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Water Quality Monitoring Plan

Halifax County Landfill Facility
Halifax County, North Carolina

Prepared for:

Halifax County Department of Public Utilities
Halifax, North Carolina

February 2016

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

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Water Quality Monitoring Plan

Halifax County Landfill Facility
Halifax County, North Carolina

Prepared For:

Halifax County Department of Public Utilities
Halifax, North Carolina

S+G Project No. HALIFAX-12-1

NORTH CAROLINA LICENSED SEAL 275 GEOLOGIST MADELINE GERMAN

2/10/16

Madeline M. German, P.G.
Project Geologist

Joan A. Smyth, P.G.
Senior Hydrogeologist

February 2016

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Halifax County, North Carolina

Water Quality Monitoring Plan

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Figure 1 Environmental Monitoring Locations

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1.0 INTRODUCTION

This Water Quality Monitoring Plan (WQMP) was prepared by Smith Gardner, Inc. to describe the water quality monitoring program at the Halifax County Landfill Facility (NC Solid Waste Permit 42-04), which is located off of Liles Road near Littleton, North Carolina. This landfill facility includes a closed unlined municipal solid waste (MSW) landfill, an active construction demolition debris (C&D) landfill (Area 1) (vertical expansion of closed MSW landfill), and an active lined monofill for coal combustion by-products. This plan also covers a proposed future C&D landfill unit (Area 2) located to the east of Area 1. This plan describes the necessary procedures to satisfy applicable regulatory requirements (see **Section 1.1**) and guidance documents (see **Section 1.2**) for groundwater and surface water quality monitoring. Additionally, sediment sampling for the Coal Ash Monofill is included as part of this WQMP.

The methods and procedures described in the WQMP are intended to facilitate the collection of true and representative samples and test data. Field procedures are presented in **Section 2.0** in their general order of implementation. Equipment requirements for each field task are presented within the applicable section. Quality assurance/quality control methods, sample preservation and shipment, laboratory procedures, and record keeping requirements are presented in **Sections 3.0 through 6.0. Section 7.0** addresses monitoring plan modifications and schedule.

Strict adherence to the procedures stipulated in this plan is required. Any variations from these procedures should be thoroughly documented and may require approval of the North Carolina Department of Environmental Quality (NC DEQ), Division of Waste Management (DWM) prior to implementation.

1.1 Regulatory Requirements

This WQMP specifies the procedures and methods to satisfy North Carolina Solid Waste Management Rules 15A NCAC 13B.0544 (b) and (c) (C&D Landfills); 15A NCAC 13B.1631, .1632, and .1633 (MSW Landfills); and .0602 (Surface Water Monitoring), which include the following requirements for detection monitoring:

- *Represent the quality of the background groundwater that has not been affected by leakage from the unit. (.0544 (b)(1)(A) and .1631 (a)(1))*

- *Represent the quality of the groundwater passing the relevant point of compliance as approved by the Division. (.0544 (b)(1)(B) and .1631 (a)(2))*

- *The groundwater monitoring programs must include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide an accurate representation of groundwater quality at the background and down-gradient wells. (.0544 (b)(1)(C) and .1632 (a))*

- *The monitoring programs must include sampling and analytical methods that are appropriate for groundwater sampling and that accurately measure target*

constituents and other monitoring parameters in groundwater samples. (.0544 (b)(1)(D) and .1632 (b))

- *The sampling procedures and frequency must be protective of human health and the environment. (.0544 (b)(1)(E) and .1632 (c))*
- *Determine groundwater elevations. (.0544 (b)(1)(F) and (.1632 (d))*
- *Establish background quality data. (.0544 (b)(1)(G) and (.1632 (e))*
- *Any statistical analysis. 0.1632 (g) and (h)*
- *Detection groundwater monitoring program. (.0544 (b)(1)(D) and (.1633)*
- *Surface water monitoring plan. Responsibility of sample collection and analysis must be defined as a part of the monitoring plan. (.0544 (c)(2)) and (.0602)*

1.2 Guidance Documents

This plan was developed in general accordance with the following guidance documents prepared by the North Carolina Department of Environmental Quality (NC DEQ), Division of Waste Management (DWM):

1. NC DEQ Guidance Document entitled "Groundwater, Surface Water, and Soil Sampling for Landfills", April 2008.
2. NC DEQ Memo entitled "New Guidelines for Electronic Submittal of Environmental Monitoring Data", October 27, 2006.
3. NC DEQ Memo entitled "Addendum to October 27, 2006, North Carolina Solid Waste Section Memorandum Regarding New Guidelines for Electronic Submittal of Environmental Data", February 23, 2007.
4. NC DEQ Memo entitled "Environmental Monitoring Data for North Carolina Solid Waste Management Facilities", October 16, 2007.

1.3 Contact Information

All correspondence and questions concerning this plan should be directed to the appropriate contact below:

1.3.1 Owner

Halifax County Department of Public Utilities
26 N. King Street (Public Works Building)
P.O. Box 70

Halifax, NC 27839
Phone: (252) 583-1451
Fax: (252) 593-5014
Contacts: Greg Griffin, Director
griffing@halifaxnc.com

Halifax County Landfill Facility
921 Liles Road
Littleton, NC 27850
P.O. Box 70
Halifax, NC 27839
Phone: (252) 586-7516
Fax: (252) 586-2685

Contact: Solid Waste Manager

1.3.2 Engineer

Smith Gardner, Inc.
14 N. Boylan Avenue
Raleigh, North Carolina 27603
Phone: (919) 828-0577

Contacts: Joan A. Smyth, P.G., Senior Hydrogeologist
joan@smithgardnerinc.com
Pieter K. Scheer, P.E., Senior Engineer
pieter@smithgardnerinc.com

1.3.3 North Carolina Department of Environmental Quality (NC DEQ)

Division of Waste Management (DWM) - Solid Waste Section:

North Carolina DEQ - Raleigh Central Office
217 W. Jones Street
Raleigh, NC 27603
1646 Mail Service Center
Raleigh, NC 27699-1646
Phone: (919) 707-8200

Contact: Elizabeth Werner, Hydrogeologist
Elizabeth.werner@ncdenr.gov
(919) 707-8253

Mary Whaley, Waste Management Specialist
mary.whaley@ncdenr.gov

1.4 Existing Site Conditions

The facility is located approximately 12 miles south of Roanoke Rapids, North Carolina. Area development is a mix of agriculture, woodlands, and rural residential.

The facility consists of approximately 241 acres owned by Halifax County. The permitted facility is generally bounded on the north by Liles Road on the south by Brewer's Creek and to the east and west by other County-owned and private property. An unnamed tributary to Brewer's Creek runs through the center of the site and separates the closed MSW/Area 1 C&D landfill unit (south side of tributary) from the ash monofill (north side of tributary).

Ground surface elevations range from approximately El. 230 (feet above mean sea level) along the unnamed tributary on the west end of the site to El. 370 at the current top of the ash monofill. The facility location and existing site conditions are shown on **Figure 1**.

1.4.1 Site Geology

According to the 1985 North Carolina Geological Map and Ground Water in the Halifax Area, North Carolina (Dept. of Conservation and Development Bulletin #51, 1946) the landfill is situated on the eastern edge of the Eastern Piedmont Physiographic Province; slightly west of the Coastal Plain overlap. Generally, Western Halifax County is underlain by felsic to intermediate, crystalline igneous and metamorphic rocks of early to late Paleozoic age. Eastern Piedmont rocks generally exhibit a northeastern strike and locally dip gently eastward due to regional metamorphism and folding that produced a broad plunging anticline. The area was simultaneously intruded by a number of felsic (granite) plutons. The granitic pluton underlying the landfill is the Butterwood Creek intrusion.

1.4.2 Site Hydrogeology

Groundwater depths generally range from near surface level in the lowland areas along Brewer's Creek and its tributary up to 45 ft. below grade along the ridge east of the closed MSW landfill/Area 1 C&D landfill. Groundwater at the site flows generally west toward Brewer's Creek and its tributary. There are minor seasonal variations in the flow pattern, but overall flow direction is consistent.

1.5 Corrective Action Plan

An Assessment of Corrective Measures[1] and Corrective Action Plan[2] (CAP)were prepared for the site in response to impacts detected in groundwater samples. The constituents

[1] G. N. Richardson & Associates, Inc., Assessment of Corrective Measures Halifax County Landfill, August 31, 2007.

of concern named in the CAP were benzene, methylene chloride, toluene, tetrachloroethene, trichloroethene and vinyl chloride. Heptachlor and alpha BHC were constituents of concern for MW-15R only. The CAP specified Monitored Natural Attenuation (MNA) and limited landfill gas recovery on the upgradient side of the landfill as the remedy for the site and required upgrade of an existing landfill gas vent trench to include a solar flare, and additional groundwater monitoring parameters. The CAP was approved[3] by NCDENR on June 8th, 2009 and was implemented shortly thereafter.

A Corrective Action Evaluation Report[4] (CAER) was prepared to evaluate the effectiveness of the MNA remedial strategy in 2012. This evaluation indicated that the remedial strategies prescribed in the CAP continued to be an effective at the site. The CAER was approved[5] by NCDENR in October 2012. Another CAER will be completed in 2017.

[2] Richardson Smith Gardner, & Associates, Corrective Action Plan Halifax County Landfill, June 2008 with revisions through May 2009.
[3] NCDENR Letter to Richardson Smith Gardner & Associates, Inc. (DOC Id 7668) dated June 8th, 2009
[4] Smith Gardner, Inc., Corrective Action Evaluation Report Halifax County Landfill, June 2012.
[5] NCDENR letter to Smith Gardner, Inc., (DOC ID 17539) dated October 30, 2012.

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2.0 MONITORING PROGRAM

This section of the Water Quality Monitoring Plan addresses each aspect of the monitoring program including monitoring frequency, monitoring network and analytical parameters, and sample collection procedures.

2.1 Monitoring Frequency

At a minimum, the County will perform water quality monitoring on a semi-annual basis through the stipulated post-closure period for the landfill. Specific monitoring locations to be monitored on a less frequent basis are noted in the monitoring network schedules in Section 2.2.

2.2 Monitoring Network and Analytical Parameters

2.2.1 Existing Network and Future Areas

2.2.1.1 Closed MSW & Area 1 C&D Landfill Units

Fourteen groundwater monitoring wells are included in the monitoring network for the closed MSW and Area 1 C&D landfill units. Monitoring well MW-1 (located along Liles Road near the facility entrance) serves as the background monitoring location. Monitoring wells (MW-2A, MW-2AD, MW-3AS, MW-3D, MW-6D, MW-7D, MW-15R, MW-16A, MW-17, MW-18S, M-18D, G-13, and G-13D) are located either down or cross gradient to the landfill footprint. Surface water is currently monitored at three surface water sampling points (SW-1, SW-2 and SW-3) located either down or cross gradient of the landfill footprint. It should be noted that G-13 and G-13d are monitored annually as "sentinel wells".

2.2.1.2 Ash Monofill

Six groundwater monitoring wells are included in the monitoring network for the ash monofill. Monitoring well MW-8 serves as the up-gradient and background monitoring location. Monitoring wells MW-9, MW-10, MW-11, MW-12, and MW-17 are located either down or cross gradient to the monofill footprint. Surface water is currently monitored at existing location SW-3, located downstream of the monofill footprint.

In addition to groundwater and surface water monitoring, sampling of discharge from the ash monofill internal stormwater basin is also performed and two sediment samples are collected from the unnamed tributary of Brewer's Creek (SS-1 and SS-2).

2.2.1.3 Area 2 C&D Landfill Unit (Future Area)

Three groundwater monitoring wells are proposed for installation upon construction of the Area 2 C&D landfill unit. Monitoring well CDMW-1 serves as the up-gradient monitoring location, while monitoring wells CDMW-2 and CDMW-3 will be down-gradient of the Area 2 footprint. Surface water will be monitored by the addition of one upstream sampling location (CDSW-1). The existing surface water location (SW-3) located downstream of Area 2 will serve as the downstream monitoring location.

2.2.2 Proposed Monitoring Network

Due to the future addition of C&D Area 2, and data from the existing network, we propose the following changes:

- Addition of three groundwater monitoring wells and one surface water monitoring location for the future C&D Area 2;
- Removal of G-13d from the monitoring network. This well, along with G-13, is included in the network as a "sentinel well" across the unnamed tributary of Brewer's Creek from monitoring well MW-6d. Historical analysis of MW-6d indicates only very low concentrations of benzene (generally between 1 and 2.5 parts per billion) since 2007. Due to this low concentration, the presence of the tributary, and the inclusion of well G-13 in the monitoring network, we believe G-13d is redundant and unnecessary.

No changes are proposed for the Ash Monofill landfill monitoring network.

Existing and proposed monitoring locations and analytical parameters are summarized in the monitoring network below. Monitoring locations are shown on **Figure 1**. Refer to **Tables 1 and 2** for monitoring well completion information and analytical parameters, respectively.

MSW & C&D Landfill Proposed Monitoring Network

Monitoring Location[1]	Relative Location	Analytical Parameters[2]
Existing Monitoring Locations:		
MW-1	Crossgradient (Background)	Appendix I; FP
MW-2A	Downgradient	Appendix II; FP; MNA
MW-2AD	Downgradient	Appendix II; FP; MNA
MW-3AS	Downgradient	Appendix II; FP; MNA
MW-3D	Downgradient	Appendix II; FP; MNA
MW-6D	Downgradient	Appendix II; FP; MNA
MW-7D	Downgradient	Appendix II; FP
MW-15R	Upgradient	Appendix II; FP
MW-16A	Upgradient	Appendix II; FP
MW-17	Downgradient	Appendix II; FP; MNA
MW-18S	Downgradient	Appendix II; FP; MNA
MW-18D	Downgradient	Appendix II; FP; MNA (Monitored Annually)
G-13	Downgradient	Appendix I; FP; MNA (Monitored Annually)
SW-1	Crossgradient	Appendix I; FP
SW-2	Downgradient	Appendix I; FP
SW-3	Crossgradient (MSW/C&D) Downgradient (Ash Monofill)	Appendix I; FP
Proposed Monitoring Locations (Upon Construction of Area 2):		
CDMW-1	Upgradient	Appendix I; C&D, THF, FP
CDMW-2	Downgradient	Appendix I; C&D, THF, FP
CDMW-3	Downgradient	Appendix I; C&D, THF, FP
CDSW-1	Crossgradient	Appendix I; C&D, THF, FP

Notes:

1. MW (or G) = Monitoring Well; SW = Surface Water.
2. Appendix I (40 CFR 258, Appendix I); Appendix II (40 CFR 258, Appendix II); FP (Field Parameters); MNA (Monotored Natural Attenuation – See **Table 3**) THF (Tetrahydrofuran).
3. C&D parameters include: alkalinity, sulfate, nitrate, chloride, manganese, iron, TDS, & mercury

Ash Monofill Proposed Monitoring Network

Monitoring Location[1]	Relative Location	Analytical Parameters[2]
Existing Monitoring Locations:		
MW-8	Upgradient (Background)	Appendix I; Ash; FP
MW-9	Downgradient	Appendix I; Ash; FP
MW-10	Downgradient	Appendix I; Ash; FP
MW-11	Downgradient	Appendix I; Ash; FP
MW-12	Crossgradient	Appendix I; Ash; FP
MW-17	Downgradient	Appendix I; Ash; FP
SW-3	Crossgradient (MSW/C&D) Downgradient (Ash Monofill)	Appendix I; Ash; FP
Internal Stormwater Basin Discharge	Downgradient	Appendix I; Ash; FP
Sediment 1 (SS-1)	Downgradient of Monofill Upstream of Basin Discharge	TCLP (Metals and Mercury)
Sediment 2 (SS-2)	Downgradient of Monofill Downstream of Basin Discharge	TCLP (Metals and Mercury)

Notes:

1. MW = Monitoring Well; SW = Surface Water.
2. Appendix I (40 CFR 258, Appendix I); Appendix II (40 CFR 258, Appendix II); FP (Field Parameters); Ash (Additional Ash-Related Parameters = Mercury, Total Organic Carbon, Chloride, and Sufate); TCLP (Toxicity Characteristic Leaching Procedure).

2.2.3 Analytical Parameters

Groundwater and surface water samples will be analyzed for Appendix I or Appendix II volatile organic compounds (VOCs) and metals plus any additional paramenters as noted in the monitoring network schedules in **Section 2.2**. Additionally, groundwater and surface water samples will be analyzed for the following field parameters:

- Temperature;
- pH;
- Specific Conductivity; and
- Turbidity.

2.3 Groundwater Sample Collection

This section presents details of the procedures and equipment required to perform groundwater field measurements and sampling from monitoring wells during each monitoring event. **Where possible, sampling will proceed from the upgradient (background) wells to downgradient (compliance) wells or, when data is available, from least to most contaminated.**

2.3.1 Monitoring Conditions and Observations

The following measurements will be recorded in a dedicated field logbook prior to sample collection:

- Depth to static water level and well bottom (to the nearest 0.01 foot);
- Water column height in the riser (based on measured well depth);
- Condition of monitoring well (well locks, steel casing, concrete pad, etc.); and

- Monitoring location conditions, including access and surroundings.

Report to the Solid Waste Manager any observed maintenance or access issues observed.

Documentation of all field activities will be in accordance with **Section 6.1**.

2.3.2 Fuel Powered Equipment

Fuel-powered equipment, such as generators or compressors for pumps, must be situated away and downwind from sampling activities. If field conditions prevent such placement, then the fuel source must be placed as far away as possible from the sampling activities. Sampling conditions 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.

2.3.3 Equipment Decontamination

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

1. Don new powder-free gloves.

2. Clean item with tap water and phosphate-free laboratory detergent (Liqui-Nox 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 equipment contamination during storage or transport.

Liqui-Nox detergent solutions should be stored in a clearly marked High-Density Polyethylene (HDPE) or Polypropylene (PP) container. Containers for pesticide-grade isopropanol will be made of inert materials such as Teflon, stainless steel, or glass.

Using dedicated sampling equipment or new disposable Teflon bailers at each well should minimize the need for decontamination in the field. Unclean equipment will be segregated from clean equipment during field activities. Clean equipment will remain in the manufacturer's packaging until use, or will be wrapped in commercial-grade aluminum foil or untreated butcher paper.

2.3.4 Water Level Measurements

2.3.4.4 Static Water Levels

Static water level and depth to the well bottom will be measured in each well prior to purging or sampling activities. Static water level and well depth measurements are necessary to calculate the static water volume 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, established by a Registered Land Surveyor on the well riser lip from where measurements will be gauged.

2.3.4.5 Contamination Prevention

New, powder-free, surgical gloves will be donned for each sampling location. Appropriate measures will be implemented during measurement activities to minimize the potential for soils, decontamination supplies, precipitation, and other potential contaminants from entering the well or contacting clean equipment.

2.3.4.6 Equipment

An electronic water level indicator, constructed of inert materials, such as stainless steel and Teflon, will be used to measure depth to groundwater in each well and/or piezometer. **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.**

2.3.5 Monitoring Well Evacuations

Water accumulated in each well may be stagnant and unrepresentative of surrounding aquifer conditions. Therefore, this water must be removed to insure that fresh formation water is sampled. Following static water level measurement the standing water in the well casing will be purged. Monitoring well evacuation should be performed in up-gradient wells first systematically moving to down-gradient well locations.

2.3.5.1 Contamination Prevention

New, powder-free, surgical gloves will be donned for well purging and sampling activities and whenever handling decontaminated field equipment. Appropriate procedures during measurement, purging, and sampling activities will be used to minimize the potential for surface soils, decontaminated supplies, precipitation, and/or other potential contaminants from entering the well or contacting cleaned equipment.

2.3.5.2 Calculations

The standing water volume in the well riser and screen will be calculated immediately before well evacuation during each monitoring event if standard purging techniques are utilized. 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:

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

where: V = one well volume (gallons)

TD = total well depth (feet)
SWL = static water level (feet)
C = volume constant for given well diameter (gallons/ft)
C = 0.163 gallons/ft for two-inch wells
C = 0.653 gallons/ft for four-inch wells

2.3.5.3 Well Purging

Equipment
Several options for well purging may be used at this site including:

- Disposable Bailers;
- Low Flow Pumps; and
- Grundfos Redi-Flo Pumps.

Disposable Bailers: Where bailers are used, 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-cleaned 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. Where bailers are used, a minimum of three well volumes will be purged unless the well runs dry.

Low Flow Pumps: Monitoring wells may be purged and sampled using the low-flow sampling method in accordance with DWM guidance (*"Groundwater, Surface Water, and Soil Sampling for Landfills"* (NCDEQ, 2008) (See **Section 1.2**)).

Grundfos Redi-Flo Pumps: Where Redi-Flo pumps are used, the same low flow techniques for sampling will be used. See above for a purging/sampling technique summary.

Technique
Depth-to-water measurements will be obtained using an electronic water level indicator capable of recording the depth to an accuracy of 0.01 foot (see **Section 2.3.4**). A determination of whether or not the water table is located within the screened interval of the well will be made. If the water table is not within the screened interval, the amount of drawdown that can be achieved before the screen is intersected will be calculated. If the water table is within the screened interval, total drawdown should not exceed 1 foot to minimize the aeration and turbidity. If the water table is above the screened interval, the drawdown amount should be minimized to keep the screen from being exposed.

If the purging equipment is non-dedicated, the equipment will be lowered into the well, taking care to minimize the water column disturbance. If conditions (i.e., water column height and well yield) allow, the pump will be placed in the uppermost portion of the water column (minimum of 18 inches of pump submergence is recommended).

The minimum volume/time period for obtaining independent Water Quality Parameter Measurements (WQPM) will be determined based on the stabilized flow rate and the volume in the pump and the discharge tubing. The bladder pump volume should be obtained from the manufacturer. Alternately, if a continuous read flow-cell is used, it can indicate when WQPM should be obtained, as long as the purged volume is equal to or greater than the calculated volume. Discharge tubing volumes are as follows:

3/8-inch inside diameter tubing:	20 milliliters per foot
1/4-inch inside diameter tubing:	10 milliliters per foot
3/16-inch inside diameter tubing:	5 milliliters per foot

Begin the well purge following calculations to determine the volume of the flow-cell or the pump and the discharge tubing. The flow rate should be based on historical data for each individual well (if available) and should not exceed 500 milliliters per minute. The initial round of WQPM should be recorded and the flow rate adjusted until drawdown in the well stabilizes. Water levels should be measured periodically to maintain a stabilized water level. The water level should not fall within one foot of the top of the well screen. If the purge rate has been reduced to 100 milliliters or less and the head level in the well continues to decline, the required water samples should be collected following WQPM stabilization, based on the criteria presented below.

If neither the head level nor the WQPM stabilize, a passive sample should be collected. Passive sampling is defined as sampling before WQMP have stabilized if the well yield is low enough that the well will purge dry at the lowest possible purge rate (generally 100 milliliters per minute or less).

WQPM stabilization is defined as: pH (+/- 0.2 S.U.), conductance (+/- 5% of reading), temperature (+/- 10% of reading or 0.2°C), and dissolved oxygen (DO) [+/- 20% of reading or 0.2 mg/L (whichever is greater)]. Oxidation reduction potential (ORP) will be measured and ideally should also fall within +/- 10mV of reading; however, this is not a required parameter. At a minimum, turbidity measurements should also be recorded at the beginning of purging, following WQPM stabilization, and following sample collection. The optimal turbidity range for micropurging is 25 Nephelometric Turbidity Units (NTU) or less. Turbidity measurements above 25 NTU are generally indicative of an excessive

purge rate or natural conditions related to excessive fines in the aquifer matrix.

WQPM stabilization should occur in most wells within five to six rounds of measurements. If stabilization does not occur following the removal of a purge volume equal to three well volumes, a passive sample will be collected.

The direct-reading equipment used at each well will be calibrated in the field according to the manufacturer's specifications prior to each day's use and checked, at a minimum, at the end of each sampling day. Calibration information should be documented in the instrument's calibration logbook and field logbook/notes.

Each well is to be sampled immediately following WQPM stabilization. The sampling flow rate must be maintained at a rate less than or equal to the purging rate. For volatile organic compounds, lower sampling rates (100 - 200 milliliters/minute) should be used. Final field parameter readings should be recorded prior to and after sampling.

2.3.5.4 Purge Rate

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

2.3.5.5 Purge Water Disposal

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 if warranted by field characteristics.

2.3.5.6 Non-Dedicated Equipment

Durable, non-dedicated equipment lowered into the well or that may come in contact with the water samples, will be disassembled to the degree practical and decontaminated before each use. Equipment decontamination procedures are described in **Section 2.3.3**.

2.3.6 Sample Collection

After purging, groundwater samples will be collected for laboratory analysis. As much as practical, samples should be collected from least contaminated location(s) first, followed by locations of increasing contamination across the site. Prior to sample collection, 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:

- Site Name;
- Sample Location or Well Number;
- Date and Time of Collection;
- Analysis Required;
- Sampler's Initials;
- Preservative Used (if any); and
- Other Pertinent Information, as Necessary.

Completed sample labels should be affixed to the sample bottle prior to sampling.

Sampling will occur within 24-hours of well purging 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.

2.3.6.1 Field Parameters

Field measurements to determine temperature, pH, and specific conductivity will be recorded immediately prior to sampling each monitoring location. Turbidity measurements may be collected for metals evaluation. The field test specimens will be collected with the sampling bailer and placed in a clean, non-conductive glass or plastic container for observation. Temperature, pH, conductivity, and turbidity meter calibration will be performed 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.

2.3.6.2 Sample Equipment

Several options for sample collection are available for this site including:

- Disposable Bailers;
- Low Flow Pumps; and
- Grundfos Redi-Flo Pumps.

These are each discussed in greater detail below.

Bailers – Where bailers are used, 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. Where bailers are used, a minimum of three well volumes will be purged unless the well runs dry.

Low Flow Pumps – Monitoring wells may be purged and sampled using the low-flow sampling method in accordance with the *Solid Waste Section Guidelines for Groundwater, Soil, and Surface Water Sampling* (NCDENR, 2008).

Depth-to-water measurements will be obtained using an electronic water level indicator capable of recording the depth to an accuracy of 0.01 foot. A determination of whether or not the water table is located within the screened interval of the well will be made. If the water table is not within the screened interval, the drawdown amount that can be achieved before the screen is intersected will be calculated. If the water table is within the screened interval, total drawdown should not exceed 1 foot to minimize the amount of aeration and turbidity. If the water table is above the top of the screened interval, the drawdown amount should be minimized to keep the screen from being exposed.

If the purging equipment is non-dedicated, the equipment will be lowered into the well, using care to minimize the disturbance to the water column. If conditions (i.e., water column height and well yield) allow, the pump will be placed in the uppermost portion of the water column (minimum of 18 inches of pump submergence is recommended).

The minimum volume/time period for obtaining independent Water Quality Parameter Measurements (WQPM) will be determined. The minimum volume/time period is determined based on the stabilized flow rate and the amount of volume in the pump and the discharge tubing (alternatively, the volume of a direct read flow-cell can be used, provided it is greater than the calculated volume of the pump and discharge tubing). The bladder pump volume should be obtained from the manufacturer. Volume from the discharge tubing is as follows:

3/8-inch inside diameter tubing:	20 milliliters per foot
1/4-inch inside diameter tubing:	10 milliliters per foot
3/16-inch inside diameter tubing:	5 milliliters per foot

Once the flow-cell or the pump and discharge tubing volume has been calculated, the well purge will begin. The flow rate should be based on historical data for that well (if available) and should not exceed 500 milliliters per minute. The initial WQPM should be recorded and the flow rate adjusted until drawdown in the well stabilizes. Water levels should be measured periodically to ensure a stabilized water level is maintained. The water level should not fall within 1 foot of the top of the well screen. If the purge rate has been reduced to 100 milliliters or less and the head level in the well continues to decline, the required water samples should be collected following stabilization of the WQPM, based on the criteria presented below.

If neither the head level nor the WQPM stabilize, a passive sample should be collected. Passive sampling is defined as sampling before WQMP have stabilized if the well yield is low enough that the well will purge dry at the lowest possible purge rate (generally 100 milliliters per minute or less).

WQPM stabilization is defined as follows: pH (+/- 0.2 S.U.), conductance (+/- 5% of reading), temperature (+/- 10% of reading or 0.2°C), and dissolved oxygen (DO) [+/- 20% of reading or 0.2 mg/L (whichever is greater)]. Oxidation reduction potential (ORP) will be measured and ideally should also fall within +/- 10mV of reading; however, this is not a required parameter. At a minimum, turbidity measurements should also be recorded at the beginning of purging, following the stabilization of the WQPM, and following samplecollection. The optimal turbidity range for micropurging is 25 Nephelometric Turbidity Units (NTU) or less. Turbidity measurements above 25 NTU are generally indicative of an excessive purge rate or natural conditions related to excessive fines in the aquifer matrix.

WQPM stabilization should occur in most wells within five to six rounds of measurements. If stabilization does not occur following the removal of a purge volume equal to three well volumes, a passive sample will be collected.

The direct-reading equipment used at each well will be calibrated in the field according to the manufacturer's specifications prior to each day's use and checked at a minimum at the end of each sampling day. Calibration information should be documented in the instrument's calibration logbook and the field book.

Each well is to be sampled immediately following stabilization of the WQPM. The sampling flow rate must be maintained at a rate that is less than or equal to the purging rate. For volatile organic compounds, lower sampling rates (100 - 200 milliliters/minute) should be used. Final field parameter readings should be recorded prior to and after sampling.

Grundfos Redi-Flo Pumps – Where Redi-Flo pumps are used, the same low flow techniques for sampling will be used. Please see above for detailed summary of purging/sampling techniques.

2.3.6.3 Purge Rate

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

2.3.6.4 Purge Water Disposal

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 if warranted by field characteristics.

2.3.6.5 Non-Dedicated Equipment

Durable, non-dedicated equipment that is lowered into the well or which may come in contact with the water samples will be thoroughly decontaminated before each use. Equipment will be disassembled to the degree practical, washed with (non-phosphate) soapy potable tap water, and triple rinsed using de-ionized water. Detailed equipment decontamination procedures are detailed in **Section 2.3.3**.

2.3.6.6 Sample Transference

Samples will be transferred directly from the disposable bailer or pump discharge tubing 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.

2.3.6.7 Sample Collection Order

Groundwater samples will be collected in the order of volatilization sensitivity. When collected, the following sampling order will be observed:

- 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;
- Microbiological; and
- Other Parameters (as applicable).

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

Samples will be collected and analyzed in an **unfiltered** state. Dissolved metal analysis samples, 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.

2.3.6.8 Decontamination

Reusable sampling equipment including water level probes, water quality 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, organic free water (Milli-Q or equivalent) and rinsing with isopropanol and organic-free water. Equipment decontamination procedures are detailed in **Section 2.3.3**.

2.3.6.9 Sample Preservation

Following sampling at each location, the sample bottles will be placed in a cooler with ice for preservation.

2.3.6.10 Field Quality Assurance

Blank samples will be prepared, handled, and analyzed as groundwater samples to ensure cross-contamination has not occurred. One set of trip blanks, as described in **Section 3.1.1**, will be prepared before leaving the laboratory to ensure that the sample containers or handling processes have not affected the sample quality. One set of 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 sample quality. Equipment blanks are discussed in **Section 3.1.2**. A duplicate groundwater sample may be collected from a single well as a laboratory accuracy check. Blanks and duplicate containers,

preservatives, handling, and transport procedures for surface water samples will be identical to those described for groundwater samples.

2.3.6.11 Sample Containers

Sample containers will be provided by the laboratory for each sampling event. Containers must be either new, 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 non-organic 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, and rinsed with tap water and non-organic water. The laboratory will provide proper preservatives in the sample containers prior to shipment (see **Section 4.0**).

2.4 Surface Water Sample Collection

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

2.4.1 Monitoring Conditions and Observations

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. Sampling event scheduling and the interpreted surface water data should account for recent weather and sampling station conditions.

Surface water level and sampling station conditions should be recorded 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 logbook prior to sample collection:

- Relative stream water level;
- Surface water clarity; and
- Monitoring location conditions, including access and surroundings.

Report to the Solid Waste Manager any observed maintenance or access issues observed.

2.4.2 Sampling Station Modifications

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

2.4.3 Sample Collection

2.4.3.1 Collection Procedure

Surface water samples will be obtained from locations with minimal turbulence and aeration. For stream sampling locations, samples will be collected if flowing water is observed during the sampling event. For pond sampling locations, water flow is not necessary. New, powder-free, surgical gloves will be donned prior to sample collection. The following procedure will be followed when conducting surface water sampling:

1. Put on new, powder-free, surgical gloves.

2. Hold the bottle by the bottom with one hand and remove the cap with the other.

3. Push the sample container slowly into the water with the mouth tilted up toward the current to fill. A water depth of six inches is generally satisfactory. Breaching the surface or losing sample preservatives while filling the container will be avoided.

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

2.4.3.2 Field Parameters

Temperature, pH, specific conductivity, and turbidity will be measured prior to sampling to assess field conditions and check the water sample stability over time. Temperature, pH, specific conductivity, and turbidity measurements will be recorded for surface water samples. Temperature, pH, conductivity and turbidity meters will be calibrated 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).

2.4.3.3 Sample Collection Order

Surface water samples will be collected in the order of parameter volatilization sensitivity. The following order will be observed:

- 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;
- Microbiological; and
- Other Parameters (as applicable).

Samples will be collected and analyzed in an **unfiltered** state. Dissolved metal analysis samples, 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. **Additional blanks and duplicate samples will not be collected with the surface water samples**.

2.4.3.4 Decontamination

Field meters which might contact surface water samples will be decontaminated between stations Equipment decontamination procedures are detailed in **Section 2.3.3**.

2.4.3.5 Sample Preservation

Following sampling at each location, the sample bottles will be placed in a cooler with ice for preservation.

2.4.3.6 Sample Containers

Sample containers will be provided by the laboratory for each surface water sampling event. Each container's preparation and preservatives will be the same as those utilized for groundwater sampling and addressed previously in **Section 2.3.6.8**.

2.5 Sediment Sample Collection

This section presents the procedures and equipment required to perform sediment sampling from the unnamed tributary downgradient of the monofill. Documentation of field activities will be in accordance with **Section 6.1**.

2.5.1 Monitoring Conditions and Observations

Sediment quality analyses are particularly sensitive to site hydrologic conditions and recent precipitation events. Changes in water flow may result in sediment movement in the stream bed. Sampling event scheduling and the interpreted sediment data should account for recent weather and sampling station conditions.

Sampling station conditions should be recorded 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 sediment quality sampling. As applicable, the following objective observations will be recorded in a dedicated field logbook prior to sample collection:

- Relative stream water level;
- Surface water clarity; and
- Monitoring location conditions, including access and surroundings.

Report to the Solid Waste Manager any observed maintenance or access issues observed.

Documentation of all field activities will be in accordance with **Section 6.1**.

2.5.2 Sampling Station Modifications

Modifications to sediment sampling station conditions may be required prior to each sampling event. When modifications are necessary, sufficient time will be allowed for settlement of suspended solids between the disturbance and sample collection. A minimum four hour settling period will be observed.

2.5.3 Sample Collection

2.5.3.1 Collection Procedure

New, powder-free, surgical gloves will be donned prior to sample collection. The following procedure will be followed when conducting sediment sampling:

1. Put on new, powder-free, surgical gloves.

2. Hold the bottle by the bottom with one hand and remove the cap with the other.

3. Collect the sediment sample with a stainless steel trowel and place in sample container.

2.5.3.2 Sample Collection Order

Sediment samples will be collected in the order of parameter volatilization sensitivity. When collected, the following order will be observed:

- 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;
- Microbiological; and
- Other Parameters (as applicable).

Additional blanks and duplicate samples will not be collected with the sediment samples.

2.5.3.3 Decontamination

Sampling equipment which might contact sediment samples will be decontaminated between stations Equipment decontamination procedures are described in **Section 2.3.3**.

2.5.3.4 Sample Preservation

Following sampling at each location, the sample bottles will be placed in a cooler with ice for preservation.

2.5.3.5 Sample Containers

Sample containers will be provided by the laboratory for each sediment sampling event. Each container's preparation and preservatives will be the same as those utilized for groundwater sampling and addressed previously in **Section 2.3.6.8**.

3.0 FIELD QA/QC PROGRAM

Field Quality Assurance/Quality Control (QA/QC) requires the routine collection and analysis of blanks to verify that the handling process has not affected the sample quality. 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.

3.1 Blank Samples

3.1.1 Trip Blanks

The laboratory will prepare a trip blank by filling each sample bottle type with laboratory grade distilled or deionized water. Trip blanks will use the specific bottle type required for the analyzed parameters from a bottle pack specifically assembled by the laboratory for each sampling event. Trip blanks are assembled in the laboratory, transported with the empty bottle packs, remain in the coolers throughout sampling, and are transported back to the laboratory for analysis. Trip blanks will only be analyzed for volatile and purgeable organics.

3.1.2 Equipment Blanks

Where wells are sampled with non-dedicated equipment, equipment blank samples will be collected at a rate of one sample per day. To collect an equipment blank, pour non-organic (Milli-Q or equivalent) water into a bailer and, handling the bailer in a manner identical to well sampling, transfer the water into the specified "blank" sample collection jars specified. Equipment blank samples are packed and sent to the laboratory with the other samples.

3.1.3 Field Blanks

As deemed necessary, field blanks will be collected. The laboratory will provide designated bottles with laboratory grade distilled or deionized water. The water will be poured from one laboratory provided container to an empty laboratory provided container for the specified analysis. This activity must be performed at the sampling location. Field blank samples will be packed in the cooler and sent to the laboratory with the other samples.

3.1.4 Blank Concentrations

The contaminant concentration levels found in the blanks will be reported but will not be used to correct 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.

3.1.5 Field Instruments

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 measurements for each sample. The specific conductivity and pH meter will be recalibrated utilizing two prepared solutions of known pH concentrations in the anticipated value range (between 4 and 10). A permanent thermometer, calibrated against a National Bureau of Standards Certified thermometer, will be used for temperature meter calibration. Other field equipment should be calibrated at least daily using the manufacturer's recommended specifications.

4.0 SAMPLE PRESERVATION AND SHIPMENT

Sample preservation methods, shipment, and Chain-of-Custody procedures observed between sampling and laboratory analysis are presented in this section.

4.1 Sample Preservation

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 analysis of inorganic metals constituents.

4.2 Storage/Transport Conditions

Proper storage and transport conditions must be maintained to preserve sample integrity 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 maximum 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 will be placed on the outside of the shipping coolers, in a manner to prevent and detect tampering with the samples.

4.3 Sample Delivery

Samples will be delivered to the analytical laboratory within a reasonable time period in person or using an overnight delivery service to insure holding time compliance. If samples are not shipped the same day, the ice used to keep the samples cool will be replenished to maintain the required maximum 4° C temperature. Sample shipment and delivery 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 contaminant concentrations in the same cooler or shipping container with other environmental samples.**

4.4 Chain of Custody

Chain-of-Custody control will be maintained from sampling through analysis to prevent tampering with analytical specimens. Chain-of-Custody control procedures 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(s) in sealed coolers. Identical container kits will be shipped by express carrier to the sampler or site or will be picked up at the laboratory.

2. After sample kit delivery but prior to sampling, the sampler will inventory the container kit checking consistency between the number and type of containers present with what is indicated in the Chain-of-Custody forms and that required for the sampling event.

3. Labels for individual sample containers will be written in the field, indicating the site name, sample location/well number, date and time of sample collection, analysis required, sampler's initials, and preservation methods used for the sample.

4. Collected specimens will be placed in the coolers on ice 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 secure area.

Once delivered to the laboratory, samples will be issued laboratory sample numbers recorded into a logbook indicating client, sample location/well number, and delivery date and time. The laboratory director or his designee will sign the Chain-of-Custody control forms and formally receive the samples.

Submitted Chain-of-Custody form copies will be placed in the laboratory's analytical project file and attached to the laboratory analysis report.

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.

5.0 LABORATORY ANALYSIS

The samples will be analyzed for parameters specified by the DWM for detection monitoring purposes including water quality field indicators (pH, conductivity, temperature, and turbidity) and those constituents listed in **Table 2**. Analytical methods from Test Methods For Evaluating Solid Waste - Physical/Chemical Methods (SW-846) or Methods For the Chemical Analysis of Water and Wastes will be consistent with the DWM's policies regarding analytical methods and reporting limits. Analysis will be performed by a laboratory certified by the DWM for the analyzed parameters.

5.1 Laboratory Quality Assurance/Quality Control

As stated above laboratory analysis will be performed by a NC Certified laboratory. Formal environmental laboratory Quality Assurance/Quality Control (QA/QC) procedures are to be utilized at all times. The laboratory must have a QA/QC program based on specific routine procedures outlined in a written laboratory Quality Assurance/Quality Control Manual. Internal quality control checks shall be undertaken regularly by the lab to assess the precision and accuracy of analytical procedures.

5.2 Data Review

During 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 contracted laboratories responsibility to verify the subcontracted work is performed by certified laboratories, using identical QA/QC procedures.

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6.0 RECORD KEEPING AND REPORTING

This section addresses the documentation and reporting requirements associated with the WQMP implementation.

6.1 Field Logbook

During sampling activities, 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;
- Sampling Date and Time;
- Climatic Conditions During Sampling Event;
- Sampling Location/Well Identification Number; and
- Signature of Field Technician.

Groundwater Sampling Observations

- Static Water Level and Well Bottom;
- Water Column Height;
- Condition of Monitoring Well;
- Monitoring Location Conditions, Including Access and Surroundings;
- Purged Water Volume and Relative Recharge Rate (High or Low);
- Observations on Purging and Sampling Event;
- Sample Collection Time; and
- Field Parameters: Temperature, pH, Specific Conductivity, and Turbidity Readings; Also DO and ORP values.

Surface Water and Sediment Sampling Observations

- Relative Stream Water Level;
- Surface Water Clarity;
- Monitoring Location Conditions, Including Access and Surroundings;
- Sample Collection Time; and
- Field Parameters: Temperature, pH, Specific Conductivity, and Turbidity Readings.

6.2 Groundwater Flow Evaluation

After each monitoring event, the potentiometric surface will be evaluated to determine the groundwater flow rate and direction at the site. The groundwater flow direction will be determined by comparing groundwater surface elevations across the site with a potentiometric surface map constructed from data collected during each event. Groundwater flow rates will be determined using the following equation:

$$V = \frac{Ki}{n}$$

where:

V = velocity (feet/day)
K = hydraulic conductivity (feet/day)
i = hydraulic gradient (feet/feet)
n = effective porosity of aquifer soils (unitless)

This evaluation will be used to determine if modifications to the WQMP may be required (see **Section 7.1**).

6.3 Reporting

A report summarizing the monitoring event and the analytical data from the event will be submitted to the DWM within 120 days of completion of the event.

Monitoring reports will include the following:

1. A discussion of site geology and hydrogeology;
2. A discussion of the monitoring event procedures and results;
3. A groundwater flow evaluation (including a potentiometric surface map);
4. Analytical laboratory reports and summary tables;
5. Graphical and/or statistical analysis of analytical data may be reported but is not required;
6. Solid Waste Environmental Monitoring Reporting Form (**Appendix A**); and
7. Laboratory Data (in Electronic Data Deliverable Format - see **Section 1.2**).

Monitoring reports may be submitted electronically by e-mail or in paper copy form. Report copies will be kept at the landfill office.

7.0 MONITORING PROGRAM MODIFICATIONS

This section addresses the procedures that should be followed with respect to water quality monitoring program modifications.

7.1 Plan Modifications and Updates

After each water quality monitoring event, a groundwater flow evaluation will be performed to determine the groundwater flow rate and direction at the site (see **Section 6.2**). If this evaluation reveals the monitoring network is insufficient to monitor for a potential release of solid waste constituents from the solid waste management area, a modified plan will be prepared and submitted to the DWM for approval.

The need for plan modifications and updates will also be determined as part of any scheduled permitting activities for the facility.

7.2 Well Abandonment/Rehabilitation

Should wells become irreversibly damaged or require rehabilitation, the DWM will be notified. If monitoring wells and/or piezometers are damaged irreversibly they will be abandoned under DWM direction following 15A NCAC 02C .0113. The abandonment procedure in unconsolidated materials involves over-drilling and/or pulling the well casing and plugging the well with a sealant such as neat cement grout and/or bentonite clay. For bedrock well completions, the abandonment encompasses plugging the interior well riser and screen with a sealant such as neat cement grout and/or bentonite clay.

7.3 Additional Well Installations

Additional well installations will be carried out in accordance with DWM directives. Monitoring wells will be installed under the supervision of a geologist or engineer who is registered in North Carolina and who will certify to the DWM that the installation complies with the North Carolina rules and regulations. For future well installations, the documentation for well construction will be submitted by the registered geologist or engineer to the DWM within sixty (60) days after well construction.

7.4 Implementation Schedule

The monitoring program proposed herein will be implemented following approval of this Water Quality Monitoring Plan by the DWM.

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Tables

Water Quality Monitoring Plan
Halifax County Landfill Facility
Halifax County, North Carolina

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SMITH+GARDNER

Table 1
Well Construction Details
Halifax County Landfill

Date: 11/23/15
By: MG

Monitoring Location	Well Installation Date	Latitude	Longitude	Well Diameter (inches)	Total Well Depth (ft. bgs)	Ground Surface Elevation (ft. amsl)	TOC Elevation (ft)	Screen Interval (ft. bgs)	Screen Geology
Closed MSW Landfill									
MW-1	NA	36.3804	77.8143	2	42.61**	321.18	323.18 ⁂	NA	NA
MW-2A	07/26/1995	36.3731	77.8141	2	14	246.43	246.43	4-14	Silt & Sand
MW-2AD	09/01/1999	36.3732	77.8140	2	40	245.65	245.65	30 - 40	Coarse Sandy PWR
MW-3AS	07/25/1995	36.3723	77.8134	2	19	248.57	251.57 ⁂	9-19	Clayey Silty Sand
MW-3D	07/25/1995	36.3723	77.8134	2	52.20**	251.73	251.73	NA	NA
MW-6D	10/30/1991	36.3742	77.8144	2	40	253.22	253.22	25 - 40	Sandy Silt
MW-7D	10/31/1991	36.3751	77.8137	2	40	249.09	249.09	25 - 40	Sandy Silt
MW-15R	08/31/1999	36.3744	77.8106	2	43	299.78	299.78	33 - 43	Sandy Clayey Silt
MW-16A	07/26/1995	36.3715	77.8111	2	15	271.46	271.46	5 - 15	Clayey Sand
MW-17	10/03/2007	36.3726	77.8138	2	25	247.75	247.75	15 - 25	Saprolite
MW-18S	10/16/2007	36.3730	77.8144	2	18	244.52	244.52	8-18	Clayey Sand/Saprolite
MW-18D	10/17/2007	36.3731	77.8145	2	52	244.04	244.04	47 - 52	Granite
G-13	NA	NA	NA	NA	NA	NA	NA	NA	NA
G-13D	NA	NA	NA	NA	NA	NA	NA	NA	NA
BP-3	NA	36.3732	77.8102	2	NA	NA	300.50	NA	NA
BP-9	NA	36.3750	77.8094	2	NA	NA	303.48	NA	NA
Coal Ash Landfill									
MW-8	3/5/1992	36.38142	77.8099596	2	20	311.12	308.43	5 - 20	NA
MW-9	1/5/1994	36.37798	77.8124915	2	25	275.51	277.26	10 - 25	PWR
MW-10	1/10/1994	36.37704	77.8111651	2	16.5	255.87	258.72	5 - 15	PWR
MW-11	1/7/1994	36.37673	77.8098319	2	20	262.04	265.93	4 - 19	clayey silt/sand
MW-12	1/7/1994	36.37806	77.8070104	2	50	325.67	329.33	34.5 - 49.5	sand
MW-17	1/7/1999	36.37841	77.8101064	2	25	291.14	294.38	15 - 25	saprolite

NOTE:

1.) ** Well depth from Environment 1 10/01/2015 Report client ID#6015
2.) ⁂3' stickup estimated, therefore groundwater elevation is also estimated
3.) NA = Not Available
4.) NM = Not Measured

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Table 2
Analytical Parameters
Halifax County Landfill

By: JAS/MMG
Date: 5/8/2014

Constituents	Synonyms
Antimony	
Arsenic	
Barium	
Beryllium	
Cadmium	
Chromium	
Cobalt	
Copper	
Lead	
Mercury	
Nickel	
Selenium	
Silver	
Thallium	
Vanadium	
Zinc	
Temperature	
pH	
Turbidity	
Specific Conductance	
Acetone	2-Propanone
Acrylonitrile	2-Propenenitrile
Benzene	
Bromochloromethane	Chlorobromomethane
Bromodichloromethane	Dibromochloromethane
Bromoform	Tribromomethane
Carbon Disulfide	
Carbon Tetrachloride	Tetrachloromethane
Chlorobenzene	
Chloroethane	Ethyl chloride
Chloroform	Trichloromethane
Dibromochloromethane	Chlorodibromomethane
1,2-Dibromo-3-chloropropane	DBCP
1,2-Dibromoethane	Ethylene dibromide, EDB
1,2-Dichlorobenzene	o-Dichlorobenzene
1,4-Dichlorobenzene	p-Dichlorobenzene
trans-1,4-Dichloro-2-butene	
1,1-Dichloroethane	Ethyldidene chloride
1,2-Dichloroethane	Ethylene dichloride
1,1-Dichloroethylene	Vinylidene chloride
cis-1,2-Dichloroethylene	
trans-1,2-Dichloroethylene	
1,2-Dichloropropane	Propylene dichloride
cis-1,3-Dichloropropene	
trans-1,3-Dichloropropene	
Ethylbenzene	

SMITH+GARDNER

Table 2
Analytical Parameters
Halifax County Landfill

By: JAS/MMG
Date: 5/8/2014

Constituents	Synonyms
2-Hexanone	Methyl butyl ketone
Methyl bromide	Bromomethane
Methyl chloride	Chloromethane
Methyl ethyl ketone	2-Butanone
Methyl iodide	Iodomethane
4-Methyl-2-pentanone	Methyl isobutyl ketone
Methylene bromide	Dibromomethane
Methylene chloride	Dichloromethane
Styrene	Ethenylbenzene
1,1,1,2-Tetrachloroethane	
1,1,2,2-Tetrachloroethane	
Tetrachloroethylene	Perchloroethylene
Toluene	Methyl benzene
1,1,1-Trichloroethane	Methyl chloroform
1,1,2-Trichloroethane	
Trichloroethylene	
Trichloroflouromethane	CFC-11
1,2,3-Trichloropropane	
Vinyl acetate	Acetic acid, ethenyl ester
Vinyl chloride	Choroethene
Xylenes	Dimethyl benzene
C&D Landfill Additional Parameter:	
Mercury	
Chloride	
Manganese	
Sulfate	
Iron	
Alkalinity	
Total Dissolved Solids	
Tetrahydrofuran	
Monitored Natural Attenuation Parameters:	
DO	
ORP	
Iron	
Alkalinity	
BOD	
COD	
TOC	
Sulfate	
Sulfide	
Nitrate	
Chloride	
Carbon Dioxide	
Ethane/Ethene	

Table 2
Analytical Parameters
Halifax County Landfill

Constituents	Synonyms
Hydrogen	
Dissolved Methane	
Volatile Fatty Acid	
SVOCs	
Acenapthene	
Acenapthylene	
Acetophenone	
2-Acetylaminofluorene	2-AAF
4-Aminobiphenyl	
Anthracene	
Benzo(a)anthracene	
Benzo(b)fluoranthene	
Benzo(k)fluoranthene	
Benzo(ghi)perylene	
Benzo(a)pyrene	
Benzyl alcohol	
Bis(2-chloroethoxy)methane	
Bis(2-chloroethyl) ether	
Bis(2-chloro-1-methylethyl) ether	
Bis(2-ethylhexyl)phthalate	
4-Bromophenyl ether	
Butyl benzyl phthalate	
p-Chloroaniline	
Chlorobenzilate	
p-Chloro-m-cresol	
2-Chloronapthalene	
2-Chlorophenol	
4-Chlorophenyl phenyl ether	
Chrysene	
m-Cresol	3-Methylphenol
o-Cresol	
p-Cresol	4-Methylphenol
Diallate	
Dibenz(a,h)anthracene	
Dibenzofuran	
Di-n-butyl phthalate	DBP
1,3-Dichlorobenzene	m-Dichlorobenzene
3,3-Dichlorobenzidine	
2,4-Dichlorophenol	
2,6-Dichlorophenol	
Diethyl phthalate	DEP
p-(Dimethylamino)azobenzene	
7,12-Dimethylbenz(a)anthracene	
3,3-Dimethylbenzidine	
2,4-Dimethylphenol	m-Xylenol

Table 2
Analytical Parameters
Halifax County Landfill

Constituents	Synonyms
Dimethyl phthalate	
m-Dinitrobenzene	
4,6-Dinitro-o-cresol	4,6-Dinitro-2-methyl phenol
2,4-Dinitrophenol	
2,4-Dinitrotoluene	
2,6-Dinitrotoluene	
Di-N-octyl phthalate	
Diphenylamine	
Ethyl methacrylate	
Ethyl methanesulfonate	
Famphur	
Fluoranthene	
Fluorene	
Hexachlorobenzene	
Hexachlorobutadiene	
Hexachlorocyclopentadiene	
Hexachloroethane	
Hexachloropropene	
Indeno(1,2,3-cd)pyrene	
Isodrin	
Isophorone	
Isosafrole	
Kepone	
Methapyrilene	
3-Methylcholanthrene	
Methyl methanesulfonate	
2-Methylnapthalene	
Napthalene	
1,4-Naphthoquinone	
1-Naphthylamine	
2-Naphthylamine	
o-Nitroaniline	2-Nitroaniline
m-Nitroaniline	3-Nitroaniline
p-Nitroaniline	
Nitrobenzene	
o-Nitrophenol	2-Nitrophenol
p-Nitrophenol	4-Nitrophenol
N-Nitrosodi-n-butylamine	
Ni-Nitrosodiethylamine	
N-Nitrosodimethylamine	
N-Nitrosodiphenylamine	
N-Nitrosodipropylamine	
N-Nitrosomethylethalamine	
N-Nitrosopiperidine	
N-Nitrosopyrrolidine	
5-Nitro-o-toluidine	

Table 2
Analytical Parameters
Halifax County Landfill

Constituents	Synonyms
Pentachlorobenzene	
Pentachloronitrobenzene	
Pentachlorophenol	
Phenacetin	
Phenanthrene	
Phenol	
p-Phenylenediamine	
Pronamide	
Pyrene	
Safrole	
1,2,4,5-Tetrachlorobenzene	
2,3,4,6-Tetrachlorophenol	
o-Toluidine	
1,2,4-Trichlorobenzene	
2,4,5-Trichlorophenol	
2,4,6-Trichlorophenol	
0,0,0-Triethyl phosphorothioate	
sym-Trinitrobenzene	1,3,5-trinitroBenzene

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Table 3

Monitoring Locations & MNA Sampling Schedule
Halifax County Landfill

Date: 3/9/2012
By: MG

Well	Detection Monitoring	Assessment Monitoring*	pH	DO	ORP	Turbidity	Temperature	Specific Conductivity	Sulfide	Iron	Chloride	Nitrate	TOC	COD
MW-1	semi		semi	semi	semi	semi	semi	semi	NM	NM	NM	NM	NM	NM
MW-2A	semi	*	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi
MW-2AD	semi	*	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi
MW-3A	NM		NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
MW-3AS	semi	*	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi
MW-3D	semi	*	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi	semi
MW-6D	semi	*	semi	semi	semi	semi	semi	semi	A-spring	A-spring	A-spring	A-spring	A-spring	A-spring
MW-7D^	semi		semi	semi	semi	semi	semi	semi	NM	NM	NM	NM	NM	NM
MW-15R	semi	*	semi	semi	semi	semi	semi	semi	NM	NM	NM	NM	NM	NM
MW-16A	semi	*	semi	semi	semi	semi	semi	semi	NM	NM	NM	NM	NM	NM
MW-17	semi	*	semi	semi	semi	semi	semi	semi	A-spring	A-spring	A-spring	A-spring	A-spring	A-spring
MW-18S	semi	*	semi	semi	semi	semi	semi	semi	A-spring	A-spring	A-spring	A-spring	A-spring	A-spring
MW-18D	A-spring		A-spring	A-spring	A-spring	A-spring	A-spring	A-spring	A-spring	A-spring	A-spring	A-spring	A-spring	A-spring
G-13	A-fall		A-fall	A-fall	A-fall	A-fall	A-fall	A-fall	A-fall	A-fall	A-fall	A-fall	A-fall	A-fall
G13D	A-fall		A-fall	A-fall	A-fall	A-fall	A-fall	A-fall	A-fall	NM	NM	NM	NM	NM

Well	Dissolved Methane	VFA	CO2	Hydrogen	BOD	ethane/ ethene
MW-1	NM	NM	NM	NM	NM	NM
MW-2A	3	3	3	3	3	3
MW-2AD	3	3	3	3	3	3
MW-3A	NM	NM	NM	NM	NM	NM
MW-3AS	3	3	3	3	3	3
MW-3D	3	3	3	3	3	3
MW-6D	3	3	3	3	3	3
MW-7D	NM	NM	NM	NM	NM	NM
MW-15R	NM	NM	NM	NM	NM	NM
MW-16A	NM	NM	NM	NM	NM	NM
MW-17	3	3	3	3	3	3
MW-18S	3	3	3	3	3	3
MW-18D	3	3	3	3	3	3
G-13	3	3	3	3	3	3
G13D	NM	NM	NM	NM	NM	NM

NOTE:
* Assesment monitoring is performed annually with detected parameters analyzed semi-annually
A-spring = well sampled annually spring event only
A- fall = well sampled annually fall event only
NM = Not Monitored
3 = well sampled every third year(both sampling events)
^ -7D wil be sampled for Appendix II every thrid year, in conjunction with the MNA sampling events (3) scheduled every third year.

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Figure

Water Quality Monitoring Plan
Halifax County Landfill Facility
Halifax County, North Carolina

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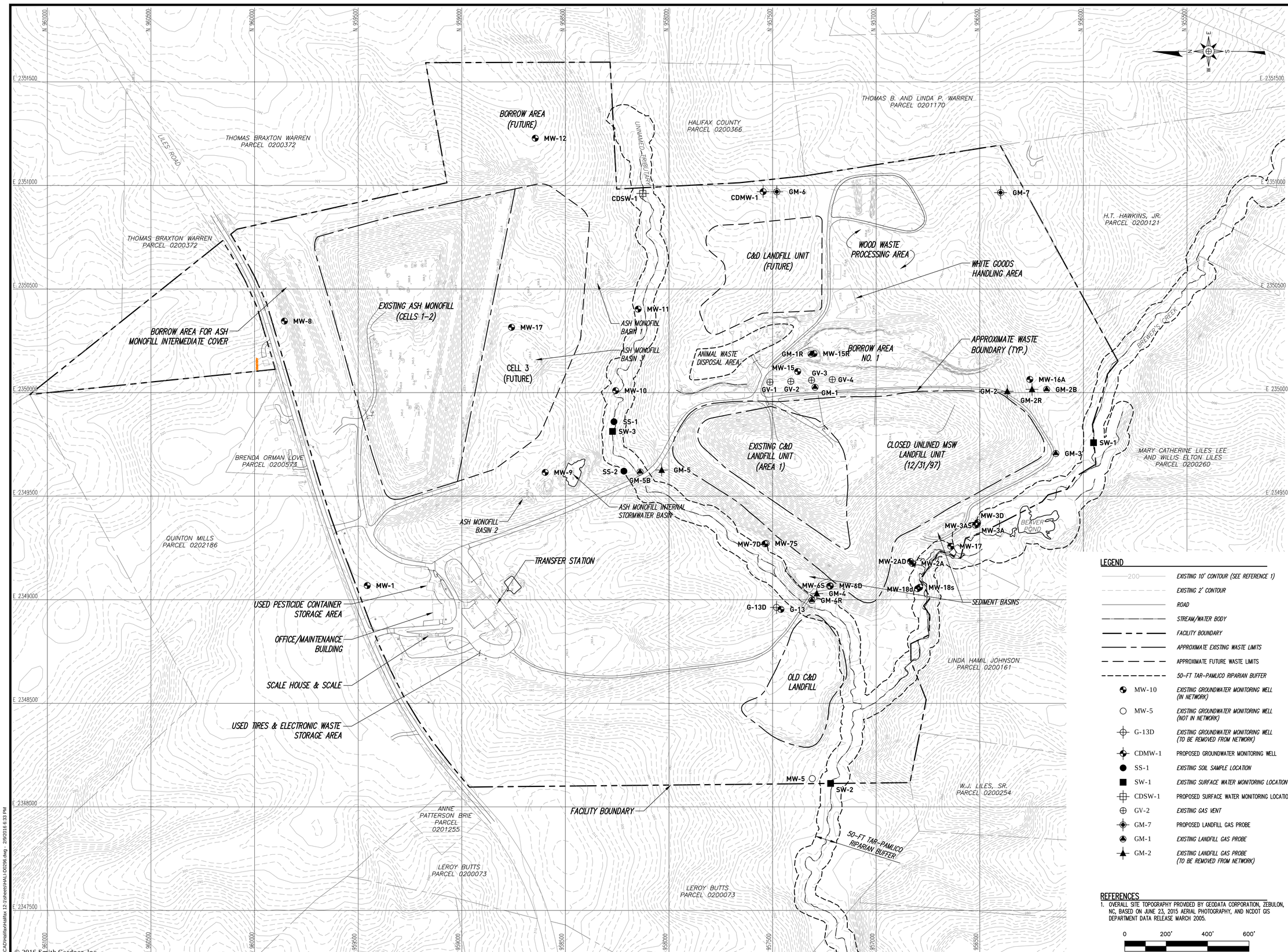

LEGEND

200	EXISTING 10' CONTOUR (SEE REFERENCE 1)
	EXISTING 2' CONTOUR
	ROAD
	STREAM/WATER BODY
	FACILITY BOUNDARY
	APPROXIMATE EXISTING WASTE LIMITS
	APPROXIMATE FUTURE WASTE LIMITS
	50-FT TAR-PAMLICO RIPARIAN BUFFER
MW-10	EXISTING GROUNDWATER MONITORING WELL (IN NETWORK)
MW-5	EXISTING GROUNDWATER MONITORING WELL (NOT IN NETWORK)
G-13D	EXISTING GROUNDWATER MONITORING WELL (TO BE REMOVED FROM NETWORK)
CDMW-1	PROPOSED GROUNDWATER MONITORING WELL
SS-1	EXISTING SOIL SAMPLE LOCATION
SW-1	EXISTING SURFACE WATER MONITORING LOCATION
CDSW-1	PROPOSED SURFACE WATER MONITORING LOCATION
GV-2	EXISTING GAS VENT
GM-7	PROPOSED LANDFILL GAS PROBE
GM-1	EXISTING LANDFILL GAS PROBE
GM-2	EXISTING LANDFILL GAS PROBE (TO BE REMOVED FROM NETWORK)

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY GEODATA CORPORATION, ZEBULON, NC, BASED ON JUNE 23, 2015 AERIAL PHOTOGRAPHY, AND NCDOT GIS DEPARTMENT DATA RELEASE MARCH 2005.

0 200' 400' 600'

PREPARED FOR:

HALIFAX COUNTY
NORTH CAROLINA
DEPARTMENT OF
PUBLIC UTILITIES

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+ GARDNER
ENGINEERS
14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

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PROJECT TITLE:

HALIFAX COUNTY

DRAWING TITLE:

ENVIRONMENTAL MONITORING LOCATIONS

DESIGNED: M.M.G.	PROJECT NO: HALIFAX 12-1
DRAWN: C.T.J.	SCALE: AS SHOWN
APPROVED:	DATE: NOV. 2015
FILENAME: HALI-D0296	
SHEET NUMBER:	DRAWING NUMBER: FIG.1

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Appendix A

Environmental Monitoring Report Form

Water Quality Monitoring Plan
Halifax County Landfill Facility
Halifax County, North Carolina

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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

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Landfill Gas Monitoring Plan

Halifax County Landfill Facility
Halifax County, North Carolina

Prepared for:

Halifax County Department of Public Utilities
Halifax, North Carolina

February 2016

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

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Landfill Gas Monitoring Plan

Halifax County Landfill Facility
Halifax County, North Carolina

Prepared For:

Halifax County Department of Public Utilities
Halifax, North Carolina

S+G Project No. HALIFAX-12-1

Madeline M. German, P.G.
Project Geologist

Joan A. Smyth, P.G.
Senior Hydrogeologist

NORTH CAROLINA LICENSED SEAL 2275 GEOLOGIST MADELINE GERMAN
2/18/16

February 2016

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+GARDNER

14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

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Halifax County Landfill Facility
Halifax County, North Carolina

Landfill Gas Monitoring Plan

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FIGURE

Figure 1 EnvironmentalMonitoring Locations

APPENDIX

Appendix A Reporting Forms

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1.0 INTRODUCTION

This Landfill Gas (LFG) Monitoring Plan (plan) was prepared by Smith Gardner, Inc. to describe the LFG monitoring program at the Halifax County Landfill Facility (NC Solid Waste Permit 42-04), which is located off of Liles Road near Littleton, North Carolina. This landfill facility includes a closed unlined municipal solid waste (MSW) landfill, an active construction demolition debris (C&D) landfill (Area 1) (vertical expansion of closed MSW landfill), and an active lined monofill for coal combustion by-products (ash monofill). This plan also covers a proposed future C&D landfill unit (Area 2) located to the east of Area 1. This plan describes the necessary procedures to satisfy applicable regulatory requirements (see **Section 1.1**) for landfill gas monitoring. Note that the wastes disposed in the ash monofill do not produce gas; thus, LFG monitoring of this unit is not required.

The Engineer has utilized the best available site data, practices, experience, and judgment to develop this plan. However, the plan may require modifications over time to accommodate changing landfill conditions, changing receptors in areas adjacent to and around the landfill, or other conditions that cannot be fully anticipated.

Uncontrolled migration of LFG (particularly methane (CH_4)) can result in loss of life, injury, loss of property, vegetative damage, and intolerable odors. Landfill monitoring includes exposure to explosive gases. Monitoring personnel should be specifically trained in the management and response for situations such as fire or explosion and confined space entry and possess an awareness of changing conditions around the landfill.

Note that this plan does not address landfill gas collection and control, air quality, or other related landfill gas regulations or requirements which may be applicable to this site at present or in the future.

1.1 Regulatory Requirements - C&D Landfills

Rule 15A NCAC 13B.0544 (d) of the North Carolina Solid Waste Management Rules requires the following for facilities having a C&D landfill:

- Owners or operators of C&D landfill units must ensure that:
  - the concentration of methane gas or other explosive gases generated by the facility does not exceed 25% of the lower explosive limit (LEL) (1.25% for methane) in on-site facility structures (excluding gas control or recovery system components);
  - the concentration of methane gas or other explosive gases does not exceed the LEL for methane or other explosive gases (5% for methane) at the facility property boundary; and
  - the facility does not release methane gas or other explosive gases in any concentration that can be detected in offsite structures.
- Owners or operators of C&D landfill units must implement a routine methane monitoring program and perform monitoring on at least a quarterly basis.

- If regulatory limits for methane gas concentrations are exceeded, a contingency plan must be implemented for the protection of human health and safety.

1.2 Guidance Document

This plan was developed generally following the Landfill Gas Monitoring Guidance document prepared by the North Carolina Department of Environmental Quality (NC DEQ), Division of Waste Management (DWM)[1].

1.3 Contact Information

All correspondence and questions concerning this plan should be directed to the appropriate contact below:

1.3.1 Owner

Halifax County Department of Public Utilities
26 N. King Street (Public Works Building)
P.O. Box 70
Halifax, NC 27839
Phone: (252) 583-1451
Fax: (252) 593-5014
Contacts: Greg Griffin, Director
griffing@halifaxnc.com

Halifax County Landfill Facility
921 Liles Road
Littleton, NC 27850
P.O. Box 70
Halifax, NC 27839
Phone: (252) 586-7516
Fax: (252) 586-2685

Contact: Solid Waste Manager

1.3.2 Engineer

Smith Gardner, Inc.
14 N. Boylan Avenue
Raleigh, North Carolina 27603
Phone: (919) 828-0577

[1] NC DEQ DWM (2010), "Landfill Gas Monitoring Guidance", NC DEQ DWM Solid Waste Section, November 2010.

Contacts: Joan A. Smyth, P.G., Senior Hydrogeologist
joan@smithgardnerinc.com
Pieter K. Scheer, P.E., Senior Engineer
pieter@smithgardnerinc.com

1.3.3 North Carolina Department of Environmental Quality (NC DEQ)

Division of Waste Management (DWM) - Solid Waste Section:

North Carolina DEQ - Raleigh Central Office
217 W. Jones Street
Raleigh, NC 27603
1646 Mail Service Center
Raleigh, NC 27699-1646
Phone: (919) 707-8200

Contact: Elizabeth Werner, Hydrogeologist
Elizabeth.werner@ncdenr.gov
(919) 707-8253

Mary Whaley, Waste Management Specialist
mary.whaley@ncdenr.gov

1.4 Existing Site Conditions

The facility is located approximately 12 miles south of Roanoke Rapids, North Carolina. Area development is a mix of agriculture, woodlands, and rural residential.

The facility consists of approximately 241 acres owned by Halifax County. The permitted facility is generally bounded on the north by Liles Road on the south by Brewer's Creek and to the east and west by other County-owned and private property. An unnamed tributary to Brewer's Creek runs through the center of the site and separates the closed MSW/Area 1 C&D landfill unit (south side of tributary) from the ash monofill (north side of tributary).

Ground surface elevations range from approximately El. 230 (feet above mean sea level) along the unnamed tributary on the west end of the site to El. 370 at the current top of the ash monofill. The facility location and existing site conditions are shown on **Figure 1**.

1.4.1 Site Geology

According to the 1985 North Carolina Geological Map and Ground Water in the Halifax Area, North Carolina (Dept. of Conservation and Development Bulletin #51, 1946) the landfill is situated on the eastern edge of the Eastern Piedmont Physiographic Province; slightly west of the Coastal Plain overlap. Generally,

Western Halifax County is underlain by felsic to intermediate, crystalline igneous and metamorphic rocks of early to late Paleozoic age. Eastern Piedmont rocks generally exhibit a northeastern strike and locally dip gently eastward due to regional metamorphism and folding that produced a broad plunging anticline. The area was simultaneously intruded by a number of felsic (granite) plutons. The granitic pluton underlying the landfill is the Butterwood Creek intrusion.

1.4.2 Local Groundwater Regime

The closed MSW/Area 1 C&D landfill unit and the future Area 2 C&D landfill unit are located between Brewer's Creek to the south and its tributary to the north. Groundwater in the upper-most aquifer generally flows through unconsolidated sediments toward either Brewer's Creek or its tributary where discharge occurs. These existing water streams create a natural barrier to LFG migration. Recharge occurs over most of the site from the non-saturated surface soils; however, some downward recharge occurs into the deeper, widely spaced bedrock fractures. These conditions are considered typical of this area.

2.0 MONITORING PROGRAM

This section of the LFG Monitoring Plan addresses each aspect of the monitoring program including monitoring frequency, monitoring network, and monitoring and reporting procedures.

2.1 Monitoring Frequency

Routine LFG monitoring will be conducted on a quarterly basis.

2.2 Monitoring Network

Existing and proposed monitoring locations are shown on **Figure 1** and are summarized in the following LFG monitoring network schedule below. Well installation information is not currently available for these wells.

Halifax County Landfill Proposed LFG Monitoring Network

Monitoring Location	
Existing Monitoring Wells/Structures:	
GM-1R	GM-4R
GM-2B	GM-5B
GM-3	
Proposed Monitoring Wells/Structures:	
GM-6*	White Goods Building*
GM-7*	

*To be monitored upon activation of Area 2 C&DLF unit.

If desired by the County, a dedicated methane monitor may be installed within the structure to be monitored.

2.2.1 Existing Network

There are ten existing LFG monitoring wells (GM-1R, GM-2, GM-2R, GM-3, GM-4, GM-4R, GM-5, GM-5B) located in the vicinity of the closed MSW/Area 1 C&D landfill unit. In addition, one facility structure, the Scalehouse, at the north end of the facility is monitored.

2.2.2 Modifications to Monitoring Network

The following modifications are proposed for the monitoring network and are reflected in the monitoring schedule shown above.

- Wells and Structures to be Removed:

  Based on the existing site conditions, including unnamed tributaries, four existing LFG monitoring wells will be removed from the routine

monitoring program (GM-2, GM-2R, GM-4, and GM-5). These wells are situated close to the landfill and each have a replacement well installed closer to the property line in the same general area, as a better indicator of LFG migration. These locations may be converted to gas vents utilizing a PVC "tee" or "candy cane" top. In addition, the scalehouse will be removed from monitoring given it is located at significant distance from any gas producing waste.

- Wells and Structure to be Added:

  In order to monitor the future Area 2 C&D landfill unit, two new LFG monitoring wells (GM-6 and GM-7) and monitoring of one additional structure (white goods building) are proposed. The new LFG monitoring well locations were determined by the existing site conditions, soil types, waste location, and nearby water bodies. The selected well locations are generally between the future Area 2 landfill unit and off-site structures.

2.2.3 LFG Monitoring Well Construction

Proposed LFG monitoring wells will be installed to approximately groundwater depth, estimated from nearby groundwater monitoring wells. Wells will be screened with 2-inch diameter 10-slot PVC well screen from the total well depth to between 5 feet and 10 feet below grade. Each well will be completed with solid PVC riser pipe, a well cap fitted with a stopcock valve or quick connect fitting, and a locking outer steel casing.

2.3 Monitoring and Reporting

Monitoring and reporting of LFG concentrations will be performed as outlined below.

2.3.1 Personnel

LFG monitoring will be performed by personnel who are familiar with the requirements of this plan and who are trained in LFG hazards and explosive gas meter use. As practical, a designated technician will be assigned to regular LFG monitoring duty.

2.3.2 Equipment

A LandtecTM GEM-2000 infrared portable gas analyzer (or equivalent) will be used to monitor LFG wells and facility structures. This analyzer, which is calibrated to methane (CH_4), operates using the infrared spectral property of methane to measure concentrations in air. Measurements of oxygen (O_2) and carbon dioxide (CO_2) will also be made with this meter. This meter may be used in oxygen deficient areas (less than 10% O_2) since oxygen is not required for a chemical combustion of flammable gases within the meter.

On the day of monitoring, prior to monitoring activities, this meter will be field calibrated. Additionally, all monitoring equipment should be regularly calibrated in accordance with manufacturer's specifications and operated only as instructed.

2.3.3 Procedures

Prior to each monitoring event, the portable gas analyzer will be calibrated with a known calibration standard in accordance with manufacturer's recommendations. General information related to the monitoring event, equipment used, calibration procedures, weather conditions, and results for each monitoring event will be recorded on the landfill gas monitoring data form (see **Appendix A**).

The following steps outline the procedure for the monitoring of LFG wells and facility structures:

- Check calibration date on the meter and calibrate according to manufacturers instructions; allowing equipment to warm up properly prior to use, per manufacturers direction.
- Purge sample tube for one minute before monitoring.

  LFG Monitoring Wells:
  - Connect instrument tubing to sample port on the monitoring well without removing the cap.
  - Open the valve and record both the initial and stabilized methane concentrations. A stabilized concentration will not vary more than 0.5 percent by volume on the instrument's scale. Also record the oxygen concentration (at two percent per volume or less to indicate air is not being drawn into the system and providing false readings) and the carbon dioxide concentration.
  - Close the valve and disconnect the tubing.
  - Record monitoring data on the LFG monitoring data form provided in **Appendix A**.
  - If any methane concentration is **greater than 50% of the LEL (2.5% CH_4)**, monitoring personnel should implement the Precautionary Action Plan (see **Section 2.3.4**).
  - If both initial and stabilized methane concentrations are less than 50% of the LEL (2.5% CH_4), move to next LFG monitoring well.

  Structures:
  - Walk through the facility structure with a methane analyzer and monitor the perimeter wall interface of the structure, the floor to wall interface in hallways and rooms, and any floor penetrations in the structure. Record the initial and stabilized methane

concentrations, oxygen concentration, and carbon dioxide concentration.
  - Record monitoring data on the LFG monitoring data form provided in **Appendix A**.
  - Notify the Solid Waste Manager and the Engineer for any methane concentration greater than 0% of the LEL.

IF A STABILIZED METHANE CONCENTRATION IS GREATER THAN 100% OF THE LEL IN A LFG MONITORING WELL OR GREATER THAN 25% OF THE LEL IN A FACILITY STRUCTURE, THE FOLLOWING ACTIONS WILL BE IMPLEMENTED:

1) Recalibrate monitoring equipment and confirm results.
2) If results are confirmed, **IMMEDIATELY** contact the Solid Waste Manager and the Engineer.
3) Implement the Immediate Action Plan located in **Section 3.1**.

2.3.4 Precautionary Action Plan

If an initial or stabilized methane concentration is equal to or greater than 50% of the LEL in a LFG monitoring well, monitoring personnel should perform the following additional steps at this location:

- Measure gas pressure in the well head (in inches of water) using magnehelic gauge or other appropriate metering device.
- Record at least one additional methane concentration measurement, inside the well just below the top of casing.
- Evaluate the surrounding area for potential receptors to or signs of LFG migration. LFG can stress vegetation and can kill trees and grass by root asphyxiation. Note stressed/dead vegetation areas on the monitoring form.
- Notify the Solid Waste Manager and the Engineer for further evaluation.

2.3.5 Record Keeping

Routine LFG monitoring events will be documented on the LFG monitoring data form provided in **Appendix A**. Completed forms will be placed in the landfill operating record located at the landfill office. These forms will be available for review by DWM personnel on request.

Documentation of any contingency plan actions (see **Section 3.0**) will also be kept in the operating record.

2.4 Maintenance

Periodic maintenance and site observations will be conducted routinely to address monitoring program components (at a minimum):

- Maintain access to LFG monitoring locations.
- Perform LFG monitoring well maintenance (maintain well locks, steel casing, concrete pad, etc.).
- Observe landfill cover conditions, areas of dead vegetation, leachate seeps, odors, etc. as indications of potential LFG-related problems.

Note deficiencies on the monitoring forms and report to the Solid Waste Manager for repair or replacement as necessary.

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3.0 CONTINGENCY PLAN

If a stabilized methane concentration is **greater than 100% of the LEL in a LFG monitoring well or greater than 25% of the LEL in a facility structure**, the County will perform both an immediate action and plan and a remediation plan as described below.

3.1 Immediate Action Plan

The Solid Waste Manager will perform the following actions for the protection of human health and safety:

1) Evacuate affected facility structures and the immediately surrounding area.
2) Determine nearby potential receptors (facility and off-site structures).
3) Perform monitoring in any other facility structure near the monitoring location having the high concentration.
4) Contact the local Fire Department (911). Coordinate evaluation of potentially affected off-site structures with the Fire Department.
5) Verbally notify the Public Utilities Director, or his designee.
6) Verbally notify the DWM (see **Section 1.1**) as soon as practical.
7) Investigate and identify the potential source(s) and conduit(s) for LFG migration that may have caused the high concentration (i.e. the path that the LFG may be taking to the monitoring location).
8) Identify the LFG extent using bar hole punch sampling methodology or other applicable alternative method as practical.
9) As appropriate, begin corrective action to control methane concentrations in structures surrounding the landfill site.

3.1.1 Reporting and Documentation

Within seven days of the detection of a high methane concentration will ensure the information regarding the exceedance and any actions taken to protect human health is placed in the operating record. The County will also prepare and submit an Environmental Monitoring Reporting Form (see **Appendix A**) with the results of the monitoring event to the DWM.

3.2 Remediation Plan

Within sixty days of the detection of a high methane concentration, a remediation plan describing the problem nature, extent, and proposed remedy will be prepared and submitted to the DWM for approval. Upon approval, the plan will be implemented and a copy will be placed in the operating record. The DWM will also be notified the plan has been implemented.

An extension may be granted by the DWM on written request and depending on severity of the situation.

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Table

Landfill Gas Monitoring Plan
Halifax County Landfill Facility
Halifax County, North Carolina

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SMITH+GARDNER

Table 1

LFG Monitoring Location Summary

By: MG
Date: 12/16/2015

Monitoring Location	Northing	Easting	Status
Network Locations			
GM-1	957295.38	2350025.65	existing
GM-2R	956248.04	2350016.23	existing
GM-3	956133.06	2349706.12	existing
GM-4R	957310.62	2348997.21	existing
GM-5B	958139.74	2349616.87	existing
GM-6	TBD	TBD	proposed
GM-7	TBD	TBD	proposed
Scalehouse	NA	NA	existing
Removed from Network			
GM-2	956367.43	2350006.59	future vent
GM-2B	956177.64	2350015.12	future vent
GM-4	957286.55	2349030.01	future vent
GM-5	958035.17	2349626.32	future vent

TBD = To Be Determined
NA = Not Available

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Figure

Landfill Gas Monitoring Plan
Halifax County Landfill Facility
Halifax County, North Carolina

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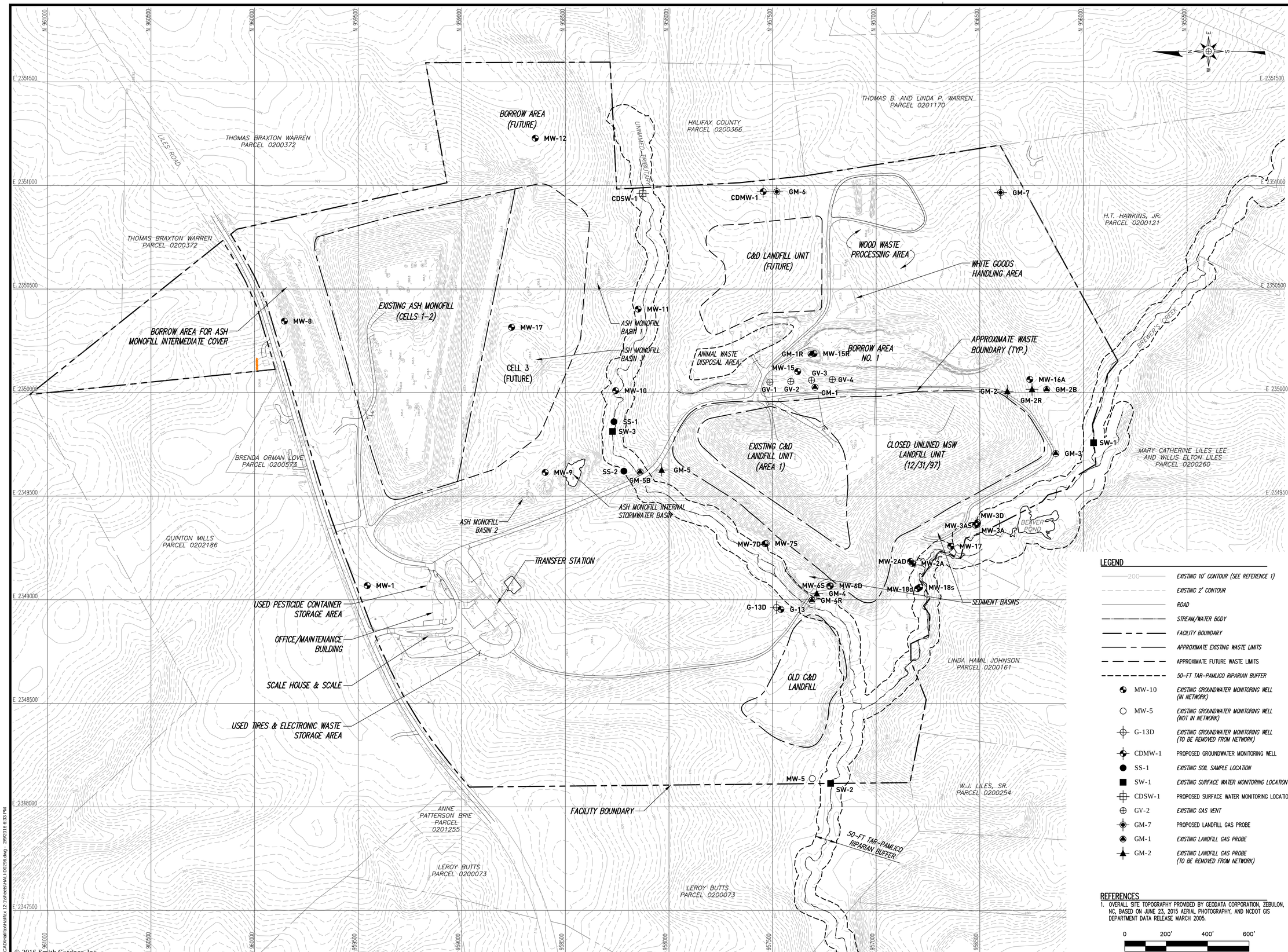

LEGEND

200	EXISTING 10' CONTOUR (SEE REFERENCE 1)
	EXISTING 2' CONTOUR
	ROAD
	STREAM/WATER BODY
	FACILITY BOUNDARY
	APPROXIMATE EXISTING WASTE LIMITS
	APPROXIMATE FUTURE WASTE LIMITS
	50-FT TAR-PAMLICO RIPARIAN BUFFER
MW-10	EXISTING GROUNDWATER MONITORING WELL (IN NETWORK)
MW-5	EXISTING GROUNDWATER MONITORING WELL (NOT IN NETWORK)
G-13D	EXISTING GROUNDWATER MONITORING WELL (TO BE REMOVED FROM NETWORK)
CDMW-1	PROPOSED GROUNDWATER MONITORING WELL
SS-1	EXISTING SOIL SAMPLE LOCATION
SW-1	EXISTING SURFACE WATER MONITORING LOCATION
CDSW-1	PROPOSED SURFACE WATER MONITORING LOCATION
GV-2	EXISTING GAS VENT
GM-7	PROPOSED LANDFILL GAS PROBE
GM-1	EXISTING LANDFILL GAS PROBE
GM-2	EXISTING LANDFILL GAS PROBE (TO BE REMOVED FROM NETWORK)

REFERENCES

1. OVERALL SITE TOPOGRAPHY PROVIDED BY GEODATA CORPORATION, ZEBULON, NC, BASED ON JUNE 23, 2015 AERIAL PHOTOGRAPHY, AND NCDOT GIS DEPARTMENT DATA RELEASE MARCH 2005.

0 200' 400' 600'

PREPARED FOR:

HALIFAX COUNTY
NORTH CAROLINA
DEPARTMENT OF
PUBLIC UTILITIES

PREPARED BY:

NC LIC. NO. C-0828 (ENGINEERING)

SMITH+ GARDNER
ENGINEERS
14 N. Boylan Avenue, Raleigh NC 27603 | 919.828.0577

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PROJECT TITLE:

HALIFAX COUNTY

DRAWING TITLE:

ENVIRONMENTAL MONITORING LOCATIONS

DESIGNED: M.M.G.	PROJECT NO: HALIFAX 12-1
DRAWN: C.T.J.	SCALE: AS SHOWN
APPROVED:	DATE: NOV. 2015
FILENAME: HALI-D0296	
SHEET NUMBER:	DRAWING NUMBER: FIG.1

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Appendix A

Reporting Forms

Landfill Gas Monitoring Plan
Halifax County Landfill Facility
Halifax County, North Carolina

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NC Division of Waste Management - Solid Waste Section

Landfill Gas Monitoring Data Form

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

Facility Name: _____ Permit Number: _____

Date of Sampling: _____ NC Landfill Rule (.0500 or .1600): _____

Name and Position of Sample Collector: _____

Type and Serial Number of Gas Meter: _____ Calibration Date of Gas Meter: _____

Date and Time of Field Calibration: _____

Type of Field Calibration Gas (15/15 or 35/50): _____ Expiration Date of Field Calibration Gas Canister: _____

Pump Rate of Gas Meter: _____

Ambient Air Temperature: _____ Barometric Pressure: _____ General Weather Conditions: _____

Instructions: Under "Location or LFG Well" identify the monitoring wells or describe the location for other tests (e.g., inside buildings). A drawing showing the location of test must be attached. Report methane readings in both % LEL and % methane by volume. A reading in percent methane by volume can be converted to % LEL as follows: % methane by volume = % LEL/20

Location or LFG Well ID	Sample Tube Purge	Time	Time Pumped (s)	Initial %LEL	Stabilized %LEL	%CH4 by Volume	%O2	%CO2	Notes

If your facility has more gas monitoring locations than there is room on this form, please attach additional sheets listing the same information as contained on this form.

Certification
To the best of my knowledge, the information reported and statements made on this data submittal and attachments are true and correct. I am aware that there are significant penalties for making any false statement, representation, or certification including the possibility of a fine and imprisonment.

_____ _____
SIGNATURE TITLE

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