Water Quality Monitoring Plan
for
Craven Ag Service (CAS) Compost Facility
Craven County, North Carolina

Prepared for

Craven Ag Service
2115 W. Highway 55
New Bern, NC 28562
Attn: Mr. J.W. (Billy) Dunham

from

Cpec Environmental Inc. (Cpec)
PO Box 743
Morehead City, NC 28557

Cpec Job Number 1883
July 2013

CPEC
Environmental, Inc.
SOIL, HYDROGEOLOGIC, & WETLAND CONSULTING
P.O.Box 743, Morehead City, NC 28557 v/fx:(252)726-4260

July 19, 2013

Mr. J.W. (Billy) Dunham
Craven Ag Service
2115 W. Highway 55
New Bern, NC 28562

Subject: Water Quality Monitoring Plan for Craven Ag Service (CAS) Compost Facility
Craven County, North Carolina
Cpec Job #1883

Dear Mr. Dunham,

One copy of the subject report is attached. Should you have any questions or comments on the report, please contact us at your convenience.

Sincerely,

Thomas H. Hinson, PG, LSS, RS
Chief Environmental Consultant

Attachment: Report

Table of Contents

Page

Table of Contents i
List of Tables ii
List of Figures ii
List of Appendices ii

1.0 Introduction 1
1.1 Site Location and Background 1
1.2 Water Quality Monitoring Plan Purpose and Scope 1
2.0 Site Characterization 1
2.1 Regional Geology and Local Topography 1
2.2 Hydrogeology 2
2.3 Water Table Surface 2
2.4 Groundwater Flow Direction and Hydraulic Gradient 2
2.5 Saturated Hydraulic Conductivity (Ksat) Estimates 3
2.6 Groundwater Flow Velocity 3
2.7 Potential Groundwater-to-Surface-Water Discharge 3
3.0 Monitoring Network and Analytical Parameters 4
3.1 Monitoring Wells 4
3.2 Surface Water Sampling Points 4
4.0 Monitoring Program 5
4.1 Guidance Documents 5
4.2 General Sampling Protocol 5
4.2.1 Fuel Powered Equipment 5
4.2.2 Decontamination of Field Equipment 5
4.2.3 Field Logbook 6
4.3 Groundwater Sample Collection 6
4.3.1 Water Level Measurements 6
4.3.2 Monitor Well Evacuation 7
4.3.3 Sample Collection 8
4.4 Surface Water Sample Collection 10
4.4.1 Surface Water Level Observation 10
4.4.2 Sample Collection 10
5.0 Field Quality Assurance/Quality Control Program 11
6.0 Sample Preservation, Shipment and Chain-of-Custody 12
7.0 Laboratory Analysis, QA/QC and Data Review 13
8.0 Record Keeping and Reporting 14
9.0 Monitoring Program Modifications 15
9.1 Well Abandonment/Rehabilitation 15
9.2 Additional Well Installations 15
10.0 Implementation Schedule. 15
11.0 References.. 15
12.0 Certification 16

List of Tables

Table 1. Representative deep soil description at the CAS Site (Tarboro Series Taxajunct) T1
Table 2. Well construction details and water table data T2
Table 3. Saturated Zone - Ksat estimates in the C2 horizon (slug test method)..... T3
Table 4a. Proposed monitor wells (see Figure 4) T4
Table 4b. Proposed surface water sampling locations (see Figure 4)..... T4
Table 5. Proposed analyte list for groundwater and surface water sampling T5

List of Figures

Figure 1. Location of the Craven Agricultural Services (CAS) composting facility, Craven County, NC F1
Figure 2. Proposed composting facility site map with local topography and drainage features..... F2
Figure 3. Water table (piezometric) surface and generalized groundwater flow direction on 05/09/13 with local topography base map.. ..... F3
Figure 4. Estimated predominate groundwater flow direction and proposed groundwater and surface water sampling locations.. ..... F4
Figure 5. Type II monitor well construction schematic F5

List of Appendices

Appendix A - Field Procedures..... A-1
Appendix B - Regulatory Correspondence B-1
Appendix C - Supporting Documentation, Slug Test Reports and DWM Reporting Forms..... C-1

1.0 INTRODUCTION

Cpec Environmental, Inc. (Cpec) was contracted by Craven Ag Services, Inc. (CAS) to perform a field investigation and prepare a Water Quality Monitoring Plan (WQMP) for the CAS Composting Facility in Craven County, North Carolina.

Cpec prepared this monitoring plan based on site specific information collected from on-site surface and subsurface investigations, survey maps, aerial photographs, technical publications, geological maps, and county, state, and federal records.

Appendix A contains Cpec's field procedures and methods. Appendix B contains correspondence documents between the CAS facility and NCDENR-Division of Waste Management (DWM), Solid Waste Section (SWS).

1.1 Site Location and Background

The CAS site had a total area of approximately 90 acres and was located south of River Road (SR 1400) near the town of Vanceboro in Craven County, North Carolina. Our investigation area encompassed approximately 38 acres within the tract (Figure 1).

The CAS facility is expanding the composting operation to include the southern portion of the investigation area. Figure 2 shows the site topography and proposed expansion areas by operation type.

1.2 Water Quality Monitoring Plan Purpose and Scope

This WQMP will serve as a guidance document for collecting and analyzing groundwater and surface water samples and managing the associated analytical results as required by NC Solid Waste Rules 15A NCAC 13B Section .0600-.0602 (Groundwater and Surface Water Monitoring). The WQMP details field and laboratory protocols that must be followed to insure that accurate and representative results are obtained for all groundwater and surface water monitoring points, and to meet the data objectives of groundwater and surface water monitoring at the site.

The WQMP addresses the following subjects:

- existing hydrogeologic setting, drainage feature influence and groundwater flow dynamics,
- groundwater sample collection procedures,
- surface water sample collection procedures,
- sample preservation, shipment and chain-of-custody,
- laboratory analytical procedures,
- quality assurance/quality control programs, and
- compliance reporting and record keeping.

The methods and procedures described in the following sections are intended to facilitate the collection of true and representative samples and test data. Field procedures, sample preservation, shipments and chain of custody requirements are presented in Sections 4.0 through 6.0. Laboratory protocol is presented in Section 7.0, and record keeping and reporting requirements are presented in Section 8.0.

Strict adherence to the procedures stipulated in this plan is required. Any variations from these procedures should be thoroughly documented.

2.0 SITE CHARACTERIZATION

2.1 Regional Geology and Local Topography

Predominate lithology in the area was Quaternary-age (unconsolidated) marine sediments (interbedded sands, silts, and clays)(Beyer, 1991). The CAS site was located on a sandy, riverine terrace north of the Neuse River floodplain near the eastern boundary of the Wicomico Surface (Morpho-stratigraphic Unit) of the North Carolina Lower Coastal Plain. The local topography was characterized as macro-scale ridge and swale with elevations ranging in elevation from *2 ft-msl to 18 ft-msl* (Figure 2).

2.2 Hydrogeology

The shallow stratigraphy (based on piezometer borings <8.0 ft-bls) was sand with texture coarsening with depth (Table 1). Based on borehole hydrogeology interpolation from DENR-DWR's Framework Query Results (Appendix C), surficial aquifer thickness was estimated at 132 feet. Based on site stratigraphy, the surficial aquifer was an unconfined system with its base at approximately *-114-ft msl*.

To better characterize the surficial aquifer system, Cpec installed 23 piezometers to define the water table surface and determine groundwater flow behavior. Table 2 presents piezometer construction details and water table data (including piezometric surface elevations). Figure 3 shows piezometer locations.

2.3 Water Table Surface

Cpec used water table elevation data from 05/09/13 to construct a water table surface map (Figure 3). In Figure 3, the thick light blue lines depict the water table contours and the large arrows indicate the general groundwater flow direction.

2.4 Groundwater Flow Direction and Hydraulic Gradient

Hydraulic conductivity and hydraulic gradients dictate groundwater flow through the surficial aquifer system. Preliminary observations shown on Figure 3 (water table surface and generalized groundwater flow direction) include:

1) In the northern field, the water table surface map shows a moderate to strong hydraulic gradient with quasi-radial flow (from South to Southwest) toward the groundwater-lowering ditch and shallow ditch/seasonal wetland, with an average hydraulic gradient on 05/09/13 of 0.00225 ft/ft. The collective influence of these drainage features on groundwater flow direction and velocity in the northern field is directly proportional to the upgradient water table surface elevation (i.e., higher water tables = greater influence on flow direction and higher groundwater flow velocities).

   Based on interviews with the site manager and business owner (Billy Dunham), the drainage features "dry up" from June to December. As the upgradient water table surface elevation falls beneath the drainage features' base elevations, we predict the flow velocities to decrease and flow direction to become more linear with a predominate flow toward the South-Southwest.

2) In the central field, groundwater flow direction was generally South-Southwest to South with the hydraulic gradient increasing in the southerly direction. The shallow ditch/seasonal wetland Northeast of the field had no influence on groundwater flow. The influence of the groundwater-lowering ditch on flow direction was minimal on 05/09/13, and can be expected to have only a slight effect even during the highest water table periods (winter months). Therefore, based on our

findings we do not predict significant reverse gradient flow toward the groundwater-lowering ditch.

3) In the southern field, the water table surface map shows a strong hydraulic gradient toward Neuse River (South-Southwest). Across the central and southern fields, the average hydraulic gradient on 05/09/13 was 0.0030 ft/ft.

In our professional option, the water table surface as measured on 05/09/13, represents the near highest water table elevations and may not be representative of predominate groundwater flow conditions throughout the year. Based on the natural landscape position and the close proximity/relative position of a robust/fixed boundary condition (i.e., Neuse River), we believe the groundwater flow direction for most of the year is South-Southwest.

2.5 Saturated Hydraulic Conductivity (Ksat) Estimates

Cpec installed three slug test wells to estimate the surficial aquifer's saturated hydraulic conductivity. Table 2 presents slug test well construction details (Ks-1 through Ks-3). Slug tests were conducted at three locations within the investigation area (Figure 3). Slug-tests wells were screened (0.50 ft screen length) below the water table surface with 1.0 ft of sand above the screen and bentonite-sealed to the land surface. Following construction, slug-tests wells were left overnight (approximately 18 hours) prior to conducting tests to ensure a competent hydraulic seal and hence, test integrity.

Cpec utilized in-situ saturated zone methods for field Ksat measurements in the C horizon. Specifically, Cpec used the falling-head slug test method for in-situ measurements. Field measurements were solved for saturated hydraulic conductivity via the Bouwer-Rice method. Appendix A describes slug test methods and slug test solution reports are located in Appendix C.

Aquifer saturated hydraulic conductivity (Ksat) estimates from slugs tests (Ks1, Ks2 and Ks3 performed at P-5, P-9 and P-12, respectively) are presented on Table 3. From a population of 15 slug tests (5 replications per slug-test well), the average aquifer Ksat was 66.86 ft/d (Table 3).

2.6 Groundwater Flow Velocity

Groundwater flow velocity (Vgw) in the surficial aquifer was calculated using:

- estimated hydraulic gradient of 0.0039 (Section 2.4);
- estimated surficial aquifer Ksat of 56 ft/d (Section 2.5); and
- effective porosity of 0.20 (Heath, 1983).

The groundwater flow velocity equation is presented in Appendix A. Average groundwater flow velocities were 0.75 ft/d and 1.00 ft/d in the northern and central/southern fields, respectively. Average water table depths (below land surface)(Table 2) were 5.14 ft (north field), 6.22 ft (central field) and 7.82 ft (southern field).

2.7 Potential Groundwater-to-Surface Water Discharge

Due to the inherent high mobility potential of nitrate in groundwater and given the aquifer's moderate to high groundwater flow velocities, Cpec concludes that the potential for groundwater-to-surface water discharge (in the major site drainage features – Figure 3) exists, but is limited to the northern field only and is primarily restricted to nitrate and the wet season (winter/spring) groundwater flow regimes.

The observed quasi-radial groundwater flow (Figure 3) north of the groundwater-lowering ditch when the water table elevation is higher than the ditch bottom (typically in the winter/spring) coupled with highly dynamic water table fluctuations following storm events (which varies groundwater flow direction and velocities) promotes aggressive hydrodynamic dispersion in the surficial aquifer in the northern field and therefore, achieves significant contaminant attenuation downgradient from contaminant sources.

Furthermore, during the wet season (winter/spring) the high organic content and anoxic conditions (within the drainage features) should promote an ideal environment for biological denitrification. The denitrification potential in the hyporheic zone (region beneath and alongside a stream bed, where there is mixing of shallow groundwater and surface water) has been well established in drained landscapes using Drainmod-N (Skaggs, et al.). These natural high denitrification dynamics within the drainage features will inhibit high concentration nitrate discharges into surface waters (i.e., site drainage features) and therefore inhibit the potential of off-site migration.

3.0 MONITORING NETWORK AND ANALYTICAL PARAMETERS

The proposed monitoring network at the CAS composting facility has been designed to monitor the upper portion of the aquifer and shall consist of four wells (one upgradient, one mid-site and two downgradient) and three surface water monitoring points (one upstream, one mid-stream and one downstream location). Figure 4 shows the locations and Table 4 provides general descriptions for the proposed water quality sampling points for the CAS site. Table 5 displays a water quality analyte list with NC groundwater concentration limits, analysis methods and sampling frequencies.

3.1. Monitoring Wells

As shown on Figure 4, Cpec proposed four monitor wells (one upgradient, one mid-site and two downgradient) based on predominant annual groundwater flow. Figure 3 shows the shortest distance and greatest groundwater flow velocities (i.e., highest hydraulic gradients) between the northern field and the groundwater-lowering ditch occurred due south of the "SECONDARY COMPOSTING (Area 2)". These site characteristics suggest that this is the most likely location for groundwater-to-surface water discharge to occur (during the highest annual water table elevations) For this reason, Cpec believes one mid-site groundwater monitoring well at this location (MW-2_Figure 4), combined with surface water sampling, will be sufficient to determine groundwater-to-surface water discharge potential at the facility.

All monitoring wells shall be constructed in accordance with 15A NCAC 2C .0100 and sampled as outlined in this monitoring plan. All groundwater monitoring wells (i.e., Type II) shall be constructed of 2 inch PVC pipe and have a screened interval to allow the infiltration of water. General monitor well construction specifications are shown on Figure 5. Monitor wells construction specifics such as total depth and screen lengths are to be determined during well installation. However, final well construction shall ensure that the depth and screen length are sufficiently adequate to provide representative groundwater samples at any time during the year.

3.2 Surface Water Sampling Points

We recommend the three surface water monitoring points (SW-1, SW-2, and SW-3)(Figure 4) be sampled on a semi-annual basis. Should a contaminant migration issue emerge at MW-2 or in the surface water samples in the future, Cpec recommends revising the WQMP (i.e., add additional monitor points) as necessary to address migration issues.

4.0 MONITORING PROGRAM

4.1 Guidance Documents

Sampling, analysis and submittals shall be performed in accordance with this plan and the following guidance documents, which may be found on the Solid Waste Section page of the NCDENR Division of Waste Management website:

- Guidelines for Groundwater, Soil, and Surface Water Sampling – NCDENR-DWM Solid Waste Section, revised 4/ 2008
- 10/27/2006 Memo from NCDENR-DWM, Solid Waste Section, "New Guidelines for Electronic Submittal of Environmental Monitoring Data"
- 2/23/2007 Memo from NCDENR-DWM, Solid Waste Section, "Addendum to October 27, 2006, North Carolina Solid Waste Section Memorandum Regarding New Guidelines for Electronic Submittal of Environmental Data"
- 10/16/2007 Memo from NCDENR-DWM, Solid Waste Section, "Environmental Monitoring Data for North Carolina Solid Waste Management Facilities"

Additionally, applicable local, state, and federal health and safety requirements will be followed. Requirements for the disposal of any investigation derived wastes will also be followed.

4.2 General Sampling Protocol

4.2.1 Fuel Powered Equipment

Fuel-powered equipment, such as generators for pumps, must be situated away and downwind from all site activities (ie. purging and sampling). If field conditions prevent such placement, then the fuel source must be placed as far away as possible from the sampling activities. The conditions of sampling must be described in detail in the field notes.

If fuel must be handled, it should be done the day before sampling. Effort should be made to avoid handling fuels on the day of sampling. If fuels must be dispensed during sampling activities, dispense fuel downwind and well away from any sampling locations. Wear gloves while working with fuel and dispose of the gloves away from sampling activities. Wash hands thoroughly after handling any fuels.

4.2.2 Decontamination of Field Equipment

All non-dedicated equipment that will come in contact with well casings and water will be decontaminated between wells. The procedure for decontaminating non-dedicated equipment is as follows:

1. Don new powder-free nitrile or latex gloves.
2. Clean item with tap water and phosphate-free laboratory detergent (Liquinox or equivalent), using a brush if necessary to remove particulate matter and surface films.
3. Rinse thoroughly with pesticide grade isopropanol and allow to air dry.
4. Rinse with organic-free water (Milli-Q water or other ultra-pure water) and allow to air dry.
5. Wrap with commercial-grade aluminum foil, if necessary, to prevent contamination of equipment during storage or transport.

It should be noted that Liqui-Nox detergent solutions will be stored in a clearly marked HDPE or PP container. Containers for pesticide-grade isopropanol will be made of inert materials such as Teflon, stainless steel, or glass.

Sampling will be planned and conducted in such a way as to minimize the need for decontamination in the field through the use of dedicated sampling equipment, such as a new disposable Teflon bailer at each well. Unclean equipment will be segregated from clean equipment during all field activities. All clean equipment will remain in the manufacturer's packaging until use, or will be wrapped in commercial-grade aluminum foil or untreated butcher paper.

4.2.3 Field Logbook

The field technician will keep an up-to-date logbook documenting important information pertaining to the technician's field activities. The field logbook will document the following:

- Site Name and Location
- Date and Time of Sampling
- Climatic Conditions During Sampling Event
- Sampling Point/Well Identification Number
- Well Static Water Level
- Height of Water Column in Well
- Purged Water Volume and Well Yield (High or Low)
- Presence of Immiscible Layers and Detection Method
- Observations on Purging and Sampling Event
- Time of Sample Collection
- Temperature, pH, Temperature, DO, ORP, Turbidity, and Conductivity Readings
- Signature of Field Technician
- Relative Stream Water Level
- Surface Water Clarity
- Changes in Surface Monitoring Point Conditions and Surroundings

4.3 Groundwater Sample Collection

Groundwater samples are collected to identify, investigate, assess and monitor the concentration of dissolved contaminant constituents. This section presents details of the procedures and equipment required to perform groundwater field measurements and sampling from monitoring wells during each monitoring event. Work shall proceed from the upgradient (background) wells to downgradient (compliance) wells.

4.3.1 Water Level Measurements

Static water level and depth to the well bottom will be measured in each well prior to any purging or sampling activities. Static water level and well depth measurements are necessary to calculate the volume of stagnant water in the well prior to purging. Additionally these measurements provide a field check on well integrity, degree of siltation, and are used to prepare potentiometric maps, calculate aquifer flow velocities and monitor changes in site hydrogeologic conditions.

Groundwater depths will be measured to a vertical accuracy of 0.01 feet relative to established wellhead elevations. Each well will have a permanent, easily identified reference point on the lip of the well riser

from which all water level measurements will be taken. The elevation of the reference point will be established by a Registered Land Surveyor.

Upon opening each well, new nitrile or latex gloves will be donned. Appropriate measures will be taken during all measurement activities to prevent soils, decontamination supplies, precipitation, and other potential contaminants from entering the well or contacting clean equipment.

An electronic water level indicator will be used to accurately measure depth to groundwater in each well and/or piezometer. The electronic water level indicator will be constructed of inert materials such as stainless steel and Teflon (example). Between each well, the device will be thoroughly decontaminated by washing with non-phosphate (Liqui-Nox) soap and rinsing with organic-free water to prevent cross contamination from one well to another.

The following measurements will be recorded in a dedicated field book prior to sample collection (see Section 4.2.1 for detailed description of field notes to be collected):

- Depth to static water level and well bottom (to the nearest 0.01 foot)
- Height of water column in the riser (based upon measured depth of well)
- Condition of wellhead protective casing, base pad and riser
- Changes in condition of well and surroundings

4.3.2 Monitor Well Evacuation

Water accumulated in each well may be stagnant and unrepresentative of surrounding aquifer conditions, and therefore must be removed to insure that fresh formation water is sampled. Each well will be purged of standing water in the well casing following the measurement of the static water level. Monitoring well evacuation should be performed in upgradient wells first, and moving to downgradient wells.

New nitrile or latex gloves will be donned for all well purging and sampling activities and whenever handling decontaminated field equipment. Appropriate measures will be taken during all measurement, purging and sampling activities to prevent surface soils, decontamination supplies, precipitation, and other potential contaminants from entering the well or contacting cleaned equipment. All monitoring/sampling will be conducted by moving from the upgradient well to the downgradient wells (moving from least contaminated to potentially most contaminated wells).

The volume of standing water in the well riser and screen will be calculated immediately before well evacuation during each monitoring event. A standing water volume will be calculated for each well using measured static water level, well depth and well casing diameter according to the following equation:

$$V = (TD - SWL) \times C$$

Where: V = One well volume
TD = Total depth of the well (in feet)
SWL = Static water level (in feet)
C = Volume constant for given well diameter (gallons/foot)
C = 0.163 gal/ft for two-inch wells
C = 0.653 gal/ft for four-inch wells.

After the volume of standing water within the casing is established, a minimum of three and a maximum of five well casing volumes of water will be evacuated from each well. New, disposable bailers with

either double or bottom check-valves will be used to purge each well. Disposable purge bailers will be constructed of fluorocarbon resin (Teflon) or inert plastic suitable for the well and ground conditions. Each bailer will be factory-clean and remain sealed in a plastic sleeve until use. A new Teflon-coated stainless steel, inert mono-filament line or nylon cord will be used for each well to retrieve the bailers.

Wells will be purged at a rate that will not cause recharge water to be excessively agitated or cascade through the screen. Care will also be taken to minimize disturbance to the well sidewalls and bottom which could result in the suspension of silt and fine particulate matter. The volume of water purged from each well and the relative rate of recharge will be documented in sampling field notes. Wells which are of very low recharge rates will be purged once until dry. Damaged, dry or low yielding, and high turbidity wells will noted for reconsideration before the next sampling event.

Purge water will be managed to prevent possible soil and surface water contamination. Well site management options may include temporary containment and disposal as leachate or portable activated carbon filtration.

Durable, non-dedicated equipment to be lowered into the well or which may contact the water samples will be thoroughly decontaminated before each use. Equipment shall be disassembled to the degree practical, washed with (non-phosphate) soapy potable tap water, and triple rinsed using de-ionized water. Equipment decontamination procedures are detailed in Section 4.2.2.

4.3.3 Sample Collection

After purging activities are complete, groundwater samples will be collected for laboratory analysis. Sampling is undoubtedly the most critical stage and the focus of the water quality monitoring program. Samples should be collected from least contaminated location(s) first, followed by locations of increasing contamination across the site. Prior to sample collection, all sample labels should be properly filled-out with permanent ink, such as Sharpie Pen. At a minimum, the label should identify the sample with the following information:

- Sample Location or Well Number
- Sample Identification Number
- Date and Time of Collection
- Analysis Required
- Sampler's Initials
- Preservative Used (if any)
- Other Pertinent Information As Necessary

Upon completion of the sample label, the label should be affixed to the sample bottle prior to sampling.

Sampling will occur within 24 hours of the purging of each well and as soon after well recovery as possible. Wells which fail to recharge or produce an adequate sample volume within 24 hours of purging will not be sampled.

Field measurements of temperature, pH, and specific conductivity will be made immediately prior to sampling each monitoring point. The field test specimens will be collected with the sampling bailer and placed in a clean, non-conductive glass or plastic container for observation. The calibration of the pH, temperature, conductivity and turbidity meters will be completed according to the manufacturers' specifications and consistent with *Test Methods for Evaluating Solid Waste -Physical/Chemical Methods (SW-846)*. A pocket thermometer and litmus paper will be available in case of meter malfunction.

Each well will be sampled using a new, factory-cleaned, disposable Teflon bailer with bottom check-valve and sample discharge mechanism. A new segment of Teflon-coated stainless steel wire, inert mono-filament line or nylon cord will be used to lower and retrieve each bailer. The bailer will be lowered into each well to the point of groundwater contact, then allowed to fill as it sinks below the water table. Bottom contact will be avoided in order to avoid suspending sediment in the samples. The bailer will be retrieved and emptied in a manner which minimizes sample agitation.

Samples will be transferred directly from the Teflon bailer into a sample container that has been specifically prepared for the preservation and storage of compatible parameters. A bottom emptying device provided will be used to transfer samples from bailer to sample container. The generation air bubbles and sample agitation will be minimized during bailer discharge. Groundwater samples will be collected and contained in the order of volatilization sensitivity.

Initially, only purgeable organics and total metals samples will be collected for laboratory analysis. Subsequently, other analytical methods may be required. When collected, the following order of sampling will be observed:

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. Microbiologicals
6. Measurements of pH, temperature, DO, ORP, conductivity and turbidity

Note: If the pump used to collect groundwater samples is not suitable to collect volatile or extractable organics then collect all other parameters and withdraw the pump and tubing. Then collect the volatile and extractable organics.

All samples will be collected and analyzed in an unfiltered state during sampling events. Samples for dissolved metal analysis, if subsequently required, will be prepared by field filtration using a decontaminated peristaltic pump and a disposable 0.45 micron filter cartridge specifically manufactured for this purpose.

All reusable sampling equipment including water level probes, pH/conductivity meters, interface probes, and filtering pumps which might contact aquifer water or samples will be thoroughly decontaminated between wells by washing with non-phosphate soapy, de-ionized water and rinsing with isopropanol and organic-free water. Equipment decontamination procedures are detailed in Section 4.2.2.

Upon completion of sampling at each location, the sample bottles will be placed in a cooler with ice (sealed in Ziploc bags) for preservation.

Field and trip blanks will be prepared, handled and analyzed as groundwater samples to ensure cross-contamination has not occurred. One set of trip blanks, as described later in this document, will be prepared before leaving the laboratory to ensure that the sample containers or handling processes have not affected the quality of the samples. One set of field (equipment) blanks will be created in the field at the time of sampling to ensure that the field conditions, equipment, and handling during sampling collection have not affected the quality of the samples. A duplicate groundwater sample may be collected from a single well as a check of laboratory accuracy. Blanks and duplicate containers, preservatives, handling, and transport procedures for surface water samples will be identical to those noted for groundwater samples.

Sample containers will be provided by the laboratory for each sampling event. Containers must be either new and factory-certified analytically clean by the manufacturer, or cleaned by the laboratory prior to shipment for sampling. Laboratory cleaning methods will be based on the bottle type and analyte of interest. Metal containers are thoroughly washed with non-phosphate detergent and tap water, and rinsed with (1:1) nitric acid, tap water, (1:1) hydrochloric acid, tap water, and deionized water, in that order. Organic sample containers are thoroughly washed with non-phosphate detergent in hot water and rinsed with tap water, distilled water, acetone, and pesticide quality hexane, in that order. Other sample containers are thoroughly washed with non-phosphate detergent and tap water, rinsed with tap water, and rinsed with deionized water. The laboratory shall provide proper preservatives in the sample containers prior to shipment (Section 6.0).

4.4 Surface Water Sample Collection

This section presents details of the procedures and equipment required to perform surface water field measurements and sampling from springs, streams and ponds during each monitoring event.

4.4.1 Surface Water Level Observation

Surface water quality analyses are particularly sensitive to site hydrologic conditions and recent precipitation events. Water levels may fluctuate significantly in comparison the groundwater table and may result in either diluting or increasing contaminant loadings. The scheduling of sampling events and the interpretation surface water data must take into account climatic, recent weather and sampling station conditions.

Surface water level and sampling station conditions will be observed one day prior to, and during each sampling event. Surface water observations will include the flood stage in streams, seasonal base flow conditions, and confirm location and timing for meaningful surface water quality sampling. The following objective observations will be recorded in a dedicated field book prior to sample collection:

- Relative stream water level
- Surface water clarity
- Changes in surface monitoring station conditions and surroundings

Modifications to surface sampling station conditions may be required prior to each sampling event. These modifications may include the removal of surface and submerged debris, slightly deepening the station to allow sample container immersion, or channeling/piping to consolidate local discharge. When modifications are required, sufficient time will be allowed for settlement of suspended solids between the disturbance and sample collection. A minimum settling period of four hours prior to sampling will be observed.

4.4.2 Sample Collection

Surface water samples will be obtained from areas of minimal turbulence and aeration. New nitrile or latex gloves will be donned prior to sample collection. The following procedure will be implemented regarding sampling of surface waters:

1. Put on new nitrile or latex gloves.
2. Hold the bottle in the bottom with one hand, and with the other, remove the cap.

3. Push the sample container slowly into the water and tilt up towards the current to fill. A water depth of six inches is generally satisfactory. Care will be taken to avoid breaching the surface or losing sample preservatives while filling the container.

If there is little current movement, the container should be moved slowly, in a lateral, side to side direction, with the mouth of the container pointing upstream.

Temperature, pH, specific conductivity and turbidity will be taken at the start of sampling as a measure of field conditions and check on the stability of the water samples over time. Measurements of temperature, pH, specific conductivity and turbidity will be recorded for all surface water samples. The calibration of the pH, temperature, conductivity , and turbidity meters will be completed at the beginning of each sampling event, according to the manufacturers' specifications and consistent with *Test Methods for Evaluating Solid Waste - Physical/Chemical Methods (SW-846)*.

Surface water samples will be collected and contained in the order of volatilization sensitivity of the parameters as follows:

- Volatile Organics and Volatile Inorganics
- Extractable Organics, Petroleum Hydrocarbons, Aggregate Organics and Oil and Grease
- Total Metals
- Inorganic Nonmetallics, Physical and Aggregate Properties and Biologicals
- Microbiologicals
- Measurements of pH, temperature, DO, ORP, conductivity and turbidity

All surface water samples will be collected unfiltered. If future dissolved metal analysis is required, samples will be prepared by field filtration using a decontaminated peristaltic filtering pump (or equivalent) and a disposable 0.45 micron filter cartridge specifically manufactured for this purpose. Surface water samples will be collected from surface water monitoring locations. Samples will be collected directly from the station in the container that has been specifically prepared for the preservation and storage of compatible parameters. Samples will be collected in a manner that assures minimum agitation. Additional blanks and duplicate samples will not be taken with the surface water samples.

All field meters which might contact surface water samples will be thoroughly decontaminated between stations by washing with non-phosphate soapy, de-ionized water and rinsed with isopropanol and organic-free water. Equipment decontamination procedures are detailed in Section 4.2.2.

Sample containers shall be prepared and provided by the laboratory for each surface water sampling event. Each sample container's preparation and preservatives shall be the same as those utilized for groundwater sampling and addressed previously in Section 4.3.3.

5.0 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

Field Quality Assurance/Quality Control (QA/QC) requires the routine collection and analysis of trip blanks to verify that the handling process has not affected the quality of the samples. Any contaminants found in the trip blanks could be attributed to:

1. interaction between the sample and the container,
2. contaminated source water, or
3. a handling procedure that alters the sample.

The laboratory will prepare a trip blank by filling each type of sample bottle with laboratory grade distilled or deionized water. Trip blanks will be placed in bottles of the specific type required for the analyzed parameters and taken from a bottle pack specifically assembled by the laboratory for each groundwater sampling event. Trip blanks will be taken prior to the sampling event and transported with the empty bottle packs. The blanks will be analyzed for volatile and purgeable organics only.

The concentration levels of any contaminants found in the trip blank will be reported but will not be used to correct the groundwater data. In the event that elevated parameter concentrations are found in a blank, the analysis will be flagged for future evaluation and possible re-sampling.

All field instruments utilized to measure groundwater characteristics will be calibrated prior to entering the field, and recalibrated in the field as required, to insure accurate measurement for each sample. The specific conductivity and pH meter shall be recalibrated utilizing two prepared solutions of known concentration in the range of anticipated values (between 4 and 10). A permanent thermometer, calibrated against a National Bureau of Standards Certified thermometer, will be used for temperature meter calibration.

6.0 SAMPLE PRESERVATION, SHIPMENT AND CHAIN-OF-CUSTODY

Methods of sample preservation, shipment, and chain-of-custody procedures to be observed between sampling and laboratory analysis are presented in the following section.

Pre-measured chemical preservatives will be provided by the analytical laboratory. Hydrochloric acid will be used as a chemical stabilizer and preservative for volatile and purgeable organic specimens. Nitric acid will be used as the preservative for samples for metals analysis.

Proper storage and transport conditions must be maintained in order to preserve the integrity of samples between collection and analysis. Ice and chemical cold packs will be used to cool and preserve samples, as directed by the analytical laboratory. Samples will be maintained at a temperature of 4° C. Dry ice is not to be used. Samples will be packed and/or wrapped in plastic bubble wrap to inhibit breakage or accidental spills.

Chain-of-Custody control documents will be placed in a waterproof pouch and sealed inside the cooler with the samples for shipping. Tape and/or custody seals shall be placed on the outside of the shipping coolers, in a manner to prevent and detect tampering with the samples.

Samples shall be delivered to the analytical laboratory within a 24-hour period in person or using an overnight delivery service to insure holding times are not exceeded. Shipment and receipt of samples will be coordinated with the laboratory. Do NOT store or ship highly contaminated samples (concentrated wastes, free product, etc.) or samples suspected of containing high concentrations of contaminants in the same cooler or shipping container with other environmental samples.

Chain-of-Custody control will be maintained from sampling through analysis to prevent tampering with analytical specimens. Chain-of-Custody control procedures for all samples will consist of the following:

1. Chain-of-Custody will originate at the laboratory with the shipment of prepared sample bottles and a sealed trip blank. Identical container kits will be shipped by express carrier to the sampler or site or picked up at the laboratory in sealed coolers.
2. Upon receipt of the sample kit, the sampler will inventory the container kit and check its consistency with number and types of containers indicated in the Chain-of-Custody forms and required for the sampling event.

3. Labels for individual sample containers will be completed in the field, indicating the site, time of sampling, date of sampling, sample location/well number, and preservation methods used for the sample.
4. Collected specimens will be placed in the iced coolers and will remain in the continuous possession of the field technician until shipment or transferal as provided by the Chain-of-Custody form has occurred. If continuous possession cannot be maintained by the field technician, the coolers will be temporarily sealed and placed in a secured area.
5. Upon delivery to the laboratory, samples will be given laboratory sample numbers and recorded into a logbook indicating client, well number, and date and time of delivery. The laboratory director or his designee will sign the Chain-of-Custody control forms and formally receive the samples. The field technician, project manager and the laboratory director will work together to insure that proper refrigeration of the samples is maintained.
6. Copies of the complete Chain-of-Custody forms will be placed in the laboratory's analytical project file and attached to the laboratory analysis report upon completion.

Chain-of-Custody forms will be used to transfer direct deliveries from the sampler to the laboratory. A coded, express delivery shipping bill shall constitute the Chain-of Custody between the sampler and laboratory for overnight courier deliveries.

7.0 LABORATORY ANALYSIS, QA/QC AND DATA REVIEW

The ground and surface water parameters will be analyzed for field indicators of water quality (pH, conductivity, temperature and turbidity) and those constituents listed in Table 5. All analytical methods are taken from *Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846)* or *Methods for the Chemical Analysis of Water and Wastes* and will be consistent with DWM policies regarding analytical methods and reporting limits. Analysis will be performed by a laboratory certified by NCDENR for the analyzed parameters.

Formal environmental laboratory Quality Assurance/Quality Control (QA/QC) procedures are to be utilized at all times. The owner/operator of the facility is responsible for selecting a laboratory contractor and insuring that the laboratory is utilizing proper QA/QC procedures. The laboratory must have a QA/QC program based upon specific routine procedures outlined in a written laboratory Quality Assurance/Quality Control Manual. The QA/QC procedures listed in the manual shall provide the lab with the necessary assurances and documentation that accuracy and precision goals are achieved in all analytical determinations. Internal quality control checks shall be undertaken regularly by the lab to assess the precision and accuracy of analytical procedures.

The internal quality control checks include the use of calibration standards, standard references, duplicate samples and spiked or fortified samples. Calibration standards shall be verified against a standard reference obtained from an outside source. Calibration curves shall be developed using at least one blank and three standards. Samples shall be diluted if necessary to insure that analytical measurements fall on the linear portion of the calibration curve. Duplicate samples shall be processed at an average frequency of 10 percent to assess the precision of testing methods, and standard references shall be processed monthly to assess accuracy of analytical procedures. Spiked or fortified samples shall be carried through all stages of sample preparation and measurement to validate the accuracy of the analysis.

During the course of the analyses, quality control data and sample data shall be reviewed by the laboratory manager to identify questionable data and determine if the necessary QA/QC requirements are being followed. If a portion of the lab work is subcontracted, it is the responsibility of the contracted

laboratory to verify that all subcontracted work is completed by certified laboratories, using identical QA/QC procedures.

8.0 RECORD KEEPING AND REPORTING

After each monitoring event, the potentiometric surface will be evaluated to determine whether the monitoring system remains adequate and to determine the rate and direction of groundwater flow at the site.

The direction of groundwater flow will be determined by a comparison of groundwater surface elevations across the site through the construction of a potentiometric surface map. Groundwater flow rate will be determined using the following equation:

$$V=KI/n$$

Where: V = Velocity (feet/day)
K = Hydraulic Conductivity (feet/day)
I = Hydraulic Gradient (foot/foot)
n = Effective Porosity of aquifer soils (unitless)

If these evaluations indicate the groundwater monitoring system is insufficient in meeting the requirements of the Rules, the monitoring system will be modified accordingly and a work plan will be submitted to NCDENR for review prior to modifications to enhance the monitoring system.

Copies of all laboratory analytical data will be forwarded to the SWS within 60 calendar days of the receipt of laboratory data. The analytical data submitted will specify the date of sample collection, the sampling point identification and include a map of sampling locations. Should a significant concentration of contaminants be detected in ground and surface water, as defined in North Carolina Solid Waste Rules, Groundwater Quality Standards, or Surface Water Quality Standards, the owner/operator of the facility shall notify the SWS and will place a notice in the facility records as to which constituents were detected.

All monitoring reports will be submitted with the following:

- An evaluation of potentiometric surface
- Analytical laboratory reports and summary tables
- A Solid Waste Environmental Monitoring Data Form (Appendix C)
- Laboratory Data submitted in accordance with the Electronic Data Deliverable Template.

Monitoring reports may be submitted electronically by e-mail or in paper copy form. Copies of all laboratory results and water quality reports for the CAS Compost Facility will be kept at the Craven Ag Service office. Reports summarizing all groundwater quality results and data evaluation will be submitted to the Division of Waste Management for each sampling event. Depending upon the analytical results received, graphical analyses may be performed to evaluate plume movement and contaminant trends over time.

9.0 MONITORING PROGRAM MODIFICATIONS

9.1 Well Abandonment/Rehabilitation

After each groundwater monitoring event, the potentiometric surface will be evaluated to determine whether the monitoring system remains adequate and to determine the rate and direction of groundwater flow at the site.

Should wells become irreversibly damaged or require rehabilitation, the SWS shall be notified. If monitoring wells and/or piezometers are damaged irreversibly they shall be abandoned under the direction of the SWS. The abandonment procedure in unconsolidated materials will consist of 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.

9.2 Additional Well Installations

Any additional well installations will be carried out in accordance with SWS directives. If future potentiometric maps reveal that the depths, location, or number of wells is insufficient to monitor potential releases of solid waste constituents from the CAS composting facility, new well locations and depths will be submitted to the SWS for approval.

All monitoring wells, new or replacement, shall be installed under the supervision of a geologist or engineer who is registered in North Carolina and who will certify to the SWS that the installation complies with North Carolina Regulations. Upon installation of future wells the documentation for the construction of each well will be submitted by the registered geologist or engineer within 30 days after well construction.

10.0 IMPLEMENTATION SCHEDULE

This Water Quality Monitoring Plan shall be implemented upon approval. Analyses shall be performed at a minimum on a semi-annual basis.

11.0 REFERENCES

Beyer, F. 1991. North Carolina: The Years Before Man. Carolina Academic Press. Durham, NC.

Heath, R.C. 1980. Basic Elements of Ground-Water Hydrology with Reference to Conditions in North Carolina. USGS, Water-Resources investigation Report 80-44.

NCAC 15A:13B North Carolina Administrative Code, Title 15A, Subchapter 13B, North Carolina Department of Environment, Health and Natural Resources. 2006. Laws and Rules for Solid Waste Management.

Skaggs, R.W. 1980. DRAINMOD reference report, Methods for design and evaluation of drainage-water management systems for soils with high water tables. United States Department of Agriculture, Soil Conservation Service.

United States Department of Agriculture, Natural Resources Conservation Service. 1996. National Soil Survey Handbook, Title 430-VI.

12.0 CERTIFICATION

The water quality monitoring plan for this facility has been prepared by a qualified geologist who is licensed to practice in the State of North Carolina. The plan has been prepared based on field assessment of site conditions and NC water quality monitoring standard protocol. In accordance with North Carolina Solid Waste Regulations, this Water Quality Monitoring Plan should provide early detection of any release of hazardous constituents to the surficial aquifer, so as to be protective of public health and the environment. No other warranties, expressed or implied, are made.

Signed _____

Printed Thomas H. Hinson

Date 07/19/13

NORTH CAROLINA LICENSED SEAL 1320 GEOLOGIST THOMAS HARDIN HINSON

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

TABLES

Table 1. Representative deep soil description at the CAS Site (Tarboro Series Taxajunct).

horizon (USDA)	**depth** (ft-bls)	**soil structure*** (USDA)	**soil texture*** (USDA)	**soil color*, mottling*, and comments**	[1] ***e* PermR** (in/hr)
A	0-0.3	single-grained; loose	sand (fine)	dark gray (10YR 4/2)	>20
C1	0.3-5.0	single-grained; loose	sand (fine to medium)	brownish yellow (10YR 6/6)	>20
C2	5.0-8.0	single-grained; loose	sand (medium to coarse)	variable colors (yellow, yellow brown, reddish brown to colorless)	>20

estimated average seasonal high water table: >5.0' below land surface (bls)*

1 ePermR - estimated permeability range (USDA, 1996)

* determined via standard USDA field methods

Table 2. Well construction details and water table data.

Well ID	screen diameter (in)	boring diameter (in)	casingL above scrn (ft)	screen length (ft)	casing HAS (ft)	total depth (ft)	ground elevation (ft/msl)	TOC elevation (ft/msl)	WT DBC 05/09/13 (ft)	WT elevation 05/09/13 (ft/msl)	WT DBS 05/09/13 (ft)	screen DBS (ft)	water column (ft)
P-1	1.25	3	4.33	1.67	0.17	5.83	13.52	13.69	3.37	10.32	3.20	4.17	2.63
P-2	1.25	3	7.00	1.00	0.92	7.08	15.82	16.74	6.60	10.14	5.68	6.08	1.40
P-3	1.25	3	4.33	1.00	1.08	4.25	11.94	13.02	3.55	9.47	2.47	3.25	1.78
P-4	1.25	3	8.00	1.00	2.83	6.17	14.53	17.36	7.94	9.42	5.11	5.17	1.06
P-5	1.25	3	7.67	1.50	1.92	7.25	15.63	17.55	7.70	9.85	5.78	5.75	1.47
P-6	1.25	3	8.00	1.00	1.92	7.08	15.81	17.73	8.04	9.69	6.12	6.08	0.96
P-7	1.25	3	7.33	1.00	2.83	5.50	13.33	16.16	6.78	9.38	3.95	4.50	1.55
P-8	1.25	3	4.00	2.00	1.50	4.50	8.59	10.09	2.93	7.16	1.43	2.50	3.07
P-9	1.25	3	8.25	1.50	1.50	8.25	14.52	16.02	8.12	7.90	6.62	6.75	1.63
P-10	1.25	3	8.25	1.50	0.38	9.38	16.11	16.48	8.35	8.13	7.98	7.88	1.40
P-11	1.25	3	6.33	2.17	1.92	6.58	13.13	15.05	6.32	8.73	4.40	4.42	2.18
P-12	1.25	3	7.75	1.67	1.75	7.67	14.54	16.29	7.54	8.75	5.79	6.00	1.88
P-13	1.25	3	6.25	1.00	1.33	5.92	13.47	14.80	5.85	8.95	4.52	4.92	1.40
P-14	1.25	3	9.92	1.67	2.25	9.33	16.94	19.19	11.10	8.09	8.85	7.67	0.48
P-15	1.25	3	6.25	1.00	1.75	5.50	14.23	15.98	5.86	10.12	4.11	4.50	1.39
P-16	1.25	3	7.75	1.50	2.50	6.75	15.27	17.77	8.59	9.18	6.09	5.25	0.66
P-17	1.25	3	9.92	1.50	3.58	7.83	16.11	19.69	10.52	9.17	6.94	6.33	0.90
P-18	1.25	3	10.25	1.50	3.75	8.00	15.44	19.19	9.85	9.34	6.10	6.50	1.90
P-19	1.25	3	10.25	1.50	3.75	8.00	13.91	17.66	8.33	9.33	4.58	6.50	3.42
P-20	1.25	3	10.25	1.50	3.08	8.67	16.66	19.74	10.40	9.34	7.32	7.17	1.35
P-21	1.25	3	10.08	1.50	3.50	8.08	15.44	18.94	9.59	9.35	6.09	6.58	1.99
P-22	1.25	3	9.92	1.50	4.17	7.25	14.42	18.59	9.23	9.36	5.06	5.75	2.19
P-23	1.25	3	10.25	1.50	4.33	7.42	14.25	18.58	8.86	9.72	4.53	5.92	2.89
Ks-1	1.25	3	8.17	0.50	1.83	6.83	15.68	17.51	7.67	9.84	5.84	6.33	1.00
Ks-2	1.25	3	9.33	0.50	1.50	8.33	14.49	15.99	8.08	7.91	6.58	7.83	1.75
Ks-3	1.25	3	8.67	0.50	2.00	7.17	14.60	16.60	7.81	8.79	5.81	6.67	1.36
									mean =	**9.13**	**5.42**		
										min =	**1.43**		
										max =	**8.85**		

casing HAS - casing height above land surface
total depth - from land surface
ground elevation - average ground elevation in feet above mean sea level
TOC elevation - Top of Casing elevation in feet above mean sea level
WT DBC - water table depth below top of well casing
WT elevation - water table elevation in feet above mean sea level
WT DBS - depth to water table below land surface
screen DBS - depth to top of well screen below land surface
water column - height of water in well above the well's base

Table 3. Saturated Zone - Ksat estimates in the C2 horizon (slug test method).

Test ID	test interval DBS (ft)		(ft)	soil horizon (USDA)	predominate soil texture (USDA)	mean *e* Ksat (ft/d)	(in/hr)	(gpd/sq.ft.)
Ks-1	6.33	to	6.83	C2	sand	64.90	32.45	485
Ks-2	7.83	to	8.33	C2	sand	79.91	39.96	598
Ks-3	6.67	to	7.17	C2	sand	55.77	27.89	417
					mean =	66.86	33.43	500

test interval - vertical interval occupied by well screen below land surface
soil horizon - soil horizon designation at well screen location
predominate soil texture - predominate soil texture at well screen location
raw displacement data are embedded in slug test solution reports located in Appendix C

Table 4a. Proposed monitor wells (see Figure 4).

Well ID	drilling method	screen diameter (in)	boring diameter (in)	total depth (ft)	screen length (ft)	casing HAS (ft)	ground elevation (ft/MSL)	TOC elevation (ft/MSL)	general monitoring location
MW-1	HSA	2	6	20	15	TBD	TBD	TBD	upgradient of operation
MW-2	HSA	2	6	20	15	TBD	TBD	TBD	upgradient of GW-lowering ditch
MW-3	HSA	2	6	20	15	TBD	TBD	TBD	downgradient of operation (West)
MW-4	HSA	2	6	20	15	TBD	TBD	TBD	downgradient of operation (East)

total depth - from land surface
casing HAS - casing height above land surface
ground elevation - average ground elevation in feet above mean sea level
TOC elevation - Top of Casing elevation in feet above mean sea level
HSA - hollow-stem auger; TBD - to be determined

Table 4b. Proposed surface water sampling locations (see Figure 4).

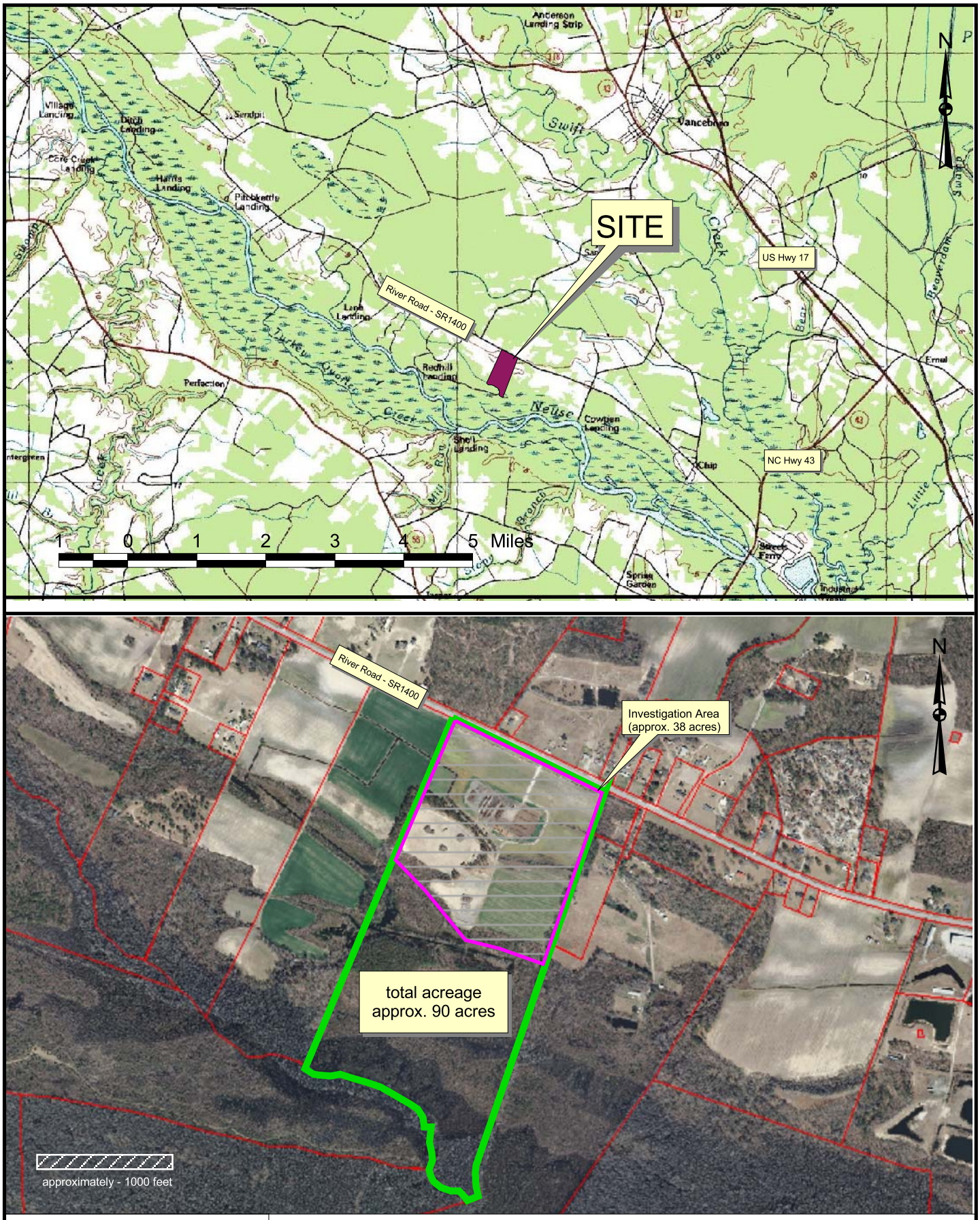
ID	general monitoring location
SW-1	East-West trending ditch: upstream of operation
SW-2	East-West trending ditch: mid-stream of operation
SW-3	East-West trending ditch: downstream of operation

Table 5. Proposed analyte list for groundwater and surface water sampling.

Constituent	NC groundwater limit (15A NCAC 02L) ug/L (unless otherwise stated)	Method ID	sample type (groundwater GW/ surface water SW)	baseline sampling (yes or no)	sampling frequency
Arsenic	10	EPA 200.7/200.8	GW/SW	y	TBD
Cadmium	2	EPA 200.7/200.8	GW/SW	y	TBD
Chromium	10	EPA 200.7/200.8	GW/SW	y	TBD
Copper	1 mg/L	EPA 200.7/200.8	GW/SW	y	TBD
Lead	15	EPA 200.7/200.8	GW/SW	y	TBD
Mercury	1	EPA 245.1	GW/SW	y	TBD
Molybdenum	no 2L limit	EPA 200.7/200.8	GW/SW	y	TBD
Nickel	100	EPA 200.7/200.8	GW/SW	y	TBD
Selenium	20	EPA 200.7/200.8	GW/SW	y	TBD
Zinc	1 mg/L	EPA 200.7/200.8	GW/SW	y	TBD
Ammonia	1 mg/L	EPA 350.1	GW/SW	y	TBD
Nitrate (as N)	10 mg/L	EPA 353.2	GW/SW	y	TBD
Nitrite (as N)	1 mg/L	EPA 353.2	GW/SW	y	TBD
Herbicides*	-	SW 846 8151A	GW/SW	y	TBD
Pesticides*	-	SW 846 8151B	GW/SW	y	TBD
Total coliform	1 cfu/100 mL	EPA 9222B	GW/SW	y	TBD

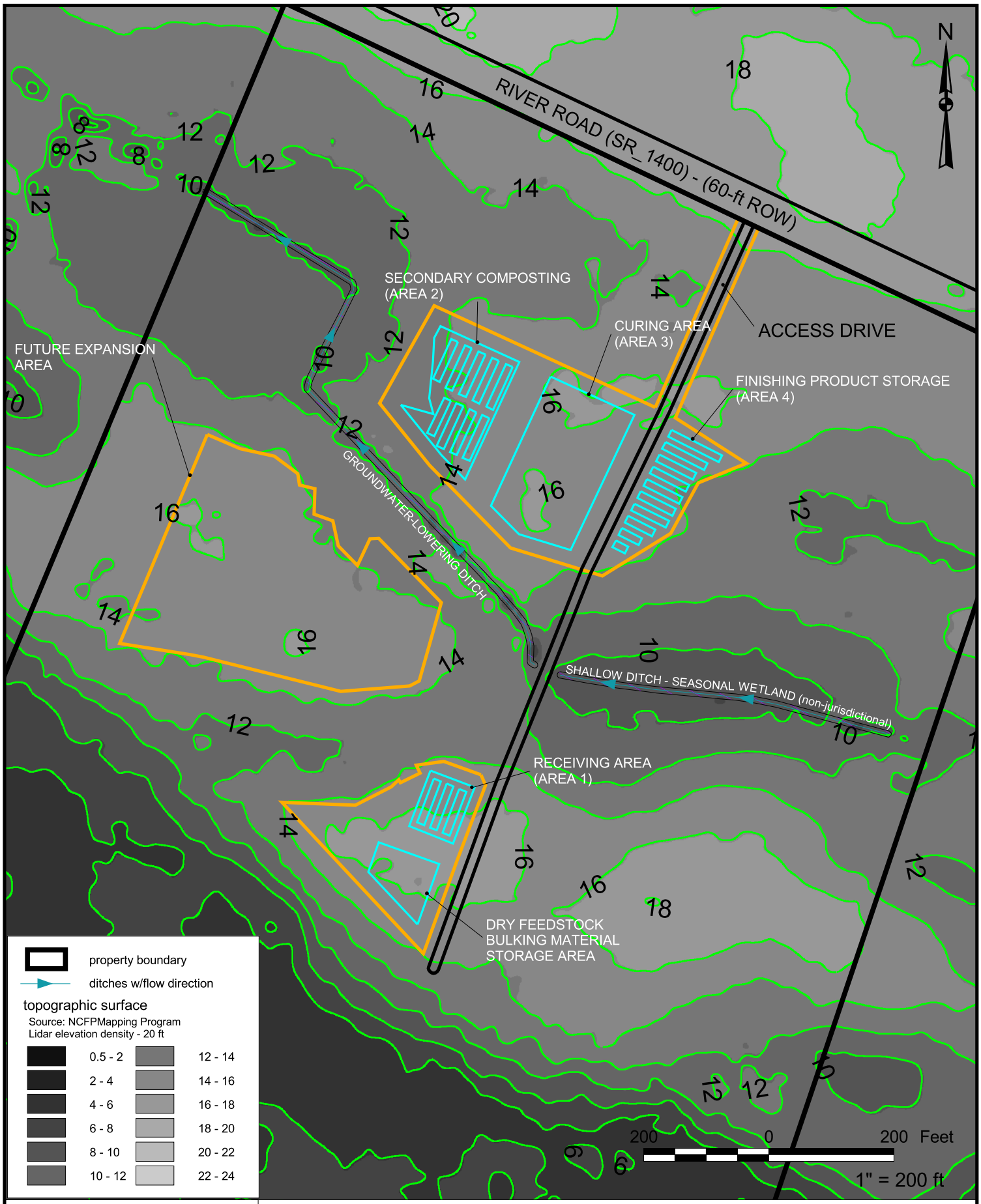
NOTE: Most recent version of EPA Method for analysis should be used
TBD - to be determined from baseline sampling
* - multiple species analysis (REF: 15A NCAC 02L .0202 for specific species concentration limits)

FIGURES



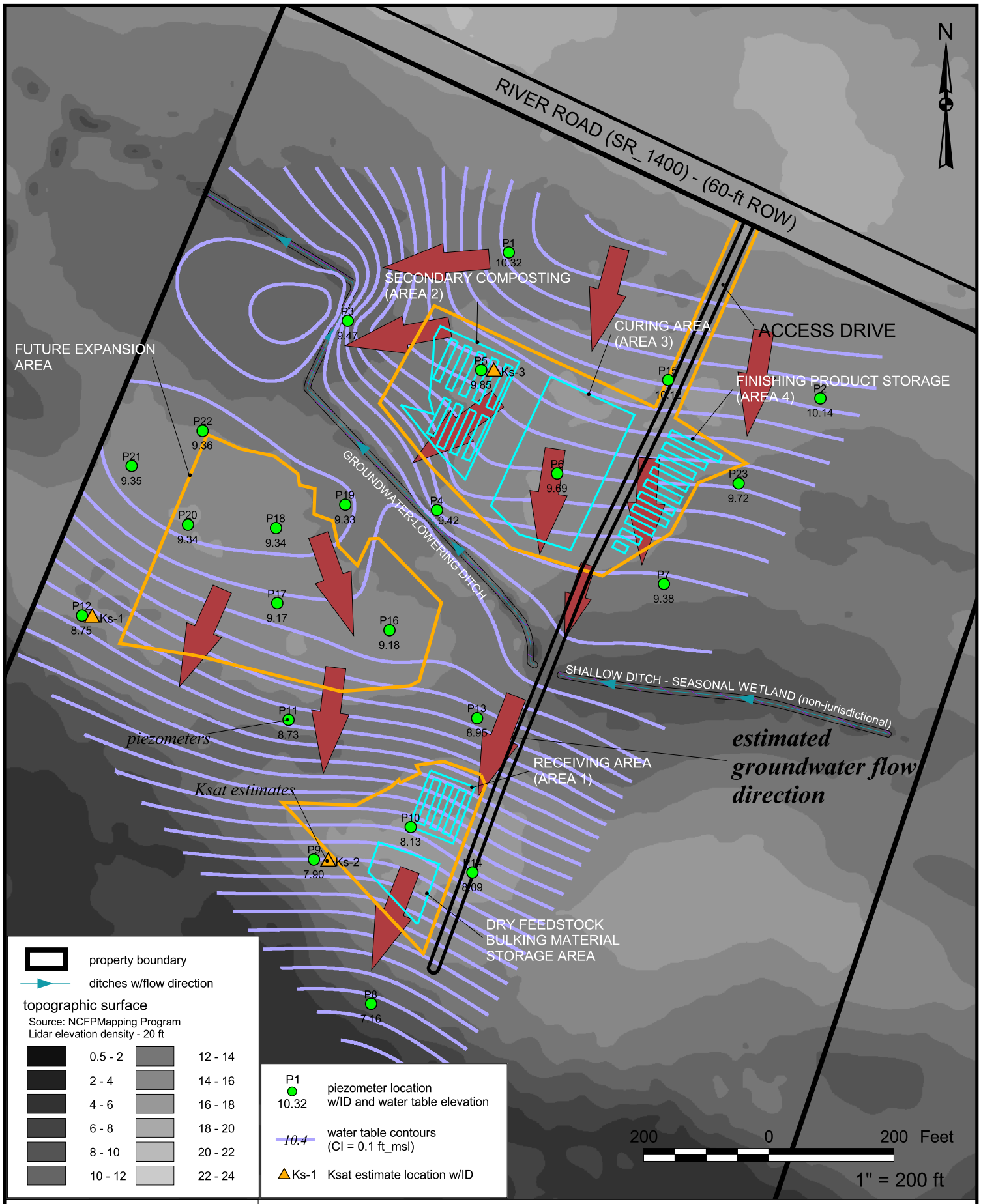
CPEC Environmental, Inc.

Figure 1. Location of the Craven Agricultural Services (CAS) composting facility, Craven County, NC.



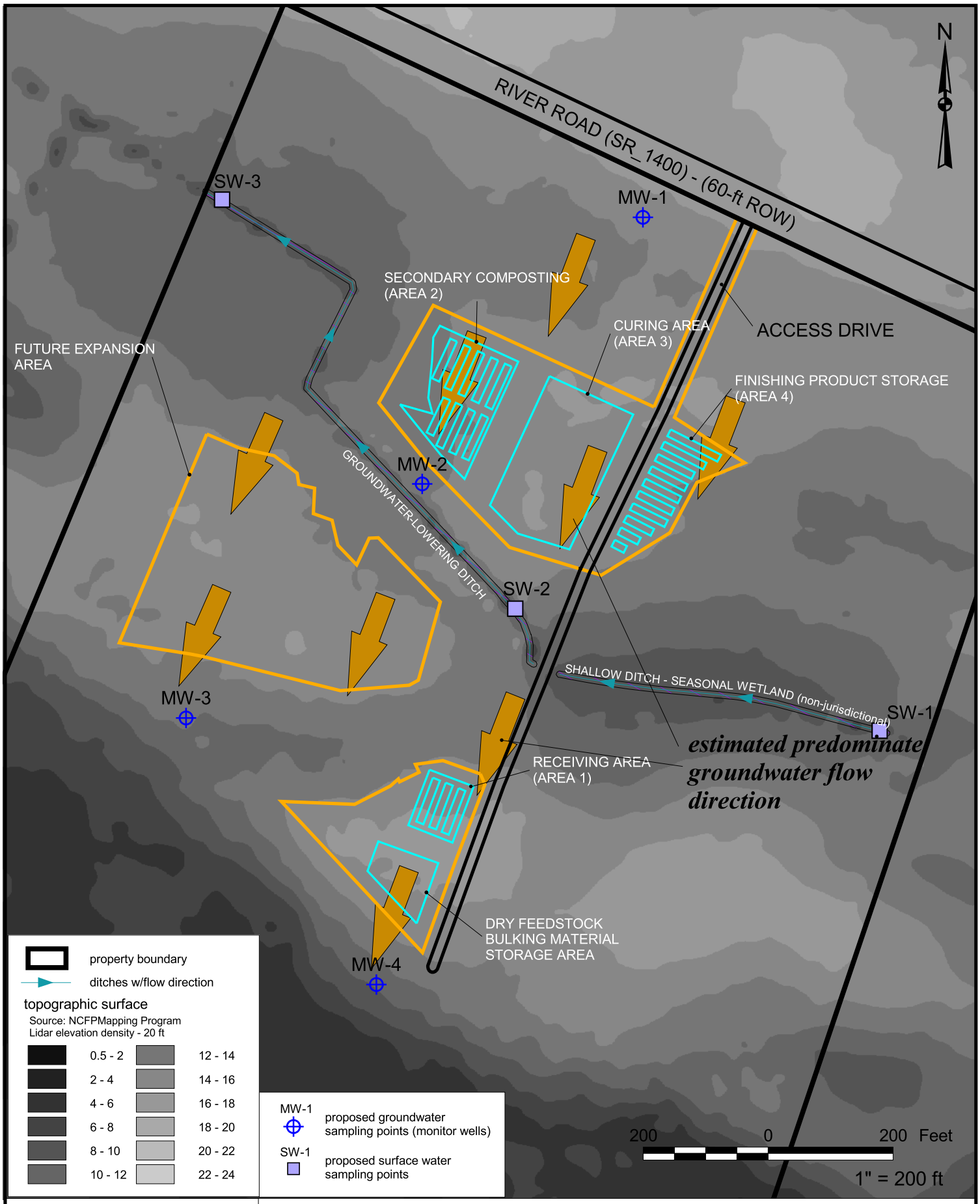
CPEC Environmental, Inc.

Figure 2. Proposed composting facility site map with local topography and drainage features.



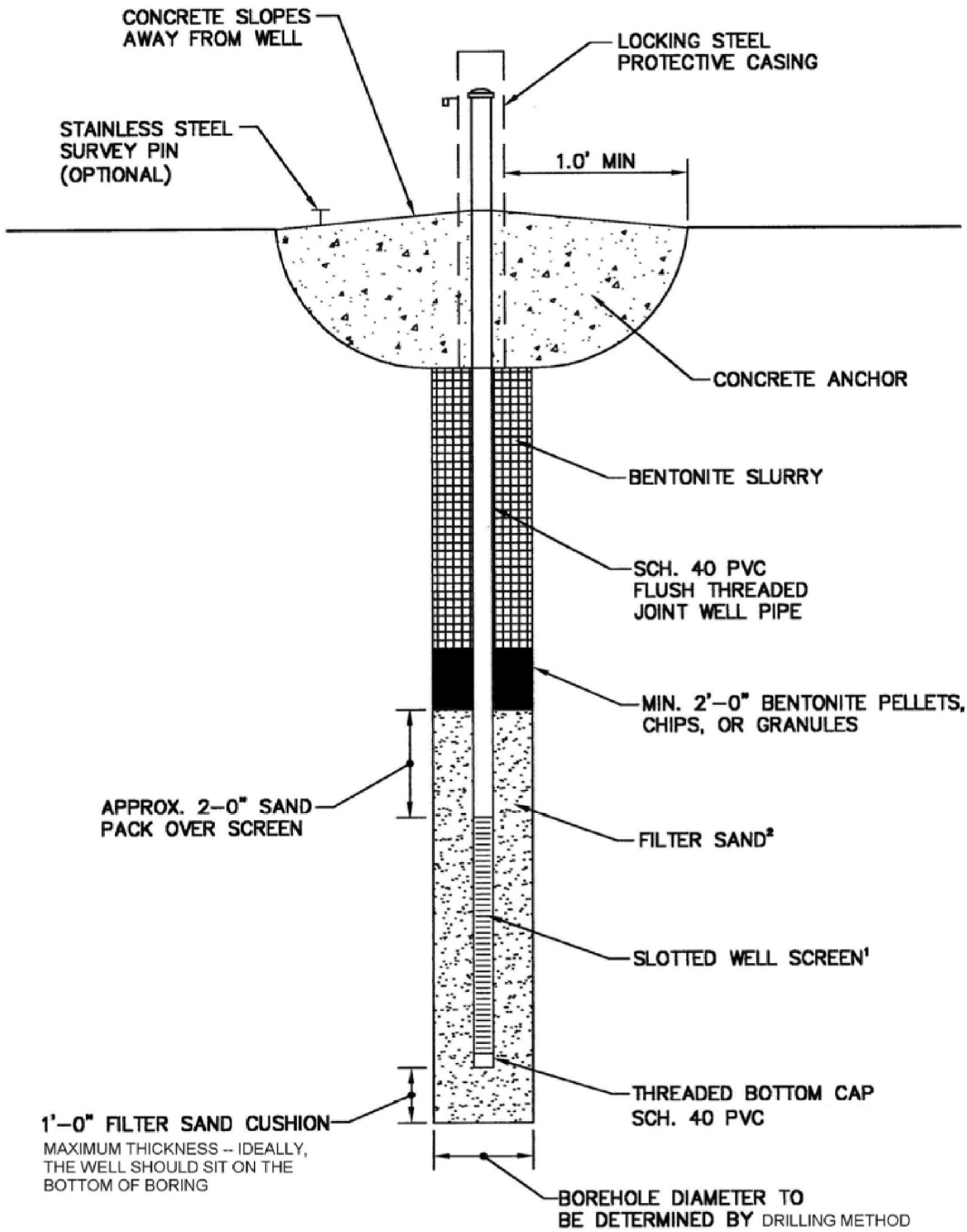
CPEC Environmental, Inc.

Figure 3. Water table (piezometric) surface and generalized groundwater flow direction on 05/09/13 with local topography base map.



CPEC Environmental, Inc.

Figure 4. Estimated predominate groundwater flow direction and proposed groundwater and surface water sampling locations.



CPEC Environmental, Inc.

Figure 5. Type II monitor well construction schematic.

APPENDICES

Appendix A - Investigation Field Procedures
Appendix B - Regulatory Correspondence
Appendix C - Supporting Documentation, Slug Test Reports and DWM Reporting Forms

Appendix A

Investigation Field Procedures

Site Survey and Mapping A-1
Subsurface Descriptions A-1
Observation Well Installation A-1
In-situ Saturated Hydraulic Conductivity Estimates A-2

Site Survey and Mapping

Before the site visit, Cpec Environmental, Inc. (Cpec) compiled all relevant site information (ownership, site maps, USGS topographic maps, tax maps, aerial photographs, etc. During the site visit, Cpec recorded (on a horizontal orthogonal grid) the location of property boundaries and other site elements such as structures, roads, fences, utilities, wells, ditches, creeks, etc. Cpec produced a comprehensive site map incorporating all pertinent site information. Cpec observed conventional surveying techniques, during land elevation readings. A registered land surveyor did not perform elevation readings.

Subsurface Descriptions

Soil-profile descriptions were described from boring cuttings. Representative samples were collected from selected soil horizons and at abrupt lithologic or hydraulic boundaries. Qualitative subsurface characterizations included: soil morphological properties (e.g., texture, structure, color, presence and type of redoximorphic features, etc.), thickness and type of restrictive horizons, depth to saprolite and bedrock (parent material), lithologic character of saprolite and bedrock, ambient soil wetness conditions, and seasonal high water table estimates.

Observation Well Installation

Cpec installed several 1.25-inch diameter observation wells for static water table measurements, aquifer transmissivity tests, and groundwater sampling (if applicable). Observation wells are "temporary" wells and <u>not</u> intended to be used for long-term groundwater monitoring.

Observation wells were constructed of flush-jointed PVC casings with 0.010-inch slot screens and no glues or solvents were used. After the well (riser and screen) was inserted into the borehole, the well annulus was backfilled with coarse silica sand to ~0.25-ft above the well screen. Bentonite was used to fill the annular space above the sand-pack to the ground surface. The bentonite seal prevents cross-contamination from above the well's screened interval. All wells were similarly constructed and completed above the finished grade. Upon completion, each well was "developed" by withdrawing five bore volumes of groundwater or until groundwater was relatively clear. After achieving atmospheric equilibrium, a static water table measurement was made. Installation methods are described below.

<u>Hand-auger method</u>

Cpec used hand augers (three-inch diameter) to bore to the target depth. The observation well was inserted into the open borehole.

In-situ Saturated Hydraulic Conductivity (K_{sat}) Estimates

Saturated zone K_{sat} estimates

Slug Test Method

Cpec conducted "slug" tests on selected observation wells to obtain saturated hydraulic conductivity (K_{sat}) estimates of the host geologic material. The tests measured the rate at which the screened interval of a water-bearing formation released or accepted a specific volume of water introduced into, or withdrawn from, the well as a single slug. The water levels were continuously changing and were measured with a pressure transducer/data logger which is compared to the static pre-test water-table level. Data collection was terminated when the water level had achieved less than a 95% recovery to pre-test levels. Field data and results are presented in Appendix C.

The slug test is one of the most commonly used field methods for obtaining in situ estimates of K_{sat}. Despite its prevalence, the method has received a considerable amount of criticism in the ground-water environmental consulting community. A primary cause of criticism is the discrepancy that was often observed between slug test estimates and other information collected during more detailed site investigations (e.g., geologic and geophysical logs, core samples, pumping tests, etc.). Although spatial variability and different data-acquisition scales can explain a portion of the observed discrepancies, a significant component of this difference undoubtedly is a product of a somewhat casual attitude that was often directed at the performance and analysis of slug tests. Since slug tests have considerable logistical and economic advantages over other alternative approaches, it was imperative that these tests be done in such a manner so to yield parameter estimates of as high a quality as possible.

A 5-year study (Butler et al, 1996) proposed practices for improving the quality and reliability of slug tests. Butler et al. (1996) proposed numerous guidelines to achieve higher quality estimates but stresses the most significant ones as:

1) considerable attention should be given to well construction and development;
2) three or more slug tests should be performed at a given well during a given test period;
3) two or more different initial head displacements (H_0) should be used at each well;
4) use of data-acquisition equipment (e.g., pressure transducers) that enables collection of a large quantity of high-quality data;
5) the slug method, whether rising-head ("slug-out") or falling-head ("slug-in"), should be designed to allow the "slug" to be introduced in a near-instantaneous manner;
6) the number of tests performed across the site, slug method, data interpretation method, and data-acquisition equipment should be carefully chosen and appropriate for site conditions.
7) Site condition considerations included aquifer anisotropy and heterogeneity; deep water tables vs. shallow water tables; unconfined vs. confined aquifers; well-screen interval below or across the static water table; highly permeable vs. hydraulically-tight materials; etc.

A common field application of the slug test was in shallow wells that partially penetrate unconfined aquifers. Most slug test analysis methods in unconfined aquifers were based on several simplifying assumptions:

1) the specific storage of the formation was negligible;
2) changes in the position of the water table due to a slug test were so small that the water table can be represented as a constant-head boundary;
3) flow above the water table can be ignored;
4) there was no near-well zone of disturbance created by drilling or development;
5) the formation was isotropic with respect to hydraulic conductivity.

In 1995, Hyder and Butler assessed the most significant well and formation parameters that introduce error into hydraulic conductivity estimates from slug tests on partially-penetrating wells in unconfined aquifers. Their assessment includes: aspect ratio [screen length (b)/screen radius (r_w)], aquifer anisotropy [vertical K_{sat} (K_z)/radial K_{sat} (K_r)], aquifer specific storage ( ), well-screen distance from boundaries (e.g., water table, confining units, etc.), and low/high permeability well skins (i.e., disturbed near-well zones created by well drilling and development). Although a comprehensive article review was not possible, several important generalizations or "rules of thumb" were derived from the article that will allow the best possible estimate of K_{sat} from slug tests. These included

1) a moderate to high aspect ratio (b/r_w = 40-200) will yield the best results in most situations and should be achieved whenever possible;
2) in homogeneous, isotropic formations with low storage coefficients (<0.001) and moderate aspect ratios (b/r_w = 40-100), the Bouwer and Rice Method (Bouwer and Rice, 1976) should provide estimates that were within 10% of the formation K_{sat}. There will, however, be considerable variation in the quality of the estimates as a function of the distance of the screened interval from aquifer boundaries;
3) when aquifer specific storage coefficients were suspected to be high (>0.001)(e.g., low permeability, clay-rich formations) and within homogenous, anisotropic formations, the Cooper et al. Method (Cooper, et al., 1967) should provide the best K_{sat} estimates;
4) in cases of a high-conductivity well skin and moderate aspect ratios (b/r_w = 40-100), the Bouwer and Rice Method will provide estimates within 25% (+ or -) of the formation K_{sat};
5) in cases of a low-conductivity well skin, the Bouwer and Rice Method estimates can be heavily weighted towards the conductivity of the skin. However, proper well development can eliminate high contrast between the formation and the well skin, therefore, reducing parameter estimate error.

Understanding the significance of compounded error, Cpec attempts to eliminate error whenever possible via following suggestions outlined above. However, error can only be minimized, not eliminated. Cpec customizes the slug method (rising-head or falling-head), data-interpretation method [Cooper et al., Bouwer and Rice, Hvorslev (Hvorslev, 1951), Auger-hole (Amoozegar and Warrick, 1986), etc.], and data-acquisition equipment (pressure transducer vs. manual readings) to each site's unique subsurface conditions.

In general, within confined aquifers, Cpec utilizes the Cooper et al. Method. Within unconfined aquifers with wells screened below the static water table, we utilize the Cooper et al. Method,

Bouwer and Rice Method, or Hvorslev Method. Within unconfined aquifers with wells screened across the static water table, we utilize the Hvorslev Method or the Auger-hole Method. The slug method (rising-head or falling-head) was chosen based on three primary criteria: static water-table depth, well screen location relative to the static water table, and perceived recovery rates. It is not uncommon for Cpec to utilize many combinations of the fore-mentioned slug and interpretation methods for results comparisons.

Appendix B

Regulatory Correspondence

April 5, 2013 – “Application Comments Letter” (DENR-DWM-Solid Waste Section).....B-1

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

Pat McCrory
Governor

Dexter R. Matthews
Director

John E. Skvarla, III
Secretary

April 5, 2013

Mr. J.W. (Billy) Dunham
Craven Ag Service
2115 W. Highway 55
New Bern, NC 28562

Re: Application for permit, Craven Ag Service Compost Facility, Craven County

Dear Mr. Dunham:

The Solid Waste Section has completed review of your revised application for permit of the above referenced facility, submitted in January 2013 by your consultants, Gary MacConnell and A.R. Rubin. The following comments should be addressed to complete the application process:

1. Groundwater:
   a. Prior to development of the groundwater monitoring plan, a field investigation should be conducted at the site. Temporary piezometers should be installed upgradient and downgradient of the composting area, and also between the northern area and the drainage ditch, to accurately determine the potentiometric groundwater surface. Soil boring logs should be prepared for each piezometer well installation to characterize site hydrogeology. The study should include an evaluation of potential groundwater to surface water discharge in the site drainage ditches.
   b. The water quality monitoring plan must be prepared by an environmental consulting firm under the seal of a board certified licensed/professional geologist that has experience with the design and construction of groundwater monitoring wells and plans. Since groundwater monitoring wells are significantly different in design from drinking water wells, the wells should be installed by a certified well driller with experience in the construction of groundwater monitoring wells.
   c. The number, spacing and depths of monitoring wells is determined based upon site specific technical information that should include investigation of aquifer thickness, groundwater flow rate, and groundwater flow direction, including seasonal and temporal fluctuations in groundwater flow.
   d. The groundwater monitoring plan must include a site map showing the location of the composting areas with respect to the entire property; a site specific topographic map with the location of the compost facility; a discussion of the site geology and hydrogeology including the results of the field study; an evaluation of whether there could be groundwater to surface water discharge for the compost areas at the site; and a sampling and analysis plan that describes sample collection and handling. The groundwater monitoring system should have at least one upgradient well. The number of downgradient wells is site specific. Detection monitoring wells are designed to monitor

1646 Mail Service Center, Raleigh, North Carolina 27699-1646
Phone: 919-707-8200 \ Internet: http://portal.ncdenr.org/web/wm

An Equal Opportunity \ Affirmative Action Employer – 50% Recycled \ 10% Post Consumer Paper

the upper portion of the aquifer. Groundwater monitoring wells are typically constructed of 2-inch PVC pipe and have a screened interval to allow the infiltration of water. They are installed in a borehole with a sand filter pack around the screen and a bentonite clay seal over the sand filter. The remainder of the borehole is grouted to the ground surface and a protective casing is installed over the riser. Groundwater monitoring wells must be installed in accordance with 15A NCAC 2C, and a well record form GW-1 must be filled out for each groundwater monitoring well and a copy submitted to the Solid Waste Section.

e. The groundwater monitoring plan should describe consistent sampling and analysis procedures that are designed to ensure monitoring results provide an accurate representation of groundwater quality at the background and downgradient wells. The plan must include procedures and techniques for sample collection, sample preservation and shipment, chain-of-custody control, and quality assurance and quality control.

f. An initial baseline groundwater sampling event should be implemented prior to operation of the new areas. Well samples should be analyzed for total metals/Method SW846 (arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc), ammonia, nitrate, nitrite, pesticides and herbicides/Method SW846, and total coliform. Based on results of the baseline sampling event, a site specific list of parameters will be considered for continued semi-annual detection monitoring events. Groundwater monitoring wells must be surveyed and tied to a permanent benchmark of known elevation measured from a USGS Survey benchmark.

2. Some of the text changes and corrections that were made to the application in the second submittal, based on the review comments, have incorrectly returned in this third submittal. For example, in G.11, "present escape of odors" was in the first submittal, and was changed to "prevent escape of odors" in the second submittal, and is now back to "present escape of odors" in the third submittal. It is possible that the review changes were made to the wrong version of the application. Please correct these errors and check entire application.
3. The feedstocks to be received at the facility are listed in three sections of the application: Section D.1, Section G.3, and Section 1.0. The list in all three places should be the same but they are not. For example, clean wood from construction operations is listed as a feedstock in Section D.1, but it is not included in the other two lists. Please correct. Where will the DAF skimmings be coming from?
4. Background and Intro, 2nd paragraph, 1st sentence – The acreages of the areas and total area appear to be incorrect.
5. Section A, 1st paragraph – The text states that the total property is over 100 acres. The property is listed as 89.34 acres on the county property website.
6. Section A – 2nd paragraph – Please clarify the 1st sentence.
7. Sections A and G - Please change Craven Ag Services, LLC to Craven Ag Service, Inc. The Secretary of State's office does not have a listing for Craven Ag Service, LLC.
8. Text and drawings should indicate that permanent makers will be maintained for (1) the curing area boundary along the north side of Area 3, to maintain the 500 foot buffer to the offsite residence, and (2) the boundaries adjacent to the floodplains and property line in all three areas.
9. Section E, 2nd paragraph – Please state that the 500 foot buffer to the residence across the road will be maintained in the northern area (or Site 3) by the placement of buffer line markers.

10. The analysis of the wood ash that was provided in consideration for the compost soil texture amendment is too high in arsenic, for both use in the pad and for a feedstock in the compost process. Is this sample from the wood ash proposed for composting? If yes, the wood ash analysis should be removed from Attachment 13. The wood ash that is proposed for composting should be sampled 4 times, taken over a period of time sufficient to represent variability or uniformity of the ash. The metal results should meet the ceiling concentrations of Table 1 in the 503 Rules (503.13). If wood ash is proposed for composting, please provide the quantity to be received as feedstock. Because of the metals, the quantity should be a small percentage of the overall volume of feedstocks received. Coal ash is not acceptable at a Type 3 compost facility.
11. For the lime mud and the wood ash, please address how the pH will be monitored and managed in the initial mix.
12. Please provide an update to the DWQ stormwater/process wastewater permit application, and the sedimentation and erosion control permit application.
13. In addition to the description of changing the soil texture in the Note #4 on Drawing C-102, it should also be described in the text of the application. The modified soil texture is required for areas used for waste receiving and storage, active composting, and curing (not just composting and curing as stated on drawing). Please provide a sketch or drawing of the boundary of areas that will receive the soil amendment, or state that the entire boundaries of Sites 1, 2, and 3 will receive the amendment in soil texture.
14. How will the reworked areas be tested/soil classified to ensure that the modified soil texture meets the requirements of 1404(a)(10)(B), that is, finer than loamy sand? The depth of soil texture modification should be 9 to 12 inches deep. Will 2 or 3 inches of ash and compost fines be enough to modify the soil texture to that depth? Drawing C-103 indicates the soil texture will be modified to 4 inches.
15. Section G.1 – Please update the sentence that states that the western site area will be developed as compost production dictates. Please update the sentence that states that a concrete pad will be developed as the facility expands.
16. Section G.3 – Please provide the volumes of all feedstocks.
17. The floodplain map in Attachment 6 should show the boundaries for all three areas. There are currently two that are outlined on the figure.
18. In the text describing the mixer, provide a reference to the mixer equipment specifications in Appendix 2 of Attachment 4 or Attachment 5.
19. Section G.5 – Please clarify 1st sentence.
20. Section G.8 – Compost failing the fecal coliform test returning to the compost process should meet the time and temperature requirements (remove the "up to" prior to the temperature).
21. Section G.11 - The temperature and time requirements for VAR in this section are not stated correctly. However, because the facility is following the windrow composting method, 15 days at a minimum temperature of 131 degrees F, with five turnings, the PFRP process will also satisfy the VAR requirement.
22. The report states that the pile size for PFRP composting will be 5 feet high and 15 feet wide. Please provide the maximum pile size for curing piles, finished product piles, and for storage of dry feedstocks. This is an indirect way of determining the maximum capacity for each area of the facility (previous comment #40 in the Nov. 2011 comments). The pile size of dry feedstocks and finished product should be no more than 30 feet high and 50 feet wide. Also, what is the distance between windrows in each of the areas?

23. What is the frequency of turning in the curing area?
24. Operations Guide:
    a. Please clarify where records will be kept.
    b. Page 5 – Please clarify last sentence of first paragraph.
    c. Pages 5 (2nd paragraph) and 8 (last paragraph) - Please change "bin" to "mixer" or "mix pad." I assumed "bin" was a storage container or bunker.
    d. Excess liquid, leachate, and process wastewater/runoff cannot be collected in the sinks or basins along the site boundaries. Please change text to state that the process wastewater/leachate will be diverted to ditches, included with stormwater, and will be regulated by the DWQ permit (or something similar). Drawings and G.5 should also be changed.
    e. Please change "Bay" to "Area."
25. Drawings – In Site 2 and Site 3, the orientation of the compost windrow, curing windrows, and finished product piles are shown in different directions. To prevent ponding of surface water, the windrows and piles should all be oriented parallel to the direction of the slope, or just slightly angled to the slope. Please orient the windrows on the diagram, and indicate the planned slope for the areas.
26. Please provide the location of the nearest USGS survey benchmark. The groundwater wells will have to be surveyed in after installation.

For the groundwater monitoring plan, other rules and requirements may apply. Please refer to NC Solid Waste Rules 15A NCAC 13B Section .0600 Monitoring Requirements, .0601 Groundwater Monitoring, and .0602 Surface Water Monitoring. Additionally, the NC Solid Waste Section has guidance documents available to the public on our portal. A few of the links for information regarding Groundwater Monitoring Plans and SWS Guidelines for Groundwater, Soil, and Surface Water Monitoring may be found at the following links:

http://portal.ncdenr.org/web/wm/sw/newmonitoringplans
http://portal.ncdenr.org/c/document_library/get_file?uuid=d28d4f91-4b6d-4c9d-afd9-47c9ee93615f&groupId=38361
An example groundwater monitoring plan from another site has been included for your reference.

Please provide one paper copy and one electronic copy (pdf) of the revised application, including drawings, and a cover letter that includes responses to comments. Responses to comments should be incorporated into the text of the application. If you have any questions on the above comments, please contact me at (919) 707-8255 or by email at donna.wilson@ncdenr.gov .

Sincerely,

Donna J. Wilson

Donna J. Wilson
Environmental Engineer
Solid Waste Section

cc: Gary MacConnell, PE A. R. Rubin Ray Williams

Appendix C

Supporting Documentation, Slug Test Reports and DWM Reporting Forms

Surficial aquifer thickness – DENR-DWR (borehole hydrogeology interpolation).....C-1
Saturated zone Ksat estimates (slug test solution reports).....C-3
DWM-SWS – Environmental Monitoring Reporting Form C-21

North Carolina Department of Environment and Natural Resources

Division of Water Resources

About DWR ▪ Contact Us ▪ Jobs ▪ News ▪ Calendar ▪ Staff

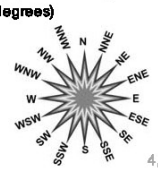
Google Search

FrameWork Query Results

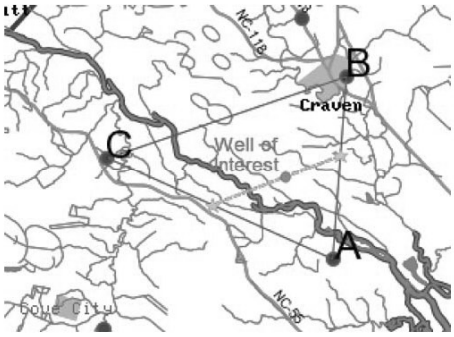
Scroll to bottom half of page for cross-section.

Framework Map with borehole locations is shown to the right and may be viewed in a separate window.

Cross-section line is oriented approximately: **WSW-ENE** (69 degrees)



4, 2, AC-AB, 616, 3



Well of Interest

Location: 35.252725, -77.185011; **Well Depth:** 210 feet; **Screen Depth:** 200 feet; **Land Surface (estimated):** 24 feet; Show Map

Approximate depths to (and elevations of) hydrogeological units (feet):

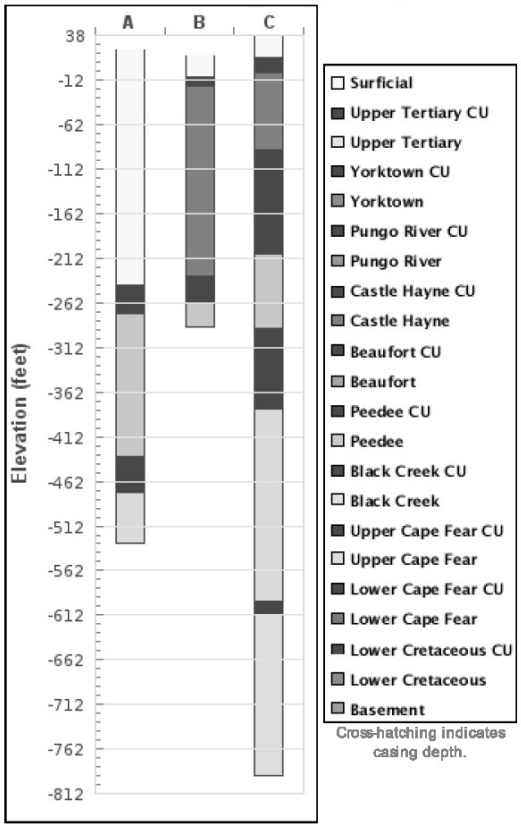
SURFICIAL	CLHCONF	CLH
0 (24)	132 (-107)	139 (-115)

- Hydrogeologic unit top depths estimated to well depth.
- If estimated land surface elevation is higher than actual then subtract the difference from the estimated depths of units.
- If estimated land surface elevation is lower than actual then add the difference to the estimated depths of units.

Elevation data not corrected to the USGS National Elevation Dataset

Units shown in this color may not be fully present due to erosion or non-deposition.

Borehole Hydrogeology

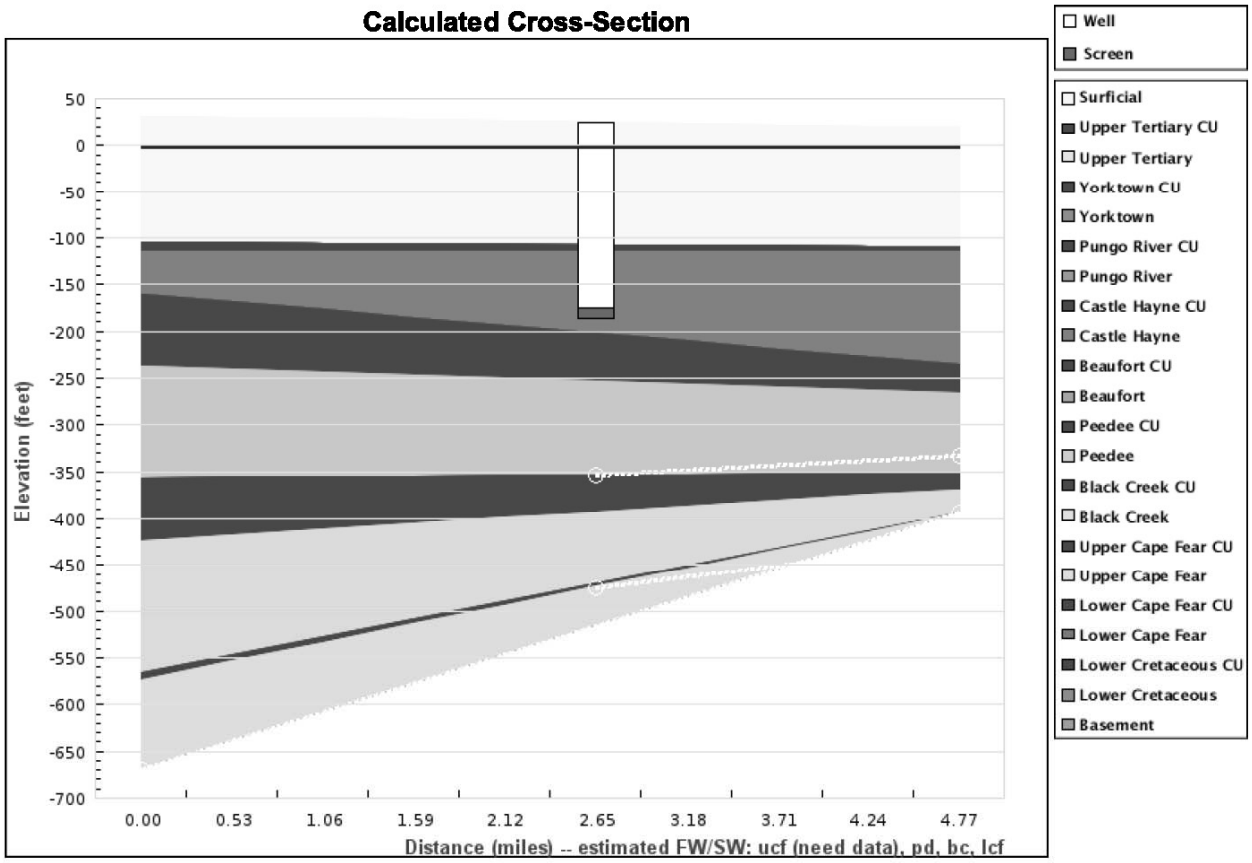


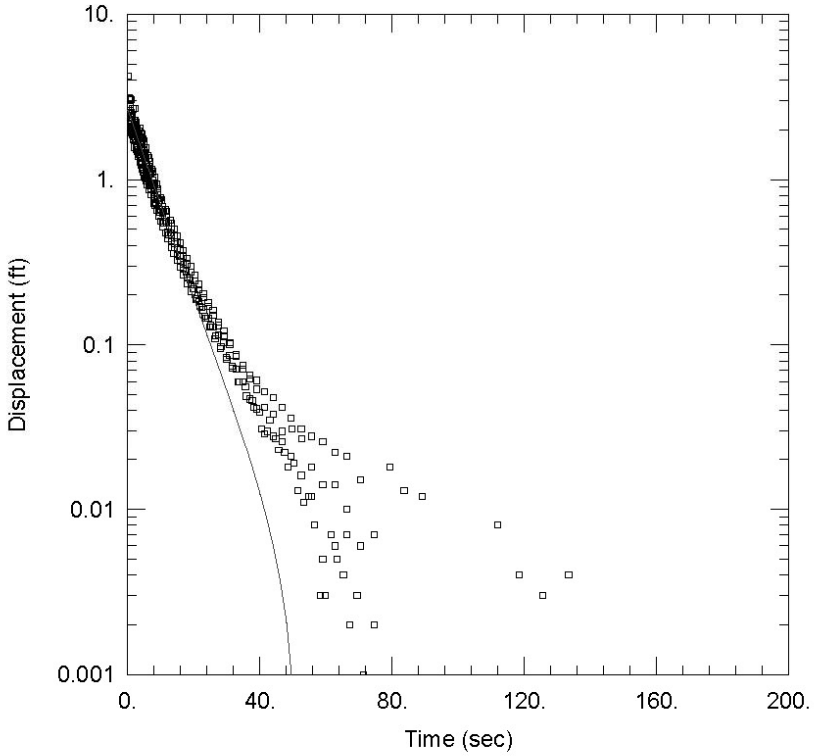
Boreholes

exclude A **A:** USGS Rice Property Test, R 21O; **Land Surface:** 23 feet; **Location:** 35.210833, -77.156667; Geophysical Logs, Hydrogeologic Units

exclude B **B:** Town of Vanceboro, Q 21G; **Land Surface:** 16 feet; **Location:** 35.303056, -77.146111; Geophysical Logs, Hydrogeologic Units

exclude C **C:** Craven Co Well 5, Q 23W; **Land Surface:** 38.48 feet; **Location:** 35.26403, -77.29414; Geophysical Logs, Hydrogeologic Units





1883_CAS

Data Set: C:\1883_SlugData\Ks1_KGS.AQT
Date: 05/16/13 Time: 15:19:33

PROJECT INFORMATION

Company: CPEC
Client: 1883_CAS
Project: 1883_CAS
Location: Craven
Test Well: Ks1
Test Date: 05/03/2013

AQUIFER DATA

Saturated Thickness: 10. ft

WELL DATA

Test Well:

Well Name	X (ft)	Y (ft)
Ks1_S1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
Ks1_S2	0	0
Ks1_S3	0	0
Ks1_S4	0	0
Ks1_S5	0	0

Initial Displacement: 2.625 ft
Total Well Penetration Depth: 6.83 ft
Casing Radius: 0.052 ft

Static Water Column Height: 1. ft
Screen Length: 0.5 ft
Well Radius: 0.052 ft
Gravel Pack Porosity: 0.2

Data Set: C:\1883_SlugData\Ks1_KGS.AQT
Title: 1883_CAS
Date: 05/16/13
Time: 15:20:42

PROJECT INFORMATION

Company: CPEC
Client: 1883_CAS
Project: 1883_CAS
Location: Craven
Test Date: 05/03/2013
Test Well: Ks1

AQUIFER DATA

Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 0.5

SLUG TEST WELL DATA

Test Well: Ks1_S1

X Location: 0. ft
Y Location: 0. ft

Initial Displacement: 2.625 ft
Static Water Column Height: 1. ft
Casing Radius: 0.052 ft
Well Radius: 0.052 ft
Well Skin Radius: 0.125 ft
Screen Length: 0.5 ft
Total Well Penetration Depth: 6.83 ft
Corrected Casing Radius (Bouwer-Rice Method): 0.048 ft
Gravel Pack Porosity: 0.2

No. of Observations: 66

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.066	2.625	10.94	0.547
0.271	2.382	12.11	0.478
0.475	2.287	12.44	0.462
1.133	2.085	13.22	0.425
1.339	2.015	14.06	0.387
1.544	1.956	14.96	0.352
1.749	1.884	15.92	0.319
1.953	1.823	16.88	0.291
2.158	1.771	17.96	0.258
2.362	1.715	19.1	0.231
2.566	1.658	20.3	0.202
2.771	1.612	21.56	0.182
2.975	1.566	22.88	0.163
3.179	1.518	24.37	0.145
3.382	1.477	25.82	0.128
3.586	1.426	27.38	0.115
3.791	1.384	29.06	0.103
3.996	1.345	30.86	0.086
4.25	1.294	32.72	0.071
4.5	1.25	34.76	0.06
4.75	1.133	36.86	0.047
5.409	1.101	39.08	0.041
5.616	1.069	41.48	0.029
5.825	1.032	44.	0.028
6.524	0.94	46.64	0.026
6.73	0.914	49.46	0.021
6.98	0.885	52.46	0.016

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
7.905	0.783	55.64	0.012
8.112	0.762	59.	0.005
8.48	0.725	62.6	0.006
9.291	0.661	66.2	0.007
9.68	0.631	70.4	0.006
10.7	0.562	74.6	0.002

Observation Well No. 1Ks1_S2

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks1_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 6.33 ft
Depth to Bottom of Screen: 6.83 ft

No. of Observations: 61

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.11	2.338	12.22	0.436
0.317	2.155	13.28	0.388
0.523	2.106	13.96	0.357
1.17	1.906	14.92	0.324
1.374	1.853	15.88	0.294
1.579	1.774	16.96	0.265
1.785	1.732	18.1	0.234
1.99	1.567	19.3	0.211
2.642	1.517	20.56	0.189
2.847	1.472	21.88	0.17
3.052	1.423	23.32	0.149
3.258	1.377	24.82	0.128
3.846	1.264	26.38	0.109
4.051	1.227	28.06	0.095
4.256	1.19	29.97	0.082
4.461	1.152	31.72	0.072
4.665	1.117	33.76	0.06
4.874	1.084	35.86	0.049
5.079	1.053	38.08	0.042
5.285	1.022	40.48	0.031
5.561	0.983	43.	0.035
5.981	0.925	45.64	0.023
6.461	0.867	48.46	0.018
7.001	0.807	51.46	0.013
7.961	0.717	54.7	0.012
8.167	0.699	58.34	0.003
8.681	0.653	61.6	0.007
9.381	0.602	65.2	0.004
9.941	0.562	69.4	0.003
10.74	0.515	73.6	0.
11.44	0.474		

Observation Well No. 2Ks1_S3

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks1_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 6.33 ft
Depth to Bottom of Screen: 6.83 ft

No. of Observations: 63

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.001	4.211	11.43	0.656
0.626	3.084	11.66	0.639
0.831	2.775	12.85	0.565
1.037	3.05	13.22	0.545
1.242	2.382	14.08	0.5
1.899	2.286	14.96	0.456
2.104	2.694	15.92	0.413
2.309	1.963	16.88	0.372
2.514	2.221	17.96	0.333
2.719	1.925	19.1	0.298
2.923	1.885	20.3	0.264
3.128	1.771	21.56	0.232
3.332	1.862	22.88	0.205
3.536	1.966	24.32	0.181
3.74	2.042	25.82	0.161
3.945	1.917	27.38	0.137
4.149	1.877	29.06	0.122
4.353	1.818	30.86	0.103
4.557	1.759	32.72	0.085
4.761	1.7	34.76	0.071
5.001	1.639	36.86	0.062
5.36	1.547	39.08	0.054
6.022	1.394	41.48	0.042
6.228	1.349	44.	0.038
6.56	1.278	46.64	0.03
7.275	1.149	49.59	0.031
7.481	1.116	52.53	0.027
8.	1.03	55.64	0.018
8.683	0.934	59.	0.014
9.08	0.882	62.6	0.014
10.04	0.778	66.2	0.01
10.28	0.752		

Observation Well No. 3Ks1_S4

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks1_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 6.33 ft
Depth to Bottom of Screen: 6.83 ft

No. of Observations: 66

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.674	2.616	11.74	0.544
1.083	2.527	12.91	0.477
1.287	2.442	13.24	0.459
1.944	2.219	14.24	0.41
2.151	2.152	14.89	0.377
2.356	2.058	15.76	0.342
2.561	2.003	16.72	0.307
2.765	1.808	17.68	0.277
3.4	1.753	18.76	0.246
3.606	1.698	19.9	0.219
3.811	1.638	21.1	0.19
4.015	1.585	22.36	0.168
4.219	1.536	23.68	0.145
4.423	1.488	25.12	0.131
4.627	1.441	26.62	0.113
4.831	1.395	28.18	0.098

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
5.036	1.353	29.86	0.084
5.24	1.31	31.66	0.074
5.445	1.268	33.52	0.06
5.649	1.228	35.56	0.056
5.853	1.193	37.66	0.046
6.058	1.156	39.88	0.039
6.264	1.121	42.28	0.03
6.52	1.078	44.8	0.027
7.391	0.951	47.44	0.022
7.597	0.922	50.26	0.019
7.803	0.897	53.26	0.011
8.26	0.794	56.44	0.008
8.909	0.768	59.8	0.003
9.28	0.73	63.4	0.005
10.1	0.66	67.17	0.002
10.48	0.629	71.2	0.001
11.5	0.559	75.4	0.

Observation Well No. 4Ks1_S5

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks1_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 6.33 ft
Depth to Bottom of Screen: 6.83 ft

No. of Observations: 71

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.476	3.119	14.96	0.42
0.684	2.507	15.92	0.377
0.893	2.397	16.88	0.345
1.1	2.238	17.96	0.309
1.307	2.373	19.1	0.275
1.514	2.675	20.3	0.243
2.159	2.283	21.56	0.216
2.364	2.217	22.88	0.193
2.568	2.134	24.32	0.17
2.775	2.055	25.82	0.151
2.979	1.879	27.38	0.131
3.632	1.815	29.06	0.114
3.837	1.758	30.86	0.101
4.042	1.699	32.72	0.087
4.247	1.642	34.76	0.075
4.89	1.491	36.86	0.066
5.096	1.443	39.08	0.061
5.3	1.401	41.48	0.052
5.504	1.355	44.	0.048
5.708	1.232	46.64	0.042
6.317	1.198	49.46	0.036
6.523	1.159	52.46	0.031
6.729	1.122	55.64	0.028
6.937	1.092	59.	0.026
7.655	0.989	62.6	0.022
7.861	0.958	66.2	0.021
8.069	0.93	70.4	0.015
8.973	0.827	74.6	0.007
9.179	0.803	79.28	0.018
9.68	0.749	83.6	0.013
10.43	0.684	89.	0.012
10.94	0.643	111.8	0.008
11.81	0.589	118.4	0.004

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
12.44	0.545	125.6	0.003
13.22	0.499	133.4	0.004
14.06	0.458		

SOLUTION

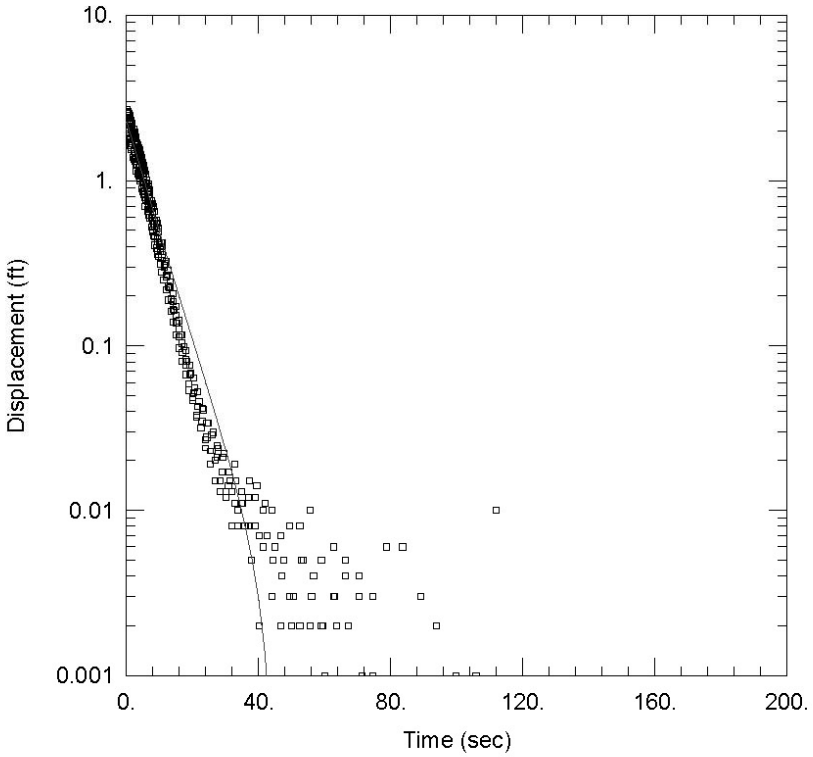
Slug Test
Aquifer Model: Unconfined
Solution Method: KGS Model

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
Kr	64.9	ft/day
Ss	1.0E-11	ft^{-1}
Kz/Kr	0.5	

K = 0.02289 cm/sec
T = K*b = 649. ft^2/day (6.978 sq. cm/sec)



1883_CAS

Data Set: C:\1883_SlugData\Ks2_KGS.AQT
Date: 05/16/13 Time: 15:26:50

PROJECT INFORMATION

Company: CPEC
Client: 1883_CAS
Project: 1883_CAS
Location: Craven
Test Well: Ks2
Test Date: 05/03/2013

AQUIFER DATA

Saturated Thickness: 10. ft

WELL DATA

Test Well:

Well Name	X (ft)	Y (ft)
Ks2_S1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
Ks2_S2	0	0
Ks2_S3	0	0
Ks2_S4	0	0
Ks2_S5	0	0

Initial Displacement: 2.264 ft
Total Well Penetration Depth: 8.33 ft
Casing Radius: 0.052 ft

Static Water Column Height: 1. ft
Screen Length: 0.5 ft
Well Radius: 0.052 ft
Gravel Pack Porosity: 0.2

Data Set: C:\1883_SlugData\Ks2_KGS.AQT
Title: 1883_CAS
Date: 05/16/13
Time: 15:29:00

PROJECT INFORMATION

Company: CPEC
Client: 1883_CAS
Project: 1883_CAS
Location: Craven
Test Date: 05/03/2013
Test Well: Ks2

AQUIFER DATA

Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 0.5

SLUG TEST WELL DATA

Test Well: Ks2_S1

X Location: 0. ft
Y Location: 0. ft

Initial Displacement: 2.264 ft
Static Water Column Height: 1. ft
Casing Radius: 0.052 ft
Well Radius: 0.052 ft
Well Skin Radius: 0.125 ft
Screen Length: 0.5 ft
Total Well Penetration Depth: 8.33 ft
Corrected Casing Radius (Bouwer-Rice Method): 0.048 ft
Gravel Pack Porosity: 0.2

No. of Observations: 64

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.15	2.264	10.68	0.34
0.4	2.016	11.34	0.299
1.025	1.804	12.06	0.262
1.23	1.759	12.84	0.224
1.436	1.722	13.62	0.192
1.64	1.68	14.46	0.164
2.297	1.508	15.36	0.137
2.503	1.458	16.32	0.116
2.707	1.407	17.28	0.099
2.911	1.355	18.36	0.081
3.115	1.237	19.5	0.068
3.702	1.195	20.7	0.056
3.907	1.155	21.96	0.046
4.112	1.117	23.28	0.041
4.317	1.082	24.72	0.034
4.977	0.969	26.22	0.03
5.182	0.935	27.78	0.024
5.388	0.903	29.46	0.022
5.592	0.867	31.26	0.015
5.796	0.769	33.12	0.015
6.47	0.749	35.16	0.011
6.675	0.72	37.31	0.015
6.881	0.692	39.48	0.014
7.087	0.666	41.88	0.011
7.771	0.592	44.4	0.005
7.977	0.568	47.04	0.004
8.182	0.548	49.86	0.002

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
8.388	0.525	52.86	0.005
8.596	0.458	56.04	0.003
9.298	0.444	59.4	0.002
9.505	0.426	63.	0.003
10.2	0.373	66.6	0.

Observation Well No. 1Ks2_S2

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks2_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 7.83 ft
Depth to Bottom of Screen: 8.33 ft

No. of Observations: 68

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.1	1.801	10.68	0.28
0.251	1.785	11.28	0.251
0.861	1.681	11.94	0.218
1.066	1.623	12.66	0.189
1.27	1.582	13.44	0.162
1.474	1.534	14.22	0.139
2.132	1.385	15.06	0.116
2.338	1.343	15.96	0.097
2.543	1.299	16.92	0.081
2.747	1.256	17.88	0.067
2.951	1.144	18.96	0.054
3.534	1.102	20.1	0.047
3.738	1.066	21.3	0.037
3.942	1.026	22.56	0.032
4.146	0.994	23.88	0.027
4.812	0.886	25.32	0.023
5.017	0.854	26.82	0.02
5.221	0.823	28.38	0.015
5.425	0.79	30.06	0.013
5.63	0.696	31.86	0.013
6.302	0.672	33.72	0.01
6.506	0.648	35.76	0.008
6.71	0.621	37.86	0.005
6.914	0.595	40.08	0.007
7.601	0.524	42.48	0.007
7.808	0.503	45.	0.006
8.014	0.487	47.64	0.005
8.22	0.463	50.46	0.003
8.426	0.406	53.46	0.005
9.125	0.39	56.64	0.004
9.332	0.374	60.	0.001
9.538	0.356	63.6	0.002
9.746	0.346	67.2	0.002
10.2	0.314	71.4	0.001

Observation Well No. 2Ks2_S3

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks2_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 7.83 ft
Depth to Bottom of Screen: 8.33 ft

No. of Observations: 74

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.069	2.592	14.06	0.206
0.275	2.571	14.96	0.173
0.479	2.53	15.92	0.142
1.136	2.3	16.88	0.116
1.342	2.245	17.96	0.094
1.546	2.138	19.1	0.076
1.75	2.139	20.3	0.064
1.954	1.933	21.56	0.053
2.535	1.872	23.01	0.042
2.74	1.811	24.32	0.034
2.945	1.751	25.82	0.029
3.15	1.689	27.38	0.025
3.354	1.637	29.06	0.021
3.558	1.583	30.86	0.017
3.762	1.529	32.72	0.019
3.966	1.481	34.76	0.013
4.171	1.43	36.86	0.012
4.374	1.383	39.08	0.012
4.579	1.335	41.48	0.01
4.783	1.289	44.	0.01
4.987	1.243	46.64	0.007
5.191	1.202	49.46	0.008
5.396	1.159	52.46	0.008
5.72	1.095	55.65	0.01
6.535	0.947	59.	0.005
6.742	0.91	62.6	0.006
6.98	0.871	66.2	0.004
7.92	0.726	70.4	0.004
8.127	0.7	74.6	0.003
8.48	0.65	78.8	0.006
9.305	0.554	83.6	0.006
9.68	0.515	89.	0.003
10.7	0.418	93.8	0.002
10.94	0.398	99.8	0.001
11.93	0.325	105.8	0.001
12.46	0.287	111.8	0.01
13.22	0.244	118.4	0.

Observation Well No. 3Ks2_S4

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks2_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 7.83 ft
Depth to Bottom of Screen: 8.33 ft

No. of Observations: 59

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.1	2.53	8.461	0.568
0.251	2.459	9.001	0.509
0.859	2.237	9.956	0.418
1.064	2.179	10.16	0.4
1.268	2.105	10.68	0.356
1.472	2.021	11.38	0.307
1.68	1.964	11.94	0.269
1.889	1.908	12.74	0.229
2.095	1.854	13.44	0.194

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
2.302	1.789	14.22	0.166
2.509	1.725	15.06	0.137
3.154	1.552	15.96	0.113
3.359	1.502	16.92	0.091
3.563	1.446	17.88	0.076
3.769	1.394	18.96	0.059
3.974	1.246	20.1	0.049
4.627	1.202	21.3	0.038
4.832	1.159	22.56	0.032
5.037	1.113	23.88	0.024
5.242	1.07	25.32	0.019
5.842	0.96	26.82	0.015
6.047	0.923	28.38	0.013
6.251	0.888	30.06	0.012
6.455	0.849	31.86	0.008
6.659	0.819	33.73	0.008
6.868	0.785	35.86	0.008
7.073	0.754	37.86	0.005
7.279	0.723	40.08	0.002
7.561	0.682	42.48	0.
7.981	0.628		

Observation Well No. 4Ks2_S5

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks2_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 7.83 ft
Depth to Bottom of Screen: 8.33 ft

No. of Observations: 65

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.292	2.697	11.75	0.314
0.495	2.628	12.44	0.269
0.703	2.543	13.22	0.228
0.912	2.487	14.06	0.185
1.118	2.395	14.96	0.153
1.324	2.314	15.92	0.127
1.531	2.225	16.88	0.104
2.176	2.033	17.96	0.083
2.382	1.966	19.1	0.067
2.586	1.91	20.3	0.052
2.792	1.834	21.56	0.043
2.996	1.645	22.88	0.035
3.652	1.585	24.32	0.028
3.856	1.53	25.82	0.023
4.061	1.474	27.38	0.021
4.267	1.42	29.06	0.017
4.472	1.372	30.86	0.014
4.676	1.32	32.72	0.011
4.881	1.273	34.76	0.011
5.085	1.226	36.86	0.008
5.289	1.181	39.08	0.008
5.494	1.138	41.48	0.006
5.72	1.09	44.	0.003
6.14	1.007	46.64	0.002
6.56	0.927	49.46	0.003
6.98	0.854	52.46	0.002
7.617	0.753	55.64	0.002
8.	0.697	59.	0.002
8.972	0.571	62.6	0.003

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
9.178	0.547	66.2	0.005
9.68	0.487	70.4	0.003
10.39	0.42	74.6	0.001
10.94	0.371		

SOLUTION

Slug Test
Aquifer Model: Unconfined
Solution Method: KGS Model

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
Kr	79.9	ft/day
Ss	0.01	ft^{-1}
Kz/Kr	0.5	

K = 0.02819 cm/sec
T = K*b = 799. ft^2/day (8.591 sq. cm/sec)

AUTOMATIC ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	Std. Error	Approx. C.I.	t-Ratio	
Kr	75.91	1.284	+/- 2.525	59.13	ft/day
Ss	1.0E-11	4.957E-5	+/- 9.751E-5	2.017E-7	ft^{-1}
Kz/Kr	0.5	not estimated			

C.I. is approximate 95% confidence interval for parameter
t-ratio = estimate/std. error
No estimation window

K = 0.02678 cm/sec
T = K*b = 759.1 ft^2/day (8.162 sq. cm/sec)

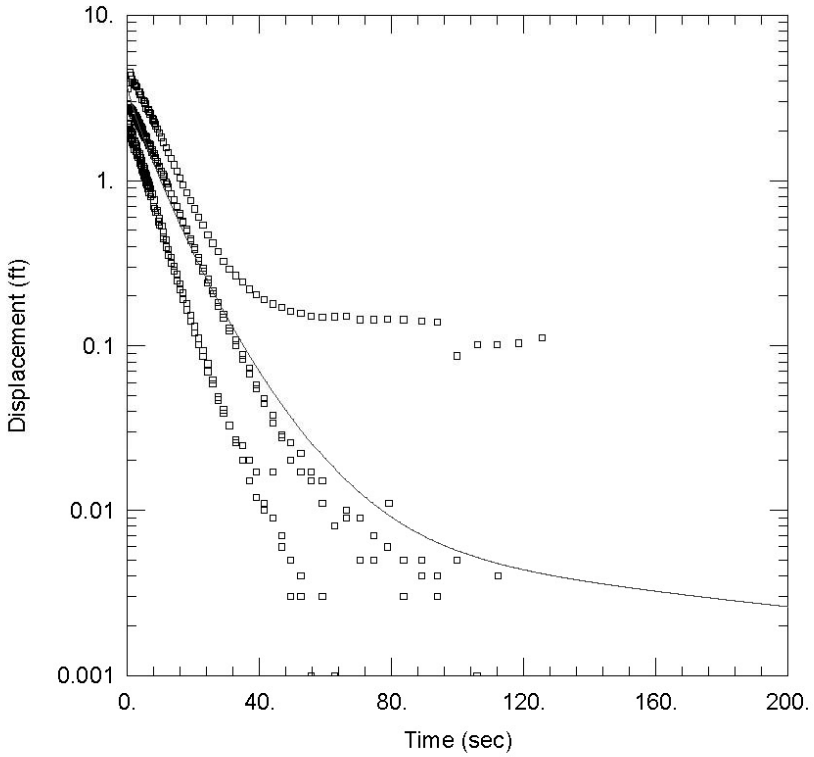
Parameter Correlations

	Kr	Ss
Kr	1.00	-0.22
Ss	-0.22	1.00

Residual Statistics

for weighted residuals

Sum of Squares . . . . . 8.527 ft^2
Variance . . . . . 0.026 ft^2
Std. Deviation . . . . . 0.1612 ft
Mean . . . . . 0.01192 ft
No. of Residuals 330
No. of Estimates 2



1883_CAS

Data Set: C:\1883_SlugData\Ks3_KGS.AQT
Date: 05/16/13 Time: 15:33:05

PROJECT INFORMATION

Company: CPEC
Client: 1883_CAS
Project: 1883_CAS
Location: Craven
Test Well: Ks3
Test Date: 05/03/2013

AQUIFER DATA

Saturated Thickness: 10. ft

WELL DATA

Test Well:

Well Name	X (ft)	Y (ft)
Ks3_S1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
Ks3_S2	0	0
Ks3_S3	0	0
Ks3_S7	0	0
Ks3_S8	0	0

Initial Displacement: 3.596 ft
Total Well Penetration Depth: 7.17 ft
Casing Radius: 0.052 ft

Static Water Column Height: 1. ft
Screen Length: 0.5 ft
Well Radius: 0.052 ft
Gravel Pack Porosity: 0.2

Data Set: C:\1883_SlugData\Ks3_KGS.AQT
Title: 1883_CAS
Date: 05/16/13
Time: 17:28:05

PROJECT INFORMATION

Company: CPEC
Client: 1883_CAS
Project: 1883_CAS
Location: Craven
Test Date: 05/03/2013
Test Well: Ks3

AQUIFER DATA

Saturated Thickness: 10. ft
Anisotropy Ratio (Kz/Kr): 0.5

SLUG TEST WELL DATA

Test Well: Ks3_S1

X Location: 0. ft
Y Location: 0. ft

Initial Displacement: 3.596 ft
Static Water Column Height: 1. ft
Casing Radius: 0.052 ft
Well Radius: 0.052 ft
Well Skin Radius: 0.125 ft
Screen Length: 0.5 ft
Total Well Penetration Depth: 7.17 ft
Corrected Casing Radius (Bouwer-Rice Method): 0.048 ft
Gravel Pack Porosity: 0.2

No. of Observations: 68

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.251	3.596	13.22	0.833
0.501	2.775	14.06	0.764
0.751	2.745	14.96	0.695
1.001	2.693	15.92	0.628
1.251	2.605	16.88	0.564
1.501	2.544	17.96	0.505
1.751	2.484	19.1	0.445
2.001	2.548	20.3	0.392
2.251	2.386	21.56	0.34
2.501	2.361	22.88	0.296
2.751	2.306	24.37	0.252
3.001	2.259	25.82	0.216
3.251	2.2	27.38	0.183
3.501	2.15	29.06	0.156
3.751	2.1	30.86	0.128
4.001	2.052	32.72	0.108
4.251	2.004	34.76	0.088
4.501	1.963	36.86	0.073
4.751	1.919	39.08	0.058
5.001	1.874	41.48	0.048
5.36	1.813	44.	0.038
5.721	1.754	46.64	0.028
6.141	1.687	49.46	0.026
6.56	1.621	52.46	0.022
6.98	1.559	55.64	0.017
7.461	1.487	59.	0.015
8.001	1.412	62.6	0.008

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
8.481	1.349	66.2	0.009
9.081	1.271	70.4	0.005
9.681	1.195	74.6	0.007
10.28	1.129	78.8	0.006
10.94	1.055	83.6	0.003
11.66	0.982	89.	0.004
12.44	0.904	93.8	0.003

Observation Well No. 1Ks3_S2

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks3_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 6.67 ft
Depth to Bottom of Screen: 7.17 ft

No. of Observations: 72

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.272	2.922	14.06	0.761
0.478	2.662	14.96	0.691
1.139	2.734	15.92	0.619
1.347	2.684	16.88	0.556
1.553	2.634	17.96	0.494
1.759	2.605	19.1	0.433
1.964	2.562	20.3	0.381
2.172	2.487	21.56	0.327
2.378	2.463	22.88	0.282
2.584	2.39	24.32	0.241
2.79	2.413	25.97	0.206
2.995	2.338	27.38	0.174
3.2	2.298	29.06	0.148
3.405	2.252	30.86	0.123
3.61	2.216	32.74	0.101
3.817	2.172	34.76	0.083
4.022	2.132	36.86	0.068
4.25	2.089	39.08	0.055
4.5	2.036	41.48	0.045
4.75	1.908	44.	0.034
5.426	1.87	46.64	0.029
5.634	1.831	49.46	0.02
5.844	1.793	52.46	0.017
6.614	1.666	55.64	0.015
6.822	1.633	59.	0.011
7.029	1.598	62.6	0.008
7.46	1.528	66.2	0.01
8.	1.449	70.4	0.009
8.48	1.377	74.6	0.005
9.081	1.298	79.17	0.011
9.68	1.219	83.6	0.005
10.76	1.091	89.	0.005
10.97	1.067	93.8	0.004
12.01	0.955	99.8	0.005
12.44	0.91	105.8	0.001
13.22	0.835	112.3	0.004

Observation Well No. 2Ks3_S3

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks3_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 6.67 ft
Depth to Bottom of Screen: 7.17 ft

No. of Observations: 73

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.665	4.491	15.92	1.032
0.871	4.488	16.88	0.938
1.078	4.308	17.96	0.843
1.283	4.083	19.1	0.758
1.489	3.927	20.3	0.674
2.134	3.863	21.56	0.601
2.341	3.796	22.88	0.536
2.547	3.743	24.32	0.47
2.752	3.679	25.82	0.417
3.399	3.433	27.38	0.373
3.605	3.427	29.06	0.326
3.812	3.312	30.86	0.292
4.018	3.311	32.72	0.266
4.223	3.069	34.76	0.244
4.93	3.05	36.86	0.22
5.135	2.978	39.08	0.205
5.345	2.911	41.48	0.19
5.551	2.732	44.	0.179
6.255	2.679	46.64	0.17
6.461	2.631	49.46	0.162
6.668	2.578	52.46	0.157
6.875	2.53	55.64	0.151
7.548	2.375	59.	0.149
7.756	2.327	62.6	0.15
7.963	2.28	66.2	0.151
8.169	2.238	70.4	0.144
8.377	2.193	74.6	0.144
8.584	2.148	78.8	0.145
9.08	2.048	83.6	0.144
9.68	1.933	89.	0.141
10.28	1.822	93.8	0.139
10.94	1.705	99.8	0.087
11.66	1.586	105.9	0.102
12.44	1.469	111.8	0.102
13.22	1.358	118.4	0.104
14.06	1.246	125.6	0.112
14.96	1.138		

Observation Well No. 3Ks3_S7

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks3_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 6.67 ft
Depth to Bottom of Screen: 7.17 ft

No. of Observations: 60

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.059	2.219	9.182	0.64
0.264	1.972	9.68	0.59
0.468	2.181	10.41	0.529
0.674	2.114	10.94	0.486
0.883	2.055	11.67	0.437

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
1.09	2.001	12.44	0.382
1.296	1.962	13.22	0.343
1.502	1.905	14.06	0.304
2.148	1.726	14.96	0.27
2.353	1.7	15.92	0.238
2.557	1.659	16.88	0.208
2.763	1.612	17.96	0.18
2.966	1.489	19.1	0.153
3.582	1.447	20.3	0.131
3.786	1.408	21.56	0.111
3.991	1.367	22.88	0.094
4.196	1.328	24.32	0.078
4.86	1.212	25.82	0.062
5.063	1.179	27.38	0.049
5.268	1.145	29.06	0.041
5.472	1.109	30.86	0.033
5.676	1.076	32.72	0.027
5.884	1.044	34.76	0.025
6.09	1.012	36.86	0.02
6.296	0.981	39.08	0.017
6.56	0.943	41.48	0.011
6.98	0.888	44.	0.009
7.46	0.827	46.64	0.007
8.	0.76	49.46	0.003
8.975	0.66	52.46	0.003

Observation Well No. 4Ks3_S8

X Location: 0. ft
Y Location: 0. ft

Radial distance from Ks3_S1: 0. ft

Partially Penetrating Well
Depth to Top of Screen: 6.67 ft
Depth to Bottom of Screen: 7.17 ft

No. of Observations: 63

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
0.066	1.937	10.75	0.458
0.27	1.883	10.96	0.443
0.474	1.946	11.66	0.395
1.13	1.793	12.44	0.354
1.336	1.754	13.22	0.318
1.54	1.701	14.06	0.285
1.744	1.655	14.96	0.249
1.948	1.544	15.92	0.22
2.54	1.5	16.88	0.192
2.745	1.46	17.96	0.165
2.949	1.417	19.1	0.141
3.153	1.38	20.3	0.12
3.822	1.265	21.56	0.102
4.026	1.23	22.88	0.086
4.23	1.195	24.32	0.07
4.435	1.16	25.82	0.059
4.64	1.127	27.38	0.047
4.846	1.095	29.06	0.039
5.05	1.063	30.86	0.033
5.254	1.032	32.72	0.026
5.458	1.002	34.77	0.02
5.661	0.971	36.86	0.015
5.866	0.943	39.08	0.012
6.072	0.914	41.48	0.01
6.277	0.888	44.	0.017

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
6.56	0.85	46.64	0.006
6.98	0.801	49.46	0.005
7.939	0.696	52.46	0.004
8.147	0.675	55.64	0.001
8.48	0.639	59.	0.003
9.345	0.564	62.6	0.001
9.68	0.537		

SOLUTION

Slug Test
Aquifer Model: Unconfined
Solution Method: KGS Model

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
Kr	55.77	ft/day
Ss	0.01	ft^{-1}
Kz/Kr	0.5	

K = 0.01967 cm/sec
T = K*b = 557.7 ft^2/day (5.997 sq. cm/sec)

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).
- 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

Affix NC Licensed/ Professional Geologist Seal

Signature Date

Facility Representative Address

NC PE Firm License Number (if applicable effective May 1, 2009)

Revised 6/2009