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

Beverly Eaves Perdue
Governor

Dexter R. Matthews
Director

Dee Freeman
Secretary

Solid Waste Section

November 1, 2010

Mr. Carl Critcher
Washington County Sanitation
P.O. Box 1007
Plymouth, North Carolina 27962

Re: Comments on Permit Amendment Application (Application)
Washington County Construction and Demolition Debris Landfill (C&DLF)
Washington County, North Carolina
Permit No. 94-04, Document ID No. (Doc ID) 11477

Dear Mr. Critcher:

On January 19, 2010, the Division of Waste Management (DWM), Solid Waste Section received the permit application titled:

- *Permit Amendment Application, Washington County C&D Landfill (Permit 94-04) Phase 2.* Prepared by: Richardson Smith Gardner & Associates (RSG), Raleigh, NC. Prepared for: Washington County Public Utilities. January 2010. Doc Id 9360.

RSG also on behalf of Washington County responded to the DWM's comments (Doc ID 6496) dated December 19, 2008 and incorporated the responses to the above-referenced Application. The Solid Waste Section conducted a review of compliance with the Solid Waste Management Rule (Rule), 15A NCAC 13B .0500 et seq. The Solid Waste Section needs the following information, and your responses to the following comments will expedite the review of the Application.

Attachment A - Facility and Engineering Plan

1. (Section 2.3 & Appendix I) Please address the following concerns:
   i. According to the DWM record, the total capacity of the C&DLF (including the tire mono-fill) was 117,795 cubic yards (cy) as described in the November 20, 2003 letter report titled "Solid Waste Management Plan, Washington County." The proposed total gross capacity of 146,222 cy in Table 1 is more than ten (10) percent of the originally proposed capacity. This variance is considered as a substantial change in accordance with N.C.G.S. 130A-294(b1)(1). The County must conduct the local governmental approval processes to adopt this new total gross capacity for the C&DLF and pay the statutorily required permit substantial amendment fee.
   ii. Due to the increase of the total gross capacity at the C&DLF, please provide a settlement analysis to satisfy that the minimum of 4-feet vertical separation requirement [Rule .0540(2)(a)].

iii. Is this proposed waste disposal rate of 10,000 tons per year consistent with the one that is described in the local government approval processes according to Rule .0536(c)(11)?
iv. Please provide the completed Local Government Approval Documentations in Appendix I.

2. (Section 5.2) This section concludes that the landfill subgrade elevation has been designed to meet the minimum requirement of four feet above the "seasonal high groundwater table and bedrock." However, the Drawing No. X1/Sheet No. 7 shows the "approximate groundwater surface" in the cross-sections. Has the seasonal high groundwater table or the long-term seasonal high groundwater table been determined? Please clarify.

3. Please provide the complete Design Hydrogeologic Report for Phase 2 area according to Rules .0538(b) and .0539(d)(3).

Attachment B – Technical Specifications

4. Please provide specifications for constructing 12-inch-thick intermediate soil cover. The maximum particle size of earthen material in the finished grades to receive the geosynthetic material must meet the manufacturer's recommendations to prevent the geosynthetic material from puncture damage (see Comment 10.i). CQA & CQC testing methods and frequencies need to be provided in the specification as well.

5. (Section 02222, Excavation) Please provide detailed survey requirements to verify/confirm the finished subgrade, such as the intervals for survey grid points, the surveyor's qualifications, restoration of the subgrade damaged by stake holes, etc.

6. (Section 02223, Embankment) Please address the following concerns:
   i. In Paragraph B.1 please specify the testing methods to verify the soil classification.
   ii. In Paragraph D. 10 and Table 1 please specify the compaction requirements related to structural fill placed in the landfill subgrade at Phase 2 area, as shown on Cross-Section B, Sheet No. 7/Drawing No. X1, in Part D.10.

7. (Section 02258, Vegetative Soil Layer (VSL)) Please address the following concerns:
   i. The alternative soil cover system proposes to construct a 24-inch thick VSL on the 4 (horizontal) to 1 (vertical) side slopes. To facilitate the vegetation growth, it is a general practice for there to be no compaction on the top 6-inch top soil layer. Should there be a minimum compaction requirement for the bottom 18-inch soil layer to prevent subsidence, local slope failure, and soil erosion? Please clarify.
   ii. (Paragraph B.4) The earthen material used in the VSL is specified in this paragraph having the maximum grain size less than 3 inches. Will the selected grain size of earthen material be based on the criteria concluded from the filter design (see Comment No. 8) and the recommendations for geomembrane protection from geosynthetic manufacturers? Please clarify.

8. (Section 02712, Drainage Composite) Please address the following concerns:
   i. Please provide a filter design calculation to ensure that the selected geotextile with AOS equivalent to U.S sieve # 70^{+} (in Table 1) can properly function as filter material preventing the DGC from clogging by fines in the overlying VSL.

ii. Please provide design calculations to demonstrate that the specified DGC has a sufficient transmissivity, with consideration of the long-term performance which is able to safely convey the surface water in the designed storm event to the drainage system.
iii. (Table 1, Note 2) Would the laboratory-measured transmissivity be determined under a simulated condition for 100-hour duration, rather than 24-hour? Please clarify.
iv. (Table 1, Note 3) Would the GCL be saturated prior to conducting the laboratory testing on interface shear strength between geocomposite and GCL? Please clarify.
v. (Paragraph D.3 - Installation, on page 02712-4) Please provide specifications to protect the in-place geomembrane or GCL during the course of deploying DGC from vehicle, equipment, tools, and unexpected long-duration exposure.
vi. (Paragraph D.6 – Cover Placement, on page 02712-6) Provide the specification of (a) the maximum ground pressure of the equipment and buffer material thickness above DGC, if equipment is allowed to directly operate on top of DGC to placing VSL material; and (b) the maximum duration that in-placed DGC can be exposed without placing any permanent cover material and the actions to be taken if this specified duration is passed.

9. (Section 02776, Geosynthetic Clay Liner) Please address the following concerns:
   i. Specify the GCL Installer's qualification as described in Section 7.2 of the CQA Plan.
   ii. (Paragraph C.1.e – Installation Procedures and Drawings, on page 02776-4) Would the Contractor be required to submit to the CQA Engineer a conceptual plan for placement of the GCL panels over the area of installation for a review and approval? Please clarify.
   iii. (Paragraphs in Section B, on page 02776-3) The paragraphs in Section B shall specify the material properties of the granular sodium bentonite applied between all overlapped seams described in the Paragraph D.3.g. and repairmen in the Paragraph D.3.i.
   iv. (Paragraph D.3.a, on page 02776-5) Because the GCL will directly contact the subgrade – 12-inch-thick intermediate soil cover, this sub-paragraph needs to specify the maximum soil grain size in the finished subgrade to prevent void fraction and/or puncture damage on GCL from the certain sizes of rock or gravel or other material.
   v. (Paragraph D.3.a, on page 02776-5) Please specify the subgrade certification requirement prior to placing GCL layer according to Rule .1624(b)(90(C)(i).
   vi. (Paragraph D.3.i, on page 02776-6) What method or practice will be used to ensure the patched area will not be removed or displaced while placing the cover material? Should dry granular sodium bentonite be applied around the damage area prior to placing the patch? Please clarify.
   vii. (Table1) Please specify the confining pressure (consideration of low normal loading condition for the cover system) and hydration condition which are simulating the field conditions for the hydraulic conductivity on the GCL according to Rule 1624(b)(9)(A)(ii).

10. (Section 02778, LLDPE Geomembrane(LLDPE-GM)) Please address the following concerns:
   i. (Paragraph D.3, on page 02778-7) Because the LLDPE-GM will directly contact the subgrade – 12-inch-thick intermediate soil cover, this sub-paragraph specifies the maximum size of grain (rock, gravel, and other material) is ½ inches. Please provide a calculation to demonstrate this maximum grain size will not create puncture damage on the 30-mil LLDPE-GM.
   ii. (Paragraph D.5, on page 02778-9) What provisions are there to avoid "fish-mouths" or wrinkles while seaming and to fix or correct the problem? Please clarify.

iii. (Paragraph D.6, on page 02778-10) Will the anchor trenches be constructed for installing the LLDPE-GM? There is no trench layout or trench detail showing on the Drawings. Please clarify.

11. Please provide the specifications of the landfill gas well or the gas vent attached lateral trenches in the final cover system.

Attachment C – Construction Quality Assurance (CQA) Manual

12. The CQA manual shall address the CQA requirements for constructing both the landfill subgrade for Phase 2 and the final cover system. However, the text in the plan (including Sections 1.2.1, 1.3.1.2, 1.3.1.3, 1.3.1.6, 1.3.2.4, and 1.4) indicate that the CQA program is solely for constructing the final cover system. Please make the necessary corrections throughout the CQA Plan.

13. (Section 1.7) Will there be a pre-construction meeting prior to commence constructing landfill cell at Phase 2 area? Please clarify.

14. (Section 3.0 – Earthwork CQA) The DWM believes the ASTM D2488 is the supplement method to the ASTM D2487 for identifying whether soil types in the top two-feet of the finished subgrade meet the requirements stated in Rule .0540(2)(b). Therefore, the Table 3.2 of the CQA Plan must specify the ASTM D2487 as the primary testing method for precisely determining soil type/classification. The ASTM Methods D4318 [Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soil] and ASTM D422 [Standard Test Method for Particle-Size Analysis of Soils] must be listed in Table 3.2 as the primary testing methods as well.

15. (Section 5.0 - Geomembrane CQA) Are the specified air pressure test requirements for 30-mil LLDPE in Table 5.2 consistent with the specifications in ASTM D 5820 which states the pressure ranges from 25 psi to 30 psi? Please clarify.

16. (Section 5.4.6.3 Geomembrane CQA Laboratory Destructive Testing) Please specify that the LLDPE-GM samples for laboratory testing will only be conducted after the samples from the same batch collected for field destructive seam testing have passed the shear strength criteria stated in Table 3 of Section 02778 in Attachment B.

Attachment D – Operations Manual

17. (Section 1.1) If the County intends to operate the permitted Convenience Center to receive recyclable goods and municipal solid wastes (MSW) through this permit process, please address the following comments in the Operations Manual without paying any additional permit modification fee:
    i. The Convenience Center must be a manned unit in order to supervise and operate waste collection and handling. The operator must be appropriately trained to conduct waste screening and emergency notification.
    ii. The description of the size of the unit, the physical features of each waste storage unit (e.g. covered roll-off boxes or covered sheds), the visible signs/ placards to identify acceptable waste streams, the minimum aisle space between each waste container for facility inspection and fire fighting, and BMPs for preventing wastes from contacting storm water runoff.

iii. The description of acceptable waste streams and the maximum quantity of each type of wastes stored on-site at any time and off-site hauling schedule.
iv. The information pertaining to contractors who will haul wastes or recyclables for off-site disposal or treatment: company names, address, phone number and owner's name, and permit numbers (for tire facility and MSW disposal and/or transfer facilities).

18. (Section 1.1) If the County plans to construct a firing range in the closed MSWLF facility, please address the following concerns:
    i. Provide documents to demonstrate that the establishment and operation of a firing range in the landfill facility will meet all requirements of any applicable zoning ordinance and federal, state, and local government regulations including an operating permit or permits, other than an approval from the DWM).
    ii. Describe (and identify on the drawings) the distance from the waste edge (South side) of the closed MSWLF to the northern boundary of the proposed firing range.
    iii. Will this range be used for the general public or only for law enforcement?
    iv. Describe the facility size and physical structures, control access, security, and operation hours.
    v. Signage of operation hours, "No Smoking," and emergency contact information must be posted in visible locations at the facility.
    vi. If utilities will be provided to the facility, the utility lines must not be installed inside the wastes limits without proper engineering design by a professional engineer registered in the State of North Carolina. The facility must be equipped with the fire/spark proof switches and lighting fixtures.
    vii. What waste management approaches will be implemented to ensure the firing range operation will not expose the environment and the ecosystem to heavy metals (especially lead - caused by the presence of lead in ammunition projectiles) pollution.
    viii. What provisions will be available to ensure the use of the proposed firing range will not:
        - Interrupt routine landfill post-closure care activities,
        - Cause a landfill fire or explosion (describe explosive gas monitoring, reporting, and control – Section 3.4; and explosive gas monitoring results must be documented and placed in the on-site operating record – Section 1.14), and
        - Threaten public life (if Convenience Center is operating in the nearby C&DLF).

19. (Sections 2.2 & 2.3) Wooden pallets are banned from disposal as defined in the NCGS Article 9, Chapter 130A-290(44a), effective October 1, 2009. Only pallets generated in C&D activities may be disposed of in a C&DLF, not pallets generated in industrial or commercial activities. If Washington County C&DLF will receive or has been receiving wooden pallets for disposal please add the above-mentioned requirement in Sections 2.2 and 2.3. Since all pallets are recyclable, wooden pallets that are ground for mulch or boiler fuel or other such uses may be added to the waste streams in Section 2.8 –Yard Waste Processing Area. Please incorporate the above-mentioned requests into the revised Operations Plan.

20. (Section 3.4) If the County proposes to construct and operate a firing range in the landfill facility, the landfill or explosive gas monitoring and control plan must be revised accordingly (please see Comment No. 18).

21. Please address the requirement stated in the Rule .0542(j)(8).

Attachment F – Erosion and Sedimentation Control Plan (ESCP)

22. The DWM has no comment on the proposed ESCP. County shall submit this plan to the Land Quality Section, Land Resources Division for a review and approval. The approved ESCP and the approval letter must be appended to the revised permit application document.

Attachment H – Water Quality Monitoring Plan

23. The Section 1.3.1 reports that groundwater flow at this C&DLF flows in the unconsolidated sediments toward discharge features, an unnamed on-site tributary on the west side of the C&DLF. However, the groundwater flow direction at this C&DLF was toward the north and east, which was concluded in the Section 5.7 of the "Site Application Report" dated October 1994, reprinted in January 1995. Based on the groundwater data the DWM has the following concerns of the Water Quality Monitoring Plan and the on-site groundwater monitoring network:
    i. Please conduct an investigation to study and explain why the groundwater flow direction has changed and to determine what the influencing factors are.
    ii. Based on the investigation results (Item i), the County needs determine the constant or long-term groundwater flow direction at this landfill facility.
    iii. Based on the investigation results, County must re-examine if the existing groundwater monitoring network will be able to provide sufficient and adequate water quality data to meet the requirements stated in Rule .0544. The DWM recommends that the County install at least one additional down-gradient compliance well on the west side of the C&DLF.

24. Please add the constituent tetrahydrofuran (THF) to your parameter list in Table 2. A memorandum was sent out on June 15, 2010 from the NC Solid Waste Section to every C&D landfill owner and operator in North Carolina requiring groundwater and surface water samples collected after January 1, 2011 to be analyzed for THF. A copy of the memorandum is attached.

25. Additionally, as a requirement of 15A NCAC 13B .0544(d), a Landfill Gas Monitoring Plan must be submitted to the SWS for approval. Owners and operators of all C&DLF units must implement a routine methane monitoring program to ensure that the concentration of methane gas or other explosive gases generated by the facility does not exceed 25 percent of the lower explosive limit at the facility property boundary or in on-site facility structures and does not releases any methane gas or other explosive gases in any concentration in off-site structures. Enclosed is a copy of the draft NC SWS Landfill Gas Monitoring Plan Guidance for assistance in preparing a Landfill Gas Monitoring Plan.

Attachment I – Local Government Approval

26. Please provide the complete local government approval documentations.

Please timely respond to the above-referenced comments to the Solid Waste Section and submit revised portions of the Application (one hard copy and an electronic copy), which incorporates the requested information. Additionally, the Solid Waste Section approves the previously submitted cost estimates for closure, and post-closure care of the Washington County Landfill. The approved costs, in year 2010 dollar values, are $162,840.00 for the closure of 3.3-acre landfill unit (Phases 1 & 2 areas), the estimated largest area of the C&DLF unit requiring the specific cover system at any time during the five-year permitted period, and $549,300.00 for the 30-year post-closure cares at 3.3-acre landfill unit. Pursuant to Rule .0547(2) Washington County must submit the DWM a financial

assurance document in accordance with Rule .0546. The approved financial assurance document will be appended to the revised permit application.

In addition, in accordance with the NCGS 130A-295.2(h), effective August 1, 2009, Washington County must also provide financial assurance sufficient to cover a minimum required amount of three million dollars ($3,000,000.00) for potential assessment and corrective action at the facility. This financial assurance requirement is in addition to the financial responsibility requirements for site closure, post-closure cares, and corrective actions. Please submit the requested financial assurance document within 30 days upon receiving this letter. Within the next 12 months, Washington County will be required to evaluate the solid waste management facility to determine the estimated costs of potential assessment and corrective action based on the criteria established in the above-reference statute. Depending on this determination, the required financial assurance amount in the future may be higher than the minimum amount of three million dollars.

The Solid Waste Section appreciates your efforts and cooperation in this matter. If you have any permitting questions, please contact me at (919) 508- 8507; and if you have any questions associated with financial assurance, please contact Donald Herndon at (919) 508-8502.

Sincerely,

Ming-Tai Chao, P.E.
Environmental Engineer II
Permitting Branch, Solid Waste Section

Christine Ritter
Hydrogeologist
Permitting Branch, Solid Waste Section

Enclosures
cc:
Pieter K. Scheer, P.E., RSG
Donna Wilson, DWM
Ray Williams, DWM
Central Files

Ed Mussler, Permitting Branch Supervisor
Dennis Shackelford, DWM
Donald Herndon, DWM

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

DIVISION OF WASTE MANAGEMENT

SOLID WASTE SECTION

LANDFILL GAS MONITORING GUIDANCE

OCTOBER 2010

TABLE OF CONTENTS

SECTION 1 - Introduction

North Carolina Solid Waste Management Rules 15A NCAC 13B require quarterly monitoring of methane gas (at MSW landfills) and quarterly monitoring of methane and other explosive landfill gases (LFG) (at C&D and other landfills) to ensure that landfill gas does not exceed the lower explosive limit (LEL) at the facility property boundary or 25 percent of the lower explosive limit in facility structures. If the concentration exceeds the specified limits, steps must be taken to ensure the protection of public health and a remediation plan must be implemented immediately. A landfill gas monitoring plan is necessary to ensure that these performance standards are met and this guidance document was developed to assist in establishing a standardized procedure for the monitoring of landfill gas.

Background

Organic matter in landfills begins to decompose almost immediately after being placed in a disposal site. Putrescible wastes such as food products and sewage sludges begin to break down by biological processes very rapidly whereas paper, cardboard or cellulose based materials are slower to decompose. However, when conditions become favorable, most organic matter will decompose. The decomposition process typically goes through several stages that depend on conditions such as pH, temperature, and moisture content. The final stage results in the production of methane and although the rate of production may vary, most landfills produce methane.

Landfill Gas Generation

Landfill gas is a natural by-product of the anaerobic decomposition of organic waste in a landfill. The composition, quantity and rate of landfill gas generation are dependent on the types of waste that are decomposing and the level of microbial activity within the wastes. The decomposition of biodegradable waste begins with aerobic decomposition which lasts until the oxygen in the landfill is depleted. The anaerobic phase then begins, resulting in landfill gas production.

There are four stages of landfill gas composition: the first stage is characterized by elevated nitrogen levels and occurs when the landfill is new. The second stage is characterized by elevated carbon dioxide levels and occurs for a relatively short period of time after the initial stage is complete. The third and fourth stages are characterized by elevated methane concentrations and represent the active life of a landfill and the post-closure time frame.

Landfill gas is generally composed of 50-55% methane (CH_4); 45-50% carbon dioxide (CO_2); less than 5% nitrogen (N_2); and less than 1% non-methane organic compounds. These individual gases generally remain co-mingled and do not naturally separate. The Solid Waste Section (SWS) Rules typically focus on methane (CH_4) and its explosive properties due to public safety issues. Hydrogen sulfide (H_2S) is also of particular concern in landfills and is typically recognized by its rotten egg odor. H_2S is immediately dangerous to life and health at concentrations of 100 parts per million (ppm).

Landfill Gas Migration

The production of landfill gas creates a positive pressure within the landfill that forces the gas to migrate. Landfill gas migrates from place to place by diffusion and pressure gradient and will follow the path of least resistance. Subsurface gas typically migrates above the groundwater table and is restricted laterally by streams. Porous soils lying above the bedrock can serve as pathways to transmit large volumes of gas. Underground off-site migration is common and can be facilitated by the presence of pipelines, buried utility corridors or trenches located within or adjacent to the landfill boundaries. Movement depends on soil type and moisture, and migration distances of 1,500 feet have been observed. Barometric pressure also influences movement. Falling barometric pressure allows methane to migrate out of the landfill and into surrounding areas.

SECTION 2 - Factors Influencing Landfill Gas Generation and Migration

Factors that affect landfill gas generation and migration through the subsurface include the following:

Waste Composition
The production of landfill gas is directly related to the amount of organic matter present in waste. The bacteria that break down the waste require small amounts of specific minerals such as calcium, potassium, magnesium and other micronutrients. Bacteria are able to thrive and produce landfill gas if the minerals/micronutrients are present. If the minerals/micronutrients are not present or if substances that inhibit bacterial growth exist, landfill gas production will occur at a reduced rate. Some forms of organic matter such as cellulose break down quickly whereas matter such as lignin breaks down more slowly. The rate at which landfill gas is produced depends on the proportions of each type of organic matter present in the waste.

Moisture Content
Landfills with higher moisture content generate higher concentrations of landfill gas in earlier stages of development (such as during leachate recirculation). Moisture accelerates the methanogenic process.

Temperature
Landfill bacteria are temperature dependant. They are able to survive and function below the freezing point, but they also function well at temperatures up to 65°C. Anaerobic bacteria produce small amounts of heat and may not be able to maintain the temperature of a shallow landfill when external temperatures decrease, so LFG generation may exhibit seasonal variations. Saturated landfills may not achieve ideal temperatures because the bacteria do not generate sufficient heat to raise the temperature of the excess water. Higher temperatures promote volatilization and chemical reactions with the waste so the trace gas component of landfill gas tends to increase with higher landfill temperatures.

Age of Landfill
Typically, landfills have an increasing generation of landfill gas for a number of years until closure at which time landfill gas generation reaches a peak and begins to subside. An evaluation of the age of the landfill and use of a landfill gas generation curve can be helpful in determining the likelihood of significant landfill gas concentrations from the landfill.

Landfill Cap
The type or presence of landfill cover can influence landfill gas generation and migration. Although a low permeability cap will reduce moisture and landfill gas generation over the longer term, initially, the installation of a landfill cap could drive landfill gas migration further from the landfill in the subsurface without proper ventilation (either passive or active). This is especially true in the case of unlined (unvented) landfills.

Water Table
Landfill gas movement in unlined landfills may be influenced by groundwater table variations. A rising water table could cause displacement and force upward movement of landfill gas.

Man-made and Natural Conduits
Structures such as drains, trenches, and buried utility corridors can act as conduits for landfill gas migration. Geologic features including fractured bedrock, porous soil, and permeable strata also provide conduits for landfill gas migration

Landfill Liner Conditions
The presence of a Subtitle-D (or equivalent) landfill liner has the capability to limit the lateral migration of landfill gas in the subsurface. Unlined landfills have no barrier to prevent lateral landfill gas migration in the subsurface.

Weather Conditions
Barometric pressure and precipitation have significant effects on landfill gas migration. Increased barometric pressure yields decreased landfill gas venting from the subsurface, until the pressure within the subsurface is greater than the atmospheric (barometric) pressure. Conversely, as the barometric pressure decreases, the landfill will vent the stored gas until pressure equilibrium is reached. Capping of a landfill can influence the effect of barometric pressure on landfill gas migration. Generally, a more permeable landfill cap will allow greater influence by barometric pressure than a less permeable landfill cap.

SECTION 3 – Current Solid Waste Section Rules Pertaining to Landfill Gas Monitoring

Web link to the 15A NCAC 13B rules - http://portal.ncdenr.org/web/wm/sw/rules

15A NCAC 13B

.0101- DEFINITIONS
.0101 (14) "Explosive gas" means Methane (CH4)
.0101(25) "Lower explosive limit" (LEL) means the lowest percent by volume of a mixture of explosive gases which will propagate a flame in air at 25 degrees Celsius and atmospheric pressure.

.0503 - SITING AND DESIGN REQUIREMENTS FOR DISPOSAL FACILITIES
.0503(2) A site shall meet the following design requirements:
(a) The concentration of explosive gases generated by the site shall not exceed:
(i) twenty-five percent of the limit for the gases in site structures (excluding gas control or recovery system components); and
(ii) the lower explosive limit for the gases at the property boundary;

.0543 - CLOSURE AND POST-CLOSURE REQUIREMENTS FOR C&DLF FACILITIES
.0553(e) Post-closure criteria.
(1) Following closure of each C&DLF unit, the owner and operator must conduct post-closure care. Postclosure care must be conducted for 30 years, except as provided under Subparagraph (2) of this Paragraph, and consist of at least the following:
(C) maintaining and operating the gas monitoring system in accordance with the requirements of Rule .0544 of this Section; and
(2) The length of the post-closure care period may be:
(A) decreased by the Division if the owner or operator demonstrates that the reduced period is sufficient to protect human health and the environment and this demonstration is approved by the Division; or
(B) increased by the Division if the Division determines that the lengthened period is necessary to protect human health and the environment.

.0544 - MONITORING PLANS AND REQUIREMENTS FOR C&DLF FACILITIES
.0544(d) Gas Control Plan
(1) Owners and operators of all C&DLF units must ensure that:
(A) the concentration of methane gas or other explosive gases generated by the facility does not exceed 25 percent of the lower explosive limit in on-site facility structures (excluding gas control or recovery system components);
(B) the concentration of methane gas or other explosive gases does not exceed the lower explosive limit for methane or other explosive gases at the facility property boundary; and
(C) the facility does not release methane gas or other explosive gases in any concentration that can be detected in offsite structures.
(2) Owners and operators of all C&DLF units must implement a routine methane monitoring program to ensure that the standards of this Paragraph are met.
(A) The type of monitoring must be determined based on soil conditions, the Hydrogeologic conditions under and surrounding the facility, hydraulic conditions on and surrounding the facility, the location of facility structures and property boundaries, and the location of all offsite

structures adjacent to property boundaries.

(B) The frequency of monitoring shall be quarterly or as approved by the Division.

(3) If methane or explosive gas levels exceeding the limits specified in Subparagraph (d)(1) of this Rule are detected, the owner and operator must:

(A) immediately take all steps necessary to ensure protection of human health and notify the Division;

(B) within seven days of detection, place in the operating record the methane or explosive gas levels detected and a description of the steps taken to protect human health; and

(C) within 60 days of detection, implement a remediation plan for the methane or explosive gas releases, place a copy of the plan in the operating record, and notify the Division that the plan has been implemented. The plan must describe the nature and extent of the problem and the proposed remedy.

(4) Based on the need for an extension demonstrated by the operator, the Division may establish alternative schedules for demonstrating compliance with Parts (3)(B) and (3)(C) of this Paragraph.

(5) For purposes of this Item, "lower explosive limit" means the lowest percent by volume of a mixture of explosive gases in air that will propagate a flame at 25 C and atmospheric pressure.

.0566 - OPERATIONAL REQUIREMENTS FOR LAND CLEARING/INERT DEBRIS (LCID) LANDFILLS

.0566(13) The concentration of explosive gases generated by the facility shall not exceed:

(a) Twenty-five percent of the lower explosive limit for the gases in facility structures.

(b) The lower explosive limit for the gases at the property boundary.

.1626 – OPERATIONAL REQUIREMENTS FOR MSWLF FACILITIES

.1626(4) Explosive gases control.

(a) Owners or operators of all MSWLF units must ensure that:

(i) The concentration of methane gas generated by the facility does not exceed 25 percent of the lower explosive limit for methane in facility structures (excluding gas control or recovery system components); and

(ii) The concentration of methane gas does not exceed the lower explosive limit for methane at the facility property boundary.

(b) Owners or operators of all MSWLF units must implement a routine methane monitoring program to ensure that the standards of (4)(a) are met. A permanent monitoring system shall be constructed on or before October 9, 1994. A temporary monitoring system shall be used prior to construction of the permanent system.

(i) The type and frequency of monitoring must be determined based on the following factors:

(A) Soil conditions;

(B) The hydrogeologic conditions surrounding the facility;

(C) The hydraulic conditions surrounding the facility; and

(D) The location of facility structures and property boundaries.

(ii) The minimum frequency of monitoring shall be quarterly.

(c) If methane gas levels exceeding the limits specified in (4)(a) are detected, the owner or operator must:

(i) Immediately take all necessary steps to ensure protection of human health and notify the Division;

(ii) Within seven days of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health; and

(iii) Within 60 days of detection, implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record, and notify the Division that the plan has been implemented. The plan shall describe the nature and extent of the problem and the proposed remedy.

(iv) Based on the need for an extension demonstrated by the operator, the Division may establish alternative schedules for demonstrating compliance with (4)(c)(ii) and (iii) of this Rule.

(d) For purposes of this Item, "lower explosive limit" means the lowest percent by volume of a mixture of explosive gases in air that will propagate a flame at 25°C and atmospheric pressure.

.1626(10) Recordkeeping requirements.

(a) The owner or operator of a MSWLF unit must record and retain at the facility, or an alternative location near the facility approved by the Division, in an operating record the following information as it becomes available:

(iii) Gas monitoring results and any remediation plans required by Item (4) of this Rule;

.1627 – CLOSURE AND POST CLOSURE REQUIREMENTS FOR MSWLF ACTIVITES

.1627(d) Post-Closure Criteria

(1) Following closure of each MSWLF unit, the owner or operator shall conduct post-closure care. Post-closure care shall be conducted for 30 years, except as provided under Subparagraph (2) of this Paragraph, and consist of at least the following:

(D)-Maintaining and operating the gas monitoring system in accordance with the requirements of Rule .1626 of this Section.

(2) The length of the post-closure care period may be:

(A) Decreased by the Division if the owner or operator demonstrates that the reduced period is sufficient to protect human health and the environment and this demonstration is approved by the Division; or

(B) Increased by the Division if the Division determines that the lengthened period is necessary to protect human health and the environment.

(3) Following completion of the post-closure care period for each MSWLF unit, the owner or operator shall notify the Division that a certification, signed by a registered professional engineer, verifying that post-closure care has been completed in accordance with the post-closure plan, has been placed in the operating record.

NOTES:

Based on the referenced rules above, the following words / phrases are presently in the Solid Waste Section rules pertaining to methane and explosive landfill gas.

Rule .0101(14) states: *"Explosive gas means Methane (CH)"*.
Rule .0503 (2)(a) refers to *"explosive gases"*.
Rule .0544(d) refers to "*Gas Control Plan*"
Rule .0544(d)(1) refers to *"methane or other explosive gases"*.
Rule .0544(d)(2) refers to "*methane monitoring program*"
Rule .0544(d)(3) refers to *"methane or explosive gas levels*"
Rule .0566 (13) refers to *"explosive gases"*.
Rule .1626 (4) refers to *"explosive gases control"*
Rule .1626(4)(a-b) refers to "*methane monitoring"* and "*methane monitoring program"*.

Monitoring Goals

Landfill design and landfill gas monitoring regulations in North Carolina require that there not be an exceedance of 100% of the Lower Explosion Limit (LEL) (equivalent to 5% methane) at the property boundary, or 25% LEL in on-site structures. These regulations were developed over time to protect the health and safety of the citizens of North Carolina and the U.S. from the asphyxiation and explosive hazards of landfill gas.

NC Rule History

A review of NC landfill guidance documents and regulations from 1972 to the present indicates that from 1972 through 1982, there was no mention of design requirements regarding the control of landfill gas, nor were there any landfill monitoring requirements for landfill gas. In 1982, the regulations were changed to require that sanitary landfill design prevent landfill gas concentrations of 100% LEL at the property boundary line and 25% inside on-site structures. Although a design requirement was added, no design requirement was established to determine if the design requirement was being met. In 1993 with the establishment of .1600 rules, requirements for designs to limit landfill gas levels to below 100% at the property boundary line and 25% in on-site structures and monitoring of landfill gas concentrations around the perimeter of the landfill and inside on-site structures were adopted.

SECTION 4 – Landfill Gas Incidents and Explosions

Hazards Involving Landfill Gas

Landfill fires may or may not be directly caused by landfill gas. The primary concern with these fires is air contamination from the resulting smoke; however they also present a variety of additional problems. In addition to concerns with containing and extinguishing landfill fires, potential reactions involving unknown chemicals in the landfill can cause uncertain hazards. Discarded consumer products in a landfill, such as pesticides, paints, solvents, cleaners, and other material can be the source of chemical releases. Heat from the fire can cause chemicals to volatilize, breakdown, and enter the environment. Also to be considered is the presence of other combustible gases in addition to methane. Whenever an environmental investigation of a landfill is prompted by odorous compounds or explosive gases, the presence of toxic substances should also be investigated. One example is hydrogen sulfide (H2S) that can cause asphyxiation and is flammable. An analysis should include alkyl benzenes, sulfur compounds, vinyl chloride, and methane, and other products associated with industrial wastes, construction and debris waste, and normal organic and inorganic waste.

Fires and explosion hazards become a concern when gases collect in confined spaces. Buildings, basements, and pits are typically regarded as confined spaces. However, landfill gases also collect in and migrate to cracks in the landfill cover, leachate "springs", cracks in adjacent structures, paved parking areas, etc. Fires can occur on the surface and underground. Surface fires involve recently buried waste near the surface in an aerobic decomposing layer, typically 1 to 4 feet below ground. These fires can be intensified by subsurface landfill gas and spread throughout the landfill. Subsurface fires occur deeper within the landfill, involve material buried for months or years, and can burn for days and months.

The following is a brief summary of some incidents involving landfill gas migration from landfills:

2007 Four employees died as a result of exposure to high concentrations of hydrogen sulfide while attempting to repair a leachate pump at a C&D landfill in Superior, Wisconsin (Journal of Environmental Heath 2008).

1999 An 8-year old girl was burned on her arms and legs when playing in an Atlanta, Georgia playground. The area was reportedly used as an illegal dumping ground many years ago (Atlanta Journal-Constitution 1999).

1994 While playing soccer in a park built over an old landfill in Charlotte, North Carolina, a woman was seriously burned by a methane explosion (Charlotte Observer 1994).

1987 Offsite landfill gas migration is suspected to have caused a house to explode in Pittsburgh, Pennsylvania (EPA 1991).

1984 Landfill gas migrated to and destroyed one house near a landfill in Akron, Ohio. Ten houses were temporarily evacuated (EPA 1991).

1983 An explosion destroyed a residence across the street from a landfill in Cincinnati, Ohio. Minor Injuries were reported (EPA 1991).

1975 In Sheridan, Colorado, landfill gas accumulated in a storm drain pipe that ran through a landfill. An explosion occurred when several children playing in the pipe lit a candle, resulting in serious injury.

1969 Methane gas migrated from an adjacent landfill into the basement of an armory in Winston-Salem, North Carolina. A lit cigarette caused the gas to explode, killing three men and seriously injuring five others (USACE 1984).

SECTION 5 - Landfill Gas Monitoring Wells

Locations

Landfill gas monitoring well locations will be site specific depending upon site geology, depth to groundwater, surface water features, on-site and off-site structures and sensitive receptors. The landfill gas monitoring wells must be spaced at least 500 feet apart depending upon site specifics. A readily accessible, unobstructed path must be maintained so that landfill gas monitoring wells are always accessible using four-wheel drive vehicles. Regardless of site specifics, the permittee must obtain approval from the Solid Waste Section for the design and installation of any landfill gas monitoring well system.

Well Construction and Installation

Landfill gas monitoring wells are the same as groundwater monitoring wells with two exceptions. Landfill gas monitoring wells are installed above the water table within the unsaturated zone and are equipped with stopcock valves or quick connect couplings on the cap, which allows for accurate landfill gas measurements. The stopcock valve must be equipped with flexible tubing and a barbconnection that will fit the gas meter's inlet tube. The stopcock valve or a quick connect coupling must be closed between monitoring events. The landfill gas monitoring well must also be capped, locked, and labeled with a permanently affixed identification plate stating the well contractor name and certification number, date of well competition, total depth of well, screen length and well ID number. See detailed schematics of a landfill gas monitoring well (Figure 1).

The depth of each landfill gas monitoring well will be site specific depending upon depth to groundwater. Landfill gas monitoring wells must be constructed the same as groundwater monitoring wells as described in 15A NCAC Subchapter 2C. Typically landfill gas monitoring wells must be installed using 2" PVC piping and screen. The screen length, also site specific, must span the majority of the unsaturated zone while still allowing for proper well construction. A North Carolina Licensed/Professional Geologist must be present to supervise the installation of all landfill gas monitoring wells. The exact locations, screened intervals, and nesting of the wells must be approved by the Solid Waste Section Hydrogeologist prior to landfill gas monitoring well installation. Each landfill gas monitoring well must be surveyed for location and elevation by a North Carolina Registered Land Surveyor. Within thirty (30) days of the completed construction of each new landfill gas monitoring well, the boring log and a diagram of each well including, but not limited to total depth, screened interval and distance above seasonal high water table must be submitted to the Solid Waste Section. The submittal must also include a scaled topographic map showing the location and identification of new, existing and abandoned landfill gas monitoring wells.

Nested and Clustered Landfill Gas Monitoring Wells

Nested and/or clustered landfill gas monitoring wells may be required in unsaturated zones of 45 feet or more to measure specific depths of the unsaturated zone. Initially, the installation of one long screen shall be sufficient. If a monitoring event shows an exceedance of the lower explosive limit, then the Solid Waste Section may require the installation of nested and/or clustered landfill gas monitoring wells.

Abandonment of Wells

An abandonment record must be submitted to the Solid Waste Section within 30 (thirty) days of the abandonment of a landfill gas monitoring well. The landfill gas monitoring well(s) must be overdrilled and sealed with grout in accordance with 15A NCAC 2C .0113(d) and certified by a North Carolina

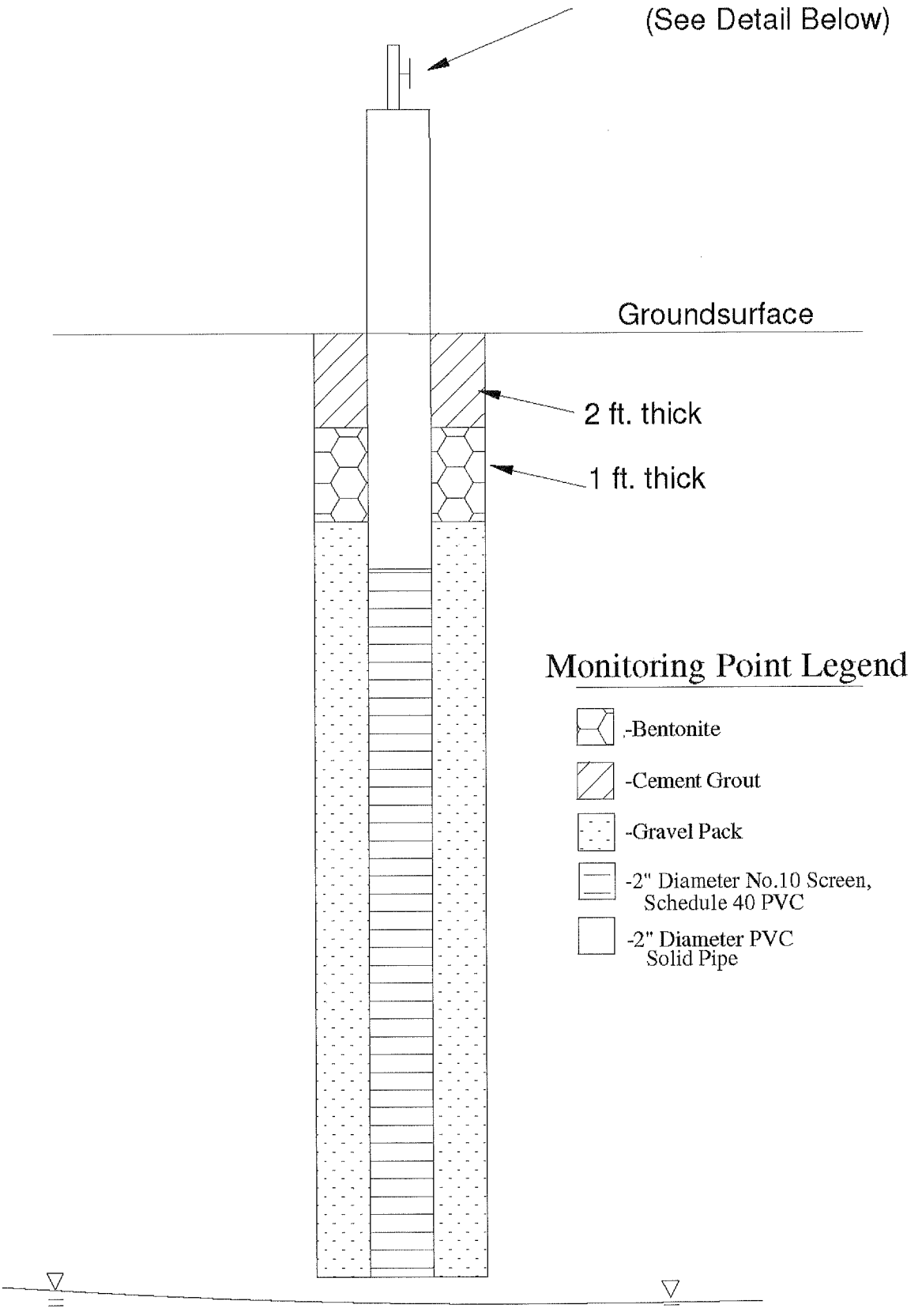
Professional Certification

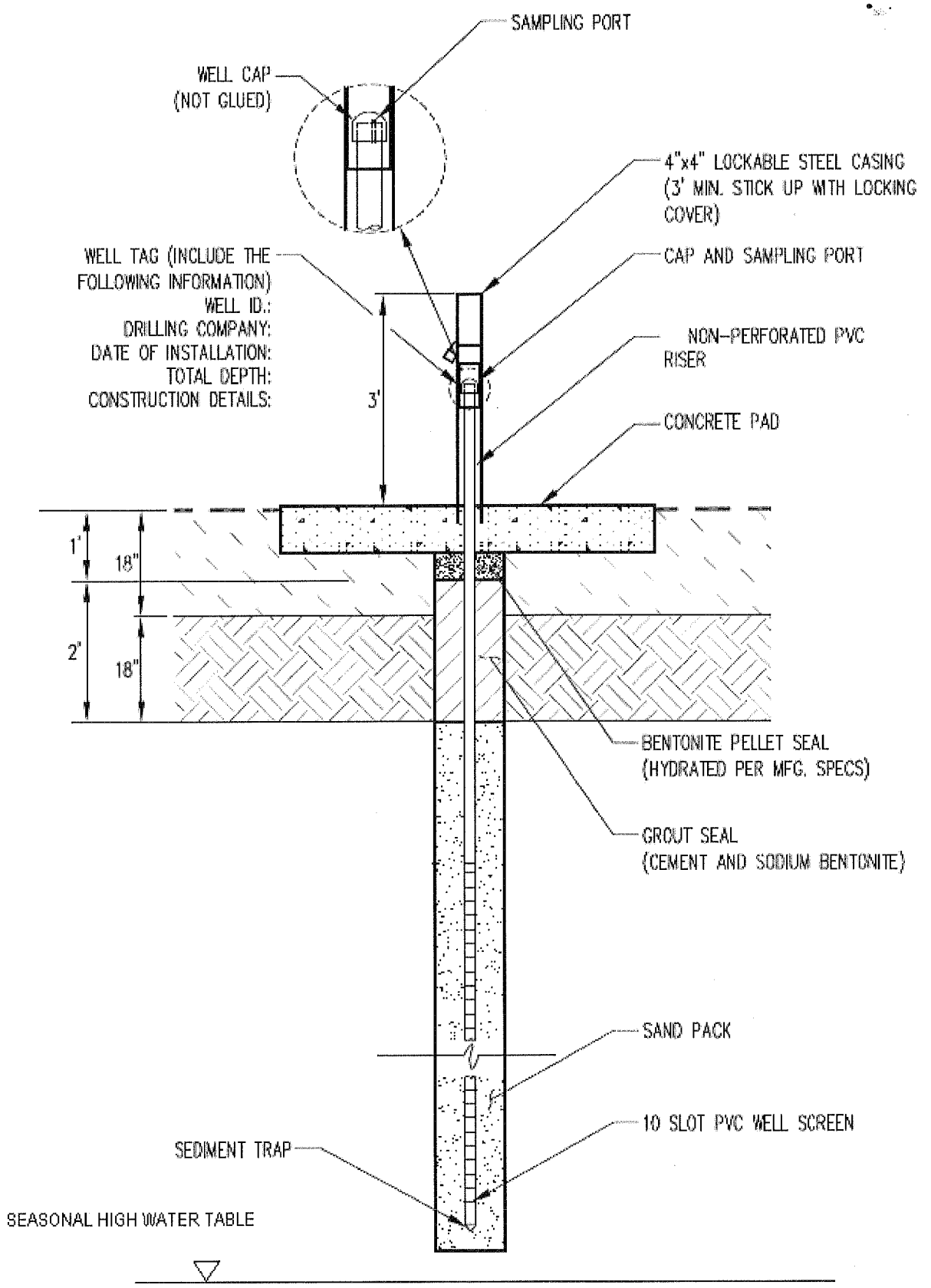
The certification statement below must be signed and sealed by a Professional Geologist and submitted with the Landfill Gas Monitoring Plan.

> The landfill gas monitoring plan for this facility has been prepared by a qualified geologist who is licensed to practice in the State of North Carolina. The plan has been prepared based on first-hand knowledge of site conditions and familiarity with North Carolina solid waste rules and industry standard protocol. This certification is made in accordance with North Carolina Solid Waste Regulations, indicating this Landfill Gas Monitoring Plan should provide early detection of any release of hazardous constituents to the uppermost aquifer, so as to be protective of public health and the environment. No other warranties, expressed or implied, are made.
>
> Signed _____
>
> Printed _____
>
> Date _____
>
> Not valid unless this document bears the seal of the above mentioned licensed professional.

In addition, the boring logs and/or well diagram must be signed and sealed with the stamp of a North Carolina Registered Land Surveyor.

Figure 1 - LANDFILL GAS MONITORING WELL DETAIL




SAMPLING PORT
WELL CAP
(NOT GLUED)
4"x4" LOCKABLE STEEL CASING
(3' MIN. STICK UP WITH LOCKING
COVER)
WELL TAG (INCLUDE THE
FOLLOWING INFORMATION)
WELL ID.:
DRILLING COMPANY:
DATE OF INSTALLATION:
TOTAL DEPTH:
CONSTRUCTION DETAILS:
CAP AND SAMPLING PORT
NON-PERFORATED PVC
RISER
3'
CONCRETE PAD
1'
18"
2'
18"
BENTONITE PELLET SEAL
(HYDRATED PER MFG. SPECS)
GROUT SEAL
(CEMENT AND SODIUM BENTONITE)
SAND PACK
10 SLOT PVC WELL SCREEN
SEDIMENT TRAP
SEASONAL HIGH WATER TABLE

SECTION 6 – Landfill Gas Monitoring Instrumentation

The person using the landfill gas monitoring instrument must understand the principles of operation and follow the manufacturer's instructions. This includes calibrating the instrument according to the manufacturer's specifications. Include the following on the top portion of the landfill gas monitoring form (See example below) : facility name, permit number, type and serial number of gas monitoring instrument, calibration date of the instrument, date and time of field calibration, type of gas used for field calibration (15/15 or 35/50), expiration date of field calibration gas canister, date of landfill gas monitoring event, name and position of sample collector, pump rate of instrument being used, ambient air temperature, and general weather conditions. Verification that the equipment was calibrated in accordance with the manufacturer's specifications is also required. When determining which field calibration gas to use, take into consideration the expected levels of methane in the landfill gas monitoring wells. If the methane levels are expected to be low, use the 15/15 gas canister (15% CO2/15% CH4). If the methane levels are expected to be high, use the 35/50 gas canister (35% CO2/50% CH4).

For every landfill gas monitoring well, please include the following: verification of sample tube purge prior to each sample taken (should be one minute), the time pumped in seconds (should be at least one minute), barometric pressure, time stabilized reading collected, percent lower explosive limit, percent methane by volume, percent oxygen, percent carbon dioxide, and any observations or comments.

The landfill gas monitoring data form (See example below) and results should be retained in the facility's operating record unless an exceedance has occurred and/or is requested by the Solid Waste Section.

Landfill gas monitoring readings from non-calibrated or inaccurately calibrated instruments are not reliable, and will therefore be rejected by the Solid Waste Section. Landfill gas monitoring readings collected with monitoring equipment that was not designed for landfill gas monitoring will also be rejected by the Solid Waste Section. There are several different landfill gas monitoring instruments on the market which may be used in order to obtain all of the information required by the Solid Waste Section.

Monitoring Times

Monitoring times are also important when conducting landfill gas monitoring. Proper landfill gas monitoring should include sampling during times when landfill gas is most likely to migrate. Landfill gas can migrate and accumulate not only in landfill gas monitoring wells; it can also migrate and accumulate in buildings and other structures. Because subsurface gas pressures are considered to be at a maximum during the afternoon hours, monitoring should be conducted in the afternoon or whenever the barometric pressure is low.

Scientific evidence also indicates that weather and soil conditions influence the migration of landfill gas. Barometric pressure and precipitation have significant effects on landfill gas migration. Increased barometric pressure generates decreased landfill gas venting from the subsurface, until the pressure within the subsurface is greater than the atmospheric (barometric) pressure. On the other hand, when the barometric pressure decreases, the landfill will vent the stored gas until a pressure equilibrium is reached. Capping of a landfill can influence the effect of barometric pressure on landfill gas migration. Generally, a more permeable landfill cap will allow greater influence by barometric pressure than a less permeable landfill cap. As a result, landfill gas monitoring should be conducted when the barometric pressure is low and soils are saturated. During the winter season when snow cover is just beginning to melt or when the ground is frozen or ice covered, landfill gas monitoring should be conducted when the barometric pressure is low.

Landfill Gas Sampling Procedures

Any accumulation of landfill gas in the landfill gas monitoring wells is the result of landfill gas migration. The following procedure is a recommended example for conducting landfill gas monitoring well sampling, but always read and follow the manufacturer's instructions because each instrument will be different.

Step 1 – Calibrate the instrument according to the manufacturer's specifications. In addition, prepare the instrument for monitoring by allowing it to properly warm up as directed by the manufacturer. Make sure the static pressure shows a reading of zero on the instrument prior to taking the first sample.
Step 2 - Connect the instrument tubing to the landfill gas monitoring well cap fitted with a stopcock valve or quick connect coupling.
Step 3 – Open the valve and record the initial reading and then the stabilized reading. A stable reading is one that does not vary more than 0.5 percent by volume on the instrument's scale.
Step 4 - Record the stabilized reading including the oxygen concentration and barometric pressure. A proper reading should have two percent oxygen by volume or less. If levels of oxygen are higher, it may indicate that air is being drawn into the system giving a false reading.
Step 5 – Turn the stopcock valve to the off position and disconnect the tubing.
Step 6 – Proceed to the next landfill gas monitoring well and repeat Steps 2 – 5.

Landfill Gas Constituent Sampling and Analysis

Sampling of landfill gas to determine volume percentages/concentrations of each constituent can be accomplished through the use of canisters which are specifically designed for landfill gas analysis. Several analytical methods are available to determine the concentrations of a variety of constituents. Typically, landfill gas analysis of this type is performed to determine the non-methane organic compounds emission rate for Tier 2 testing under the Clean Air Act (Title V Subpart WWW 60.754). Isotropic identification of landfill methane can be accomplished to identify one source of methane from another. In this case, isotopes of carbon and hydrogen in the methane are analyzed to determine the methane source.

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): _____

Type of Gas Monitoring Instrument and Serial Number: _____

Date Instrument Was Calibrated: _____ Name and Position of Sample Collector _____

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 Instrument Used to Monitor Wells: _____

Ambient Air Temperature: _____ 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	Barometric Pressure	Time Pumped in Seconds	Initial Time Reading Collected	Initial %LEL	Stabilized %LEL	Stabilized% Methane By Volume	Stabilized %Oxygen	Stabilized% Carbon Dioxide	Observat and Comme

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

SECTION 7 - References

Agency for Toxic Substances & Disease Registry. "Landfill Gas Primer- An Overview for Environmental Health Professionals. 2001." http://www.atsdr.cdc.gov/HAC/landfill/html/toc.html (accessed February 24. 2010).

California Environmental Protection Agency. "Landfill Gas Monitoring Well Functionality at 20 California Landfills, 2008". http://www.calrecycle.ca.gov/Publications/Organics/2008022.pdf (accessed February 24 2010).

Florida Department of Environmental Protection. Gas Management Systems, under Rule 62-701.530. http://www.dep.state.fl.us/waste/quick_topics/rules/default.htm (accessed February 24, 2010).

Missouri Department of Natural Resources, Flood Grant Team. "An Analysis of Landfill Gas Monitoring Well Design and Construction, 2007". http://www.clu-in.org/conf/itrc/directpush/prez/Missouri_Study.pdf (accessed February 24, 2010).

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Wisconsin Department of Natural Resources. Environmental Monitoring for Landfills, under Chapter NR 507.22. http://www.dnr.state.wi.us/org/aw/wm/information/wiacsss.htm (accessed February 24, 2010).

"Landfill Gas-an Overview" Landfill-gas.com. Web, 22, Feb. 2010 http://www.landfill-gas.com/webpage -LFG-overview.doc

SECTION 8 – Suggested Outline for a Landfill Gas Monitoring Plan

1. Introduction
   1.1. Background (project overview, site observations, NCDENR rules referenced)
   1.2. Site Geology with discussion of groundwater depth and flow (potentiometric surface map)
   1.3. Regulatory Limits
2. Landfill Gas Monitoring
   2.1. Landfill Gas Monitoring Well Locations (discussion of reasoning behind proposed locations, discussion of well construction, reference map showing proposed locations, reference table displaying well ID, well depth, screen interval and depth to groundwater)
   2.2. Structure and Ambient Sampling
   2.3. Landfill Gas Monitoring Frequency
3. Landfill Gas Sampling Procedures
   3.1. Detection Equipment Used (discussion of calibration procedures)
   3.2. Landfill Gas Sampling Procedure
4. Record Keeping and Reporting
   4.1. Landfill Gas Monitoring Data Form
   4.2. Sampling Reports
   4.3. Permanent Record Keeping
5. Contingency Plan
6. Certification of Professional Geologist
7. Certification of Registered Land Surveyor

Figures

Map displaying proposed landfill gas monitoring well locations

Potentiometric Surface Map

Diagram showing construction of stopcock valve or quick connect coupling on well cap

Diagram showing well construction of each landfill gas monitoring well

Table

Table displaying well ID, well depth, screen interval, depth to groundwater

Example of landfill gas monitoring data form

SECTION 9 – Checklist of Items to be Included in a Landfill Gas Monitoring Plan

1. Depth to groundwater discussion
2. Well locations
    a. Number of wells
    b. Well spacing
3. Instrumentation being used
    a. Calibration procedures
4. Sampling procedures as per the manufacture's instructions
5. Map of well locations
6. Table describing each well location
    a. Well ID
    b. Well depth
    c. Screen interval
    d. Depth to groundwater
    e. Subsurface lithology
7. Diagram of cap construction w/ stopcock valve or quick connect coupling
8. Diagram of well construction
9. Potentiometric surface map
10. Professional Geologist certification
11. Registered Land Surveyor certification