acetone and hexane or other suitable solvents. Use pesticide grade methylene chloride when cleaning sample containers. Store all solvents away from potential sources of contamination.

c.) Analyte-Free Water Sources: Analyte-free water is water in which all analytes of interest and all interferences are below method detection limits. Maintain documentation (such as results from equipment blanks) to demonstrate the reliability and purity of analyte-free water source(s). The source of the water must meet the requirements of the analytical method and must be free from the analytes of interest. In general, the following water types are associated with specific analyte groups:

1. *Milli-Q (or equivalent polished water)*: suitable for all analyses.

2. *Organic-free*: suitable for volatile and extractable organics.
3. *Deionized water*: may not be suitable for volatile and extractable organics.
4. *Distilled water*: not suitable for volatile and extractable organics, metals or ultratrace metals.

Use analyte-free water for blank preparation and the final decontamination water rinse. In order to minimize long-term storage and potential leaching problems, obtain or purchase analyte-free water just prior to the sampling event. If obtained from a source (such as a laboratory), fill the transport containers and use the contents for a single sampling event. Empty the transport container(s) at the end of the sampling event. Discard any analyte-free water that is transferred to a dispensing container (such as a wash bottle or pump sprayer) at the end of each sampling day.

d.) Acids:

1. *Reagent Grade Nitric Acid*: 10 - 15% (one volume concentrated nitric acid and five volumes deionized water). Use for the acid rinse unless nitrogen components (e.g., nitrate, nitrite, etc.) are to be sampled. If sampling for ultra-trace levels of metals, use an ultra-pure grade acid.
2. *Reagent Grade Hydrochloric Acid*: 10% hydrochloric acid (one volume concentrated hydrochloric and three volumes deionized water). Use when nitrogen components are to be sampled.
3. If samples for both metals and the nitrogen-containing components are collected with the equipment, use the hydrochloric acid rinse, or thoroughly rinse with hydrochloric acid after a nitric acid rinse. If sampling for ultra trace levels of metals, use an ultra-pure grade acid.
4. Freshly prepared acid solutions may be recycled during the sampling event or cleaning process. Dispose of any unused acids according to local ordinances.

Reagent Storage Containers

The contents of all containers must be clearly marked.

a.) Detergents:

1. Store in the original container or in a HDPE or PP container.

b.) Solvents:

1. Store solvents to be used for cleaning or decontamination in the original container until use in the field. If transferred to another container for field use, use either a glass or Teflon container.
2. Use dispensing containers constructed of glass, Teflon or stainless steel. Note: If stainless steel sprayers are used, any gaskets that contact the solvents must be constructed of inert materials.

c.) Analyte-Free Water:

1. Transport in containers appropriate for the type of water stored. If the water is commercially purchased (e.g., grocery store), use the original containers when transporting the water to the field. Containers made of glass, Teflon, polypropylene or HDPE are acceptable.
2. Use glass or Teflon to transport organic-free sources of water on-site. Polypropylene or HDPE may be used, but are not recommended.

3. Dispense water from containers made of glass, Teflon, HDPE or polypropylene.
4. Do not store water in transport containers for more than three days before beginning a sampling event.
5. If working on a project that has oversight from EPA Region 4, use glass containers for the transport and storage of all water.
6. Store and dispense acids using containers made of glass, Teflon or plastic.

General Requirements

a.) Prior to use, clean/decontaminate all sampling equipment (pumps, tubing, lanyards, split spoons, etc.) that will be exposed to the sample.

b.) Before installing, clean (or obtain as certified pre-cleaned) all equipment that is dedicated to a single sampling point and remains in contact with the sample medium (e.g., permanently installed groundwater pump). If you use certified pre-cleaned equipment no cleaning is necessary.

1. Clean this equipment any time it is removed for maintenance or repair.
2. Replace dedicated tubing if discolored or damaged.

c.) Clean all equipment in a designated area having a controlled environment (house, laboratory, or base of field operations) and transport it to the field, pre-cleaned and ready to use, unless otherwise justified.

d.) Rinse all equipment with water after use, even if it is to be field-cleaned for other sites. Rinse equipment used at contaminated sites or used to collect in-process (e.g., untreated or partially treated wastewater) samples immediately with water.

e.) Whenever possible, transport sufficient clean equipment to the field so that an entire sampling event can be conducted without the need for cleaning equipment in the field.

f.) Segregate equipment that is only used once (i.e., not cleaned in the field) from clean equipment and return to the in-house cleaning facility to be cleaned in a controlled environment.

g.) Protect decontaminated field equipment from environmental contamination by securely wrapping and sealing with one of the following:

1. Aluminum foil (commercial grade is acceptable)
2. Untreated butcher paper
3. Clean, untreated, disposable plastic bags. Plastic bags may be used for all analyte groups except volatile and extractable organics. Plastic bags may be used for volatile and extractable organics, if the equipment is first wrapped in foil or butcher paper, or if the equipment is completely dry.

Cleaning Sample Collection Equipment

a.) <u>On-Site/In-Field Cleaning</u> – Cleaning equipment on-site is not recommended because environmental conditions cannot be controlled and wastes (solvents and acids) must be containerized for proper disposal.

1. Ambient temperature water may be substituted in the hot, sudsy water bath and hot water rinses.

NOTE: Properly dispose of all solvents and acids.

2. Rinse all equipment with water after use, even if it is to be field-cleaned for other sites.
3. Immediately rinse equipment used at contaminated sites or used to collect in-process (e.g., untreated or partially treated wastewater) samples with water.

b.) Heavily Contaminated Equipment - In order to avoid contaminating other samples, isolate heavily contaminated equipment from other equipment and thoroughly decontaminate the equipment before further use. Equipment is considered heavily contaminated if it:

1. Has been used to collect samples from a source known to contain significantly higher levels than background.
2. Has been used to collect free product.
3. Has been used to collect industrial products (e.g., pesticides or solvents) or their byproducts.

NOTE: *Cleaning heavily contaminated equipment in the field is not recommended.*

c.) On-Site Procedures:

1. Protect all other equipment, personnel and samples from exposure by isolating the equipment immediately after use.
2. At a minimum, place the equipment in a tightly sealed, untreated, plastic bag.
3. Do not store or ship the contaminated equipment next to clean, decontaminated equipment, unused sample containers, or filled sample containers.
4. Transport the equipment back to the base of operations for thorough decontamination.
5. If cleaning must occur in the field, document the effectiveness of the procedure, collect and analyze blanks on the cleaned equipment.

d.) Cleaning Procedures:

1. If organic contamination cannot be readily removed with scrubbing and a detergent solution, pre-rinse equipment by thoroughly rinsing or soaking the equipment in acetone.
2. Use hexane only if preceded and followed by acetone.
3. In extreme cases, it may be necessary to steam clean the field equipment before proceeding with routine cleaning procedures.
4. After the solvent rinses (and/or steam cleaning), use the appropriate cleaning procedure. Scrub, rather than soak, all equipment with sudsy water. If high levels of metals are suspected and the equipment cannot be cleaned without acid rinsing, soak the equipment in the appropriate acid. Since stainless steel equipment should not be exposed to acid rinses, do not use stainless steel equipment when heavy metal contamination is suspected or present.
5. If the field equipment cannot be cleaned utilizing these procedures, discard unless further cleaning with stronger solvents and/or oxidizing solutions is effective as evidenced by visual observation and blanks.
6. Clearly mark or disable all discarded equipment to discourage use.

e.) General Cleaning - Follow these procedures when cleaning equipment under controlled conditions. Check manufacturer's instructions for cleaning restrictions and/or recommendations.

1. *Procedure for Teflon, stainless steel and glass sampling equipment*: This procedure must be used when sampling for ALL analyte groups. (Extractable organics, metals, nutrients, etc. or if a single decontamination protocol is desired to clean all Teflon, stainless steel and glass equipment.) Rinse equipment with hot tap water. Soak equipment in a hot, sudsy water solution (Liqui-Nox or equivalent). If necessary, use a brush to remove particulate matter or surface film. Rinse thoroughly with hot tap water. If samples for trace metals or inorganic analytes will be collected with the equipment that is not stainless steel, thoroughly rinse (wet all surfaces) with the appropriate acid solution. Rinse thoroughly with analyte-free water. Make sure that all equipment surfaces are thoroughly flushed with water. If samples for volatile or extractable organics will be collected, rinse with isopropanol. Wet equipment surfaces thoroughly with free-flowing solvent. Rinse thoroughly with analyte-free water. Allow to air dry. Wrap and seal as soon as the equipment has air-dried. If isopropanol is used, the equipment may be air-dried without the final analyte-free water rinse; however, the equipment must be completely dry before wrapping or use. Wrap clean sampling equipment according to the procedure described above.
2. *General Cleaning Procedure for Plastic Sampling Equipment*: Rinse equipment with hot tap water. Soak equipment in a hot, sudsy water solution (Liqui-Nox or equivalent). If necessary, use a brush to remove particulate matter or surface film. Rinse thoroughly with hot tap water. Thoroughly rinse (wet all surfaces) with the appropriate acid solution. Check manufacturer's instructions for cleaning restrictions and/or recommendations. Rinse thoroughly with analyte-free water. Be sure that all equipment surfaces are thoroughly flushed. Allow to air dry as long as possible. Wrap clean sampling equipment according to the procedure described above.

Appendix B - Collecting Soil Samples

Soil samples are collected for a variety of purposes. A methodical sampling approach must be used to assure that sample collection activities provide reliable data. Sampling must begin with an evaluation of background information, historical data and site conditions.

Soil Field Screening Procedures

Field screening is the use of portable devices capable of detecting petroleum contaminants on a real-time basis or by a rapid field analytical technique. Field screening should be used to help assess locations where contamination is most likely to be present.

When possible, field-screening samples should be collected directly from the excavation or from the excavation equipment's bucket. If field screening is conducted only from the equipment's bucket, then a minimum of one field screening sample should be collected from each 10 cubic yards of excavated soil. If instruments or other observations indicate contamination, soil should be separated into stockpiles based on apparent degrees of contamination. At a minimum, soil suspected of contamination must be segregated from soil observed to be free of contamination.

a.) Field screening devices – Many field screen instruments are available for detecting contaminants in the field on a rapid or real-time basis. Acceptable field screening instruments must be suitable for the contaminant being screened. The procdedure for field screening using photoionization detectors (PIDs) and flame ionization detectors (FIDs) is described below. If other instruments are used, a description of the instrument or method and its intended use must be provided to the Solid Waste Section. Whichever field screening method is chosen, its accuracy must be verified throughout the sampling process. Use appropriate standards that match the use intended for the data. Unless the Solid Waste Section indicates otherwise, wherever field screening is recommended in this document, instrumental or analytical methods of detection must be used, not olfactory or visual screening methods.

b.) Headspace analytical screening procedure for filed screening (semi-quantitative field screening) - The most commonly used field instruments for Solid Waste Section site assessments are FIDs and PIDs. When using FIDs and PIDs, use the following headspace screening procedure to obtain and analyze field-screening samples:

1. Partially fill (one-third to one-half) a clean jar or clean ziplock bag with the sample to be analyzed. The total capacity of the jar or bag may not be less than eight ounces (app. 250 ml), but the container should not be so large as to allow vapor diffusion and stratification effects to significantly affect the sample.
2. If the sample is collected from a spilt-spoon, it must be transferred to the jar or bag for headspace analysis immediately after opening the split-spoon. If the sample is collected from an excavation or soil pile, it must be collected from freshly uncovered soil.

3. If a jar is used, it must be quickly covered with clean aluminum foil or a jar lid; screw tops or thick rubber bands must be used to tightly seal the jar. If a zip lock bag is used, it must be quickly sealed shut.
4. Headspace vapors must be allowed to develop in the container for at least 10 minutes but no longer than one hour. Containers must be shaken or agitated for 15 seconds at the beginning and the end of the headspace development period to assist volatilization. Temperatures of the headspace must be warmed to at least 5° C (approximately 40° F) with instruments calibrated for the temperature used.
5. After headspace development, the instrument sampling probe must be inserted to a point about one-half the headspace depth. The container opening must be minimized and care must be taken to avoid the uptake of water droplets and soil particulates.
6. After probe insertion, the highest meter reading must be taken and recorded. This will normally occur between two and five seconds after probe insertion. If erratic meter response occurs at high organic vapor concentrations or conditions of elevated headspace moisture, a note to that effect must accompany the headspace data.
7. All field screening results must be documented in the field record or log book.

Soil Sample Collection Procedures for Laboratory Samples

The number and type of laboratory samples collected depends on the purpose of the sampling activity. Samples analyzed with field screening devices may not be substituted for required laboratory samples.

a.) General Sample Collection - When collecting samples from potentially contaminated soil, care should be taken to reduce contact with skin or other parts of the body. Disposable gloves should be worn by the sample collector and should be changed between samples to avoid cross-contamination. Soil samples should be collected in a manner that causes the least disturbance to the internal structure of the sample and reduces its exposure to heat, sunlight and open air. Likewise, care should be taken to keep the samples from being contaminated by other materials or other samples collected at the site. When sampling is to occur over an extended period of time, it is necessary to insure that the samples are collected in a comparable manner. All samples must be collected with disposable or clean tools that have been decontaminated. Disposable gloves must be worn and changed between sample collections. Sample containers must be filled quickly. Soil samples must be placed in containers in the order of volatility, for example, volatile organic aromatic samples must be taken first, organics next, then heavier range organics, and finally soil classification samples. Containers must be quickly and adequately sealed, and rims must be cleaned before tightening lids. Tape may be used only if known not to affect sample analysis. Sample containers must be clearly labeled. Containers must immediately be preserved according to procedures in this Section. Unless specified

otherwise, at a minimum, the samples must be immediately cooled to 4 ± 2°C and this temperature must be maintained throughout delivery to the laboratory.

b.) Surface Soil Sampling - Surface soil is generally classified as soil between the ground surface and 6-12 inches below ground surface. Remove leaves, grass and surface debris from the area to be sampled. Select an appropriate, pre-cleaned sampling device and collect the sample. Transfer the sample to the appropriate sample container. Clean the outside of the sample container to remove excess soil. Label the sample container, place on wet ice to preserve at 4°C, and complete the field notes.

c.) Subsurface Soil Sampling – The interval begins at approximately 12 inches below ground surface. Collect samples for volatile organic analyses. For other analyses, select an appropriate, pre-cleaned sampling device and collect the sample. Transfer the sample to the appropriate sample container. Clean the outside of the sample container to remove excess soil. Label the sample container, place on wet ice to preserve at 4°C, and complete field notes.

d.) Equipment for Reaching the Appropriate Soil Sampling Depth - Samples may be collected using a hollow stem soil auger, direct push, Shelby tube, split-spoon sampler, or core barrel. These sampling devices may be used as long as an effort is made to reduce the loss of contaminants through volatilization. In these situations, obtain a sufficient volume of so the samples can be collected without volatilization and disturbance to the internal structure of the samples. Samples should be collected from cores of the soil. Non-disposable sampling equipment must be decontaminated between each sample location. **NOTE:** *If a confining layer has been breached during sampling, grout the hole to land.*

e.) Equipment to Collect Soil Samples - Equipment and materials that may be used to collect soil samples include disposable plastic syringes and other "industry-standard" equipment and materials that are contaminant-free. Non-disposable sampling equipment must be decontaminated between each sample location.

Appendix C - Collecting Groundwater Samples

Groundwater samples are collected to identify, investigate, assess and monitor the concentration of dissolved contaminant constituents. To properly assess groundwater contamination, first install sampling points (monitoring wells, etc.) to collect groundwater samples and then perform specific laboratory analyses. All monitoring wells should be constructed in accordance with 15A NCAC 2C .0100 and sampled as outlined in this section. Groundwater monitoring is conducted using one of two methods:

1. Portable Monitoring: Monitoring that is conducted using sampling equipment that is discarded between sampling locations. Equipment used to collect a groundwater sample from a well such as bailers, tubing, gloves, and etc. are disposed of after sample collection. A new set of sampling equipment is used to collect a groundwater sample at the next monitor well.

2. Dedicated Monitoring: Monitoring that utilizes permanently affixed down-well and well head components that are capped after initial set-up. Most dedicated monitoring systems are comprised of an in-well submersible bladder pump, with air supply and sample discharge tubing, and an above-ground driver/controller for regulation of flow rates and volumes. The pump and all tubing housed within the well should be composed of Teflon or stainless steel components. This includes seals inside the pump, the pump body, and fittings used to connect tubing to the pump. Because ground water will not be in contact with incompatible constituents and because the well is sealed from the surface, virtually no contamination is possible from intrinsic sources during sampling and between sampling intervals. All dedicated monitoring systems must be approved by the Solid Waste Section before installation.

Groundwater samples may be collected from a number of different configurations. Each configuration is associated with a unique set of sampling equipment requirements and techniques:

1. Wells without Plumbing: These wells require equipment to be brought to the well to purge and sample unless dedicated equipment is placed in the well.

2. Wells with In-Place Plumbing: Wells with in-place plumbing do not require equipment to be brought to the well to purge and sample. In-place plumbing is generally considered permanent equipment routinely used for purposes other than purging and sampling, such as for water supply.

3. Air Strippers or Remedial Systems: These types of systems are installed as remediation devices.

Groundwater Sample Preparation

The type of sample containers used depends on the type of analysis performed. First, determine the type(s) of contaminants expected and the proper analytical method(s). Be sure to consult your selected laboratory for its specific needs and requirements prior to sampling.

Next, prepare the storage and transport containers (ice chest, etc.) before taking any samples so that each sample can be placed in a chilled environment immediately after collection.

Use groundwater purging and sampling equipment constructed of only non-reactive, non-leachable materials that are compatible with the environment and the selected analytes. In selecting groundwater purging and sampling equipment, give consideration to the depth of the well, the depth to groundwater, the volume of water to be evacuated, the sampling and purging technique, and the analytes of interest. Additional supplies, such as reagents and preservatives, may be necessary.

All sampling equipment (bailers, tubing, containers, etc.) must be selected based on its chemical compatibility with the source being sampled (e.g., water supply well, monitoring well) and the contaminants potentially present.

a.) Pumps - All pumps or pump tubing must be lowered and retrieved from the well slowly and carefully to minimize disturbance to the formation water. This is especially critical at the air/water interface.

1. *Above-Ground Pumps*
   - Variable Speed Peristaltic Pump: Use a variable speed peristaltic pump to purge groundwater from wells when the static water level in the well is no greater than 20- 25 feet below land surface (BLS). If the water levels are deeper than 18-20 feet BLS, the pumping velocity will decrease. A variable speed peristaltic pump can be used for normal purging and sampling, and sampling low permeability aquifers or formations. Most analyte groups can be sampled with a peristaltic pump if the tubing and pump configurations are appropriate.
   - Variable Speed Centrifugal Pump: A variable speed centrifugal pump can be used to purge groundwater from 2-inch and larger internal diameter wells. **Do not use** this type of pump to collect groundwater samples. When purging is complete, do not allow the water that remains in the tubing to fall back into the well. Install a check valve at the end of the purge tubing.
2. *Submersible Pumps*
   - Variable Speed Electric Submersible Pump: A variable speed submersible pump can be used to purge and sample groundwater from 2-inch and larger internal diameter wells. A variable speed submersible pump can be used for normal purging and sampling, and sampling low permeability aquifers or formations. The pump housing, fittings, check valves and associated hardware must be constructed of stainless steel. All other materials must be

compatible with the analytes of interest. Install a check valve at the output side of the pump to prevent backflow. If purging **and** sampling for organics, the entire length of the delivery tube must be Teflon, polyethylene or polypropylene (PP) tubing; the electrical cord must be sealed in Teflon, polyethylene or PP and any cabling must be sealed in Teflon, polyethylene or PP, or be constructed of stainless steel; and all interior components that contact the sample water (impeller, seals, gaskets, etc.) must be constructed of stainless steel or Teflon.

3. *Variable Speed Bladder Pump*: A variable speed, positive displacement, bladder pump can be used to purge and sample groundwater from 3/4-inch and larger internal diameter wells.
    - A variable speed bladder pump can be used for normal purging and sampling, and sampling low permeability aquifers or formations.
    - The bladder pump system is composed of the pump, the compressed air tubing, the water discharge tubing, the controller and a compressor, or a compressed gas supply.
    - The pump consists of a bladder and an exterior casing or pump body that surrounds the bladder and two (2) check valves. These parts can be composed of various materials, usually combinations of polyvinyl chloride (PVC), Teflon, polyethylene, PP and stainless steel. Other materials must be compatible with the analytes of interest.
    - If purging and sampling for organics, the pump body must be constructed of stainless steel. The valves and bladder must be Teflon, polyethylene or PP; the entire length of the delivery tube must be Teflon, polyethylene or PP; and any cabling must be sealed in Teflon, polyethylene or PP, or be constructed of stainless steel.
    - Permanently installed pumps may have a PVC pump body as long as the pump remains in contact with the water in the well.

b.) <u>Bailers</u>

1. *Purging*: Bailers must be used with caution because improper bailing can cause changes in the chemistry of the water due to aeration and loosening particulate matter in the space around the well screen. Use a bailer if there is non-aqueous phase liquid (free product) in the well or if non-aqueous phase liquid is suspected to be in the well.
2. *Sampling*: Bailers must be used with caution.
3. *Construction and Type*: Bailers must be constructed of materials compatible with the analytes of interest. Stainless steel, Teflon, rigid medical grade PVC, polyethylene and PP bailers may be used to sample all analytes. Use disposable bailers when sampling grossly contaminated sample sources. NCDENR recommends using dual check valve bailers when collecting samples. Use bailers with a controlled flow bottom to collect volatile organic samples.

4. *Contamination Prevention*: Keep the bailer wrapped (foil, butcher paper, etc.) until just before use. Use protective gloves to handle the bailer once it is removed from its wrapping. Handle the bailer by the lanyard to minimize contact with the bailer surface.

c.) Lanyards

1. Lanyards must be made of non-reactive, non-leachable material. They may be cotton twine, nylon, stainless steel, or may be coated with Teflon, polyethylene or PP.
2. Discard cotton twine, nylon, and non-stainless steel braided lanyards after sampling each monitoring well.
3. Decontaminate stainless steel, coated Teflon, polyethylene and PP lanyards between monitoring wells. They do not need to be decontaminated between purging and sampling operations.

Water Level and Purge Volume Determination

The amount of water that must be purged from a well is determined by the volume of water and/or field parameter stabilization.

a.) General Equipment Considerations - Selection of appropriate purging equipment depends on the analytes of interest, the well diameter, transmissivity of the aquifer, the depth to groundwater, and other site conditions.

1. Use of a pump to purge the well is recommended unless no other equipment can be used or there is non-aqueous phase liquid in the well, or non-aqueous phase liquid is suspected to be in the well.
2. Bailers must be used with caution because improper bailing:
    - Introduces atmospheric oxygen, which may precipitate metals (i.e., iron) or cause other changes in the chemistry of the water in the sample (i.e., pH).
    - Agitates groundwater, which may bias volatile and semi-volatile organic analyses due to volatilization.
    - Agitates the water in the aquifer and resuspends fine particulate matter.
    - Surges the well, loosening particulate matter in the annular space around the well screen.
    - May introduce dirt into the water column if the sides of the casing wall are scraped.

NOTE: *It is critical for bailers to be slowly and gently immersed into the top of the water column, particularly during the final stages of purging. This minimizes turbidity and disturbance of volatile organic constituents.*

b.) Initial Inspection

1. Remove the well cover and remove all standing water around the top of the well casing (manhole) before opening the well.
2. Inspect the exterior protective casing of the monitoring well for damage. Document the results of the inspection if there is a problem.
3. It is recommended that you place a protective covering around the well head. Replace the covering if it becomes soiled or ripped.

4. Inspect the well lock and determine whether the cap fits tightly. Replace the cap if necessary.

c.) Water Level Measurements - Use an electronic probe or chalked tape to determine the water level. Decontaminate all equipment before use. Measure the depth to groundwater from the top of the well casing to the nearest 0.01 foot. Always measure from the same reference point or survey mark on the well casing. Record the measurement.

1. *Electronic Probe*: Decontaminate all equipment before use. Follow the manufacturer's instructions for use. Record the measurement.
2. *Chalked Line Method*: Decontaminate all equipment before use. Lower chalked tape into the well until the lower end is in the water. This is usually determined by the sound of the weight hitting the water. Record the length of the tape relative to the reference point. Remove the tape and note the length of the wetted portion. Record the length. Determine the depth to water by subtracting the length of the wetted portion from the total length. Record the result.

d.) Water Column Determination - To determine the length of the water column, subtract the depth to the top of the water column from the total well depth (or gauged well depth if silting has occurred). The total well depth depends on the well construction. If gauged well depth is used due to silting, report total well depth also. Some wells may be drilled in areas of sinkhole, karst formations or rock leaving an open borehole. Attempt to find the total borehole depth in cases where there is an open borehole below the cased portion.

e.) Well Water Volume - Calculate the total volume of water, in gallons, in the well using the following equation:

$$V = (0.041)d \times d \times h$$

Where:

V = volume in gallons
d = well diameter in inches
h = height of the water column in feet

The total volume of water in the well may also be determined with the following equation by using a casing volume per foot factor (Gallons per Foot of Water) for the appropriate diameter well:

$$V = [\text{Gallons per Foot of Water}] \times h$$

Where:

V = volume in gallons
h = height of the water column in feet

Record all measurements and calculations in the field records.

f.) Purging Equipment Volume - Calculate the total volume of the pump, associated tubing and flow cell (if used), using the following equation:

$$V = p + ((0.041)d \times d \times l) + fc$$

Where:

V = volume in gallons
p = volume of pump in gallons
d = tubing diameter in inches
l = length of tubing in feet

fc = volume of flow cell in gallons

g.) If the groundwater elevation data are to be used to construct groundwater elevation contour maps, all water level measurements must be taken within the same 24 hour time interval when collecting samples from multiple wells on a site, unless a shorter time period is required. If the site is tidally influenced, complete the water level measurements within the time frame of an incoming or outgoing tide.

Well Purging Techniques

The selection of the purging technique and equipment is dependent on the hydrogeologic properties of the aquifer, especially depth to groundwater and hydraulic conductivity.

a.) Measuring the Purge Volume - The volume of water that is removed during purging must be recorded. Therefore, you must measure the volume during the purging operation.

1. Collect the water in a graduated container and multiply the number of times the container was emptied by the volume of the container, OR
2. Estimate the volume based on pumping rate. This technique may be used only if the pumping rate is constant. Determine the pumping rate by measuring the amount of water that is pumped for a fixed period of time, or use a flow meter.
    - Calculate the amount of water that is discharged per minute: D = Measured Amount/Total Time In Minutes
    - Calculate the time needed to purge one (1) well volume or one (1) purging equipment volume: Time = V/D
      Where: V = well volume or purging equipment volume
      D = discharge rate
    - Make new measurements each time the pumping rate is changed.
3. Use a totalizing flow meter.
    - Record the reading on the totalizer prior to purging.
    - Record the reading on the totalizer at the end of purging.
    - To obtain the volume purged, subtract the reading on the totalizer prior to purging from the reading on the totalizer at the end of purging.
    - Record the times that purging begins and ends in the field records.

b.) Purging Measurement Frequency - When purging a well that has the well screen fully submerged and the pump or intake tubing is placed within the well casing above the well screen or open hole, purge a minimum of one (1) well volume prior to collecting measurements of the field parameters. Allow at least one quarter (1/4) well volume to purge between subsequent measurements. When purging a well that has the pump or intake tubing placed within a fully submerged well screen or open hole, purge until the water level has stabilized (well recovery rate equals the purge rate), then purge a minimum of one (1) volume of the pump, associated tubing and flow cell (if used) prior to collecting measurements of the field parameters. Take measurements of the field parameters no sooner than two (2) to three (3) minutes apart. Purge at least

three (3) volumes of the pump, associated tubing and flow cell, if used, prior to collecting a sample. When purging a well that has a partially submerged well screen, purge a minimum of one (1) well volume prior to collecting measurements of the field parameters. Take measurements of the field parameters no sooner than two (2) to three (3) minutes apart.

c.) Purging Completion - Wells must be adequately purged prior to sample collection to ensure representation of the aquifer formation water, rather than stagnant well water. This may be achieved by purging three volumes from the well or by satisfying any one of the following three purge completion criteria:

1.) Three (3) consecutive measurements in which the three (3) parameters listed below are within the stated limits, dissolved oxygen is no greater than 20 percent of saturation at the field measured temperature, and turbidity is no greater than 20 Nephelometric Turbidity Units (NTUs).

- Temperature: + 0.2° C
- pH: + 0.2 Standard Units
- Specific Conductance: + 5.0% of reading

Document and report the following, as applicable. The last four items only need to be submitted once:

- Purging rate.
- Drawdown in the well, if any.
- A description of the process and the data used to design the well.
- The equipment and procedure used to install the well.
- The well development procedure.
- Pertinent lithologic or hydrogeologic information.

2.) If it is impossible to get dissolved oxygen at or below 20 percent of saturation at the field measured temperature or turbidity at or below 20 NTUs, then three (3) consecutive measurements of temperature, pH, specific conductance and the parameter(s) dissolved oxygen and/or turbidity that do not meet the requirements above must be within the limits below. The measurements are:

- Temperature: + 0.2° C
- pH: + 0.2 Standard Units
- Specific Conductance: + 5.0% of reading
- Dissolved Oxygen: + 0.2 mg/L or 10%, whichever is greater
- Turbidity: + 5 NTUs or 10%, whichever is greater

Additionally, document and report the following, as applicable, except that the last four(4) items only need to be submitted once:

- Purging rate.
- Drawdown in the well, if any.
- A description of conditions at the site that may cause the dissolved oxygen to be high and/or dissolved oxygen measurements made within the screened or open hole portion of the well with a downhole dissolved oxygen probe.

- A description of conditions at the site that may cause the turbidity to be high and any procedures that will be used to minimize turbidity in the future.
- A description of the process and the data used to design the well.
- The equipment and procedure used to install the well.
- The well development procedure.
- Pertinent lithologic or hydrogeologic information.

3.) If after five (5) well volumes, three (3) consecutive measurements of the field parameters temperature, pH, specific conductance, dissolved oxygen, and turbidity are not within the limits stated above, check the instrument condition and calibration, purging flow rate and all tubing connections to determine if they might be affecting the ability to achieve stable measurements. It is at the discretion of the consultant/contractor whether or not to collect a sample or to continue purging. Further, the report in which the data are submitted must include the following, as applicable. The last four (4) items only need to be submitted once.

- Purging rate.
- Drawdown in the well, if any.
- A description of conditions at the site that may cause the Dissolved Oxygen to be high and/or Dissolved Oxygen measurements made within the screened or open hole portion of the well with a downhole dissolved oxygen probe.
- A description of conditions at the site that may cause the turbidity to be high and any procedures that will be used to minimize turbidity in the future.
- A description of the process and the data used to design the well.
- The equipment and procedure used to install the well.
- The well development procedure.
- Pertinent lithologic or hydrogeologic information.

If wells have previously and consistently purged dry, and the current depth to groundwater indicates that the well will purge dry during the current sampling event, minimize the amount of water removed from the well by using the same pump to purge and collect the sample:

- Place the pump or tubing intake within the well screened interval.
- Use very small diameter Teflon, polyethylene or PP tubing and the smallest possible pump chamber volume. This will minimize the total volume of water pumped from the well and reduce drawdown.
- Select tubing that is thick enough to minimize oxygen transfer through the tubing walls while pumping.

- Pump at the lowest possible rate (100 mL/minute or less) to reduce drawdown to a minimum.
- Purge at least two (2) volumes of the pumping system (pump, tubing and flow cell, if used).
- Measure pH, specific conductance, temperature, dissolved oxygen and turbidity, then begin to collect the samples.

Collect samples immediately after purging is complete. The time period between completing the purge and sampling cannot exceed six hours. If sample collection does not occur within one hour of purging completion, re-measure the five field parameters: temperature, pH, specific conductance, dissolved oxygen and turbidity, just prior to collecting the sample. If the measured values are not within 10 percent of the previous measurements, re-purge the well. The exception is "dry" wells.

d.) Lanyards

1. Securely fasten lanyards, if used, to any downhole equipment (bailers, pumps, etc.).
2. Use bailer lanyards in such a way that they do not touch the ground surface.

Wells Without Plumbing

a.) Tubing/Pump Placement

1. If attempting to minimize the volume of purge water, position the intake hose or pump at the midpoint of the screened or open hole interval.
2. If monitoring well conditions do not allow minimizing of the purge water volume, position the pump or intake hose near the top of the water column. This will ensure that all stagnant water in the casing is removed.
3. If the well screen or borehole is partially submerged, and the pump will be used for both purging and sampling, position the pump midway between the measured water level and the bottom of the screen. Otherwise, position the pump or intake hose near the top of the water column.

b.) Non-dedicated (portable) pumps

1. *Variable Speed Peristaltic Pump*
   - Wear sampling gloves to position the decontaminated pump and tubing.
   - Attach a short section of tubing to the discharge side of the pump and into a graduated container.
   - Attach one end of a length of new or precleaned tubing to the pump head flexible hose.
   - Place the tubing as described in one of the options listed above.
   - Change gloves before beginning to purge.
   - Measure the depth to groundwater at frequent intervals.
   - Record these measurements.
   - Adjust the purging rate so that it is equivalent to the well recovery rate to minimize drawdown.

- If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdrawal rate with the recharge rate.
- If the water table continues to drop during pumping, lower the tubing at the approximate rate of drawdown so that water is removed from the top of the water column.
- Record the purging rate each time the rate changes.
- Measure the purge volume.
- Record this measurement.
- Decontaminate the pump and tubing between wells (see Appendix C) or if precleaned tubing is used for each well, only the pump.

2. *Variable Speed Centrifugal Pump*
    - Position fuel powered equipment downwind and at least 10 feet from the well head. Make sure that the exhaust faces downwind.
    - Wear sampling gloves to position the decontaminated pump and tubing.
    - Place the decontaminated suction hose so that water is always pumped from the top of the water column.
    - Change gloves before beginning to purge.
    - Equip the suction hose with a foot valve to prevent purge water from re-entering the well.
    - Measure the depth to groundwater at frequent intervals.
    - Record these measurements.
    - To minimize drawdown, adjust the purging rate so that it is equivalent to the well recovery rate.
    - If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdrawal rate with the recharge rate.
    - If the water table continues to drop during pumping, lower the tubing at the approximate rate of drawdown so that the water is removed from the top of the water column.
    - Record the purging rate each time the rate changes.
    - Measure the purge volume.
    - Record this measurement.
    - Decontaminate the pump and tubing between wells or if precleaned tubing is used for each well, only the pump.
3. *Variable Speed Electric Submersible Pump*
    - Position fuel powered equipment downwind and at least 10 feet from the well head. Make sure that the exhaust faces downwind.
    - Wear sampling gloves to position the decontaminated pump and tubing.
    - Carefully position the decontaminated pump.

- Change gloves before beginning to purge.
- Measure the depth to groundwater at frequent intervals.
- Record these measurements.
- To minimize drawdown, adjust the purging rate so that it is equivalent to the well recovery rate.
- If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdrawal rate with the recharge rate.
- If the water table continues to drop during pumping, lower the tubing or pump at the approximate rate of drawdown so that water is removed from the top of the water column.
- Record the purging rate each time the rate changes.
- Measure the purge volume.
- Record this measurement.
- Decontaminate the pump and tubing between wells or only the pump if precleaned tubing is used for each well.

4. *Variable Speed Bladder Pump*
    - Position fuel powered equipment downwind and at least 10 feet from the well head. Make sure that the exhaust faces downwind.
    - Wear sampling gloves to position the decontaminated pump and tubing.
    - Attach the tubing and carefully position the pump.
    - Change gloves before beginning purging.
    - Measure the depth to groundwater at frequent intervals.
    - Record these measurements.
    - To minimize drawdown, adjust the purging rate so that it is equivalent to the well recovery rate.
    - If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdrawal rate with the recharge rate.
    - If the water table continues to drop during pumping, lower the tubing or pump at the approximate rate of drawdown so that water is removed from the top of the water column.
    - Record the purging rate each time the rate changes.
    - Measure the purge volume.
    - Record this measurement.
    - Decontaminate the pump and tubing between wells or if precleaned tubing is used for each well, only the pump.

c.) <u>Dedicated Portable Pumps</u>

1. *Variable Speed Electric Submersible Pump*
    - Position fuel powered equipment downwind and at least 10 feet from the well head. Make sure that the exhaust faces downwind.
    - Wear sampling gloves.

- Measure the depth to groundwater at frequent intervals.
- Record these measurements.
- Adjust the purging rate so that it is equivalent to the well recovery rate to minimize drawdown.
- If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdraw with the recharge rate.
- Record the purging rate each time the rate changes.
- Measure the purge volume.
- Record this measurement.

2. *Variable Speed Bladder Pump*
    - Position fuel powered equipment downwind and at least 10 feet from the well head. Make sure that the exhaust faces downwind.
    - Wear sampling gloves.
    - Measure the depth to groundwater at frequent intervals.
    - Record these measurements.
    - Adjust the purging rate so that it is equivalent to the well recovery rate to minimize drawdown.
    - If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdraw with the recharge rate.
    - Record the purging rate each time the rate changes.
    - Measure the purge volume.
    - Record this measurement.
3. *Bailers* - Using bailers for purging is not recommended unless care is taken to use proper bailing technique, or if free product is present in the well or suspected to be in the well.
    - Minimize handling the bailer as much as possible.
    - Wear sampling gloves.
    - Remove the bailer from its protective wrapping just before use.
    - Attach a lanyard of appropriate material.
    - Use the lanyard to move and position the bailer.
    - Lower and retrieve the bailer slowly and smoothly.
    - Lower the bailer carefully into the well to a depth approximately a foot above the water column.
    - When the bailer is in position, lower the bailer into the water column at a rate of 2 cm/sec until the desired depth is reached.
    - Do not lower the top of the bailer more than one (1) foot below the top of the water table so that water is removed from the top of the water column.
    - Allow time for the bailer to fill with aquifer water as it descends into the water column.

- Carefully raise the bailer. Retrieve the bailer at the same rate of 2 cm/sec until the bottom of the bailer has cleared to top of the water column.
- Measure the purge volume.
- Record the volume of the bailer.
- Continue to carefully lower and retrieve the bailer as described above until the purging is considered complete, based on either the removal of 3 well volumes.
- Remove at least one (1) well volume before collecting measurements of the field parameters. Take each subsequent set of measurements after removing at least one quarter (1/4) well volume between measurements.

Groundwater Sampling Techniques

a.) Purge wells.

b.) Replace protective covering around the well if it is soiled or torn after completing purging operations.

c.) Equipment Considerations

1. The following pumps are approved to collect volatile organic samples:
    - Stainless steel and Teflon variable speed submersible pumps
    - Stainless steel and Teflon or polyethylene variable speed bladder pumps
    - Permanently installed PVC bodied pumps (As long as the pump remains in contact with the water in the well at all times)
2. Collect sample from the sampling device and store in sample container. Do not use intermediate containers.
3. To avoid contamination or loss of analytes from the sample, handle sampling equipment as little as possible and minimize equipment exposure to the sample.
4. To reduce chances of cross-contamination, use dedicated equipment whenever possible. "Dedicated" is defined as equipment that is to be used solely for one location for the life of that equipment (e.g., permanently mounted pump). Purchase dedicated equipment with the most sensitive analyte of interest in mind.
    - Clean or make sure dedicated pumps are clean before installation. They do not need to be cleaned prior to each use, but must be cleaned if they are withdrawn for repair or servicing.
    - Clean or make sure any permanently mounted tubing is clean before installation.
    - Change or clean tubing when the pump is withdrawn for servicing.
    - Clean any replaceable or temporary parts.

- Collect equipment blanks on dedicated pumping systems when the tubing is cleaned or replaced.
- Clean or make sure dedicated bailers are clean before placing them into the well.
- Collect an equipment blank on dedicated bailers before introducing them into the water column.
- Suspend dedicated bailers above the water column if they are stored in the well.

Sampling Wells Without Plumbing

a.) Sampling with Pumps – The following pumps may be used to sample for organics:

- Peristaltic pumps
- Stainless steel, Teflon or polyethylene bladder pumps
- Variable speed stainless steel and Tefloṇ submersible pumps

1. *Peristaltic Pump*

- Volatile Organics: One of three methods may be used.
  - Remove the drop tubing from the inlet side of the pump; submerge the drop tubing into the water column; prevent the water in the tubing from flowing back into the well; remove the drop tubing from the well; carefully allow the groundwater to drain into the sample vials; avoid turbulence; do not aerate the sample; repeat steps until enough vials are filled. OR
  - Use the pump to fill the drop tubing; quickly remove the tubing from the pump; prevent the water in the tubing from flowing back into the well; remove the drop tubing from the well; carefully allow the groundwater to drain into the sample vials; avoid turbulence; do not aerate the sample; repeat steps until enough vials are filled. OR
  - Use the pump to fill the drop tubing; withdraw the tubing from the well; reverse the flow on the peristaltic pumps to deliver the sample into the vials at a slow, steady rate; repeat steps until enough vials are filled.
- Extractable Organics: If delivery tubing is not polyethylene or PP, or is not Teflon lined, use pump and vacuum trap method. Connect the outflow tubing from the container to the influent side of the peristaltic pump. Turn pump on and reduce flow until smooth and even. Discard a

small portion of the sample to allow for air space. Preserve (if required), label, and complete field notes.

- Inorganic samples: These samples may be collected from the effluent tubing. If samples are collected from the pump, decontaminate all tubing (including the tubing in the head) or change it between wells. Preserve (if required), label, and complete field notes.

2. *Variable Speed Bladder Pump*
    - If sampling for organics, the pump body must be constructed of stainless steel and the valves and bladder must be Teflon. All tubing must be Teflon, polyethylene, or PP and any cabling must be sealed in Teflon, polyethylene or PP, or made of stainless steel.
    - After purging to a smooth even flow, reduce the flow rate.
    - When sampling for volatile organic compounds, reduce the flow rate to 100-200mL/minute, if possible.
3. *Variable Speed Submersible Pump*
    - The housing must be stainless steel.
    - If sampling for organics, the internal impellers, seals and gaskets must be constructed of stainless steel, Teflon, polyethylene or PP. The delivery tubing must be Teflon, polyethylene or PP; the electrical cord must be sealed in Teflon; any cabling must be sealed in Teflon or constructed of stainless steel.
    - After purging to a smooth even flow, reduce the flow rate.
    - When sampling for volatile organic compounds, reduce the flow rate to 100-200mL/minute, if possible.

b.) Sampling with Bailers - A high degree of skill and coordination are necessary to collect representative samples with a bailer.

1. *General Considerations*
    - Minimize handling of bailer as much as possible.
    - Wear sampling gloves.
    - Remove bailer from protective wrapping just before use.
    - Attach a lanyard of appropriate material.
    - Use the lanyard to move and position the bailers.
    - Do not allow bailer or lanyard to touch the ground.
    - If bailer is certified precleaned, no rinsing is necessary.
    - If both a pump and a bailer are to be used to collect samples, rinse the exterior and interior of the bailer with sample water from the pump before removing the pump.
    - If the purge pump is not appropriate for collecting samples (e.g., non-inert components), rinse the bailer by collecting a single bailer of the groundwater to be sampled.
    - Discard the water appropriately.

- Do not rinse the bailer if Oil and Grease samples are to be collected.

2. *Bailing Technique*
    - Collect all samples that are required to be collected with a pump before collecting samples with the bailer.
    - Raise and lower the bailer gently to minimize stirring up particulate matter in the well and the water column, which can increase sample turbidity.
    - Lower the bailer carefully into the well to a depth approximately a foot above the water column. When the bailer is in position, lower the bailer into the water column at a rate of 2 cm/sec until the desired depth is reached.
    - Do not lower the top of the bailer more than one foot below the top of the water table, so that water is removed from the top of the water column.
    - Allow time for the bailer to fill with aquifer water as it descends into the water column.
    - Do not allow the bailer to touch the bottom of the well or particulate matter will be incorporated into the sample. Carefully raise the bailer. Retrieve the bailer at the same rate of 2 cm/sec until the bottom of the bailer has cleared to top of the water column.
    - Lower the bailer to approximately the same depth each time.
    - Collect the sample. Install a device to control the flow from the bottom of the bailer and discard the first few inches of water. Fill the appropriate sample containers by allowing the sample to slowly flow down the side of the container. Discard the last few inches of water in the bailer.
    - Repeat steps for additional samples.
    - As a final step measure the DO, pH, temperature, turbidity and specific conductance after the final sample has been collected. Record all measurements and note the time that sampling was completed.

c.) <u>Sampling Low Permeability Aquifers or Wells that have Purged Dry</u>

1. Collect the sample(s) after the well has been purged. Minimize the amount of water removed from the well by using the same pump to purge and collect the sample. If the well has purged dry, collect samples as soon as sufficient sample water is available.
2. Measure the five field parameters temperature, pH, specific conductance, dissolved oxygen and turbidity at the time of sample collection.
3. Advise the analytical laboratory and the client that the usual amount of sample for analysis may not be available.

Appendix D - Collecting Samples from Wells with Plumbing in Place

In-place plumbing is generally considered permanent equipment routinely used for purposes other than purging and sampling, such as for water supply.

a.) Air Strippers or Remedial Systems - These types of systems are installed as remediation devices. Collect influent and effluent samples from air stripping units as described below.

1. Remove any tubing from the sampling port and flush for one to two minutes.
2. Remove all hoses, aerators and filters (if possible).
3. Open the spigot and purge sufficient volume to flush the spigot and lines and until the purging completion criteria have been met.
4. Reduce the flow rate to approximately 500 mL/minute (a 1/8" stream) or approximately 0.1 gal/minute before collecting samples.
5. Follow procedures for collecting samples from water supply wells as outlined below.

b.) Water Supply Wells – Water supply wells with in-place plumbing do not require equipment to be brought to the well to purge and sample. Water supply wells at UST facilities must be sampled for volatile organic compounds (VOCs) and semivolatile compounds (SVOCs).

1. *Procedures for Sampling Water Supply Wells*
   - Label sample containers prior to sample collection.
   - Prepare the storage and transport containers (ice chest, etc.) before taking any samples so each collected sample can be placed in a chilled environment immediately after collection.
   - You must choose the tap closest to the well, preferably at the wellhead. The tap must be before any holding or pressurization tank, water softener, ion exchange, disinfection process or before the water line enters the residence, office or building. If no tap fits the above conditions, a new tap that does must be installed.
   - The well pump must not be lubricated with oil, as that may contaminate the samples.
   - The sampling tap must be protected from exterior contamination associated with being too close to a sink bottom or to the ground. If the tap is too close to the ground for direct collection into the appropriate container, it is acceptable to use a smaller (clean) container to transfer the sample to a larger container.
   - Leaking taps that allow water to discharge from around the valve stem handle and down the outside of the faucet, or taps in which water tends to run up on the outside of the lip, are to be avoided as sampling locations.

- Disconnect any hoses, filters, or aerators attached to the tap before sampling.
- Do not sample from a tap close to a gas pump. The gas fumes could contaminate the sample.

2. *Collecting Volatile Organic Samples*
    - Equipment Needed: VOC sample vials [40 milliliters, glass, may contain 3 to 4 drops of hydrochloric acid (HCl) as preservative]; Disposable gloves and protective goggles; Ice chest/cooler; Ice; Packing materials (sealable plastic bags, bubble wrap, etc.); and Lab forms.
    - Sampling Procedure: Run water from the well for at least 15 minutes. If the well is deep, run water longer (purging three well volumes is best). If tap or spigot is located directly before a holding tank, open a tap after the holding tank to prevent any backflow into the tap where you will take your sample. This will ensure that the water you collect is "fresh" from the well and not from the holding tank. After running the water for at least 15 minutes, reduce the flow of water. The flow should be reduced to a trickle but not so slow that it begins to drip. A smooth flow of water will make collection easier and more accurate. Remove the cap of a VOC vial and hold the vial under the stream of water to fill it. Be careful not to spill any acid that is in the vial. For best results use a low flow of water and angle the vial slightly so that the water runs down the inside of the vial. This will help keep the sample from being agitated, aerated or splashed out of the vial. It will also increase the accuracy of the sample. As the vial fills and is almost full, turn the vial until it is straight up and down so the water won't spill out. Fill the vial until the water is just about to spill over the lip of the vial. The surface of the water sample should become mounded. It is a good idea not to overfill the vial, especially if an acid preservative is present in the vial. Carefully replace and screw the cap onto the vial. Some water may overflow as the cap is put on. After the cap is secure, turn the vial upside down and gently tap the vial to see if any bubbles are present. If bubbles are present in the vial, remove the cap, add more water and check again to see if bubbles are present. Repeat as necessary. After two samples without bubbles have been collected, the samples should be labeled and prepared for shipment. Store samples at 4° C.

3. *Collecting Extractable Organic and/or Metals Samples*

- Equipment Needed: SVOC sample bottle [1 liter, amber glass] and/or Metals sample bottle [0.5 liter, polyethylene or glass, 5 milliliters of nitric acid (HNO3) preservative]; Disposable gloves and protective goggles; Ice Chest/Cooler; Ice; Packing materials (sealable plastic bags, bubble wrap, etc.); and Lab forms.
- Sampling Procedure: Run water from the well for at least 15 minutes. If the well is deep, run the water longer (purging three well volumes is best). If tap or spigot is located directly before a holding tank, open a tap after the holding tank to prevent any backflow into the tap where you will take your sample. This will ensure that the water you collect is "fresh" from the well and not from the holding tank. After running the water for at least 15 minutes, reduce the flow. Low water flow makes collection easier and more accurate. Remove the cap of a SVOC or metals bottle and hold it under the stream of water to fill it. The bottle does not have to be completely filled (i.e., you can leave an inch or so of headspace in the bottle). After filling, screw on the cap, label the bottle and prepare for shipment. Store samples at 4° C.

Appendix E - Collecting Surface Water Samples

The following topics include 1.) acceptable equipment selection and equipment construction materials and 2.) standard grab, depth-specific and depth-composited surface water sampling techniques.

Facilities which contain or border small rivers, streams or branches should include surface water sampling as part of the monitoring program for each sampling event. A simple procedure for selecting surface water monitoring sites is to locate a point on a stream where drainage leaves the site. This provides detection of contamination through, and possibly downstream of, site via discharge of surface waters. The sampling points selected should be downstream from any waste areas. An upstream sample should be obtained in order to determine water quality upstream of the influence of the site.

a.) General Cautions
    1. When using watercraft take samples near the bow away and upwind from any gasoline outboard engine. Orient watercraft so that bow is positioned in the upstream direction.
    2. When wading, collect samples upstream from the body. Avoid disturbing sediments in the immediate area of sample collection.
    3. Collect water samples prior to taking sediment samples when obtaining both from the same area (site).
    4. Unless dictated by permit, program or order, sampling at or near man-made structures (e.g., dams, weirs or bridges) may not provide representative data because of unnatural flow patterns.
    5. Collect surface water samples from downstream towards upstream.

b.) Equipment and Supplies - Select equipment based on the analytes of interest, specific use, and availability.

c.) Surface Water Sampling Techniques - Adhere to all general protocols applicable to aqueous sampling when following the surface water sampling procedures addressed below.
    1. *Manual Sampling*: Use manual sampling for collecting grab samples for immediate in-situ field analyses. Use manual sampling in lieu of automatic equipment over extended periods of time for composite sampling, especially when it is necessary to observe and/or note unusual conditions.
        - Surface Grab Samples - Do not use sample containers containing premeasured amounts of preservatives to collect grab samples. If the sample matrix is homogeneous, then the grab method is a simple and effective technique for collection purposes. If homogeneity is not apparent, based on flow or vertical variations (and should never be assumed), then use other collection protocols. Where practical, use the actual sample container submitted to the laboratory for collecting samples to be analyzed for oil and grease, volatile organic compounds (VOCs), and microbiological samples. This procedure eliminates the possibility of contaminating the sample with an intermediate collection container. The use of

unpreserved sample containers as direct grab samplers is encouraged since the same container can be submitted for laboratory analysis after appropriate preservation. This procedure reduces sample handling and eliminates potential contamination from other sources (e.g., additional sampling equipment, environment, etc.).

1. Grab directly into sample container.
2. Slowly submerge the container, opening neck first, into the water.
3. Invert the bottle so the neck is upright and pointing towards the direction of water flow (if applicable). Allow water to run slowly into the container until filled.
4. Return the filled container quickly to the surface.
5. Pour out a few mL of sample away from and downstream of the sampling location. This procedure allows for the addition of preservatives and sample expansion. Do not use this step for volatile organics or other analytes where headspace is not allowed in the sample container.
6. Add preservatives, securely cap container, label, and complete field notes. If sample containers are attached to a pole via a clamp, submerge the container and follow steps 3 – 5 but omit steps 1 and 2.

- Sampling with an Intermediate Vessel or Container: If the sample cannot be collected directly into the sample container to be submitted to the laboratory, or if the laboratory provides prepreserved sample containers, use an unpreserved sample container or an intermediate vessel (e.g., beakers, buckets or dippers) to obtain the sample. These vessels must be constructed appropriately, including any poles or extension arms used to access the sample location.
    1. Rinse the intermediate vessel with ample amounts of site water prior to collecting the first sample.
    2. Collect the sample as outlined above using the intermediate vessel.
    3. Use pole mounted containers of appropriate construction to sample at distances away from shore, boat, etc. Follow the protocols above to collect samples.
- Peristaltic Pump and Tubing: The most portable pump for this technique is a 12 volt peristaltic pump. Use appropriately precleaned, silastic tubing in the pump head and attach polyethylene, Tygon, etc. tubing to the pump. This technique is not acceptable for Oil and Grease, EPH, VPH or VOCs. Extractable organics can be collected through the pump if flexible interior-wall Teflon, polyethylene or PP tubing is used in the pump head or if used with the organic trap setup.

1. Lower appropriately precleaned tubing to a depth of 6 – 12 inches below water surface, where possible.
2. Pump 3 – 5 tube volumes through the system to acclimate the tubing before collecting the first sample.
3. Fill individual sample bottles via the discharge tubing. Be careful not to remove the inlet tubing from the water.
4. Add preservatives, securely cap container, label, and complete field notes.

- Mid-Depth Grab Samples: Mid-depth samples or samples taken at a specific depth can approximate the conditions throughout the entire water column. The equipment that may be used for this type of sampling consists of the following depth-specific sampling devices: Kemmerer, Niskin, Van Dorn type, etc. You may also use pumps with tubing or double check-valve bailers. Certain construction material details may preclude its use for certain analytes. Many Kemmerer samplers are constructed of plastic and rubber that preclude their use for all volatile and extractable organic sampling. Some newer devices are constructed of stainless steel or are all Teflon or Teflon-coated. These are acceptable for all analyte groups without restriction.
    1. Measure the water column to determine maximum depth and sampling depth prior to lowering the sampling device.
    2. Mark the line attached to the sampler with depth increments so that the sampling depth can be accurately recorded.
    3. Lower the sampler slowly to the appropriate sampling depth, taking care not to disturb the sediments.
    4. At the desired depth, send the messenger weight down to trip the closure mechanism.
    5. Retrieve the sampler slowly.
    6. Rinse the sampling device with ample amounts of site water prior to collecting the first sample. Discard rinsate away from and downstream of the sampling location.
    7. Fill the individual sample bottles via the discharge tube.
- Double Check-Valve Bailers: Collect samples using double check-valve bailers if the data requirements do not necessitate a sample from a strictly discrete interval of the water column. Bailers with an upper and lower check-valve can be lowered through the water column. Water will continually be displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. Sampling with this type of bailer must follow the same protocols outlined above, except that a messenger weight is not applicable. Although not designed specifically for this kind of sampling, a bailer is acceptable when a mid-depth sample is required

1. As the bailer is dropped through the water column, water is displaced through the body of the bailer. The degree of displacement depends upon the check-valve ball movement to allow water to flow freely through the bailer body.
2. Slowly lower the bailer to the appropriate depth. Upon retrieval, the two check valves seat, preventing water from escaping or entering the bailer.
3. Rinse the sampling device with ample amounts of site water prior to collecting the first sample.
4. Fill the individual sample bottles via the discharge tube. Sample bottles must be handled as described above.

- Peristaltic Pump and Tubing: The most portable pump for this technique is a 12 volt peristaltic pump. Use appropriately precleaned, silastic tubing in the pump head and attach HDPE, Tygon, etc. tubing to the pump. This technique is not acceptable for Oil and Grease, EPH, VPH or VOCs. Extractable organics can be collected through the pump if flexible interior-wall Teflon, polyethylene or PP tubing is used in the pump head, or if used with an organic trap setup.
    1. Measure the water column to determine the maximum depth and the sampling depth.
    2. Tubing will need to be tied to a stiff pole or be weighted down so the tubing placement will be secure. Do not use a lead weight. Any dense, non-contaminating, non-interfering material will work (brick, stainless steel weight, etc.). Tie the weight with a lanyard (braided or monofilament nylon, etc.) so that it is located below the inlet of the tubing.
    3. Turn the pump on and allow several tubing volumes of water to be discharged before collecting the first sample.
    4. Fill the individual sample bottles via the discharge tube. Sample bottles must be handled as described above.

Attachment 3
New Guidelines for the Submittal of Environmental Monitoring Data

Solid Waste Section Memorandum, October 27, 2006

North Carolina Department of Environment and Natural Resources
Dexter R. Matthews, Director
Division of Waste Management
Michael F. Easley, Governor
William G. Ross Jr., Secretary

October 27, 2006

To: SW Director/County Manager/Consultant/Laboratory

From: NC DENR-DWM, Solid Waste Section

Re: New Guidelines for Electronic Submittal of Environmental Monitoring Data

The Solid Waste Section receives and reviews a wide variety of environmental monitoring data from permitted solid waste management facilities, including the results from groundwater and surface water analyses, leachate samples, methane gas readings, potentiometric measurements, and corrective action data. We are in the process of developing a database to capture the large volume of data submitted by facilities.

To maintain the integrity of the database, it is critical that facilities, consultants, and laboratories work with the Solid Waste Section to ensure that environmental samples are collected and analyzed properly with the resulting data transferred to the Solid Waste Section in an accurate manner.

In order to better serve the public and to expedite our review process, the Solid Waste Section is requesting specific formatting for environmental monitoring data submittals for all solid waste management facilities.

Effective, December 1, 2006, please submit a Solid Waste Environmental Monitoring Data Form in addition to your environmental monitoring data report. This form will be sent in lieu of your current cover letter to the Solid Waste Section. The Solid Waste Environmental Monitoring Data Form must be filled out completely, signed, and stamped with a Board Certified North Carolina Geologist License Seal.

The solid waste environmental monitoring data form will include the following:

1. Contact Information
2. Facility Name
3. Facility Permit Number
4. Facility Address
5. Monitoring Event Date (MM/DD/YYYY)
6. Water Quality Status: Monitoring, Detection Monitoring, or Assessment Monitoring
7. Type of Data Submitted: Groundwater Monitoring Wells, Groundwater Potable Wells, Leachate, Methane Gas, or Corrective Action Data
8. Notification of Exceedance of Groundwater, Surface Water, or Methane Gas (in table form)
9. Signature
10. North Carolina Geologist Seal

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Most of these criteria are already being included or can be added with little effort. The Solid Waste Environmental Monitoring Data Form can be downloaded from our website: http://www.wastenotnc.org/swhome/enviro_monitoring.asp.

The Solid Waste Section is also requesting a new format for monitoring wells, potable wells, surface water sampling locations, and methane probes. This format is essential in the development and maintenance of the database. The Solid Waste Section is requesting that each sampling location at all North Carolina solid waste management facilities have its own unique identification number. We are simply asking for the permit number to be placed directly in front of the sampling location number (example: 9901-MW1 = Permit Number 99-01 and Monitoring Well MW-1). No changes will need to be made to the well tags, etc. This unique identification system will enable us to accurately report data not only to NCDENR, but to the public as well. We understand that this new identification system will take some time to implement, but we feel that this will be beneficial to everyone involved in the long term.

Additionally, effective December 1, 2006, the Practical Quantitation Limits (PQLs) established in 1994 will change. The Solid Waste Section is requiring that all solid waste management facilities use the new Solid Waste Reporting Limits (SWRL) for all groundwater analyses by a North Carolina Certified Laboratory. Laboratories must also report any detection of a constituent even it is detected below the new SWRL (e.g., J values where the constituent was detected above the detection limit, but below the quantitation limit).

PQLs are technology-based analytical levels that are considered achievable using the referenced analytical method. The PQL is considered the lowest concentration of a contaminant that the lab can accurately detect and quantify. PQLs provided consistency and available numbers that were achievable by the given analytical method. However, PQLs are not health-based, and analytical instruments have improved over the years resulting in lower achievable PQLs for many of the constituents. As a result, the Solid Waste Section has established the SWRLs as the new reporting limits eliminating the use of the PQLs.

We would also like to take this opportunity to encourage electronic submittal of the reports. This option is intended to save resources for both the public and private sectors. The Solid Waste Section will accept the entire report including narrative text, figures, tables, and maps on CD-ROM. The CD-ROM submittal shall contain a CD-ROM case and both CD-ROM and the case shall be labeled with the site name, site address, permit number, and the monitoring event date (MM/DD/YYYY). The files may be a .pdf, .txt, .csv, .xls, or .doc type. Also, analytical lab data should be reported in an .xls file. We have a template for analytical lab data available on the web at the address listed above.

If you have any questions or concerns, please call (919) 508-8400. Thank you for your anticipated cooperation in this matter.

Attachment 4
Environmental Monitoring Data Form

DENR USE ONLY: ☐ Paper Report ☐ Electronic Data - Email CD (data loaded: Yes / No) Doc/Event #:

NC DENR
Division of Waste Management - Solid Waste

Environmental Monitoring Reporting Form

Notice: This form and any information attached to it are "Public Records" as defined in NC General Statute 132-1. As such, these documents are available for inspection and examination by any person upon request (NC General Statute 132-6).

Instructions:

- **Prepare one form for each individually monitored unit.**
- **Please type or print legibly.**
- Attach a notification table with values that attain or exceed NC 2L groundwater standards or NC 2B surface water standards. The notification must include a preliminary analysis of the cause and significance of each value. (e.g. naturally occurring, off-site source, pre-existing condition, etc.).
- Attach a notification table of any groundwater or surface water values that equal or exceed the reporting limits.
- Attach a notification table of any methane gas values that attain or exceed explosive gas levels. This includes any structures on or nearby the facility (NCAC 13B .1629 (4)(a)(i).
- In accordance with NC General Statutes Chapter 89C and 89E and NC Solid Waste Management Rules 15A NCAC 13B, be sure to affix a seal to the bottom of this page, when applicable.
- Send the original signed and sealed form, any tables, and Electronic Data Deliverable to: Compliance Unit, NCDENR-DWM, Solid Waste Section, 1646 Mail Service Center, Raleigh, NC 27699-1646.

Solid Waste Monitoring Data Submittal Information

Name of entity submitting data (laboratory, consultant, facility owner):

Contact for questions about data formatting. Include data preparer's name, telephone number and E-mail address:

Name: _____ Phone: _____

E-mail: _____

Facility name:	Facility Address:	Facility Permit #	NC Landfill Rule: (.0500 or .1600)	Actual sampling dates (e.g., October 20-24, 2006)

Environmental Status: (Check all that apply)

☐ Initial/Background Monitoring ☐ Detection Monitoring ☐ Assessment Monitoring ☐ Corrective Action

Type of data submitted: (Check all that apply)

☐ Groundwater monitoring data from monitoring wells
☐ Groundwater monitoring data from private water supply wells
☐ Leachate monitoring data
☐ Surface water monitoring data
☐ Methane gas monitoring data
☐ Corrective action data (specify) _____
☐ Other(specify)

Notification attached?

☐ No. No groundwater or surface water standards were exceeded.
☐ Yes, a notification of values exceeding a groundwater or surface water standard is attached. It includes a list of groundwater and surface water monitoring points, dates, analytical values, NC 2L groundwater standard, NC 2B surface water standard or NC Solid Waste GWPS and preliminary analysis of the cause and significance of any concentration.
☐ Yes, a notification of values exceeding an explosive methane gas limit is attached. It includes the methane monitoring points, dates, sample values and explosive methane gas limits.

Certification

To the best of my knowledge, the information reported and statements made on this data submittal and attachments are true and correct. Furthermore, I have attached complete notification of any sampling values meeting or exceeding groundwater standards or explosive gas levels, and a preliminary analysis of the cause and significance of concentrations exceeding groundwater standards. I am aware that there are significant penalties for making any false statement, representation, or certification including the possibility of a fine and imprisonment.

Facility Representative Name (Print) Title (Area Code) Telephone Number

Signature Date

Affix NC Licensed/ Professional Geologist/Engineer Seal here:

Revised 01/2007

Attachment 5
February 23, 2007 Addendum to the
October 27, 2006 Memorandum

North Carolina Department of Environment and Natural Resources

Dexter R. Matthews, Director | Division of Waste Management | Michael F. Easley, Governor
William G. Ross Jr., Secretary

February 23, 2007

MEMORANDUM

To: Solid Waste Directors, Landfill Operators, North Carolina Certified Laboratories, and Consultants

From: North Carolina Division of Waste Management, Solid Waste Section

Re: Addendum to October 27, 2006, North Carolina Solid Waste Section Memorandum Regarding New Guidelines for Electronic Submittal of Environmental Data.

The purpose of this addendum memorandum is to provide further clarification to the October 27, 2006, North Carolina Solid Waste Section memo titled, "New Guidelines for Electronic Submittal of Environmental Data."

The updated guidelines is in large part due to questions and concerns from laboratories, consultants, and the regulated community regarding the detection of constituents in groundwater at levels below the previous practical quantitation limits (PQLs). The North Carolina Solid Waste Section solicited feedback from the regulated community, and, in conjunction with the regulated community, developed new limits. The primary purpose of these changes was to improve the protection of public health and the environment. The North Carolina Solid Waste Section is concerned about analytical data at these low levels because the earliest possible detection of toxic or potentially carcinogenic chemicals in the environment is paramount in the North Carolina Solid Waste Section's mission to protect human health and the environment. Low level analytical data are critical for making the correct choices when designing site remediation strategies, alerting the public to health threats, and protecting the environment from toxic contaminants. The revised limits were updated based on readily available laboratory analytical methodology and current health-based groundwater protection standards.

Definitions

Many definitions relating to detection limits and quantitation limits are used in the literature and by government agencies, and commonly accepted procedures for calculating these limits exist. Except for the Solid Waste Section Limit and the North Carolina 2L Standards, the definitions listed below are referenced from the Environmental Protection Agency (EPA). The definitions are also an attempt to clarify the meaning of these terms as used by the North Carolina Solid Waste Section.

Method Detection Limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

Method Reporting Limit or Method Quantitation Limit (MRL or MQL) is the minimum concentration of a target analyte that can be accurately determined by the referenced method.

Practical Quantitation Limit (PQL) is a quantitation limit that represents a practical and routinely achievable quantitation limit with a high degree of certainty (>99.9% confidence) in the results. Per EPA Publication Number SW-846, the PQL is the lowest concentration that can be reliably measured within specified limits of precision and accuracy for a specific laboratory analytical method during routine laboratory operating conditions in accordance with "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods. The PQL appears in older NCDENR literature; however, it is no longer being used by the North Carolina Solid Waste Section.

Solid Waste Section Limit (SWSL) is the lowest amount of analyte in a sample that can be quantitatively determined with suitable precision and accuracy. The SWSL is the concentration below which reported analytical results must be qualified as estimated. *The SWSL is the updated version of the PQL that appears in older North Carolina Solid Waste Section literature. The SWSL is the limit established by the laboratory survey conducted by the North Carolina Solid Waste Section. The nomenclature of the SWRL described in the October 27, 2006, memorandum has changed to the SWSL.*

North Carolina 2L Standards (2L) are water quality standards for the protection of groundwaters of North Carolina as specified in 15A NCAC 2L .0200, Classifications and Water Quality Standards Applicable to the Groundwaters of North Carolina.

Method Detection Limits (MDLs)

Clarification of detection limits referenced in the October 27, 2006, memorandum needed to be addressed because of concerns raised by the regulated community. The North Carolina Solid Waste Section is now requiring laboratories to report to the method detection limit.

Method detection limits are statistically determined values that define the concentration at which measurements of a substance by a specific analytical protocol can be distinguished from measurements of a blank (background noise). Method detection limits are matrix-specific and require a well defined analytical method. In the course of routine operations, laboratories generally report the highest method detection limit for all the instruments used for a specific method.

In many instances, the North Carolina Solid Waste Section gathers data from many sources prior to evaluating the data or making a compliance decision. Standardization in data reporting significantly enhances the ability to interpret and review data because the reporting formats are comparable. Reporting a method detection limit alerts data users of the known uncertainties and limitations associated with using the data. Data users must understand these limitations in order to minimize the risk of making poor environmental decisions. Censoring data below unspecified or non-statistical reporting limits severely biases data sets and restricts their usefulness.

Solid Waste Section Limits (SWSLs)

Due to comments from the regulated community, the North Carolina Solid Waste Section has changed the nomenclature of the new limits referenced on Page 2 of the October 27, 2006, memorandum, from the North Carolina Solid Waste Reporting Limits (SWRL) to the Solid Waste Section Limits (SWSL). Data must be reported to the laboratory specific method detection limits and must be quantifiable at or below the SWSL. The SWSLs must be used for both groundwater and surface water data reported to the North Carolina Solid Waste Section. The PQLs will no longer be used.

The North Carolina Solid Waste Section has considered further feedback from laboratories and the regulated community and has made some additional changes to the values of the SWSLs. These changes may be viewed on our webpage:
http://www.wastenotnc.org/sw/swenvmonitoringlist.asp

Analytical Data Reporting Requirements

The strategy for implementing the new analytical data reporting requirements involves reporting the actual laboratory method detection limit with all analytical laboratory results along with the following requirements:

1) Any analyte detected at a concentration greater than the MDL but less than the SWSL is known to be present, but the uncertainty in the value is higher than a value reported above the SWSL. As a result, the actual concentration is estimated. The estimated concentration is reported along with a qualifier ("J" flag) to alert data users that the result is between the MDL and the SWSL. Any analytical data below quantifiable levels should be examined closely to evaluate whether the analytical data should be included in any statistical analysis. A statistician should make this determination. If an analyte is detected below the North Carolina 2L Standards, even if it is a quantifiable concentration, compliance action may not be taken unless it is statistically significant increase over background.

These analytical results may require additional confirmation.

2) Any analyte detected at a concentration greater than the SWSL is present, and the quantitated value can be reported with a high degree of confidence. These analytes are reported without estimated qualification. The laboratory's MDL and SWSL must be included in the analytical laboratory report. Any reported concentration of an organic or inorganic constituent at or above the North Carolina 2L Standards will be used for compliance purposes, unless the inorganic constituent is not statistically significant). Exceedance of the North Carolina 2L Standards or a statistically significant increase over background concentrations define when a violation has occurred. Any reported concentration of an organic or inorganic constituent at or above the SWSL that is not above an North Carolina 2L Standard will be used as a tool to assess the integrity of the landfill system and predict the possibility that a constituent concentration may exceed the North Carolina 2L Standards in the future.

These analytical results may be used for compliance without further confirmation.

Failure to comply with the requirements described in the October 27, 2006, memorandum and this addendum to the October 27, 2006, memorandum will constitute a violation of 15A NCAC 13B .0601, .0602, or .1632(b), and the analytical data will be returned and deemed unacceptable. Submittal of unacceptable data may lead to enforcement action.

Electronic Data Deliverable (EDD) Submittal

The North Carolina Solid Waste Section would also like to take this opportunity to encourage electronic submittal of the reports in addition to the analytical laboratory data. This option is intended to save resources for both the public and private sectors.

The North Carolina Solid Waste Section will accept the entire report including narrative text, figures, tables, and maps on CD-ROM. Please separate the figures and tables from the report when saving in order to keep the

size of the files smaller. The CD-ROM submittal shall contain a CD-ROM case and both CD-ROM and the case shall be labeled with the site name, site address, permit number, and the monitoring event date (MM/DD/YYYY). The reporting files may be submitted as a .pdf, .txt, .csv, .xls,. or .doc type.

Also, analytical lab data and field data should be reported in .xls files. The North Carolina Solid Waste Section has a template for analytical lab data and field data. This template is available on our webpage: http://www.wastenotnc.org/swhome/enviro_monitoring.asp. Methane monitoring data may also be submitted electronically in this format.

Pursuant to the October 27, 2006, memorandum, please remember to submit a Solid Waste Section Environmental Monitoring Reporting Form in addition to your environmental monitoring data report. This form should be sealed by a geologist or engineer licensed in North Carolina if hydrogeologic or geologic calculations, maps, or interpretations are included with the report. Otherwise, any representative that the facility owner chooses may sign and submit the form. Also, if the concentration of methane generated by the facility exceeds 100% of the lower explosive limits (LEL) at the property boundary or exceeds 25% of the LEL in facility structures (excluding gas control or recovery system components), include the exceedance(s) on the North Carolina Solid Waste Section Environmental Monitoring Reporting Form.

If you have any questions or concerns, please feel free to contact Jaclynne Drummond (919-508-8500) or Ervin Lane (919-508-8520).

Thank you for your continued cooperation with this matter.

Attachment 6
October 16, 2007 Memorandum

North Carolina Department of Environment and Natural Resources

Dexter R. Matthews, Director | Division of Waste Management | Michael F. Easley, Governor
William G. Ross Jr., Secretary

October 16, 2007

MEMORANDUM

To: Solid Waste Directors, Landfill Operators, North Carolina Certified Laboratories, and Consultants

From: North Carolina Division of Waste Management, Solid Waste Section

Re: **Environmental Monitoring Data for North Carolina Solid Waste Management Facilities**

The purpose of this memorandum is to provide a reiteration of the use of the Solid Waste Section Limits (SWSLs), provide new information on the Groundwater Protection Standards, and provide a reminder of formats for environmental monitoring data submittals.

The updated guidelines are in large part due to questions and concerns from laboratories, consultants, and the regulated community regarding the detection of constituents in groundwater at levels below the previous Practical Quantitation Limits (PQLs). The North Carolina Solid Waste Section solicited feedback from the regulated community, and, in conjunction with the regulated community, developed new limits. The primary purpose of these changes was to improve the protection of public health and the environment.

Data must be reported to the laboratory specific method detection limits and must be quantifiable at or below the SWSLs. The SWSLs must be used for both groundwater and surface water data reported to the North Carolina Solid Waste Section. The PQLs will no longer be used.

In June 2007, we received new information regarding changes to the Groundwater Protection Standards. If a North Carolina 2L Groundwater Standard does not exist, then a designated Groundwater Protection Standard is used pursuant to 15A NCAC 13B .1634. Toxicologists with the North Carolina Department of Health and Human Services calculated these new Groundwater Protection Standards. Questions regarding how the standards were calculated can be directed to the North Carolina Department of Health and Human Services.

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We have reviewed the new results from the North Carolina Department of Public Health and have updated our webpage accordingly. The list of Groundwater Protection Standards, North Carolina 2L Standards and SWSLs are subject to change and will be reviewed every year or sooner if new scientific and toxicological data become available. Please review our website periodically for any changes to the 2L NC Standards, Groundwater Protection Standards, or SWSLs. Specific updates will be noted on our website.

http://www.wastenotnc.org/sw/swenvmonitoringlist.asp

In addition, the following should be included with environmental monitoring data submittals:

1. Environmental Monitoring Data Form as a cover sheet:
http://www.wastenotnc.org/swhome/EnvMonitoring/NCEnvMonRptForm.pdf
2. Copy of original laboratory results.
3. Table of detections and discussion of 2L exceedances.
4. Electronic files on CD or sent by email. These files should include the written report as a Portable Document Format (PDF) file and the laboratory data as an excel file following the format of the updated Electronic Data Deliverable (EDD) template on our website:
http://www.wastenotnc.org/swhome/enviro_monitoring.asp

If you have any questions or concerns, please feel free to contact Donald Herndon (919-508-8502), Ervin Lane (919-508-8520) or Jaclynne Drummond (919-508-8500).

Thank you for your continued cooperation with these matters.

Attachment 7
November 5, 2014 Memorandum

North Carolina Department of Environment and Natural Resources
Division of Waste Management

Pat McCrory
Governor

John E. Skvarla, III
Secretary

November 5, 2014

MEMORANDUM

To: **Solid Waste Directors, Public Works Directors, Landfill Operators, and Landfill Owners**

From: **Solid Waste Section**

Re: **Groundwater, Surface Water, Soil, Sediment, and Landfill Gas Electronic Document Submittal**

The Solid Waste Section is continuing its efforts to improve efficiencies in document management. All groundwater, surface water, soil, sediment, and landfill gas documents submitted to the Solid Waste Section are stored electronically and are made readily available for the public to view on our webpage. Please remember that hard copies/paper copies are not required, and should not be submitted. The submittal of these electronic documents following a consistent electronic document protocol will also assist us in our review. Please follow these procedures when submitting all groundwater, surface water, soil, sediment, and landfill gas documents to the Solid Waste Section.

Submittal Method and Formatting

- All files must be in portable document format (pdf) except for Electronic Data Deliverables (EDDs) unless otherwise specified by the Solid Waste Section. All pdf files should meet these requirements:
    - Optical Characteristic Recognition (OCR) applied;
    - Minimum of 300 dpi;
    - Free of password protections and/or encryptions (applies to EDDs as well);
    - Optimized to reduce file size; and
    - Please begin using the following naming convention when submitting all electronic files: Permit Number (00-00)_Date of Document (YYYYMMDD). For example: 00-00_20140101.
- Please submit all files via email or by file transfer protocol (FTP) via email to the appropriate Hydrogeologist unless otherwise specified by the Solid Waste Section. If the electronic file is greater than 20 MB, please submit the file via FTP or on a CD. If submitting a CD, please mail the CD to the appropriate Hydrogeologist. The CD should be labeled with the facility name, permit number, county, name of document, date of monitoring event (if applicable), and the date of document.
- Please be sure a signed Environmental Monitoring Data Form is submitted as part of the electronic file for all water quality and landfill gas documents (monitoring, alternate source demonstration, assessment, investigation, corrective action). This completed form should be the first page of the document before the cover/title page and should not be submitted as an individual file. Blank forms can be downloaded at http://www.wastenotnc.org/swhome/EnvMonitoring/NCEnvMonRptForm.pdf

Monitoring Data

Monitoring data documents may include any or all of the following: 1) groundwater and surface water monitoring; 2) soil and sediment, and 3) landfill gas monitoring. In addition to the above procedures, at a minimum, please include the following:

Groundwater and Surface Water Monitoring

- A copy of the laboratory report(s).
- A copy of the sampling log(s).
- A separate table of detections and exceedances for each monitoring location.

1646 Mail Service Center, Raleigh, North Carolina 27699-1646
Phone: 919-707-8200

2090 US Highway 70, Swannanoa, North Carolina 28778-82111
Phone: 828-296-4500

http://portal.ncdenr.org/web/wm/
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    - All analytical results should be reported in micrograms per liter (ug/L) except for field parameters and specific Monitored Natural Attenuation (MNA) parameters.
    - Please also include the laboratory's method detection limit (MDL) in ug/L, the Solid Waste Section Limit (SWSL) in ug/L, the appropriate NC regulatory standard in ug/L (2L, 2B, GWPS, IMAC), and the Federal Maximum Contaminant Level (MCL) in ug/L.
    - Please **BOLD** each exceedance result.
- A separate table of field parameters for each monitoring location.
- An Electronic Data Deliverable (EDD) spreadsheet for each monitoring event submitted in the correct format. All analytical results should be reported in micrograms per liter (ug/L) except for field parameters and specific Monitored Natural Attenuation (MNA) parameters. The blank EDD template can be downloaded at http://www.wastenotnc.org/swhome/enviro_monitoring.asp. Please pay attention to the formats within the spreadsheet. Any EDD received that is not formatted correctly will be emailed back to be resubmitted via email within five (5) days.
- A separate groundwater monitoring well construction table.
    - Please also include the date the well was drilled, well diameter, total well depth, depth to top of screened interval (in feet), screened interval (in feet), geology of screened interval, TOC elevation, ground elevation, groundwater elevation, GPS coordinates (latitude and longitude), and depth to water (in feet).
- A separate groundwater table with groundwater flow rate(s).
- A recent facility figure that includes labeled groundwater and surface water monitoring locations.
- A groundwater flow map with an arrow(s) indicating flow direction(s), including date the measurements were taken.

Soil and Sediment Sampling

- A copy of the laboratory report(s).
- A copy of the sampling log(s).
- A separate table of detections and exceedances for each sampling location.
    - Please also include the results in micrograms per liter (ug/L), the laboratory's method detection limit (MDL) in ug/L, and the appropriate NC regulatory standard (PSRG) in ug/L.
    - Please **BOLD** each exceedance result.
- A separate table of soil and/or sediment characteristics.
- A recent facility figure that includes labeled sampling locations.

Landfill Gas Monitoring

- A blank Landfill Gas Monitoring Data Form can be found within the *Landfill Gas Monitoring Guidance* document and can be downloaded at http://portal.ncdenr.org/c/document_library/get_file?uuid=da699f7e-8c13-4249-9012-16af8aefdc7b&groupId=38361.
- A separate table of landfill gas detections and exceedances for each monitoring location. Please **BOLD** each exceedance result.
- A recent facility figure that includes labeled landfill gas monitoring locations (both permanent and temporary).

If you have any questions or concerns regarding electronic submittals, please feel free to contact the Hydrogeologist overseeing your facility. The Solid Waste Section greatly appreciates your assistance on this matter. Working together, we can continue to provide excellent customer service to you and to the public.

- Jackie Drummond, Asheville Regional Office, 828-296-4706, jaclynne.drummond@ncdenr.gov
- Ervin Lane, Raleigh Central Office, 919-707-8288, ervin.lane@ncdenr.gov
- Elizabeth Werner, Raleigh Central Office, 919-707-8253, elizabeth.werner@ncdenr.gov
- Christine Ritter, Raleigh Central Office, 919-707-8254, christine.ritter@ncdenr.gov
- Perry Sugg, Raleigh Central Office, 919-707-8258, perry.sugg@ncdenr.gov

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Phone: 828-296-4500
http://portal.ncdenr.org/web/wm/
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Attachment 8
Monitoring well construction logs

David Garrett, P.G., P.E.

Engineering and Geology

Boring No. MW-1

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**822.00**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA/NQWL core**	Water Level, TOB	**42**
Date Started	**8/27/02**	Date Ended	**8/28/02**	Water Level, 24 Hr.	**34**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**NA**
Comments	**Cleared access road through woods**	Total Depth	**44.0**	Date of Observation	**8/31/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data
0 – 822.00		SANDY SILT: Hard, tan-brown, dry sandrock	
2 – 820.00			
4 – 818.00			
6 – 816.00			
8 – 814.00			
10 – 812.00			
12 – 810.00			
14 – 808.00		PWR: Very hard, dry, refusal at 19 feet	
16 – 806.00			Grout
18 – 804.00			
20 – 802.00		GRANITE: Core Run #1: Dry, REC = 82%, RQD = 75%	
22 – 800.00			
24 – 798.00		GRANITE: Core Run #2: Dry, REC = 66%, RQD =66%	
26 – 796.00			
28 – 794.00			
30 – 792.00		GRANITE: Core Run #3: Fractured zone, REC = 60%, RQD = 60%	Bentonite Seal
32 – 790.00			
34 – 788.00		GRANITE: Core Run #4: REC = 100%, RQD = 100%	Sand Pack
36 – 786.00			

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**822.00**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA/NQWL core**	Water Level, TOB	**42**
Date Started	**8/27/02**	Date Ended	**8/28/02**	Water Level, 24 Hr.	**34**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**NA**
Comments	**Cleared access road through woods**	Total Depth	**44.0**	Date of Observation	**8/31/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data
38 — 784.00			
40 — 782.00		GRANITE: Core Run #5: REC = 100%, RQD = 100%	0.010" Slotted Screen
42 — 780.00			
44 — 778.00			

David Garrett, P.G., P.E.

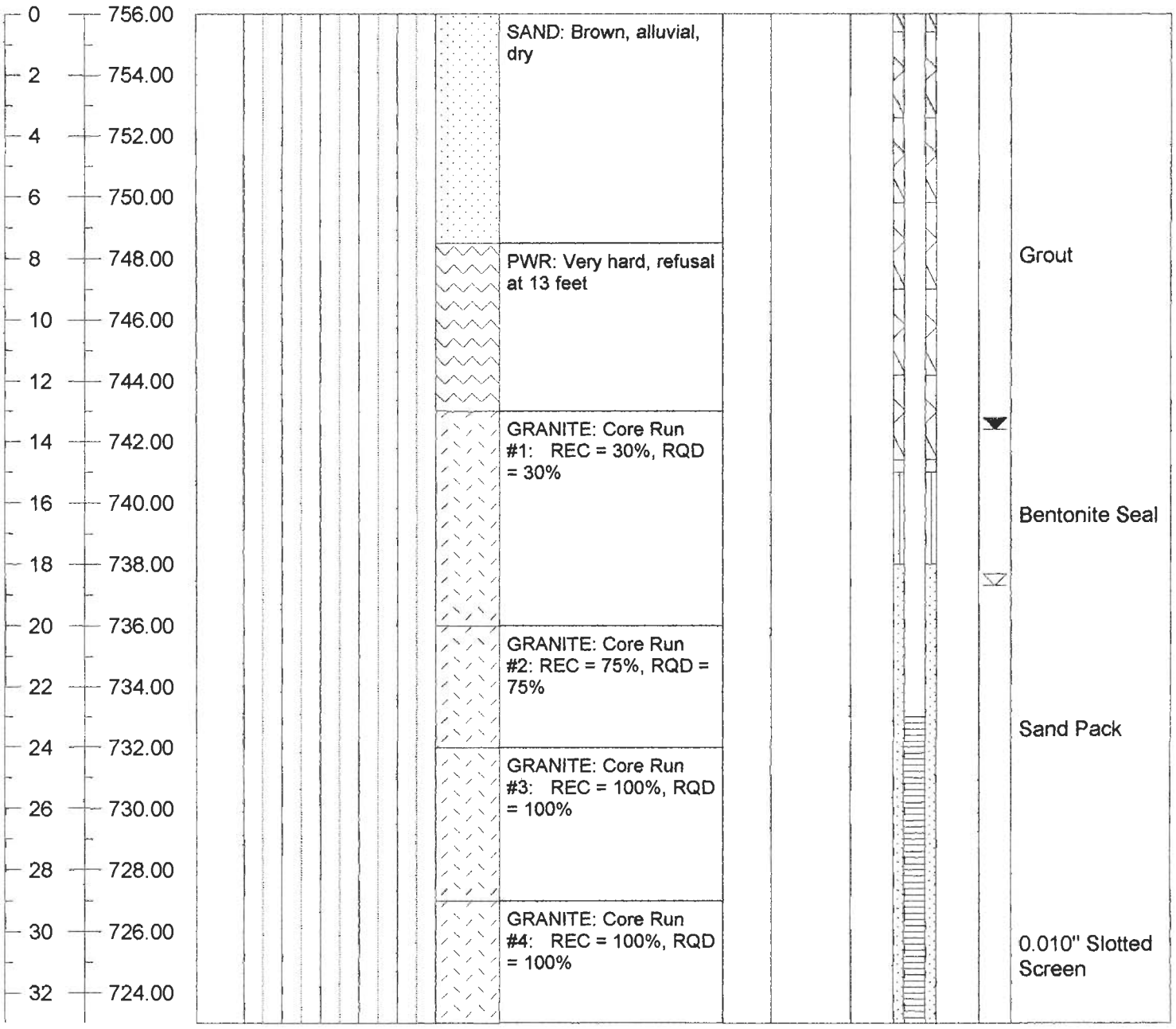
Engineering and Geology

Boring No. MW-2

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**756.00**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA/NQWL core**	Water Level, TOB	**18.7**
Date Started	**8/26/02**	Date Ended	**8/26/02**	Water Level, 24 Hr.	**13.6**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**NA**
Comments	**Cleared access road through woods**	Total Depth	**33.0**	Date of Observation	**8/31/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

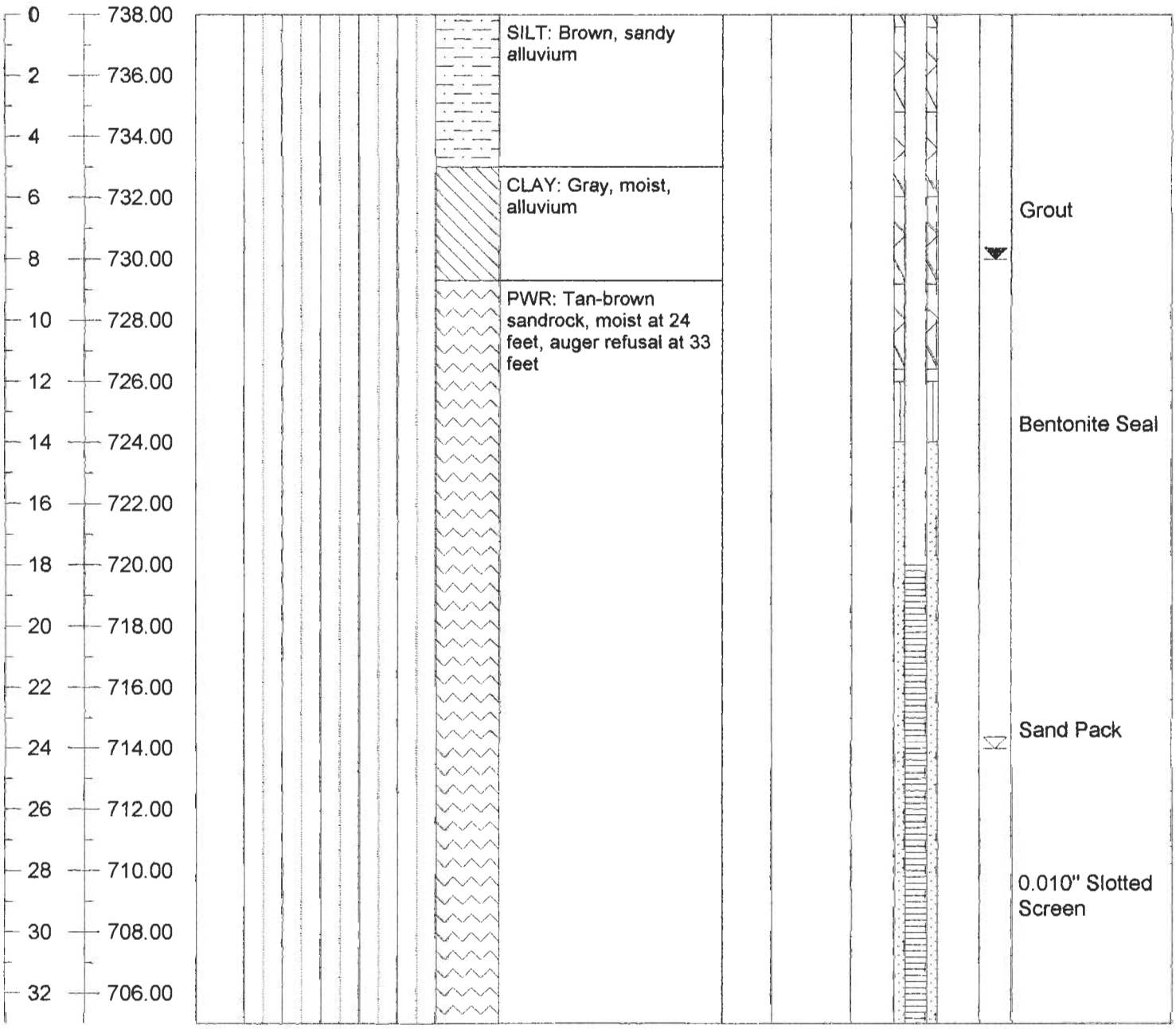
Engineering and Geology

Boring No. MW-3

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**738.00**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**24.0**
Date Started	**8/25/02**	Date Ended	**8/25/02**	Water Level, 24 Hr.	**8.0**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**NA**
Comments	**Cleared access road through woods**	Total Depth	**33.0**	Date of Observation	**8/31/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

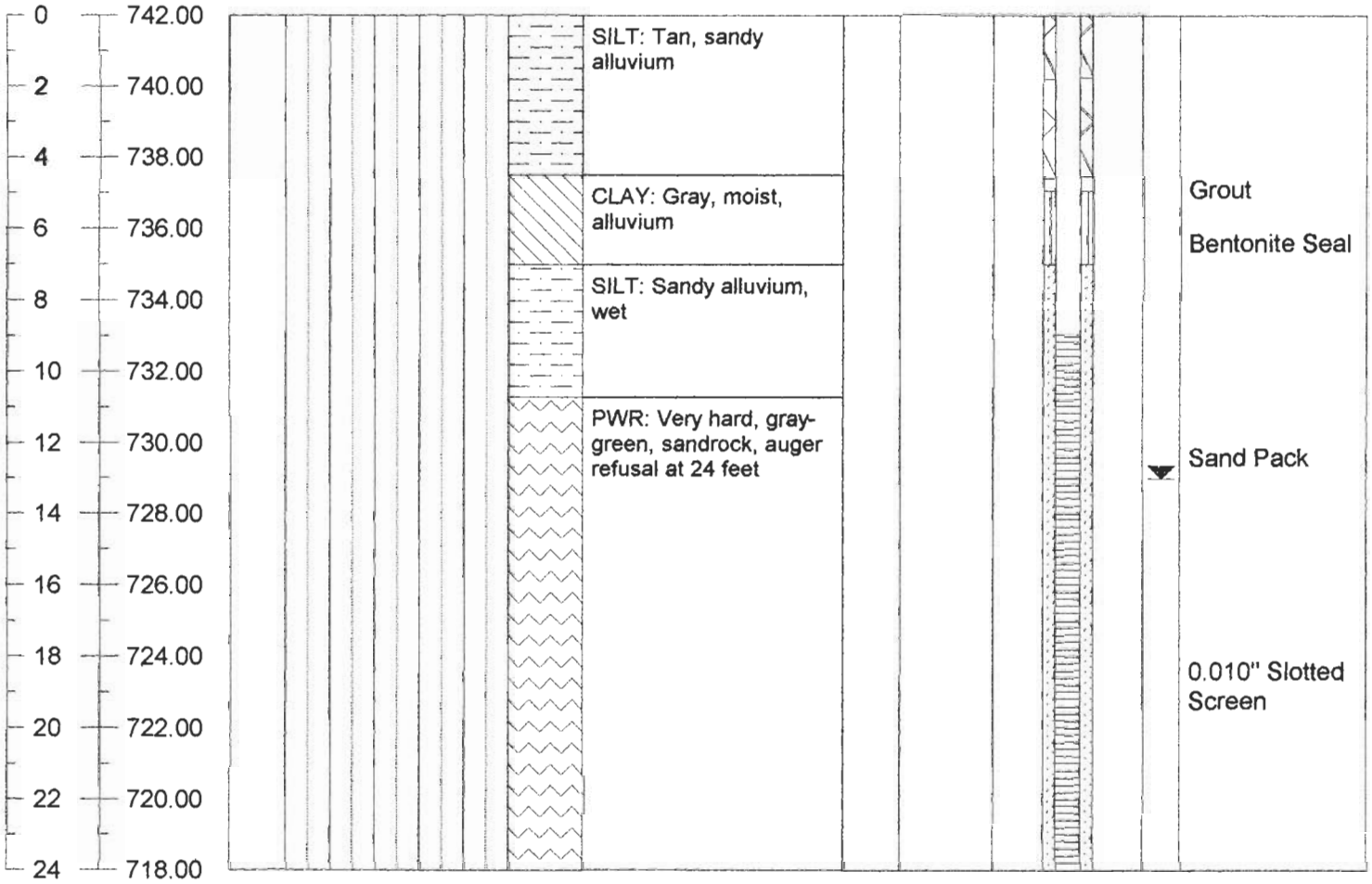
Engineering and Geology

Boring No. MW-4

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**742.00**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA**	Water Level, TOB	**NA**
Date Started	**8/25/02**	Date Ended	**8/25/02**	Water Level, 24 Hr.	**13.0**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**NA**
Comments	**Cleared access road through woods**	Total Depth	**24.0**	Date of Observation	**8/31/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



David Garrett, P.G., P.E.

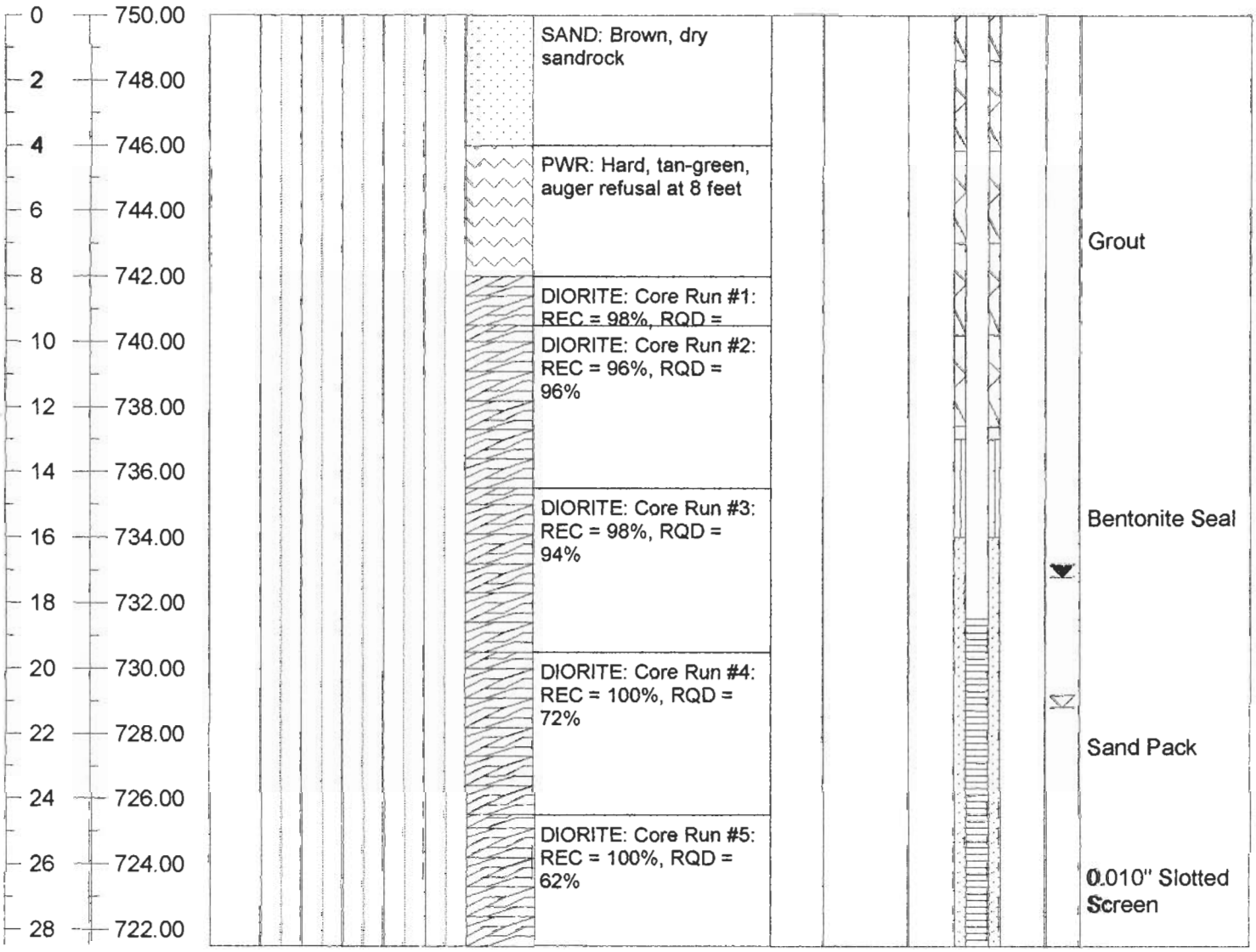
Engineering and Geology

Boring No. MW-5

Client and Project	**A-1 Sandrock CDLF (Guilford County)**			Collar Elevation	**750.00**
Equipment	**Dietrich D50 ATV**	Drilling Method	**HSA/NQWL core**	Water Level, TOB	**21.2**
Date Started	**8/27/02**	Date Ended	**8/27/02**	Water Level, 24 Hr.	**17.2**
Drilling Firm	**Bore & Core (Seiler)**	Logged by	**David Garrett**	Stabilized Level	**NA**
Comments	**Cleared access road through woods**	Total Depth	**28.5**	Date of Observation	**8/31/02**

All depths are given in feet and referenced b.g.s.

Depth and Elev.	SPT Value and Plot	Soil Description, OVA and USCS Symbol	Piezometer Constuction Data



SCS ENGINEERS
Environmental Consultants
2520 Whitehall Park Drive, Suite 450
Charlotte, NC 28273
704 504-3107 FAX 704 504-3174

A-1 Sandrock CDLF and Recycling
Greensboro, NC (Permit # 41-17)

Logged By: Kelly Grant, Driller
SCS Project No. 02214704.00

Test Boring Log **MW-6**

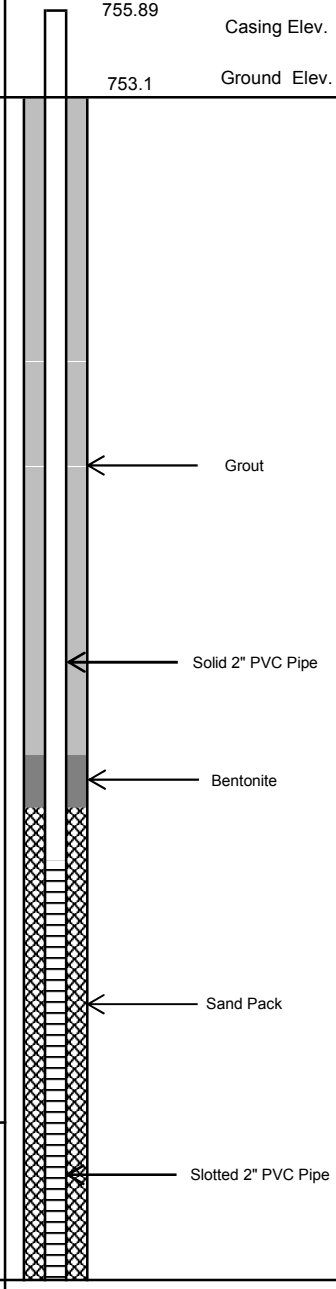
Northing 816,499.93
Easting 1,748,826.85

Total Bore Depth: 45' below ground surface

DEPTH, FT.	ELEVATION	SAMPLE #	DEPTH IN FT.	6" SPT VALUE	6" SPT VALUE	6" SPT VALUE	STRATIGRAPHIC DESCRIPTION
0–12							Stiff tan-brown sandy clay
12	741.1						
12–22							Hard brown sandy clay
22	731.1						
22–31							Dense white-orange rocky soil w/ quartz
31	722.1						
31–45							Hard gray sandy clay (PWR)
38–45							Wet from 38 to 45 feet
45	708.1						
45–50							Boring terminated at 45.0 feet

WATER LEVEL

PIEZOMETER DATA



Drilling Company:	American Environmental Drilling, Inc.	Date Started:	4/2/2015	Completion Water Level:	38'	below top of casing
Drilling Method:	Rotary Hollow Stem Auger	Date Ended:	4/2/2015	24 Hour Water Level:	39'	below top of casing
Boring Diameter:	7.5-inch O.D.					

APPENDIX 9
Landfill Gas Monitoring Plan

Landfill Gas Monitoring Plan for A-1 Sandrock CDLF
Solid Waste Permit #41-17 (Guilford County)

1.0 Introduction

The following plan has been prepared as a standalone document in accordance with current NCDENR Solid Waste Section (SWS) guidance, including the recent addition of hydrogen sulfide (H_2S) monitoring. The monitoring locations, methods, and thresholds for action have not changed, but the 2010 guidance document requires that attention be given specifically to well construction, equipment calibration, sampling procedures, and data keeping, in a plan that is organized in a standardized format. Landfill staff and monitoring personnel should view the SWS document "Landfill Gas Monitoring Guidance," November 2010, online at

http://portal.ncdenr.org/c/document_library/get_file?uuid=da699f7e-8c13-4249-9012-16af8aefdc7b&groupId=38361.

1.1 Background Information

Monitoring of landfill gas (LFG) is required at C&D landfills by Solid Waste Rule 15A NCAC 13B .0544. Landfill gas is a by-product from the decomposition of organic waste in a sanitary landfill, including certain C&D wastes. Landfill gas typically comprises about 50 percent methane, which can be explosive under certain conditions, as well as carbon dioxide, nitrogen, water, and small amounts of hydrogen sulfide. LFG has been known to promote the migration of contaminants into ground water. The Solid Waste Rules typically focus on the explosive properties from a public safety standpoint. Landfill gas migrates in soil above the ground water table and is restricted laterally by streams. Highly porous soils that tend to occur near the soil-rock interface within the Piedmont are considered to be a good pathway for gas migration.

Past experience suggests that up-gradient areas should be targeted for monitoring, especially if porous soils are present. In addition, this zone typically is an aquifer, thus fluctuations in the water table will affect the gas migration pattern or rate, as does surface saturation, frozen soils, and variation in barometric pressure. The Guidance suggests that the ideal time to sample for subsurface gas is during times of low barometric pressure. Pipelines and other utility trenches can serve as pathways for gas migration, with the potential to convey gas for considerable distances. Open landfills are not as likely to experience subsurface gas migration, but once a low permeability cover is installed, lateral migration into adjacent soils may be more likely if gas is present.

1.2 Current Site Conditions

The subject landfill is situated high on a ridge bounded on three sides by blue line streams, which act as natural barriers to gas migration. Potentiometric contours reflect the surface topography, which slopes moderately to the west but diverges sharply to the north and south (toward the streams) along the margins of the disposal area. Topographic relief near the streams is moderately steep to very steep, with elevation changes from the footprint to the streams on the order of 10 to 20 feet on the south side and 20 to 30 feet on the north and west sides. The landfill is unlined and is mostly excavated to the approved base grades. Onsite soils are mostly porous, weathered granite and extend 20 to 50 feet beneath the surface. The water table is approximately 25 to 40 feet deep over most of the site, except near the streams where water levels are 8 to 10 feet deep.

The approved base grades are a minimum of 8 to 12 feet above the level of the streams and a minimum of 4 feet above groundwater and/or bedrock. Lateral separation to the streams is 50 feet minimum; these dimensions provide little opportunity for gas to migrate beyond the facility boundary on the three sides bound by streams. On the up-gradient (southeast) side the topography increases by approximately 14 feet between the approved footprint and the nearest occupied structures, located approximately 750 feet from the approved disposal footprint. However, soils on this side of the site are derived from diorite, which results in a more clayey (less porous) soil type, and the landfill is mostly above-ground on the east side at this stage of development.

Back to the north, pipelines are present that could serve as potential conduits for off-site landfill gas migration – the nearest pipeline (sewer line) is a target for gas monitoring – although the pipelines are located across a deeply incised stream. The facility offices are also located across the stream, approximately 550 feet from the waste boundary. No occupied structures appear to be at risk for gas migration near this facility.

1.3 Regulatory Requirements

Thresholds that trigger responsive action are methane levels of 100 percent of the LEL, (the lower explosive limit, about 5 percent by volume) in soil-gas or air at the facility boundary; 25 percent of the LEL within onsite structures, not limited to just buildings but inclusive of drainage structures and utility vaults; zero in off-site structures. The contingency plan (**Section 5**) contains a summary of action required if a regulatory threshold is exceeded. Solid Waste Section guidance requires that LFG be monitored with a calibrated meter that is capable of detecting hydrogen sulfide, whereas the action limits are 4% by volume at 100% LEL and 1% by volume at 25% LEL.

1.4 Rationale for LFG Sampling Point Locations

Seven soil-gas monitoring points are located around existing Phase 1 and are relevant to the new Phase 2A (see **Drawing M1**). Points LFG-1 and LFG-2 are located on the up gradient side of the unlined landfill, opposite of ground water flow (refer to Section 1.1). Points LFG-3 through LFG-6 are strategically located relative to the sanitary sewer pipeline, albeit the topography of these locations and the water table make it unlikely that landfill gas would migrate in those directions (at least not very far). LFG-7 is so-located to provide uniform spacing, with the unlikelihood of any soil-gas migrating more than 50 feet from the landfill perimeter, though it is of interest to note that a small H_2S seep was observed at the far northwest corner of Phase 1, evidenced by the browning of vegetation and the characteristic "rotten egg" odor that persisted for a few weeks in 2013.

The gas seep area was mitigated by digging out the temporary soil cover and some of the underlying waste, in what amounted to two test pits that were allowed to vent for 2 to 3 weeks prior to replacing the excavated materials and enhancing the thickness of the soil cover. No trace of the gas seep has been observed since. However the Operator is alert to keeping an eye on that spot. It is known that sheetrock debris had been concentrated in that area. Continued reaction between the sheetrock and water is unlikely now that the soil cover is functional. With regard to this event, a new sampling point, LFG-8, had been added to the northwest corner (**Drawing M1**). The sampling point will be situated within 50 feet of the waste boundary, as are the other sampling locations.

2.0 LFG Monitoring

2.1 Locations and Logistics

LFG monitoring for this facility currently consists of sampling soil-gas adjacent to the landfill footprint via bar-hole punch test locations spaced approximately 500 foot apart (see **Drawing M1**). The monitored points reflect the emphasis on the up gradient side to the east, which is the only conceivable direction that gas could migrate offsite. The LFG monitoring points are situated along the nearest pipeline corridor, where the migration of gas (if present) could travel off-site; others focus on the up-gradient area where deep soils and ground water exist, and occupied structures are proximal. It is the facility's intent to implement monitoring at more points to the west and south as future phases are built. Tentative sampling points are shown as LFG-9 through LFG-12, with the understanding that these sampling points are to be activated during future expansion, and the logistics may be subject to revision for PTC applications for the future cells and phases.

The bar-hole punch test was prescribed and approved for the facility as it was brand new (opened in 2009) and had not received waste. This is a simple test of the soil-gas adjacent to the landfill, justified based on the presence of porous soils, topography, and natural barriers. The landfill has now received some 225,000 cubic yards of waste, comprised of mostly inert materials with paper, wood, and other potentially combustible materials – the same kind of materials that can degrade slowly to form landfill gas – so it is conceivable that at some time in the future, the Solid Waste Section may require permanent gas monitoring wells for this facility. Due to the age of the waste, it is likely that reactions leading to the production of landfill gas are becoming more active.

In anticipation of possible future requirements, this plan presents procedures for both bar-hole punch tests and sampling of monitoring wells. A SWS-endorsed well construction schematic is provided, which includes sealed construction and a specialized port at the top to facilitate sampling. Presumably, the monitoring wells would be located near the same points as currently monitored with the bar-hole punch test, for the same reasoning described above. This plan will be amended in the future to include data tables for the monitoring wells, if required. Data recording protocols will remain the same.

Landfill gas monitoring will be performed quarterly during the active life of the landfill, estimated at 20 years, and throughout the post-closure care period, 30 years unless future data warrant a schedule revision, which will be subject to approval by the SWS.

2.2 Structures and Ambient Sampling

Within the offices and any future buildings on-site, atmospheric sampling for methane shall be conducted. Methane is heavier than air and tends to accumulate in the lower zones with restricted circulations, i.e., crawlspaces, closets, and corners of rooms near the floor, cracks in walls, floor slabs, or foundations, crawlspace vents, drainage pipes, and utility vaults (excluding sanitary sewer manholes). Methane detection in and around the structures, though unlikely, would signify a problem such that the site manager should be notified – immediate action may be required – refer to the Contingency Plan (**Section 5**).

Ambient monitoring overlaps the building foundations and includes a "walk-around" at the toe of covered (vegetated) slopes to survey for gas that may be seeping through the cover. A key to potential side slope seepage includes stained soil, wetness with visible bubbling, or distressed (or absent) vegetation. Any detection of methane in the ambient monitoring should be noted on a site map and a special notation recorded in the monitoring report. Follow up sampling or close attention in future sampling events might be warranted. The site manager should be alerted to any ambient gas detection.

2.3 Sampling Schedule

Quarterly methane and hydrogen sulfide monitoring will be conducted at all subsurface gas detection locations and in all occupied structures located on the landfill property. In addition, enclosed structures, such as manholes, utility vaults, and buried drainage pipes should be checked for gas prior to servicing, in addition to the routine monitoring. The passive gas vents for the final cover, when installed, are not required to be monitored.

Monitoring times are also important when conducting landfill gas monitoring. Proper landfill gas monitoring should include sampling during times when landfill gas is most likely to migrate. LFG monitoring should be conducted when the barometric pressure is low and soils are saturated. During the winter season when snow cover is just beginning to melt or when the ground is frozen or ice covered, landfill gas monitoring should be conducted when the barometric pressure is low.

3.0 LFG Sampling Program

3.1 Equipment and Calibration

A-1 Sandrock enlists the services of an experienced third-party firm to conduct the monitoring. That firm utilizes a landfill gas instrument that meets the requirements of SWS Landfill Gas Monitoring Guidance with respect to detecting methane, oxygen, carbon dioxide, and hydrogen sulfide. Calibration shall occur prior to instrument use and according to the manufacturer's specifications. Should this element of the program change, this plan will be amended accordingly.

3.2 LFG Sampling Procedures

The following procedure is recommended for conducting landfill gas monitoring well sampling and/or bar-hole punch testing *(shown in italics)*. The sampling equipment shall consist of a good-quality gas meter capable of detecting methane (LEL) and oxygen levels – most modern meters include carbon monoxide or carbon dioxide, depending on the meter and hydrogen sulfide readings. In deference to the professionals who have conducted the sampling for years, these procedures are guidelines; no changes to the current sampling program are warranted.

Step 1 Calibrate the instrument according to the manufacturer's specifications. In addition, prepare the instrument for monitoring by allowing it to properly warm up as directed by the manufacturer. Make sure the static pressure shows a reading of zero on the instrument prior to taking the first sample.

Step 2 Purge sample tube for at least one minute prior to taking reading. Connect the instrument tubing to the landfill gas monitoring well cap fitted with a stopcock valve or quick connect coupling.

Step 2 Alternate *Drive the bar into the ground to a depth of 3 feet at the sampling location using a hammer or backhoe bucket. Heavy gauge rebar is ideal for this task. The bar-hole needs to be near-vertical and free of obstructions. Drilling a hole with a modified concrete drill (an extension is required to reach the desired depth) has been demonstrated to expedite the making of a boring with less smearing of the side walls.*

Step 3 Open the valve and record the initial reading and then the stabilized reading. A stable reading is one that does not vary more than 0.5 percent by volume on the instrument's scale.

Step 3 Alternate *Cover the hole upon extraction of the drill to retain any gas present. Without completely lifting the cover, gently insert the sampling tube beneath the cover and obtain an initial reading. Allow time for a stabilized reading as described above.*

Step 4 Record the stabilized reading including the oxygen concentration and barometric pressure. A proper reading should have two percent oxygen by volume or less. If levels of oxygen are higher, it may indicate that air is being drawn into the system giving a false reading.

Step 5 Turn the stopcock valve to the off position and disconnect the tubing.

Step 5 Alternate *Backfill the hole with cuttings or native soil; tamp the backfill with a rod or equipment handle.*

Step 6 Proceed to the next landfill gas monitoring well and repeat Steps 2 – 5.

4.0 Record Keeping and Reporting

The sampling technician shall record the date, time, location, sampling personnel, calibration data, gas pump rate, barometric pressure (from local weather reports), ambient temperature, general weather conditions at the time of sampling, initial and stabilized concentrations of methane (see the **Landfill Gas Monitoring Data Form**) following this text). These monitoring records shall be maintained in the landfill operating record. Should methane be detected at any sampling location, the facility manager should be notified and, depending on the concentrations, a report to the Solid Waste Section <u>might</u> be warranted. In any event a qualified engineer should be consulted.

5.0 Contingency Plan

Solid Waste Rule .0544 (d) (3) requires the following responses in the event that methane and/or hydrogen sulfide concentrations are detected that exceed the regulatory limits:

A Immediately take all steps necessary to ensure protection of human health and notify the Division – at a minimum, occupied structures should be evacuated and ventilated until the methane concentrations subside; close monitoring of structures shall be implemented; for facility boundary violations, further evaluation is warranted, subject to notification and approval by the Division.

B Within seven days of detection, place in the operating record the methane or explosive gas levels detected and a description of the steps taken to protect human health;

C Within 60 days of detection, implement a remediation plan for the methane or explosive gas releases, place a copy of the plan in the operating record, and notify the Division that the plan has been implemented. The plan must describe the nature and extent of the problem and the proposed remedy.

D Based on the need for an extension demonstrated by the operator, the Division may establish alternative schedules for demonstrating compliance with the limits.

E "Lower explosive limit" means the lowest percent by volume of a mixture of explosive gases in air that will propagate a flame at 25° C at atmospheric pressure.

F Upon completion of mitigation activities, a thorough report shall be placed in the operating record to document the incident and outcome.

6.0 Professional Certification

The certification statement below must be signed and sealed by a North Carolina Professional Geologist or Professional Engineer and submitted with the Landfill Gas Monitoring Plan.

> The landfill gas monitoring plan for this facility has been prepared by a qualified geologist or engineer who is licensed to practice in the State of North Carolina. The plan has been prepared based on first-hand knowledge of site conditions and familiarity with North Carolina solid waste rules and industry standard protocol. This certification is made in accordance with North Carolina Solid Waste Regulations, indicating this Landfill Gas Monitoring Plan should provide early detection of any release of hazardous constituents to the uppermost aquifer, so as to be protective of public health and the environment. No other warranties, expressed or implied, are made.
>
> Signed _____
>
> Printed ___G. David Garrett, PG, PE_____
>
> Date _____May 1, 2015_____

Not valid unless this document bears the seal of the above mentioned licensed professional.

If wells are installed in the future, the well locations shall be shown on a topographic map that is signed and sealed by a registered surveyor.

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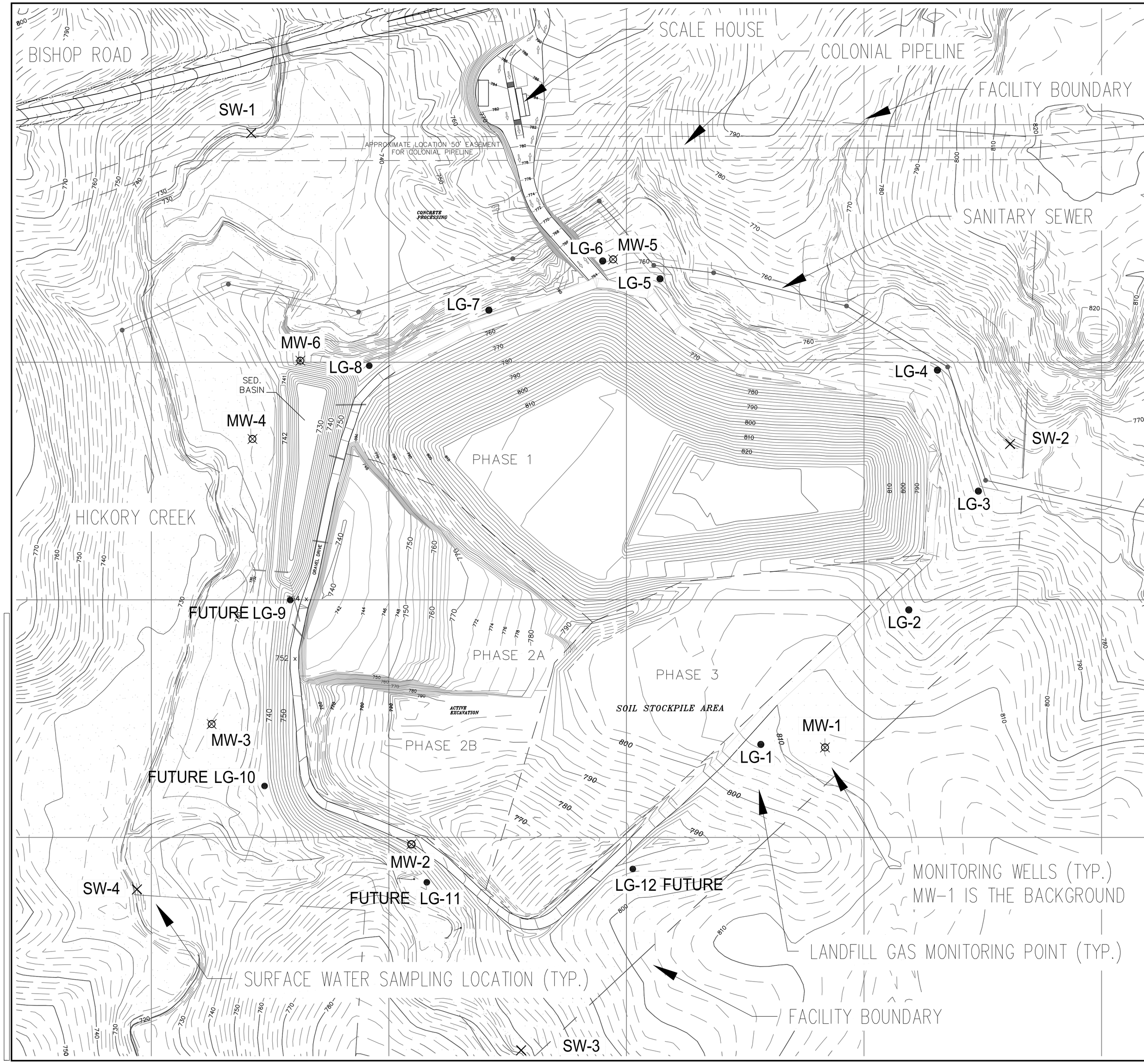


300 0 300 600 900

Scale 1" = 300'

Bar is 1" on original drawing

LEGEND

PROPOSED

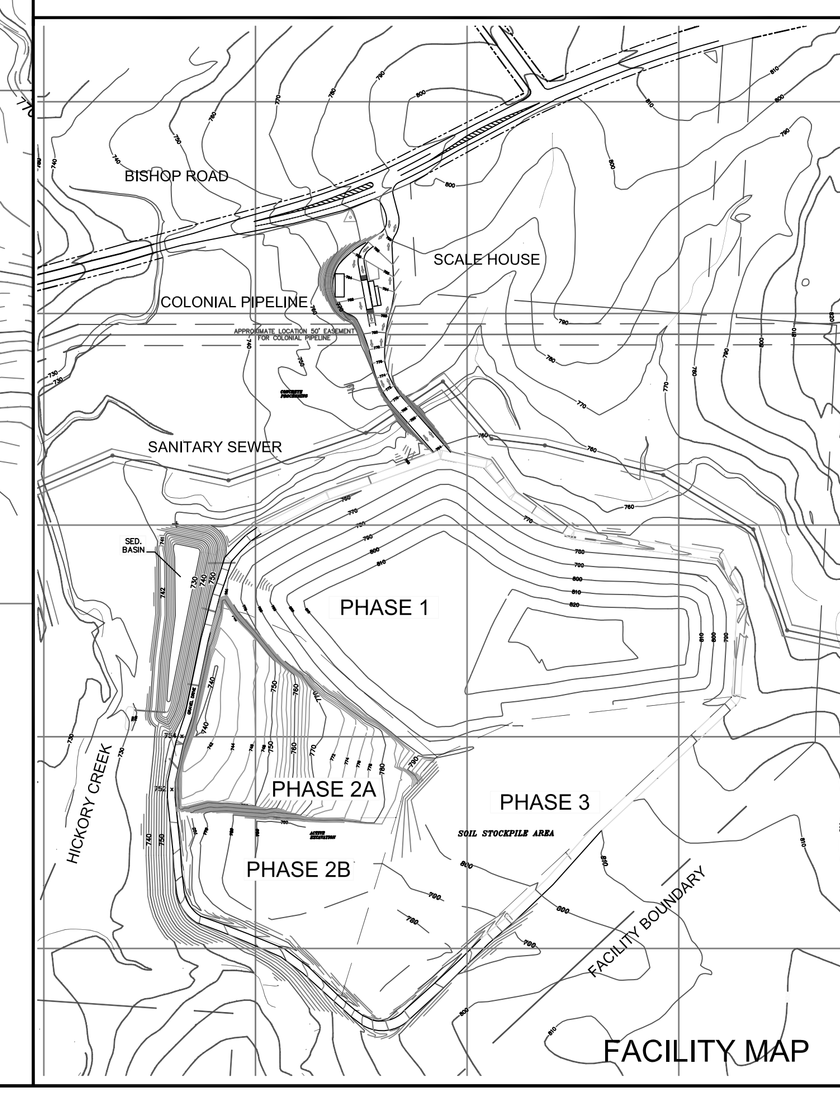
- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (280)
- CELL AND WASTE LIMITS

NOTE:
CONTOURS SHOWN FOR CELLS 1A / 1B, 2A AND 2B REPRESENT FINAL TOP OF WASTE GRADES

EXISTING

- 2 FOOT ELEVATION CONTOUR
- 10 FOOT ELEVATION CONTOUR (280)
- FACILITY BOUNDARY
- SANITARY SEWER
- WATERCOURSE BUFFER ZONE
- PROPERTY BUFFER ZONE
- 100 YR FLOODPLAIN
- WATERCOURSE

BASE GRADE CONTOURS FOR PHASE 2 ARE AS SURVEYED IN APRIL 2015



FACILITY MAP

NORTH CAROLINA PROFESSIONAL SEAL 22068 ENGINEER DAVID G. GARRETT

7/28/2015

NC CORP. LICENSE NO. C-1837

NO.	REVISION	DATE
1	ADDED MW-6 AND REGULATORY REVIEW	7-14-2014
2		
3		
4		
5		
6		

SHEET TITLE: WATER AND GAS MONITORING LOCATIONS

PROJECT TITLE: PERMIT RENEWAL APPLICATION PHASE 2 PERMIT TO CONSTRUCT

CLIENT: A-1 SANDROCK, INC.
PERMIT NO. 41-17-CDLF-2008
2091 BISHOP ROAD
GREENSBORO, NC 27406

SCS ENGINEERS, PC
2520 WHITEHALL PARK DRIVE, SUITE 450
CHARLOTTE, NORTH CAROLINA 28273
PHONE: (704) 504-3107 FAX: (704) 504-3174

PROJ. NO. 0224141704.00 T3
DSN. BY: GDG
DWN. BY: GDG
CHK. BY: SCL
QA RVW BY:
APP. BY:

DATE: 4/30/2015

SCALE: AS SHOWN

DRAWING NO. M1

Sheet 6 of 6

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NC Division of Waste Management - Solid Waste Section

Landfill Gas Monitoring Data Form

Notice: This form and any information attached to it are "Public Records" as defined in NC General Statute 132-1. As such, these documents are available for inspection and examination by any person upon request (NC General Statute 132-6).

Facility Name: _____Permit Number: _____

Date of Sampling: _____ NC Landfill Rule (.0500 or .1600): _____

Name and Position of Sample Collector: _____

Type and Serial Number of Gas Meter: _____ Calibration Date of Gas Meter: _____

Date and Time of Field Calibration: _____

Type of Field Calibration Gas (15/15 or 35/50): _____ Expiration Date of Field Calibration Gas Canister: _____

Pump Rate of Gas Meter: _____

Ambient Air Temperature: _____ Barometric Pressure: _____ General Weather Conditions: _____

Instructions: Under "Location or LFG Well" identify the monitoring wells or describe the location for other tests (e.g., inside buildings). A drawing showing the location of test must be attached. Report methane readings as both % LEL and % CH4 by volume. A reading in percent methane by volume can be converted to % LEL as follows: % methane by volume = % LEL/20

Location or LFG Well ID	Sample Tube Purge	Time	Time Pumped (sec)	Initial %LEL	Stabilized %LEL	%CH4 by volume	%O2	%CO2	%H2S	Notes

If your facility has more gas monitoring locations than there is room on this form, please attach additional sheets listing the same information as contained on this form.

Certification
To the best of my knowledge, the information reported and statements made on this data submittal and attachments are true and correct. I am aware that there are significant penalties for making any false statement, representation, or certification including the possibility of a fine and imprisonment.

_____ _____
SIGNATURE TITLE

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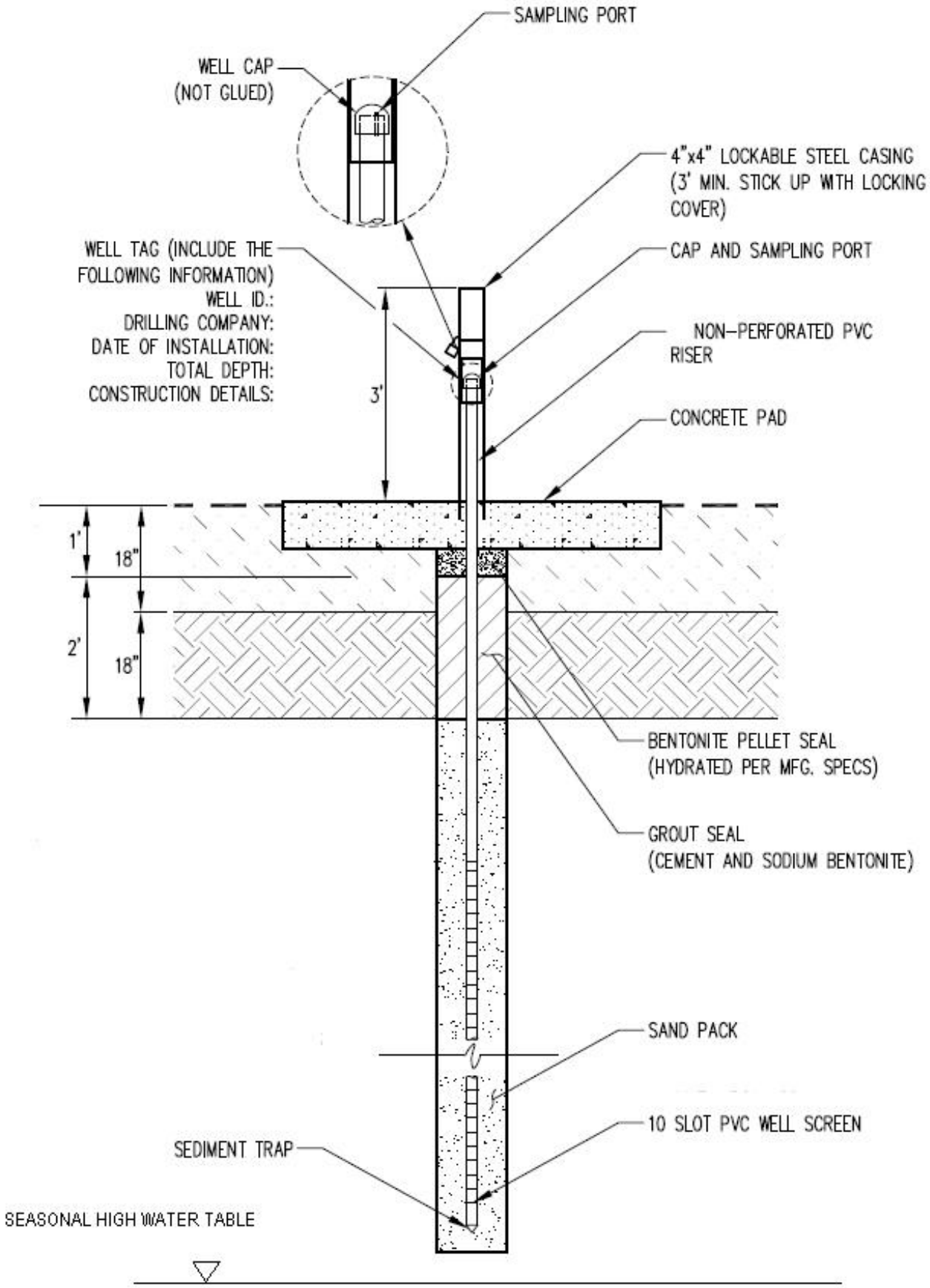
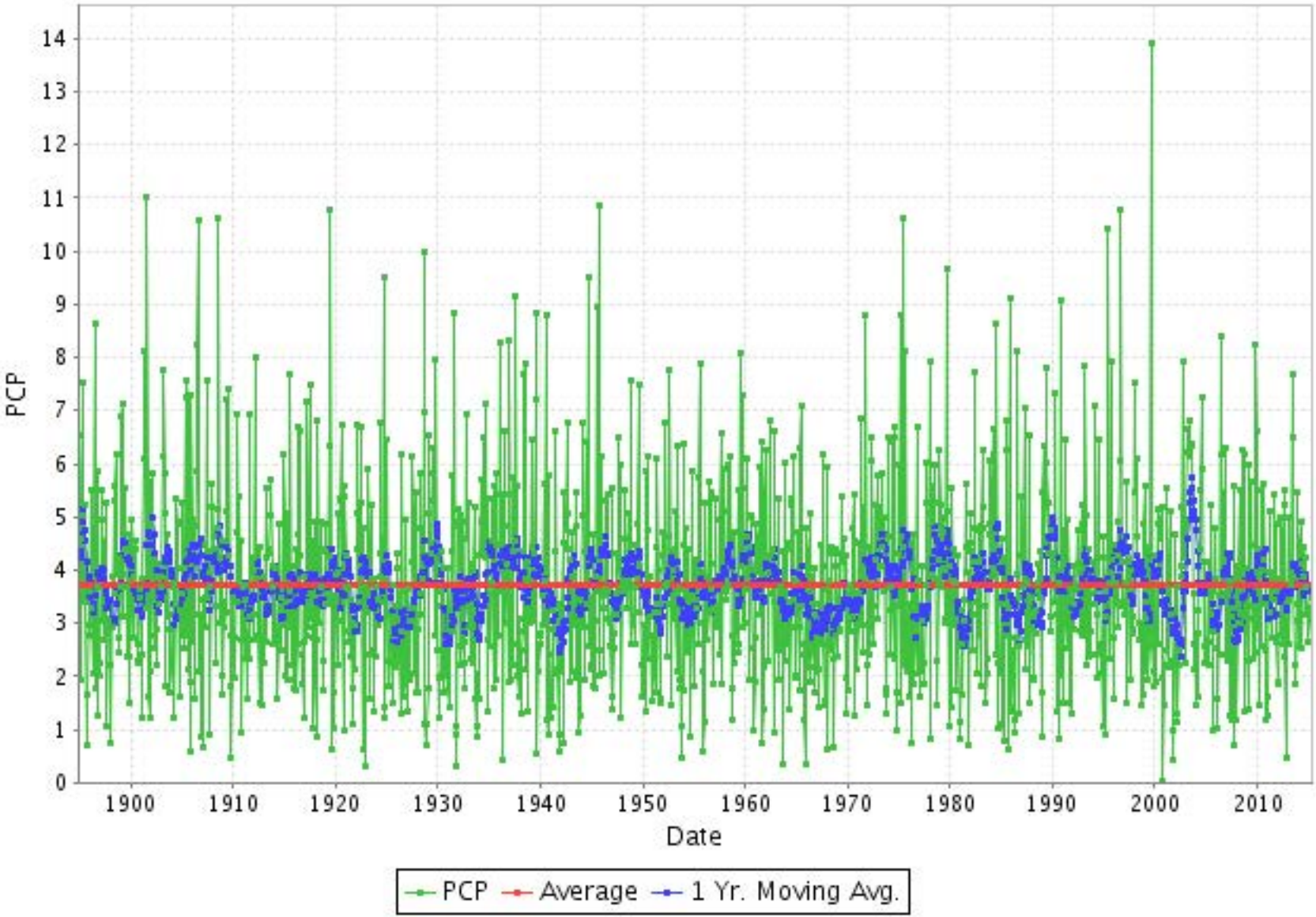
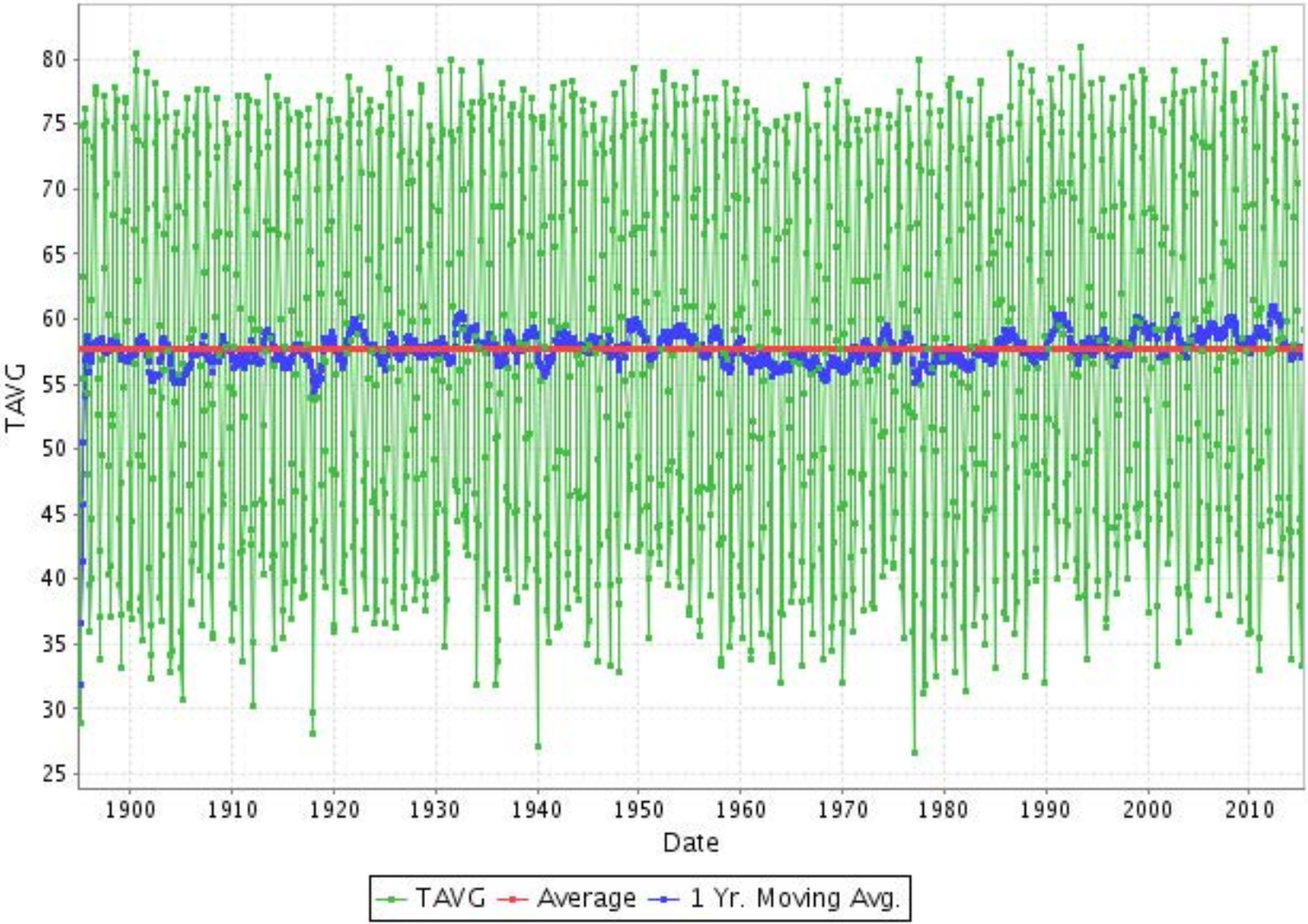

SAMPLING PORT
WELL CAP
(NOT GLUED)
4"x4" LOCKABLE STEEL CASING
(3' MIN. STICK UP WITH LOCKING
COVER)
WELL TAG (INCLUDE THE
FOLLOWING INFORMATION)
WELL ID.:
DRILLING COMPANY:
DATE OF INSTALLATION:
TOTAL DEPTH:
CONSTRUCTION DETAILS:
CAP AND SAMPLING PORT
NON-PERFORATED PVC
RISER
3'
CONCRETE PAD
1'
18"
2'
18"
BENTONITE PELLET SEAL
(HYDRATED PER MFG. SPECS)
GROUT SEAL
(CEMENT AND SODIUM BENTONITE)
SAND PACK
10 SLOT PVC WELL SCREEN
SEDIMENT TRAP
SEASONAL HIGH WATER TABLE

APPENDIX 10
NOAA Regional Climatic Data

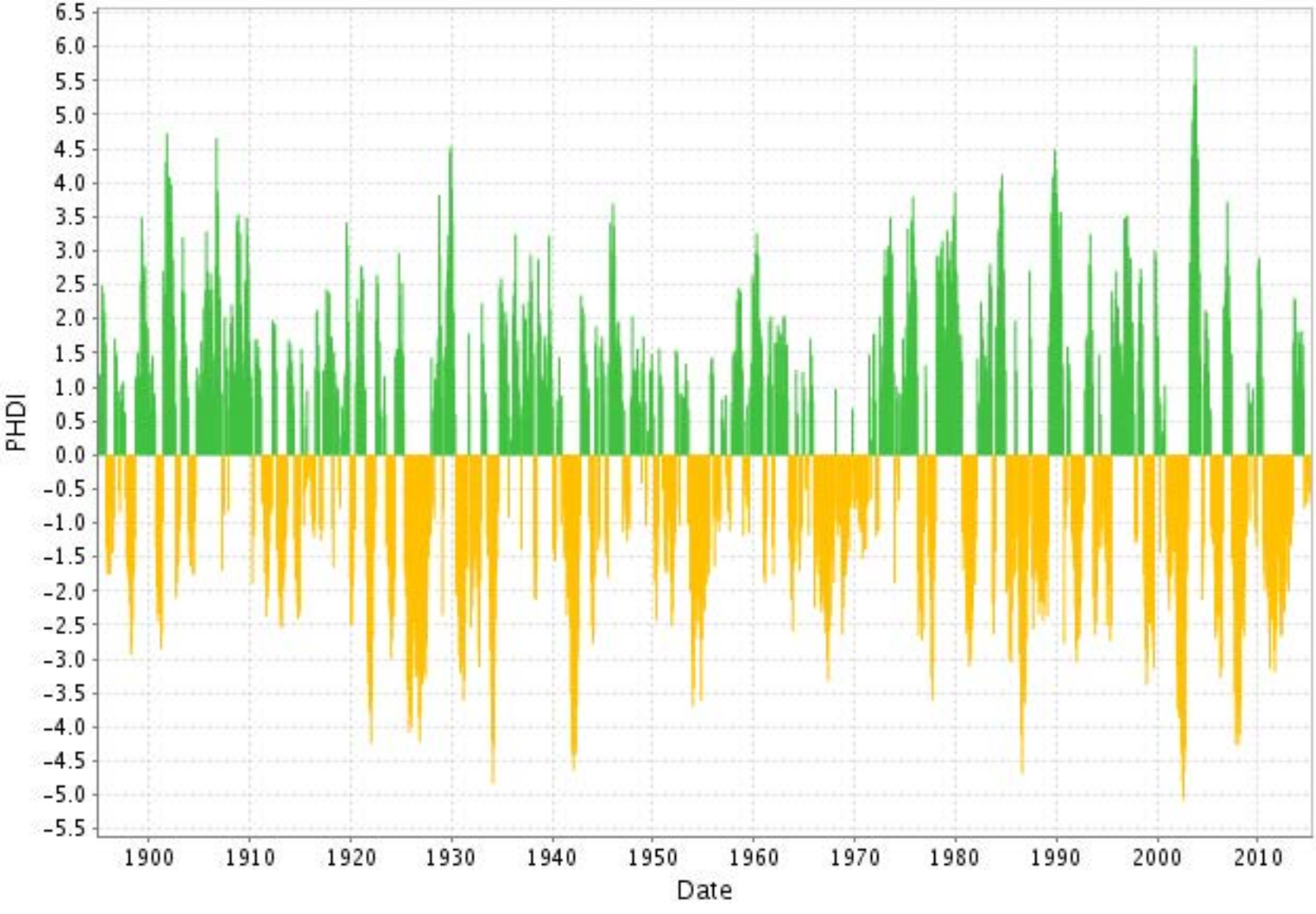
NC Northern Piedmont - PCP
189501 - 201504



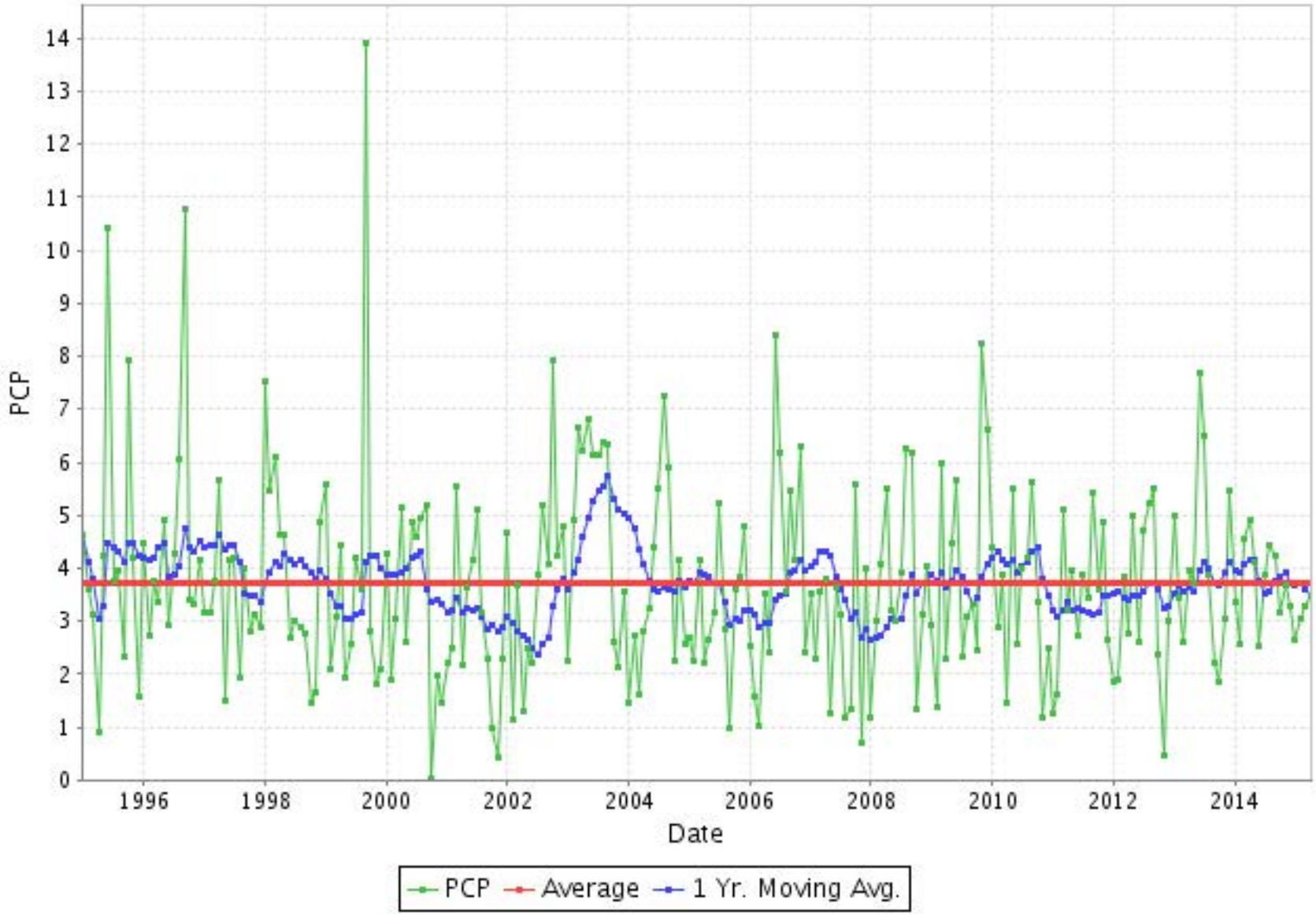
NC Northern Piedmont - TAVG
189501 - 201504



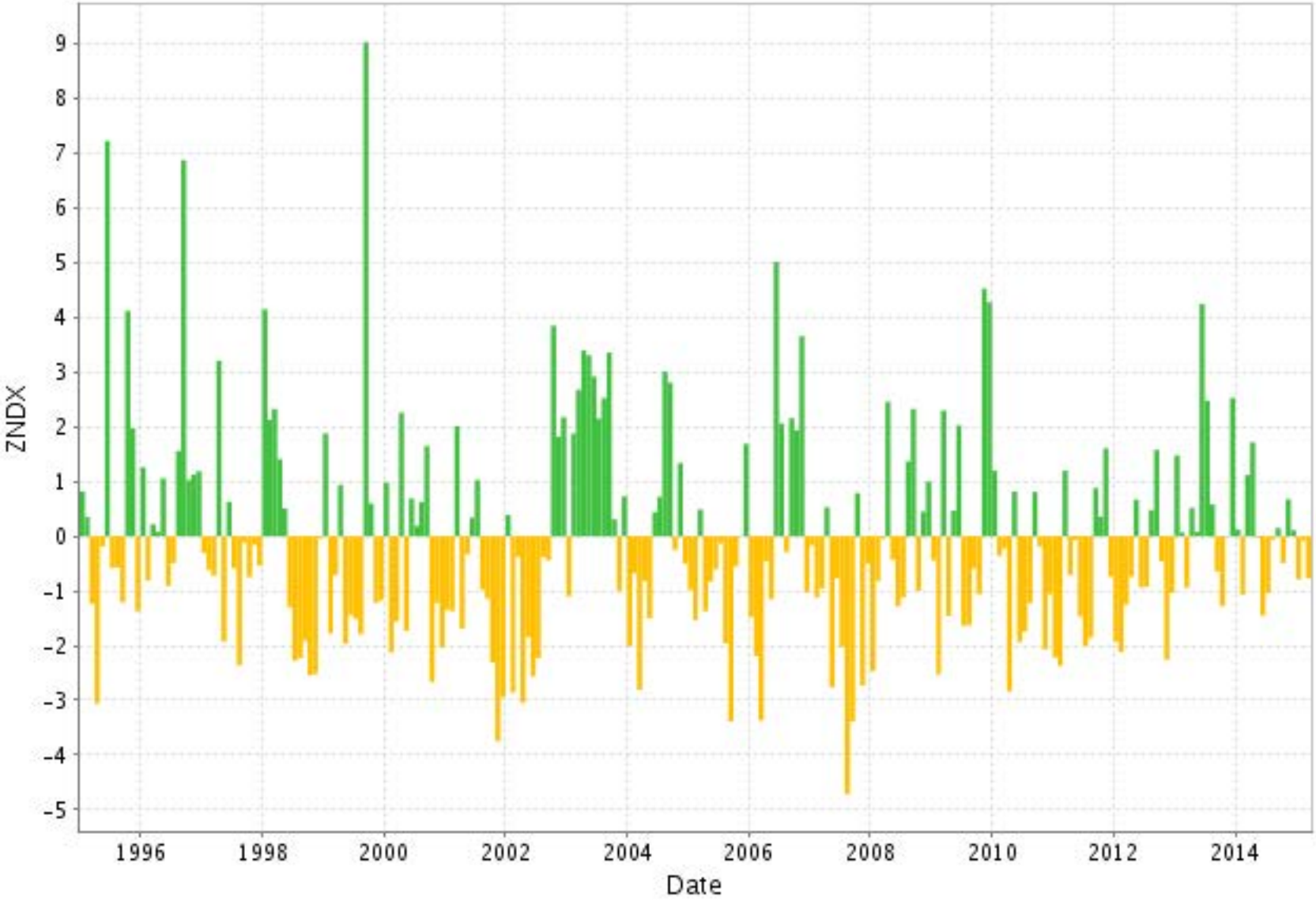
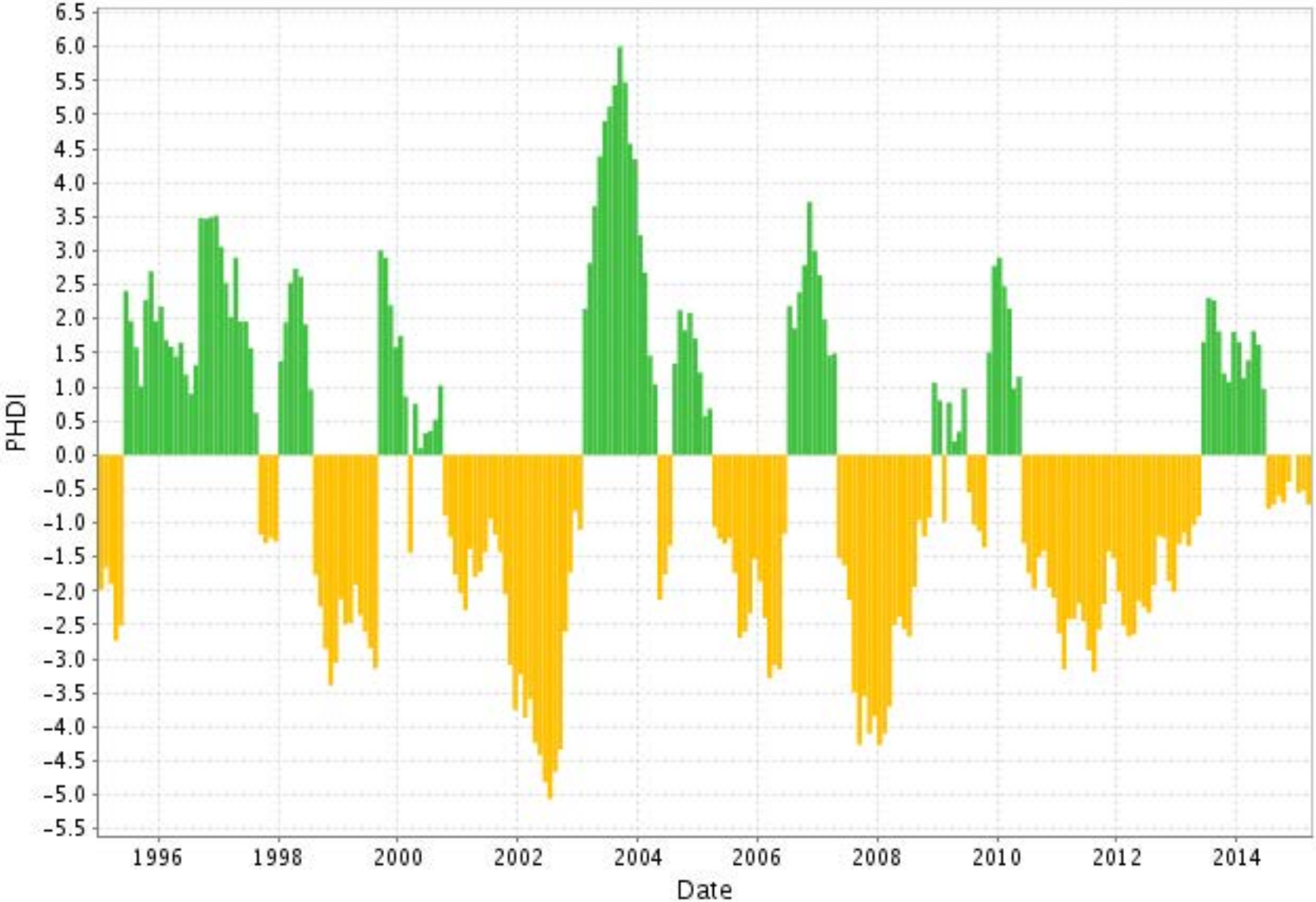
NC Northern Piedmont – PHDI
189501 – 201504



NC Northern Piedmont - PCP
199501 - 201504



NC Northern Piedmont - ZNDX
199501 - 201504



NC Northern Piedmont – PHDI
199501 – 201504