MSWLF FACILITY PERMIT TO CONSTRUCT PHASE II

Fac/Perm/Co ID# 44-07
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DIN
Carmen Johnson

HAYWOOD COUNTY

WAYNESVILLE, NORTH CAROLINA

APPROVED
DIVISION OF WASTE MANAGEMENT
SOLID WASTE SECTION
DATE 1-26-01 BY BS (GL)
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March 2000

Municipal Engineering Services Company, P.A.
Garner and Boone, North Carolina

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HAYWOOD COUNTY

WAYNESVILLE, NORTH CAROLINA

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE

3/22/2000

March 2000

Municipal Engineering Services Company, P.A.
Garner and Boone, North Carolina

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SECTION 1.0

FACILITY REPORT

Background

Haywood County, North Carolina currently owns and operates a Subtitle D Sanitary Landfill (Permit No. 44-07), located at 3898 Fines Creek Road, S.R. 1338, approximately 13 miles northwest of Waynesville, North Carolina. The new Phase is a horizontal expansion located just southwest of the existing Phase 1. Access to the landfill will be the same as is presently being used. Waste currently received in the existing Phase with the exception of land clearing/inert debris(LCID) and construction/demolition(C&D) will be disposed of in the new Phase. The Municipal Solid Waste portion of the waste stream is processed through the baler facility located near Waynesville. The waste is transferred from this facility to the landfill via County owned transfer trucks.

General

The Facility can only accept Municipal Solid Wastes within Haywood County which includes but is not limited to Household, Industrial, and Animal waste. The Facility will not accept any Hazardous or PCB wastes. The LCID waste will be sent to the existing LCID landfill and where the C & D will be stockpiled so that it can be ground up and used for daily cover. Tires will be placed in a trailer and white goods on a pad for freon removal and loaded on a truck. This will be handled at the baler facility. The baler facility is currently handling all of the waste collected at the convenient sites.

In accordance with North Carolina Solid Waste Management Rules, the County has applied for and received an Amendment to Permit # 44-07 for the vertical expansion of Phase 1. The Amendment allows Haywood County to continue disposing of municipal solid wastes in Phase 1 until the waste reaches the proposed contour elevations as show on the Operation Plan. The remainder of the facility is on land adjacent to Phase 1 and part of the approved site suitability.

The Facility will consist of a total of seven Phases of development. Phase 2 will consist of approximately 10.26 acres, with Phase 3 being constructed approximately 9 years later consisting of about 4.89 acres, Phase 4 being constructed approximately 4 years after Phase 3 consisting of about 7.83 acres, Phase 5 being constructed approximately 4 years after Phase 4 consisting of about 13.24, Phase 6 being constructed approximately 7 years after Phase 5 consisting of about 13.25 acres and finally the remaining 13.28 acres of Phase 7 will be constructed with approximately 4 years of life about 4 years after Phase 6.

Phase 2 will consist of 5 Cells, which could be constructed individually during the 5 year permit for Phase 2; however, this will not happen. Cell 1 will consist of approximately 1.47 acres, Cell 2 will consist of about 2.53 acres, Cell 3 will contain approximately 2.91 acres, Cell 4 will consist of approximately 1.84 acres, and Cell 5 will have approximately 1.51 acres.

1.1 Waste Stream

1.1.1 Waste Types

The Facility will accept Municipal Solid Waste: any solid waste resulting from the operation of residential, commercial, industrial, governmental, or institutional establishments that would normally be collected, processed, and disposed of through a public or private solid waste management service is considered Municipal Solid Waste.

LCID along with C&D will be taken to the C&D recycling storage area and LCID landfill near Canton, N.C.

Spoiled foods, animal carcasses, abattoir waste, hatchery waste, and other animal waste will be accepted, and covered immediately upon dumping.

Asbestos waste will be accepted and managed in accordance with 40 CFR 61. The waste will be covered immediately with soil in a manner that will not cause airborne conditions and must be disposed of separate and apart from other solid wastes:

i. At the bottom of the working face or;
ii. In an area not contiguous with other disposal areas. Separate areas will be clearly designated so that asbestos is not exposed by future land disturbing activities.

Wastewater treatment sludges must pass the paint filter test and the TCLP test before they may be accepted and co-disposed in the lined area. Hazardous waste as defined within 15A NCAC 13A, to also include hazardous waste from conditional exempt small quantity generators, Polychlorinated biphenyls (PCB) waste as defined in 40 CFR 761 are prohibited.

1.1.2 Disposal Rates

The Facility is open for 5.5 days per week. The tonnage per year for the fiscal year 98-99 is 44,023 tons. The average monthly disposal rates will be approximately 3,669 tons per month. During the year there is a seasonal increase of approximately 200-300 tons a month due to summer tourism, and a marginal increase during the beginning of the school year and the Holiday Season. The winter months sees a decrease of the average monthly tonnage rates. The life of the Facility will depend on Disposal Rates and Compaction, which can vary through out the life of the Facility. This variance can either increase or decrease the life of the Facility. All calculations are based on an annual growth in the waste stream of 5.3% which is the average annual growth between FY 94-95 and 98-99 based on the N.C. Annual Solid Waste Report. The annual projected population growth based on the N.C. Office of State Planning is approximately 0.5% from 2000 to 2010.

1.1.3 Service Area

The landfill will accept only waste from Haywood County.

1.1.4 Waste Segregation

Haywood County has a blue bag system of recycling where the recyclables from the municipalities are placed in one blue bag and they are picked up at the curb. The bags are taken to the material recovery system at the baler facility where the recyclables are separated by hand picking. This material is mixed with the recyclables that come from the convenience sites already separated. Yard waste, land clearing/inert debris, construction/demolition debris, white goods, scrap metal, batteries, used motor oil and tires have been taken out of the waste stream and are disposed or managed separately from the municipal solid waste. The municipal solid waste is all that is disposed in the White Oak Landfill.

1.1.5 Equipment Requirements

Haywood County Landfill has and uses the following equipment:

1. Trash packer,
2. Pan,
3. Dozer,
4. Track loader,
5. Track hoe,
6. Bale stacker, and
7. Leachate tanker w/ road tractor.

1.2 Landfill Capacity

Haywood County is currently utilizing the approximate 718,796 cubic yards of airspace in their existing lined landfill (Phase 1).

The Life Expectancy calculations were calculated for Phases 2-7 of development with a vertical expansion being included when a Phase is constructed adjacent to the previous Phase. Phase 2 has a life expectancy of approximately 9 years utilizing approximately 1,159,361 cubic yards of airspace. Each successive phase will vary in size due to being able to expand onto the previously filled areas. The Operation Plan of the Engineering Report will delineate this more clearly. Each individual Phase volume other than Phase 2 is estimated. The air space is a net volume excluding the capping requirements.

LIFE EXPECTANCY CALCULATIONS PHASES 2-7
HAYWOOD COUNTY SOLID WASTE LINED LANDFILL

Given:

**Landfill Volume Available(Phases 2-7):	= 8,335,231 cubic yards
Annual Growth of 5.3% based on Annual Reports from FY 94-95 to FY 98-99	
Compaction Rate:	= 1000 lbs/cubic yards
Trash to Daily Cover Ratio:	= 8:1

Total Site Life Expectancy:

Volume Available	= 8,335,231 cubic yards
Daily Cover	= 926,137 cubic yards
Trash	= 7,409,094 cubic yards
	= 3,704,547 tons @ 1,000 lbs/cubic yard

therefore;

Life Expectancy, based on 5.3% growth and 44,023 tons reported in FY 98-99, is approximately = 32 years

** Determined by Autodesk 14 computer program.

LIFE EXPECTANCY CALCULATIONS PHASE 2
HAYWOOD COUNTY SOLID WASTE LINED LANDFILL

Given:

**Landfill Volume Available(Phase 2): = 1,159,361 cubic yards
Compaction Rate: = 1000 lbs/cubic yards
Trash to Daily Cover Ratio: = 8:1
Annual Growth of 5.3% based on Annual Reports from FY 94-95 to FY 98-99

Phase 2 Life Expectancy:

Volume Available	= 1,159,361 cubic yards
Daily Cover	= 128,818 cubic yards
Trash	= 1,030,543 cubic yards
	= 515,272 tons @ 1000 lbs/cubic yard

therefore;

Life Expectancy, based on 5.3% growth and 44,023 tons reported in FY 98-99, is approximately = 9.0 years

LIFE EXPECTANCY CALCULATIONS PHASE 3
HAYWOOD COUNTY SOLID WASTE LINED LANDFILL

Given:

Landfill Volume Available(Phase 3):= 668,508 cubic yards
Compaction Rate: = 1000 lbs/cubic yards
Trash to Daily Cover Ratio: = 8:1
Annual Growth of 5.3% based on Annual Reports from FY 94-95 to FY 98-99

Phase 3 Life Expectancy:

Volume Available	= 668,508 cubic yards
Daily Cover	= 74,279 cubic yards
Trash	= 594,259 cubic yards
	= 297,130 tons @ 1000 lbs/cubic yard

therefore;

Life Expectancy, based on 5.3% growth and 44,023 tons reported in FY 98-99, is approximately = 4 years

LIFE EXPECTANCY CALCULATIONS PHASE 4
HAYWOOD COUNTY SOLID WASTE LINED LANDFILL

Given:

Landfill Volume Available(Phase 4): = 1,070,433 cubic yards
Compaction Rate: = 1000 lbs/cubic yards
Trash to Daily Cover Ratio: = 8:1
Annual Growth of 5.3% based on Annual Reports from FY 94-95 to FY 98-99

Phase 4 Life Expectancy:

Volume Available	=	1,070,433 cubic yards
Daily Cover	=	154,598 cubic yards
Trash	=	915,835 cubic yards
	=	457,918 tons @ 1000 lbs/cubic yard

therefore;

Life Expectancy, based on 5.3% growth and 44,023 tons reported in FY 98-99, is approximately = 4 years

LIFE EXPECTANCY CALCULATIONS PHASE 5
HAYWOOD COUNTY SOLID WASTE LINED LANDFILL

Given:

Landfill Volume Available(Phase 5): = 1,811,398 cubic yards
Compaction Rate: = 1000 lbs/cubic yards
Trash to Daily Cover Ratio: = 8:1
Annual Growth of 5.3% based on Annual Reports from FY 94-95 to FY 98-99

Phase 5 Life Expectancy:

Volume Available	=	1,811,398 cubic yards
Daily Cover	=	201,266 cubic yards
Trash	=	1,610,132 cubic yards
	=	805,066 tons @ 1000 lbs/cubic yard

therefore;

Life Expectancy, based on 5.3% growth and 44,023 tons reported in FY 98-99, is approximately = 7 years

LIFE EXPECTANCY CALCULATIONS PHASE 6
HAYWOOD COUNTY SOLID WASTE LINED LANDFILL

Given:

Landfill Volume Available(Phase 6): = 1,810,031 cubic yards
Compaction Rate: = 1000 lbs/cubic yards
Trash to Daily Cover Ratio: = 8:1
Annual Growth of 5.3% based on Annual Reports from FY 94-95 to FY 98-99

Phase 6 Life Expectancy:

Volume Available = 8,335,231 cubic yards
Daily Cover = 926,137 cubic yards
Trash = 7,409,094 cubic yards
= 615,689 tons @ 1000 lbs/cubic yard

therefore;

Life Expectancy, based on 5.3% growth and 44,023 tons reported in FY 98-99, is approximately = 4 years

LIFE EXPECTANCY CALCULATIONS PHASE 7
HAYWOOD COUNTY SOLID WASTE LINED LANDFILL

Given:

Landfill Volume Available(Phase 7): = 1,815,499 cubic yards
Projected Annual Weight: = 85,800,000 lbs. per year
Compaction Rate: = 1000 lbs/cubic yards
Trash to Daily Cover Ratio: = 8:1
Annual Growth of 5.3% based on Annual Reports from FY 94-95 to FY 98-99

Phase 2 Life Expectancy:

Volume Available = 1,815,499 cubic yards
Daily Cover = 258,601 cubic yards
Trash = 1,556,898 cubic yards
= 778,449 tons @ 1000 lbs/cubic yard

therefore;

Life Expectancy, based on 5.3% growth and 44,023 tons reported in FY 98-99, is approximately = 4 years

SOIL CALCULATIONS PHASES 2-7
HAYWOOD COUNTY SOLID WASTE LINED LANDFILL

Soil Available on Site	=	2,504,662 c.y.
Soil Needed for Construction	=	331,968 c.y.
Soil Needed for Daily Cover	=	1,041,904 c.y.
Soil Needed for Closure	=	202,473 c.y.
Total Soil Needed	=	1,576,345 c.y.

The soil available on site is excess material after the subbase of all Phases is prepared. Soil available on site is from the entire facility, soil needed for construction, daily cover, and closure is also for all Phases. The County has available space within the property that can be used for a borrow site when needed.

1.3 Containment and Environmental Control Systems

Haywood County Lined Landfill Facility will be lined with a Base Liner System consisting of a cohesive soil liner with a permeability no greater than 1.0×10^{-7} cm/sec, sixty (60) mil High Density Polyethylene (HDPE) liner, 3.0' of protective cover, and leachate collection system consisting of leachate trenches and pipes to collect the leachate. The leachate will be gravity fed into the existing leachate lagoon. The trash will be covered daily with either a synthetic cover and/or on-site soils to control disease vectors. The cap system will consist of twelve inches (12") bridging material (temporary cover), eighteen inches (18") of soil liner with a permeability no greater than 1.0×10^{-5} cm/sec, forty (40) mil Linear Low Density Polyethylene (LLDPE) flexible membrane liner, drainage layer, twenty four inches (24") of protective/erosive layer. The cap will contain a gas venting system consisting of a series of washed stone trenches below the soil liner that will be vented through pipes that penetrate the cap. The cap system will also include the proper seeding and mulching of the erosive layer and other erosion control devices.

1.4 Leachate Management

1.4.1 Performance and Design Concepts

A HELP model has been created for the design of the leachate collection system, along with performance calculations which are located in Section 2.2.3 of this report. The storm water is diverted using a 60 mil HDPE liner which separates the leachate collection system from each of 3 individual cells.

1.4.2 Normal Operating Conditions

The average monthly values of leachate generation are located in the HELP model Section 2.2.3 of this report, and performance calculations are in Section 2.2.6 of this report.

Surge Volumes created by storm events are calculated in the HELP model and performance calculations in Section 2.2.3 of this report.

1.4.3 Leachate Management System

Leachate pipeline operation capacity is located in the performance calculations in Section 2.2.6 of this report.

Capacity of the lagoon is located in the performance calculations in Section 2.1.7 of this report.

Final Disposal plans and applicable discharge limits, including documented prior approval of the waste water treatment plant which may be designated in the plan. Appropriate documentation is located in Section 2.1.8 of this report.

1.4.4 Contingency Plan

In the event the Leachate Lagoon or the Town of Waynesville Waste Water Treatment Plant (WWTP) cannot handle a storm surge, the Leachator Pump system can be turned off, which will stop the flow of leachate from the MSWLF facility until such a time as the leachate can either be recirculated, pumped to the lagoon or sent to the Waynesville WWTP. In the case of extreme emergency situations the county will apply for acceptance into a private pretreated Waste Water Treatment Plant in Winston Salem and they will pump and haul the leachate from the Town of Waynesville to the WWTP in Winston Salem. Any abnormal storm events can be handled. If any rain or other event requires storage of leachate or storm water in the cell, the Division of Solid Waste will be notified immediately followed by written communication.

1.5 Special Engineering Features

Haywood County Landfill Facility will have storm water diversion berms within each phase of development. The new Phases will be approximately 62.75 acres, all of which will be used for Municipal Solid Waste Landfill.

The Facility will consist of a total of seven Phases of development. Phase 2 will be built consisting of approximately 10.26 acres, with Phase 3 being constructed approximately 12 years later consisting of about 4.89 acres, Phase 4 being constructed approximately 7 years after Phase 3 consisting of about 7.83 acres, Phase 5 being constructed approximately 11 years after Phase 4 consisting of about 13.24, Phase 6 being constructed approximately 19 years after Phase 5 consisting of about 13.25 acres and finally the remaining 13.28 acres of Phase 7 will be constructed with approximately 19 years of life about 19 years after Phase 6.

The second Phase will consist of 5 Cells, which can be constructed individually during the 5 year permit for Phase 2. Cell 1 will consist of approximately 1.47 acres, Cell 2 will consist of about 2.53 acres, Cell 3 will contain approximately 2.91 acres, Cell 4 will consist of approximately 1.84 acres, and Cell 5 will have approximately 1.51 acres.

Storm water coming in contact with solid waste is leachate and will be sent to the leachate lagoon. The leachate will be recirculated and/or pumped and hauled to the Town of Waynesville Waste Water Treatment Plant.

1.6 Facility Drawings

1.6 **Facility Drawings**

At end of file

SECTION 2.0

ENGINEERING PLAN

2.1 Analysis of the Facility Design

The MSWLF unit shall be located a minimum of 300' from the property lines, 500' from existing wells, and 50' from any stream, river or lake, and the post settlement subbase elevation shall be prepared a minimum of six feet above the seasonal high groundwater table and bedrock. The landfill subgrade shall be adequately free of organic material and consist of *in situ* soils. The base liner system consists of a 60 mil HDPE geomembrane liner which is installed above and in direct uniform contact with a compacted clay liner.

Haywood County has an existing leachate lagoon in which its leachate is either recirculated or pumped and hauled, which will be able to handle the additional leachate generated from the new landfill. Odor and vector controls will be practiced when necessary. A groundwater monitoring system already exists around the leachate lagoon.

Haywood County will cap their landfill within 180 days after the final receipt of solid waste. The cap system will consist of 12 inches bridging material (temporary cover), 18 inches of soil liner with a permeability no greater than 1.0×10^{-5} cm/sec, 40 mil. Linear Low Density Polyethylene (LLDPE), drainage layer, 24 inches of protective/erosive layer. The cap contains gas venting system consisting of a series of washed stone trenches below the soil liner that will be vented through pipes that penetrate the cap. The cap system will also include the proper seeding and mulching of the erosive layer and other erosion control devices.

2.1.1 Base Liner System Standards

The base liner system consists of a geomembrane liner which is installed above and in direct uniform contact with a compacted clay liner.

1. The site shall meet the following design requirements for Landfill subgrade.

   The landfill subgrade shall be adequately free of organic material and consist of *in situ* soils.

2. The site shall meet the following material requirements for the Base Liner System.

   The soil materials used in construction of the compacted clay liner shall consist of on-site sources and may posses adequate native properties or may require bentonite conditioning to meet the permeability requirement. The soil shall be free of particles greater than three inches in any direction.

   The compacted clay liner shall be 24 inches (0.61 m) thick with a permeability not to exceed 1.0×10^{-7} cm/sec.

   The geomembrane liner material shall be high density polyethylene geomembrane with a thickness of 60 mils. which has a demonstrated water vapor transmission rate of not more than 0.03 gm/m^2-day. The liner and seaming materials shall have chemical and physical

resistance not adversely affected by environmental exposure, waste placement and leachate generation.

3. The site shall meet the following design requirements for the Leachate Collection System.

   The Leachate Collection System is designed with stone filled trenches, collection pipes and 0.6 cm double bonded drainage net that allows less than one foot of head on the liner.

   The impingement rate on the drainage layer is at least equal to the peak monthly precipitation rate.

   The geometry of the landfill shall control and contain the volume of leachate generated by the 24-hour, 25-year storm.

   The collection pipe along with the drainage net flow capacity shall drain the critical volume of leachate generated by the 24-hour, 25-year storm which fell in a one hour period in 4.85 hours.

   The Leachate Collection System provides a 36" zone of protection separating the composite liner from landfilling activities.

   The Leachate Collection System includes a pipe network with clean-outs and geotextile and filter fabrics.

   The Leachate Collection Piping has a minimum nominal diameter of six inches.

   The chemical properties of the pipe and all materials used in installation shall not be adversely affected by waste placement or leachate generated by the landfill.

   The pipe provides adequate structural strength to support the maximum static and dynamic loads and stresses imposed by the overlying materials and any equipment used in construction and operation of the landfill.

   The Geosynthetic filter materials have adequate permeability and soil particle retention, and chemical and physical resistance which is not adversely affected by waste placement, and overlying material or leachate generated by the landfill.

2.1.2 Horizontal Separation Requirements

1. The MSWLF units are located a minimum of 300' from the property lines.
2. The MSWLF units are located a minimum of 500' from existing residences/wells.
3. The MSWLF units are located a minimum of 50' from any stream, river, or lake.

2.1.3 Vertical Separation Requirements

The MSWLF units are designed so that post settlement bottom elevation of the base liner system is a minimum of four feet above the seasonal high ground-water table and bedrock.

2.1.4 Location Coordinates and Survey Control

Survey control coordination will be furnished upon request.

2.1.5 Sedimentation and Erosion Control Plan

The Sedimentation and Erosion control plan has been completed for the 24-hour, 25-year storm. It is submitted under Section 2.2.2 of this application.

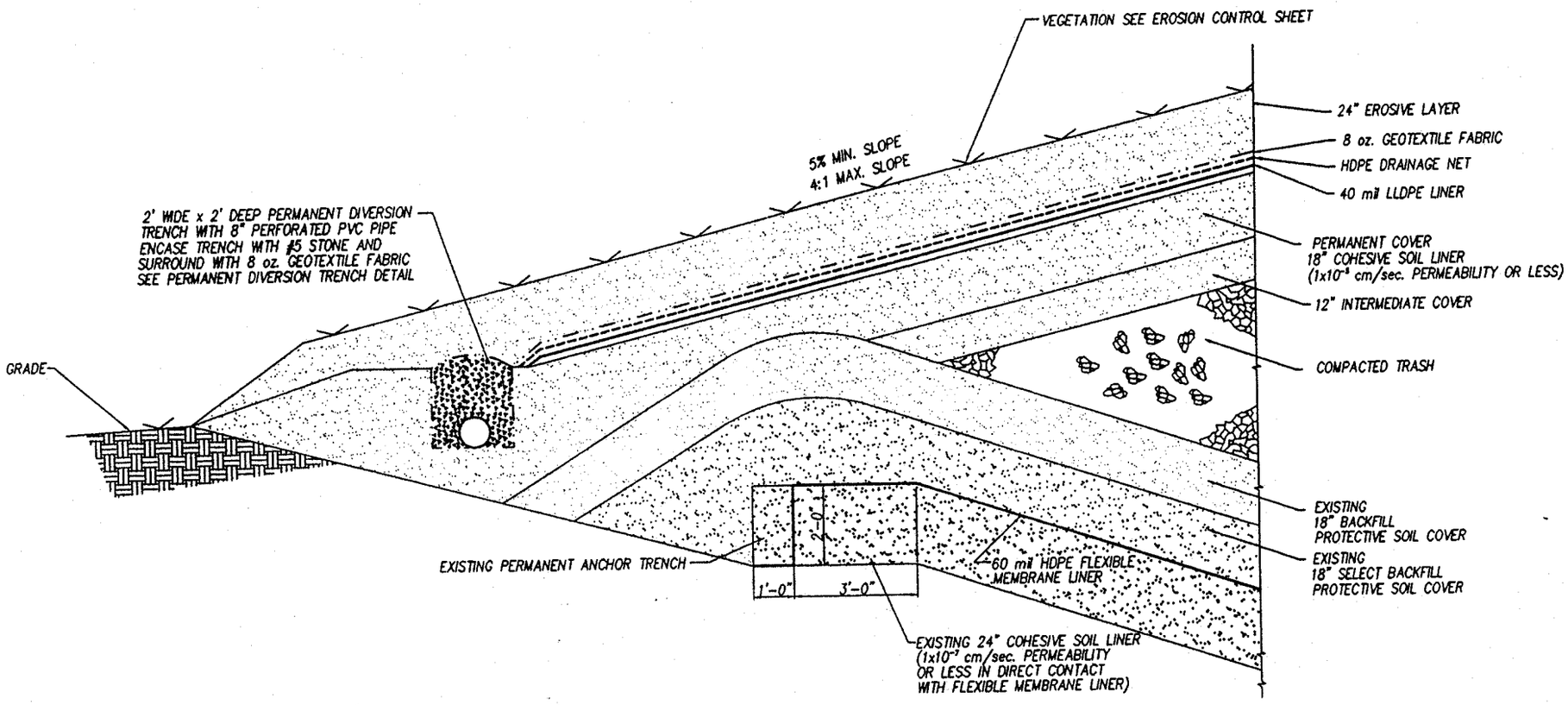
2.1.6 Cap System Standards

Haywood County will cap their landfill within 180 days after the final receipt of solid waste. The cap system will consist of 12 inches bridging material (temporary cover), 18 inches of soil liner with a permeability no greater than 1.0×10^{-5} cm/sec, 40 mil. Linear Low Density Polyethylene (LLDPE), drainage layer, 24 inches of protective/erosive layer. The cap contains a gas venting system that consists of a series of washed stone trenches below the soil liner that will be vented through pipes that penetrate the cap. The cap system will also include the proper seeding and mulching of the erosive layer and other erosion control devices.

Prior to beginning closure, Haywood County will notify the Division of Solid Waste that a notice of the intent to close the unit has been placed in the operating record. The County will begin closure activities no later than thirty (30) days after the date on which the landfill receives the final wastes or if the landfill has remaining capacity and there is a reasonable likelihood that the landfill will receive additional wastes, no later than one year after the most recent receipt of wastes. Extensions beyond the one-year deadline for beginning closure may be granted by the Division of Solid Waste if the County demonstrates that the landfill has the capacity to receive additional waste and the County has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the closed landfill.

The County will complete closure activities in accordance with the closure plan within 180 days following the final receipt of waste. Extensions of the closure period may be granted by the Division of Solid Waste if the County demonstrates that closure will, of necessity, take longer than one hundred eighty (180) days and the County has taken and will continue to take all steps to prevent threats of human health and environment from the enclosed landfill.

Following closure of the landfill, the County will record a notation on the deed to the landfill property and notify the Division of Solid Waste that the notation has been recorded and a copy has been placed in the operating record. The notation on the deed will in perpetuity notify any potential purchaser of the property that the land has been used as a landfill and its use is restricted under the closure plan approved by the Division of Solid Waste. The County may request permission from the Division to remove the notation from the deed if all waste is removed from the landfill.



TYPICAL CLOSURE DETAIL AT PERMANENT ANCHOR TRENCH

NOT TO SCALE

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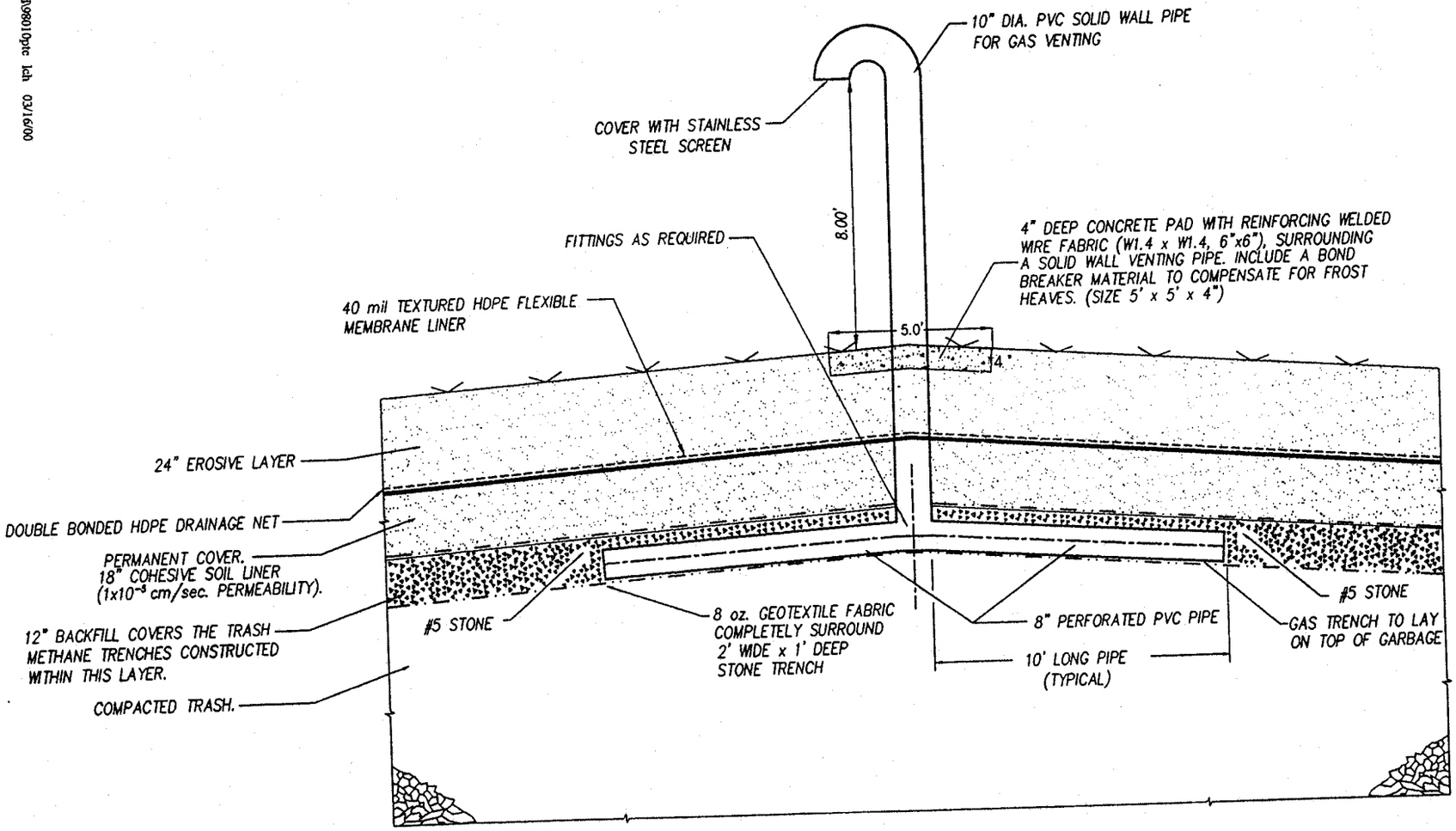


TYPICAL METHANE GAS COLLECTION TRENCH CLOSURE DETAIL AND CAP COVER DETAIL

N.T.S.

E:\documents\haywood\98010ptc lch 03/16/00

2.1.7 Leachate Storage Requirements

Haywood County has an existing leachate lagoon it is designed with a minimum of two feet of freeboard. Odor and vector controls will be practiced when necessary. A groundwater monitoring system is installed. The lagoon is protected from degradation and damage by an 8' high chain link fence.

The management of leachate is a major daily operational task. The generation of leachate should always be kept to a minimum. The leachate that is generated will either be recirculated into the existing cell or pumped and hauled to the Town of Waynesville Waste Water Treatment Plant. The leachate that is hauled to the treatment plant will be tested according to the Department of Environmental Management's pump and haul permit. The reason for this testing is to assure the Town that the leachate will not harm the biological processes in their treatment facility. The County will also record rainfall events as they occur and leachate generation to track the effect rainfall amounts have on the amount of leachate that is generated.

The leachate will be collected in the existing lined lagoon which will hold approximately 500,000 gallons at 14 feet deep. The Lagoon is 16 feet deep which allows for 2 feet of free board. In the event that the lagoon fills up faster than it can be recirculated or hauled away, a valve can be turned off which will allow the lagoon to be drained. Once the leachate levels have been lowered, the valve can be opened. Leachate will be a management problem from the time the garbage is placed in the landfill until long after closure has taken place. Consequently, it is imperative that stormwater be delivered away from any solid waste and managed properly.

All stormwater falling outside of the existing lined areas will be diverted away from the lined section through the use of diversion berms and ditches. Stormwater that falls within the lined area but does not come in contact with solid waste will be diverted through the leachate collection system by a system of valves, which will allow stormwater to be diverted into a riser basin. Phase 2 is broken up into three cells. While the first cell is being filled, the other two cells will allow stormwater to pass to the riser basin. When cell 2 starts to receive waste, the valve controlling storm water will be closed, allowing the resulting leachate to reach the main sewer line . When cell 3 starts to receive waste, the valve controlling storm water will be closed, allowing the resulting leachate to reach the main sewer line.

Haywood County will close the leachate lagoon within 180 days after liquid collection has ceased.

All solid waste will be removed from the leachate lagoon, connecting sewer lines, and manholes. All solid waste removed will be properly handled and disposed of according to federal and State requirements. All connecting lines will be disconnected and securely capped or plugged.

All waste residues, contaminated system components (composite liner system), contaminated subsoils, structures and equipment contaminated with waste will be removed and appropriately disposed. If the groundwater surrounding the impoundment is contaminated, other corrective actions to remediate a contaminant plume may be required by the Department. If the groundwater surrounding the lagoon is found not to be contaminated, the liner system may remain in place if drained and cleaned to remove all traces of waste, and both liners punctured so that drainage is allowed. The lagoon is to be backfilled and re-graded to the surrounding topography.

2.2 Summary of the Facility Design

Several factors have been looked at in the design and stability of the landfill. The first is earthwork calculations to see if the facility will need to borrow material from another source. After the construction of the first Phase of operation, there will be an excess of 11,086 cubic yards of material left on site. An Erosion Control plan has been developed and approved by the Land Quality Section of NCDENR, and the calculations are in section 2.2.2.

HELP Model Summary

A Model, "Hydrologic Evaluation of Landfill Performance" (HELP) has been performed to simulate precipitation and leachate generation under certain conditions. The analysis is done through the landfill with 8 and 25 ft. of solid waste with no runoff for the 1st through 5th year of operation including recirculation. Simulation was also done on a closed landfill. The maximum head on the liner of 0.0148 inches occurs after 2 years of operation with 8 ft. of solid waste and no surface runoff. See sec. 2.2.3 "Landfill with 8 ft. of solid waste 2nd year" peak daily values for years 1 through 5. The drainage layer (layer 5) is a double bonded 200 mil thick drainage net.

Leachate Collection System Calculations Summary

The leachate collection system consists of a 200 mil double bonded drainage net that is the drainage layer, stone filled trenches and collection pipes. The adequacy of the drainage layer is demonstrated in the HELP models (see sec.2.2.3).

Calculations have been performed for the Leachate Collection Pipes, and are located in Section 2.2.4. The calculations uses Manning's equation and the orifice equation to determine the adequacy of the leachate piping system to drain the leachate. The system adequately drains the 24hr 25yr storm. See calculations in section 2.2.4.

Strength of the HDPE leachate pipe calculations have been done and are located in section 2.2.5. The SDR 17 HDPE pipe can handle the loads created by at least 250' of waste. See section 2.2.5 for calculations.

Liner System Calculation Summary

Several calculations were done for the stress on the textured flexible geomembrane liner during construction. The thermal stress on the liner created by the temperature changing 100°F is 0.67% which is well within the 13% elongation yield limit. (see sec. 2.2.6) The self-weight stress on the textured flexible geomembrane liner shows that on a 3:1 slope the total length of slope allowed far exceeds the longest slope design (see sec. 2.2.6).

The Anchor trench has also been analyzed and the design depth of the Anchor trench is 4.0 ft. which allows pullout just prior to liner failure. (see sec. 2.2.6). An analysis of the drainage net for anchor trench requirements was analyzed and no anchor trench was required; however, the drainage net will be placed in the same anchor trench as the flexible membrane liner.(see sec.2.2.6).

The factor of safety for the sliding of the protective soil cover was analyzed showing a factor of safety greater than 1 for the interface between the soil and double bonded drainage net. (see sec. 2.2.6). The stresses due to the placement of protective cover were also analyzed (see sec. 2.2.6). Soil placed on the 3:1 embankment 50 ft. high does not effect the drainage net or the liner. The soil is buttressed enough at the base to have a negative effect on the slopes.

Foundation Analysis Summary

The landfill foundation will consist of *in situ* soils or compacted fill soils. The on-site soils are predominately silts, sandy silts, silty sands and weathered rock overlying fractured gneiss bedrock. The overburden soils generally become moderately dense to very dense with deeper depths. The full load induced by the final closed landfill will be on the order of about 6.9 tsf after the completion of Phases 2 through 7. Provided the marginal subgrade soils are stabilized with geogrid and ABC stone as outlined in Van Der Horst Geotechnical Engineering's (VDHGE) geotechnical evaluation report, the proposed foundation subgrade soils will satisfactorily support the proposed loading.

The foundation substrata will consolidate and compress over time due to the applied landfill loads. Based on the settlement analysis performed by VDHGE, estimated total and differential settlements will be on the order of 22 and 16 inches, respectively, and will occur gradually over time as the proposed loads are applied and could continue up to 20 years after closure of the landfill.

The geotechnical evaluation reports by VDHGE are located in Section 2.2.8.

Slope Stability Analysis Summary

To take the effects of earth quake loading into account during slope stability analysis, a seismic probability coefficient of 0.10 was used in the slope stability analysis by VDHGE. Based on the slope stability analysis performed by VDHGE using SB-SLOPE software program developed by Von Guten Engineering Software, a minimum factor of safety of 1.359 was computed. Therefore, the stability of slopes planned for the Haywood County Landfill exhibit satisfactory factors of safety against mass slope failure and shallow surface failure, provided geotechnical recommendations presented in VDHGE's report are followed.

The geotechnical evaluation reports by VDHGE are located in Sections 2.2.8.

2.2.1 Earthwork Calculations

*Left over from subbase preparation Phase 1:	228,397 cubic yards
Composite Liner System Phase 1:	32,783 cubic yards
Protective Cover Phase 1:	49,174 cubic yards
Net Material After Construction Phase 1:	146,440 cubic yards excess
Daily Cover Phase 1:	11,154 cubic yards
Closure System Phase 1:	55,144 cubic yards
Net Material After Closure of Phase 1:	80,142 cubic yards excess

*Determined by Autodesk 14 computer program.

2.2.2 Erosion Control

EROSION CONTROL PLAN

FOR

HAYWOOD COUNTY MUNICIPAL SOLID WASTE LANDFILL FACILITY

WAYNESVILLE, NC

G98010

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE

10/7/99

October 1999

Municipal Engineering Services Co., PA
Garner and Boone, North Carolina

DRAINAGE AREAS

Area Designation	Area (ac.)
ST1	5.31
ST2	4.35
ST3	3.91
RB1	2.97
RB1A	7.59
RB1B	6.72
DD1	6.57
DD2	3.65
DA1	3.04

TOTAL DISTURBED AREA = 41.07 ACRES

TOTAL DRAINAGE AREA = 44.11 ACRES

Runoff Coefficients

C = .25 Grassy Areas

Areas Draining Into Riser Basin #1

Area	A	I	C
ST1	= 5.31 acs.	7.25 in/hr.	.25
	= 5.31 acs.	7.25 in/hr.	.25

$Q_{(25)}$ = CIA = (.25)(7.25)(5.31) = 9.62 cfs.

Areas Draining Into Riser Basin #2

Area	A	I	C
RB1	= 2.97 acs.	7.25 in/hr.	.25
RB1A	= 7.59 acs.	7.25 in/hr.	.25
RB1B	= 6.72 acs.	7.25 in/hr.	.25
	= 17.28 acs.	7.25 in/hr.	.25

$Q_{(25)}$ = CIA = (.25)(7.25)(17.28) = 31.32 cfs (for basin sizing)

Area	A	I	C
RB1	= 2.97 acs.	7.25 in/hr.	.25
RB1A	= 7.59 acs.	7.25 in/hr.	.25
RB1B	= 6.72 acs.	7.25 in/hr.	.25
DA1	= 3.04 acs.	7.25 in/hr.	.25
	= 20.32 acs.	7.25 in/hr.	.25

$Q_{(25)}$ = CIA = (.25)(7.25)(20.32) = 36.83 cfs(for spillway sizing)

Areas Draining Into Sediment Trap #1

Area	A	I	C
ST2	= 4.35 acs.	7.25 in/hr.	.25
	= 4.35 acs.	7.25 in/hr.	.25

$Q_{(25)}$ = CIA = (.25)(7.25)(4.35) = 7.88 cfs.

Areas Draining Into Sediment Trap #2

Area	A	I	C
ST3	= 3.91 acs.	7.25 in/hr.	.25
	= 3.91 acs.	7.25 in/hr.	.25

$Q_{(25)}$ = CIA = (.25)(7.25)(3.91) = 7.09 cfs.

Areas Draining Into Diversion Ditch #1

Area	A	I	C
DD1	= 6.57 acs.	7.25 in/hr.	.25
	= 6.57 acs.	7.25 in/hr.	.25

$Q_{(25)}$ = CIA = (.25)(7.25)(6.57) = 11.91 cfs.

Areas Draining Into Diversion Ditch #2

Area	A	I	C
DD2	= 3.65 acs.	7.25 in/hr.	.25
	= 3.65 acs.	7.25 in/hr.	.25

$Q_{(25)}$ = CIA = (.25)(7.25)(3.65) = 6.62 cfs.

DESIGN RISER BASIN #1

Q = 9.62 cfs
A = 5.31 acs.

Surface area of riser basin:

Surface area S = .01Q S=(.01)(9.62) =0.0962 acs.
S = 0.0962 x 43560 ft^2 = 4,191 ft^2

Depth of riser basin:

depth = Capacity/surface area

Capacity needed is 1800 ft^3/acre.
Capacity = (1800)(5.31) = 9,558 ft^3.

Due to the location and the shape of the basin the average end method of calculating the storage of the basin is as follows:

bottom area at elevation 2600 = 2193
½ Riser Height 2603 = 5334

therfore:

2193 + 5334 = 7527 ÷ 2 = (3763.5)(3') = 11,290.5 ft^3

The actual storage capacity of the basin is adequate to contain the runoff.

Principal spillway barrel size:

Use Capacity of 0.2 cfs/acre
Q = (9.62)(.2) = 1.92 cfs
1.5% grade

$D = 16\,(Q\,n \div \sqrt{s})^{.375}$ Use corrugated metal pipe

Q = 1.92 cfs n = .024 s = .015

$D = 16[(1.92)(.024) \div \sqrt{.015}]^{.375} = 11.09"$ Use 12" pipe diameter

Outlet Protection

L = 14' W = 15' d_{50} = 9" 13.5" min. thickness

Riser pipe for Principal spillway:

18" pipe diameter

Footing for riser pipe:

Weight of water: $\pi r^2 h(62.4) = 661.62$ given: $r = 0.75'$ $h = 6'$

Concrete: 150 lbs per ft^3

4.41 ft^3 of concrete needed

use 6.25 ft^3 of concrete

1'x2.5'x2.5' footing.

Emergency Spillway:

$Q = C_W L H^{3/2}$ $C_W = 3.0$ $H = 1$ $Q = 9.62$

$L = Q \div (C_w)(H^{3/2}) = 9.62 \div (3)(1^{3/2}) = 3.21'$ Required

The Calculation for the Emergency Spillway Outlet Channel came out wider than the required size. Therefore, we will use the wider spillway to match the outlet channel. See Calculation sheet included.

Bottom of Weir = 10'
Top of Weir = 18'
Line with 12" Rip Rap

Elevations:

Top of Dam	2608.0'
Emergency Spillway	2606.5'
Riser Crest	2606.0'
Conduit Inlet	2600.0'
Conduit Outlet	2585.0'
Bottom Elevation	2600.0'

			G98010 HAYWOOD COUNTY					
			SPILLWAY CALCULATION					
			RISER BASIN #1					
		n =	0.034	12" stone				
		B =	10.00					
		S =	0.5					
		Y =	0.125					
		M =	2					
		Depth =	1.5					
	W =	16	minimum top width					
	R =	0.121342	R value					
	Q =	9.705078	Flow					
	A =	1.28125	Adjusted Area of flow					
	P =	10.55902	Adjusted Wetted Perimeter					
	V =	7.574695		Va =10.7				
Shear Stress		3.9		0-.45	jute netting		5.00max.	15" stone
				.46-1.45	straw with net		6.00max.	18" stone
				1.45-2.00	synthetic mat		7.00max.	21" stone
				2.00max.	6" stone		8.00max.	24" stone
				3.00max.	9" stone			
				4.00max.	**12" stone**			

DESIGN RISER BASIN #2

Q = 31.32 cfs
A = 17.28 acs.

Surface area of riser basin:

Surface area S = .01Q S=(.01)(31.32) =0.3132 acs.
S = 0.3132 x 43560 ft^2 = 13,643 ft^2

Depth of riser basin:

depth = Capacity/surface area

Capacity needed is 1800 ft^3/acre.
Capacity = (1800)(17.28) = 31,104 ft^3.

Due to the location and the shape of the basin the average end method of calculating the storage of the basin is as follows:

bottom area at elevation 2510 = 2638
½ Riser Height 2515 = 13,788

therfore:

2638 + 13,788 = 16,426 ÷ 2 = (8213)(5') = 41,065 ft^3

The actual storage capacity of the basin is adequate to contain the runoff.

Principal spillway barrel size:

Use Capacity of 0.2 cfs/acre
Q = (36.83)(.2) = 7.37 cfs
1.5% grade

$D = 16 (Q\ n \div \sqrt{s})^{.375}$ Use corrugated metal pipe

Q = 7.37 cfs n = .024 s = .015

$D = 16[(7.37)(.024) \div \sqrt{.015}]^{.375} = 18.36"$ Use 21" pipe diameter

Outlet Protection

L = 21' W = 22.75' d_{50} = 9" 13.5" min. thickness

Riser pipe for Principal spillway:

33" pipe diameter

Footing for riser pipe:

Weight of water: $\pi r^2 h(62.4) = 3{,}734$ given: $r = 1.38'$ $h = 10'$
Concrete: 150 lbs per ft^3
24.89 ft^3 of concrete needed
use 32.0 ft^3 of concrete
2'x4'x4' footing.

Emergency Spillway:

$Q = C_W L H^{3/2}$ $C_W = 3.0$ $H = 1$ $Q = 36.83$ (drainage area)
$L = Q \div (C_w)(H^{3/2}) = 36.83 \div (3)(1^{3/2}) = 12.28'$ Required

The Calculation for the Emergency Spillway Outlet Channel came out wider than the required size. Therefore, we will use the wider spillway to match the outlet channel. See Calculation sheet included.

Bottom of Weir = 20'
Top of Weir = 26'
Line with 18" Rip Rap

Elevations:

Top of Dam	2522.0'
Emergency Spillway	2520.5'
Riser Crest	2520.0'
Conduit Inlet	2510.0'
Conduit Outlet	2505.0'
Bottom Elevation	2510.0'

			G98010 HAYWOOD COUNTY					
			SPILLWAY CALCULATION					
			RISER BASIN #2					
		n =	0.036	18" stone				
		B =	20.00					
		S =	0.5					
		Y =	0.192					
		M =	2					
		Depth =	1.5					
	W =	26	minimum top width					
	R =	0.187631	R value					
	Q =	37.43935	Flow					
	A =	3.913728	Adjusted Area of flow					
	P =	20.85865	Adjusted Wetted Perimeter					
	V =	9.566159		Va = 13.2				
Shear Stress		5.9904		0-.45	jute netting		5.00max.	15" stone
				.46-1.45	straw with net		**6.00max.**	**18" stone**
				1.45-2.00	synthetic mat		7.00max.	21" stone
				2.00max.	6" stone		8.00max.	24" stone
				3.00max.	9" stone			
				4.00max.	12" stone			

DESIGN SEDIMENT TRAP #1

Q = 7.88 cfs
A = 4.35 acs.

Surface area of basin:

Surface area S = .01Q S=.01(7.88) = 0.0788 acs.
S = 0.0788 x 43560 ft^2 = 3432.5 ft^2

Depth of basin:

depth = Capacity/surface area

Capacity needed is 1800 ft^3/acre.
Capacity = (1800)(4.35) = 7,830 ft^3.

Due to the location and the shape of the basin the average end method of calculating the storage of the basin is as follows:

bottom area at elevation 2545 = 4,045
top of Spillway 2548 = 6,147

therfore:

4045 + 6147 = 10,192 ÷ 2 = (5096)(3') = 15,288 ft^3

The actual storage capacity of the basin is adequate to contain the runoff.

Spillway:

Bottom of Weir = 12.0' NC Erosion and Sediment Control Design Manual Table 6.60a
Top of Weir = 20.0'

Elevations:

Top of Dam	2550.0'
Emergency Spillway	2548.0'
Bottom Elevation	2545.0'

DESIGN SEDIMENT TRAP #2

Q = 7.09 cfs
A = 3.91 acs.

Surface area of basin:

Surface area S = .01Q S=.01(7.09) = 0.0709 acs.
S = 0.0709 x 43560 ft^2 = 3,089 ft^2

Depth of basin:

depth = Capacity/surface area

Capacity needed is 1800 ft^3/acre.
Capacity = (1800)(3.91) = 7,038 ft^3.

Due to the location and the shape of the basin the average end method of calculating the storage of the basin is as follows:

bottom area at elevation 2540 = 1830
top of Spillway 2543 = 2975

therfore:

1830 + 2975 = 4805 ÷ 2 = (2402.5)(3') = 7,207.5 ft^3

The actual storage capacity of the basin is adequate to contain the runoff.

Spillway:

Bottom of Weir = 10.0' NC Erosion and Sediment Control Design Manual Table 6.60a
Top of Weir = 18.0'

Elevations:

Top of Dam	2545.0'
Emergency Spillway	2543.0'
Bottom Elevation	2540.0'

DESIGN DIVERSION DITCHES

			G98010 HAYWOOD COUNTY					
			DITCH CALCULATIONS					
			DIVERSION DITCH #1					
		n =	0.03	GRASS				
		B =	5.00					
		S =	0.012					
		Y =	0.57					
		M =	2					
		Depth =	1					
	W =	9	minimum top width					
	R =	0.463604	R value					
	Q =	11.3753	Flow					
	A =	3.4998	Adjusted Area of flow					
	P =	7.549117	Adjusted Wetted Perimeter					
	V =	3.250271		Va =4				
Shear Stress		0.426816		**0-.45**	**jute netting**		5.00max.	15" stone
				.46-1.45	straw with net		6.00max.	18" stone
				1.45-2.00	synthetic mat		7.00max.	21" stone
				2.00max.	6" stone		8.00max.	24" stone
				3.00max.	9" stone			
				4.00max.	12" stone			

			G98010 HAYWOOD COUNTY					
			DITCH CALCULATIONS					
			DIVERSION DITCH #2					
		n =	0.03	6" STONE				
		B =	1.00					
		S =	0.055					
		Y =	0.58					
		M =	2					
		Depth =	1					
	W =	5	minimum top width					
	R =	0.348597	R value					
	Q =	7.208464	Flow					
	A =	1.2528	Adjusted Area of flow					
	P =	3.593839	Adjusted Wetted Perimeter					
	V =	5.753883		Va =7.7				
	Shear Stress	1.99056		0-.45	jute netting		5.00max.	15" stone
				.46-1.45	straw with net		6.00max.	18" stone
				1.45-2.00	synthetic mat		7.00max.	21" stone
				2.00max.	**6" stone**		8.00max.	24" stone
				3.00max.	9" stone			
				4.00max.	12" stone			

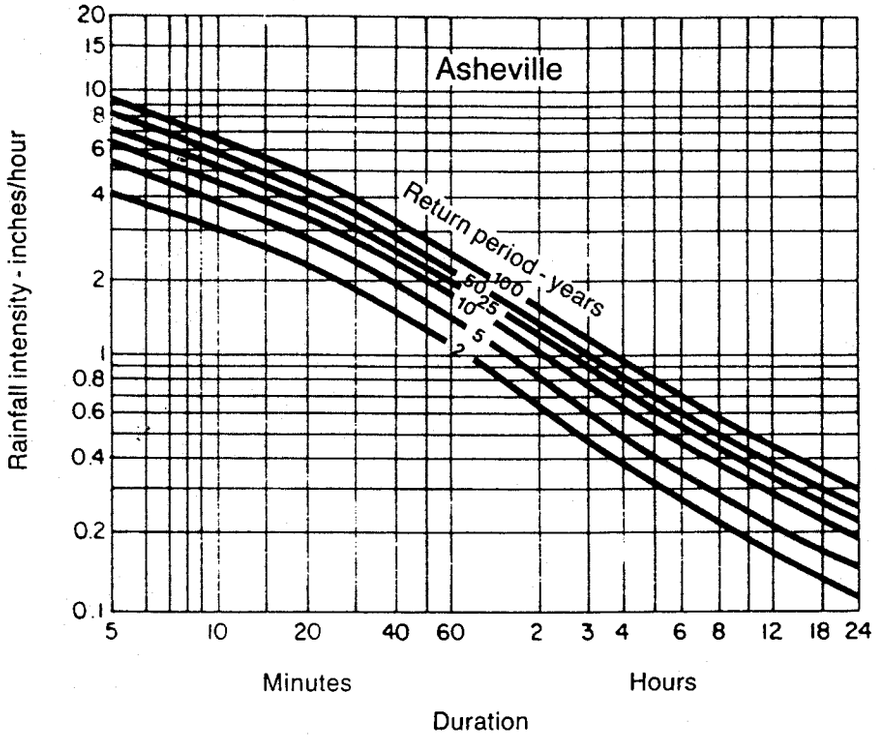


Figure 8.03f Rainfall intensity duration curves—Asheville.

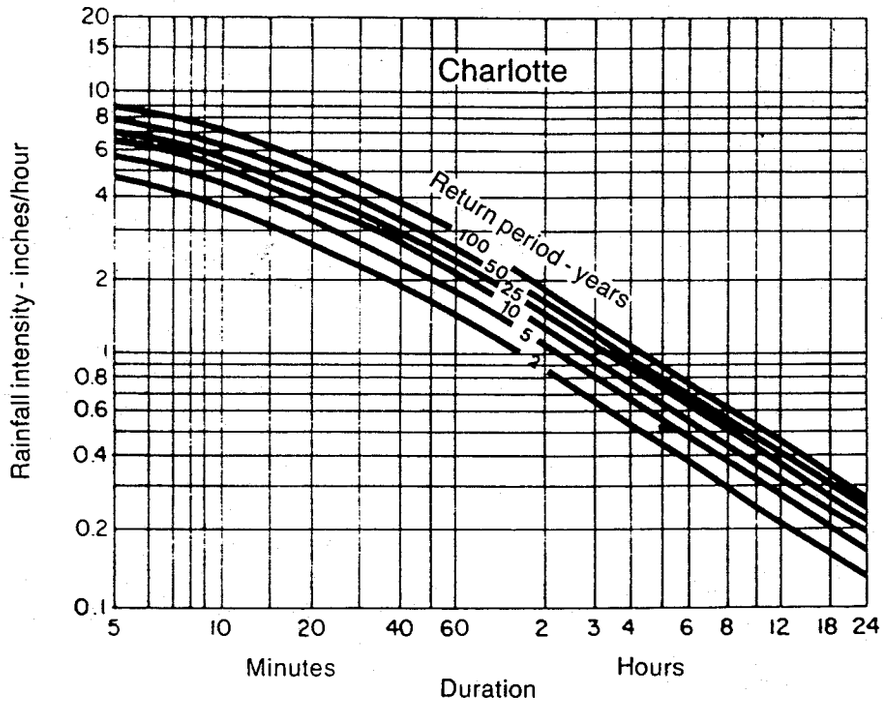
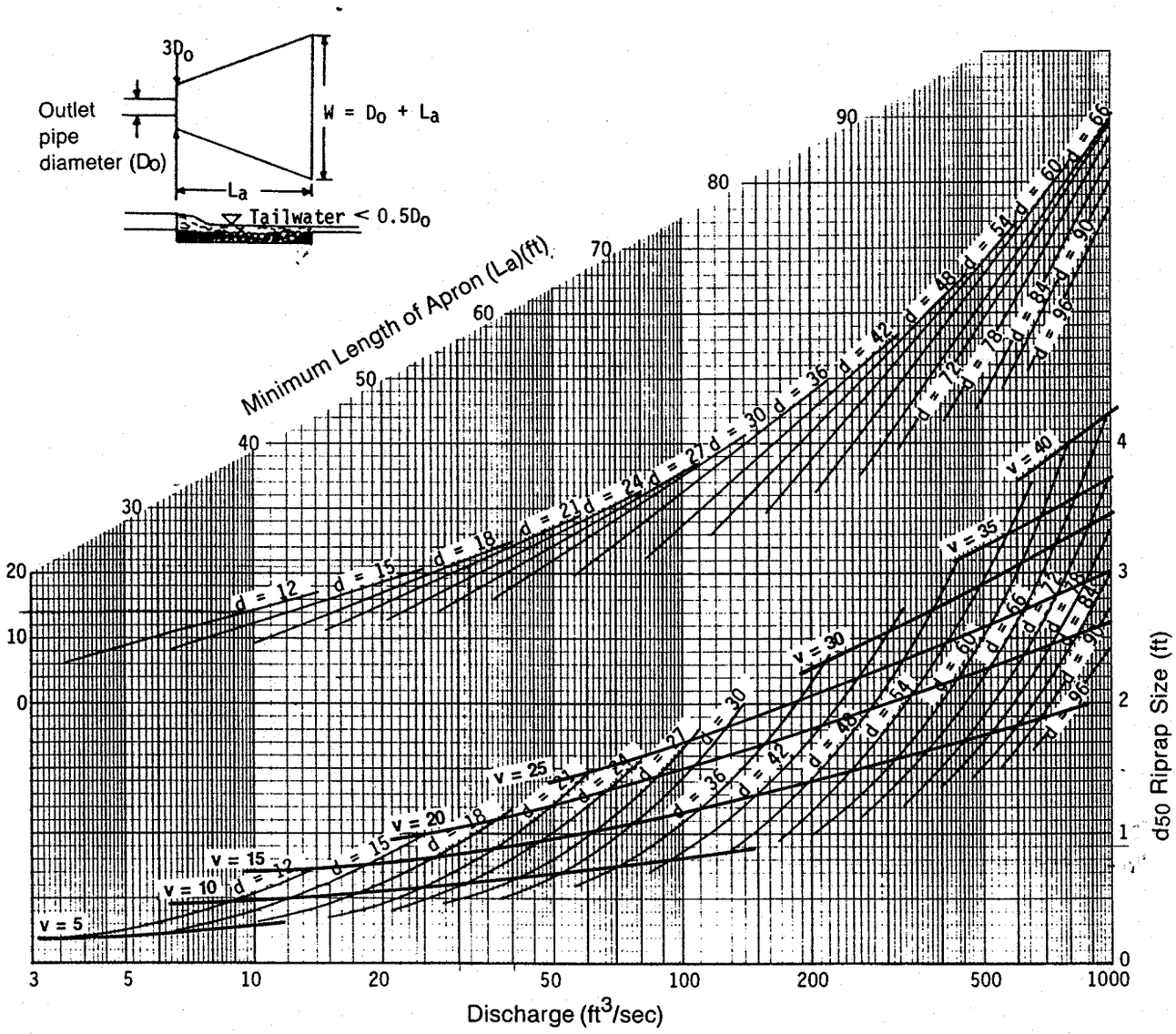
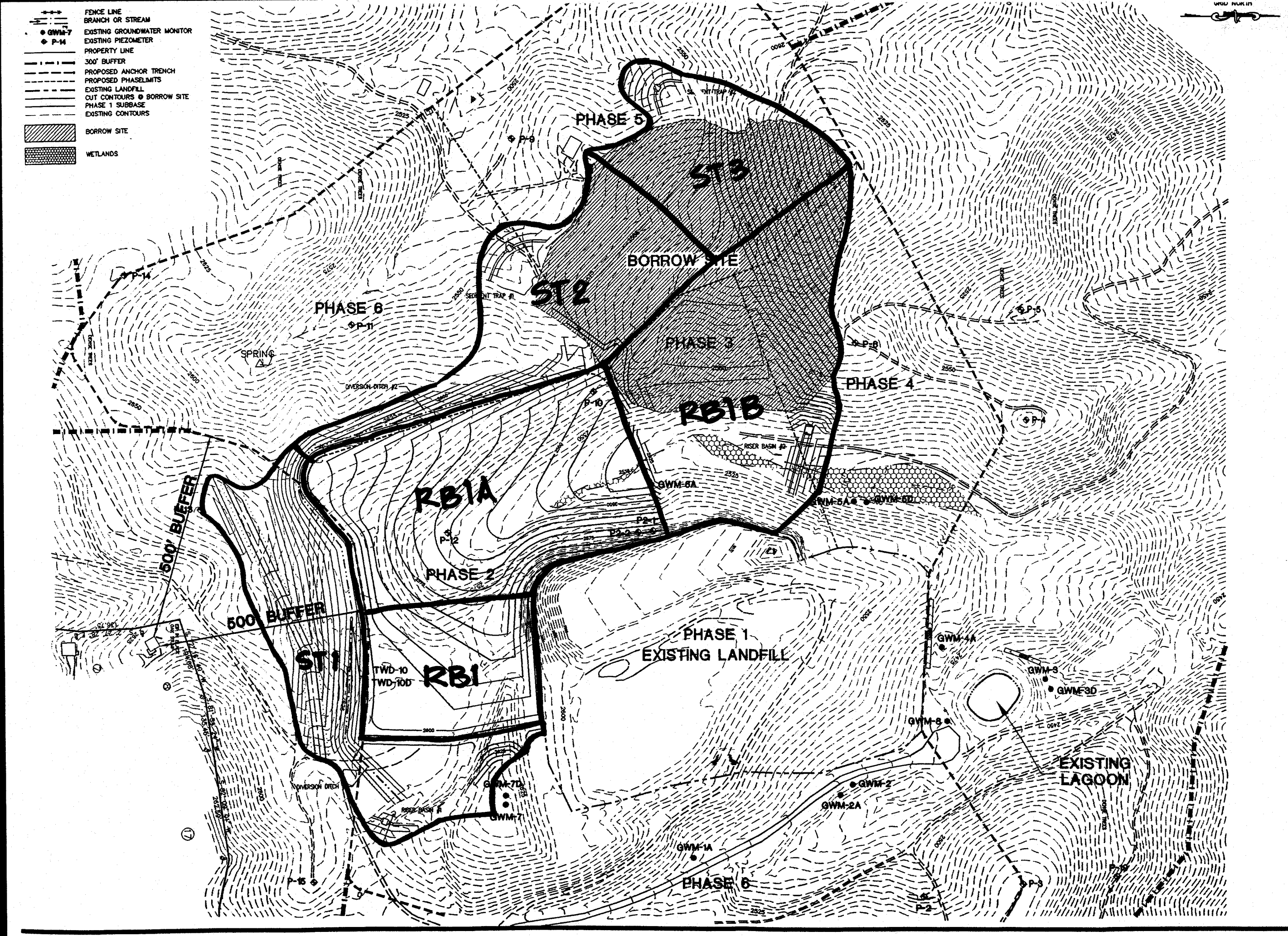


Figure 8.03g Rainfall intensity duration curves—Charlotte.



Curves may not be extrapolated.

Figure 8.06a Design of outlet protection protection from a round pipe flowing full, minimum tailwater condition (T_w < 0.5 diameter).



Municipal Engineering Services Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL FACILITY
HAYWOOD COUNTY
NORTH CAROLINA

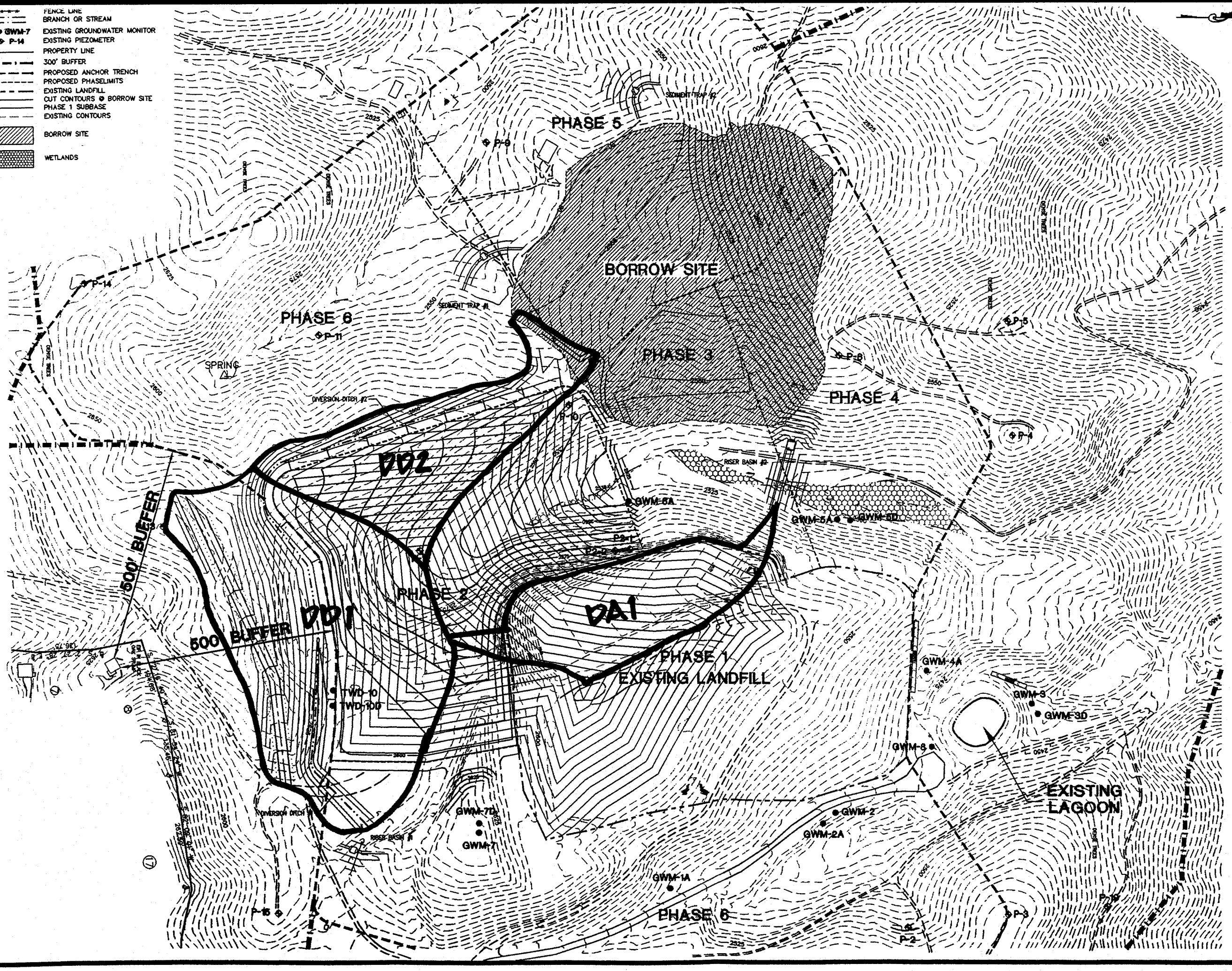
DATE	BY	REV.	DESCRIPTION

PHASE 2
EROSION CONTROL PLAN

SCALE: 1"= 100'
DATE: 01/28/99
DRWN. BY: L. HAMPTON
CHKD. BY: M. SULLIVAN
PROJECT NUMBER: G98010
DRAWING NO.: EC1
SHEET NO.: 3 OF 4

DRAINAGE/DISTURBED AREAS FOR SEDIMENT TRAPS & RISER BASINS

FENCE LINE
BRANCH OR STREAM
GWM-7 EXISTING GROUNDWATER MONITOR
P-14 EXISTING PIEZOMETER
PROPERTY LINE
300' BUFFER
PROPOSED ANCHOR TRENCH
PROPOSED PHASELIMITS
EXISTING LANDFILL
CUT CONTOURS @ BORROW SITE
PHASE 1 SUBBASE
EXISTING CONTOURS
BORROW SITE
WETLANDS



Municipal Engineering Company, P.A.
Municipal Services

MUNICIPAL SOLID WASTE LANDFILL FACILITY
HAYWOOD COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

PHASE 2
EROSION CONTROL PLAN

SCALE: 1"= 100'
DATE: 9/28/99
DRWN. BY: L. HAMPTON
CHKD. BY: K. SULLIVAN
PROJECT NUMBER
699010
DRAWING NO. EC1
SHEET NO. 3 OF 4

DRAINAGE/DISTURBED AREAS FOR DIVERSION DITCHES 1 & 2

2.2.3 HELP Model

INSERT FIRST HELP MODEL
PHASE 2 OPEN 1st YEAR

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.04    (10 APRIL 1995)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3\HAYWOOD.D4
TEMPERATURE DATA FILE:        C:\HELP3\HAYWOOD.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\HAYWOOD.D13
EVAPOTRANSPIRATION DATA:      c:\help3\HAYWOOD.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\HAYWOOD1.D10
OUTPUT DATA FILE:             C:\HELP3\HAYWOOD1.OUT


TIME:  10: 2     DATE:   9/23/1999


******************************************************************************

     TITLE:  Haywood Co. Phase 2 Open 1st year

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  12
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4710 VOL/VOL
          FIELD CAPACITY               =      0.3420 VOL/VOL
          WILTING POINT                =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3932 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                MATERIAL TEXTURE NUMBER  19
THICKNESS                    =     96.00   INCHES
POROSITY                     =      0.1680 VOL/VOL
FIELD CAPACITY               =      0.0730 VOL/VOL
WILTING POINT                =      0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0763 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  14
THICKNESS                    =     36.00   INCHES
POROSITY                     =      0.4790 VOL/VOL
FIELD CAPACITY               =      0.3710 VOL/VOL
WILTING POINT                =      0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3973 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC


                        LAYER  4
                        --------

              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER  20
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0160 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   10.0000000000     CM/SEC
SLOPE                        =      2.00   PERCENT
DRAINAGE LENGTH              =    100.0    FEET


                        LAYER  5
                        --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER  6
                        --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
```

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	91.70	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.694	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.164	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.691	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	36.601	INCHES
TOTAL INITIAL WATER	=	36.601	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ASHEVILLE NORTH CAROLINA

STATION LATITUDE	=	35.26	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	96	
END OF GROWING SEASON (JULIAN DATE)	=	298	
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	75.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	84.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	77.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ASHEVILLE NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.21	4.02	5.47	3.96	3.87	3.56
4.06	3.88	3.48	2.79	3.24	4.07

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING

COEFFICIENTS FOR ASHEVILLE NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
36.00	38.30	45.80	54.50	61.10	67.30
70.40	69.80	64.50	53.90	44.70	38.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ASHEVILLE NORTH CAROLINA
AND STATION LATITUDE = 35.48 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.07	163604.125	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	30.828	111906.484	68.40
DRAINAGE COLLECTED FROM LAYER 4	14.2210	51622.383	31.55
PERC./LEAKAGE THROUGH LAYER 6	0.000009	0.034	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0034		
CHANGE IN WATER STORAGE	0.021	75.177	0.05
SOIL WATER AT START OF YEAR	36.601	132861.953	
SOIL WATER AT END OF YEAR	36.622	132937.125	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.052	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.17	4.28	4.59	2.70	4.00	4.24
	4.07	3.75	3.13	3.32	4.82	4.00

STD. DEVIATIONS	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00

RUNOFF

TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

EVAPOTRANSPIRATION

TOTALS	1.439	1.707	2.629	3.254	2.989	5.145
	4.234	2.767	3.269	0.927	1.460	1.008
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	1.4438	0.8807	3.4721	1.3051	0.8666	0.3167
	0.0151	0.0006	0.3503	0.5590	2.5951	2.4160
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0041	0.0028	0.0099	0.0038	0.0025	0.0009
	0.0000	0.0000	0.0010	0.0016	0.0076	0.0069
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 1

	INCHES		CU. FEET	PERCENT
PRECIPITATION	45.07	(0.000)	163604.1	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	30.828	(0.0000)	111906.48	68.401

LATERAL DRAINAGE COLLECTED FROM LAYER 4	14.22104 (	0.00000)	51622.383	31.55323
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001 (	0.00000)	0.034	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.003 (	0.000)		
CHANGE IN WATER STORAGE	0.021 (	0.0000)	75.18	0.046

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 1

	(INCHES)	(CU. FT.)
PRECIPITATION	1.61	5844.300
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 4	0.33440	1213.87744
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00059
AVERAGE HEAD ON TOP OF LAYER 5	0.030	
MAXIMUM HEAD ON TOP OF LAYER 5	0.595	
SNOW WATER	0.65	2360.6431

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2757
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1281

*** MAXIMUM HEADS ARE COMPUTED USING THE MOUND EQUATION. ***

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FINAL WATER STORAGE AT END OF YEAR 1

LAYER	(INCHES)	(VOL/VOL)
1	4.7179	0.3932
2	7.3482	0.0765
3	14.3043	0.3973
4	0.0033	0.0166

5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.000	

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INSERT SECOND HELP MODEL
PHASE 2 OPEN 5 YEARS w/25 FT. OF SOLID WASTE

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.04    (10 APRIL 1995)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\HAYWOOD.D4
TEMPERATURE DATA FILE:       C:\HELP3\HAYWOOD.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\HAYWOOD.D13
EVAPOTRANSPIRATION DATA:     c:\help3\HAYWOOD.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\HAYWOOD2.D10
OUTPUT DATA FILE:            C:\HELP3\HAYWOOD2.OUT


TIME:  10:11     DATE:   9/23/1999


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     TITLE:  Haywood Co. Phase 2 Open 5 years w/ 25 ft of solid waste

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  12
          THICKNESS                  =     12.00   INCHES
          POROSITY                   =      0.4710 VOL/VOL
          FIELD CAPACITY             =      0.3420 VOL/VOL
          WILTING POINT              =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.3925 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.419999997000E-04 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
```

```
                MATERIAL TEXTURE NUMBER  19
THICKNESS                    =    300.00   INCHES
POROSITY                     =      0.1680 VOL/VOL
FIELD CAPACITY               =      0.0730 VOL/VOL
WILTING POINT                =      0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0734 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                        LAYER  3
                        --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER  14
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.4790 VOL/VOL
FIELD CAPACITY               =      0.3710 VOL/VOL
WILTING POINT                =      0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3946 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC


                        LAYER  4
                        --------

              TYPE 2 - LATERAL DRAINAGE LAYER
                MATERIAL TEXTURE NUMBER  20
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0139 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   10.0000000000     CM/SEC
SLOPE                        =      2.00   PERCENT
DRAINAGE LENGTH              =    100.0    FEET


                        LAYER  5
                        --------

              TYPE 4 - FLEXIBLE MEMBRANE LINER
                MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER  6
                        --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER  16
```

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 200. FEET.

SCS RUNOFF CURVE NUMBER	=	91.80	
FRACTION OF AREA ALLOWING RUNOFF	=	50.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.492	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.164	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.691	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	46.457	INCHES
TOTAL INITIAL WATER	=	46.457	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ASHEVILLE NORTH CAROLINA

STATION LATITUDE	=	35.26	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	96	
END OF GROWING SEASON (JULIAN DATE)	=	298	
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	75.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	84.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	77.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ASHEVILLE NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.21	4.02	5.47	3.96	3.87	3.56
4.06	3.88	3.48	2.79	3.24	4.07

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING

COEFFICIENTS FOR ASHEVILLE NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
36.00	38.30	45.80	54.50	61.10	67.30
70.40	69.80	64.50	53.90	44.70	38.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ASHEVILLE NORTH CAROLINA
AND STATION LATITUDE = 35.48 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.07	163604.125	100.00
RUNOFF	2.449	8891.056	5.43
EVAPOTRANSPIRATION	30.491	110681.617	67.65
DRAINAGE COLLECTED FROM LAYER 4	12.1456	44088.621	26.95
PERC./LEAKAGE THROUGH LAYER 6	0.000008	0.030	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0029		
CHANGE IN WATER STORAGE	-0.016	-57.217	-0.03
SOIL WATER AT START OF YEAR	46.457	168640.000	
SOIL WATER AT END OF YEAR	46.442	168582.781	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.026	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	53.32	193551.609	100.00
RUNOFF	5.716	20750.246	10.72
EVAPOTRANSPIRATION	24.361	88430.211	45.69
DRAINAGE COLLECTED FROM LAYER 4	23.4674	85186.656	44.01

PERC./LEAKAGE THROUGH LAYER 6	0.000013	0.047	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0057		
CHANGE IN WATER STORAGE	-0.225	-815.526	-0.42
SOIL WATER AT START OF YEAR	46.442	168582.781	
SOIL WATER AT END OF YEAR	46.217	167767.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.018	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	47.31	171735.266	100.00
RUNOFF	3.605	13086.854	7.62
EVAPOTRANSPIRATION	29.606	107468.828	62.58
DRAINAGE COLLECTED FROM LAYER 4	13.7996	50092.613	29.17
PERC./LEAKAGE THROUGH LAYER 6	0.000009	0.032	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0033		
CHANGE IN WATER STORAGE	0.299	1087.017	0.63
SOIL WATER AT START OF YEAR	46.217	167767.250	
SOIL WATER AT END OF YEAR	46.516	168854.266	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.081	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.19	149519.734	100.00
RUNOFF	3.265	11853.396	7.93

EVAPOTRANSPIRATION	27.268	98981.516	66.20
DRAINAGE COLLECTED FROM LAYER 4	10.4216	37830.473	25.30
PERC./LEAKAGE THROUGH LAYER 6	0.000007	0.025	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0025		
CHANGE IN WATER STORAGE	0.235	854.298	0.57
SOIL WATER AT START OF YEAR	46.516	168854.266	
SOIL WATER AT END OF YEAR	46.752	169708.562	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.029	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.31	160845.297	100.00
RUNOFF	2.806	10185.865	6.33
EVAPOTRANSPIRATION	29.233	106117.523	65.97
DRAINAGE COLLECTED FROM LAYER 4	11.7192	42540.844	26.45
PERC./LEAKAGE THROUGH LAYER 6	0.000008	0.028	0.00
AVG. HEAD ON TOP OF LAYER 5	0.0029		
CHANGE IN WATER STORAGE	0.537	1947.935	1.21
SOIL WATER AT START OF YEAR	46.752	169708.562	
SOIL WATER AT END OF YEAR	47.288	171656.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0146	53.097	0.03

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.46	3.98	5.30	5.25	4.50	3.87
	4.17	2.91	2.05	2.48	3.92	4.37
STD. DEVIATIONS	1.04	1.67	3.72	1.56	1.32	1.65
	1.31	0.58	0.87	1.53	2.70	0.74
RUNOFF						
TOTALS	0.370	0.395	0.561	0.364	0.321	0.219
	0.126	0.040	0.099	0.086	0.394	0.593
STD. DEVIATIONS	0.431	0.409	0.697	0.106	0.336	0.236
	0.088	0.046	0.125	0.081	0.443	0.067
EVAPOTRANSPIRATION						
TOTALS	1.086	1.482	2.377	3.476	3.620	4.500
	3.720	2.552	2.167	1.350	1.062	0.799
STD. DEVIATIONS	0.317	0.235	0.155	0.336	0.563	0.777
	1.473	0.673	0.749	0.596	0.337	0.140
LATERAL DRAINAGE COLLECTED FROM LAYER 4						
TOTALS	1.8403	2.4724	2.4053	2.3894	1.3570	0.2310
	0.0495	0.0111	0.0895	0.0901	0.7319	2.6431
STD. DEVIATIONS	0.4105	1.2998	1.3547	1.5924	1.0935	0.2255
	0.0930	0.0248	0.2001	0.1952	0.9000	1.8216
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5						
AVERAGES	0.0052	0.0078	0.0068	0.0070	0.0039	0.0007
	0.0001	0.0000	0.0003	0.0003	0.0022	0.0075
STD. DEVIATIONS	0.0012	0.0041	0.0039	0.0047	0.0031	0.0007
	0.0003	0.0001	0.0006	0.0006	0.0026	0.0052

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	46.24	(4.524)	167851.2	100.00
RUNOFF	3.568	(1.2787)	12953.48	7.717
EVAPOTRANSPIRATION	28.192	(2.4444)	102335.93	60.968
LATERAL DRAINAGE COLLECTED FROM LAYER 4	14.31070	(5.25915)	51947.840	30.94874
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00001	(0.00000)	0.032	0.00002
AVERAGE HEAD ON TOP OF LAYER 5	0.003	(0.001)		
CHANGE IN WATER STORAGE	0.166	(0.2940)	603.30	0.359

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.46	8929.800
RUNOFF	0.845	3067.2627
DRAINAGE COLLECTED FROM LAYER 4	0.44198	1604.40491
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00075
AVERAGE HEAD ON TOP OF LAYER 5	0.039	
MAXIMUM HEAD ON TOP OF LAYER 5	0.685	
SNOW WATER	2.61	9473.1387

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2835

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1281

*** MAXIMUM HEADS ARE COMPUTED USING THE MOUND EQUATION. ***

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)

1	3.9589	0.3299
2	23.6116	0.0787
3	9.4661	0.3944
4	0.0037	0.0185
5	0.0000	0.0000
6	10.2480	0.4270
SNOW WATER	0.000	

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INSERT FINAL HELP MODEL
PHASE 2 CLOSED

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.04   (10 APRIL 1995)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
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PRECIPITATION DATA FILE:     C:\HELP3\HAYWOOD.D4
TEMPERATURE DATA FILE:       C:\HELP3\HAYWOOD.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\HAYWOOD.D13
EVAPOTRANSPIRATION DATA:     c:\help3\HAYWOOD.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\HAYWOODC.D10
OUTPUT DATA FILE:            C:\HELP3\HAYWOODC.OUT


TIME:  10:12     DATE:   9/23/1999


******************************************************************************

     TITLE:  Haywood Co. Phase 2 Closed

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER  12
          THICKNESS                  =     24.00   INCHES
          POROSITY                   =      0.4710 VOL/VOL
          FIELD CAPACITY             =      0.3420 VOL/VOL
          WILTING POINT              =      0.2100 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.3863 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.419999997000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
                                  --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
```

MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	4.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 23

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4610	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.900000032000E-05	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 12

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4710	VOL/VOL
FIELD CAPACITY	=	0.3420	VOL/VOL
WILTING POINT	=	0.2100	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3420	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.419999997000E-04	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 19

```
THICKNESS                    =    360.00   INCHES
POROSITY                     =      0.1680 VOL/VOL
FIELD CAPACITY               =      0.0730 VOL/VOL
WILTING POINT                =      0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0730 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                        LAYER  7
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          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  14
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.4790 VOL/VOL
FIELD CAPACITY               =      0.3710 VOL/VOL
WILTING POINT                =      0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3710 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.249999994000E-04 CM/SEC


                        LAYER  8
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER  20
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   10.0000000000     CM/SEC
SLOPE                        =      2.00   PERCENT
DRAINAGE LENGTH              =    100.0    FEET


                        LAYER  9
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            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =      4.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      4.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER 10
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              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  16
THICKNESS                    =     24.00   INCHES
```

POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 300. FEET.

SCS RUNOFF CURVE NUMBER	=	91.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	8.195	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.891	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.410	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	67.109	INCHES
TOTAL INITIAL WATER	=	67.109	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM ASHEVILLE NORTH CAROLINA

STATION LATITUDE	=	35.26	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	96	
END OF GROWING SEASON (JULIAN DATE)	=	298	
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	71.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	75.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	84.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	77.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ASHEVILLE NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.21	4.02	5.47	3.96	3.87	3.56
4.06	3.88	3.48	2.79	3.24	4.07

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR ASHEVILLE NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
36.00	38.30	45.80	54.50	61.10	67.30
70.40	69.80	64.50	53.90	44.70	38.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ASHEVILLE NORTH CAROLINA
AND STATION LATITUDE = 35.48 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	45.07	163604.125	100.00
RUNOFF	5.321	19316.641	11.81
EVAPOTRANSPIRATION	31.382	113915.922	69.63
DRAINAGE COLLECTED FROM LAYER 2	8.3638	30360.598	18.56
PERC./LEAKAGE THROUGH LAYER 4	0.000149	0.540	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0025		
DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.539	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.003	10.358	0.01
SOIL WATER AT START OF YEAR	67.109	243604.562	
SOIL WATER AT END OF YEAR	67.112	243614.922	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.071	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	53.32	193551.609	100.00

RUNOFF	12.384	44954.797	23.23
EVAPOTRANSPIRATION	24.788	89979.727	46.49
DRAINAGE COLLECTED FROM LAYER 2	16.8046	61000.668	31.52
PERC./LEAKAGE THROUGH LAYER 4	0.000278	1.010	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0049		
DRAINAGE COLLECTED FROM LAYER 8	0.0003	1.008	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.657	-2384.625	-1.23
SOIL WATER AT START OF YEAR	67.112	243614.922	
SOIL WATER AT END OF YEAR	66.455	241230.297	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.032	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	47.31	171735.266	100.00
RUNOFF	7.744	28109.510	16.37
EVAPOTRANSPIRATION	29.761	108031.359	62.91
DRAINAGE COLLECTED FROM LAYER 2	10.0611	36521.781	21.27
PERC./LEAKAGE THROUGH LAYER 4	0.000177	0.641	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0029		
DRAINAGE COLLECTED FROM LAYER 8	0.0002	0.640	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.256	-927.966	-0.54
SOIL WATER AT START OF YEAR	66.455	241230.297	
SOIL WATER AT END OF YEAR	66.199	240302.328	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0000	-0.060	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	41.19	149519.734	100.00
RUNOFF	6.678	24239.426	16.21
EVAPOTRANSPIRATION	27.576	100100.023	66.95
DRAINAGE COLLECTED FROM LAYER 2	6.5063	23617.814	15.80
PERC./LEAKAGE THROUGH LAYER 4	0.000114	0.415	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0019		
DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.414	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.430	1562.064	1.04
SOIL WATER AT START OF YEAR	66.199	240302.328	
SOIL WATER AT END OF YEAR	66.629	241864.391	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.005	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.31	160845.297	100.00
RUNOFF	6.007	21804.160	13.56
EVAPOTRANSPIRATION	29.394	106698.945	66.34
DRAINAGE COLLECTED FROM LAYER 2	8.4908	30821.779	19.16
PERC./LEAKAGE THROUGH LAYER 4	0.000148	0.536	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0025		

DRAINAGE COLLECTED FROM LAYER 8	0.0001	0.534	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.404	1466.711	0.91
SOIL WATER AT START OF YEAR	66.629	241864.391	
SOIL WATER AT END OF YEAR	67.033	243331.109	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0146	53.161	0.03

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.46	3.98	5.30	5.25	4.50	3.87
	4.17	2.91	2.05	2.48	3.92	4.37
STD. DEVIATIONS	1.04	1.67	3.72	1.56	1.32	1.65
	1.31	0.58	0.87	1.53	2.70	0.74
RUNOFF						
TOTALS	0.786	0.876	1.251	0.810	0.655	0.438
	0.241	0.078	0.194	0.164	0.839	1.295
STD. DEVIATIONS	0.821	0.878	1.539	0.229	0.697	0.476
	0.169	0.089	0.245	0.156	0.931	0.133
EVAPOTRANSPIRATION						
TOTALS	1.040	1.436	2.337	3.430	3.847	4.956
	3.678	2.509	2.192	1.436	0.978	0.740
STD. DEVIATIONS	0.300	0.231	0.142	0.343	0.575	0.888
	1.447	0.630	0.752	0.513	0.267	0.136
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.5735	2.0490	1.9266	1.6096	0.4715	0.0031
	0.0016	0.0001	0.0003	0.0001	0.5329	1.8771
STD. DEVIATIONS	0.8855	1.1521	1.7341	0.6580	0.7498	0.0032
	0.0026	0.0002	0.0003	0.0000	0.5753	0.6442

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 10

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0054	0.0078	0.0066	0.0057	0.0016	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0019	0.0064
STD. DEVIATIONS	0.0030	0.0044	0.0059	0.0023	0.0026	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0020	0.0022

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	46.24	(4.524)	167851.2	100.00
RUNOFF	7.627	(2.8057)	27684.91	16.494
EVAPOTRANSPIRATION	28.580	(2.5147)	103745.20	61.808
LATERAL DRAINAGE COLLECTED FROM LAYER 2	10.04532	(3.98299)	36464.527	21.72432
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00017	(0.00006)	0.628	0.00037

AVERAGE HEAD ON TOP OF LAYER 3	0.003 (	0.001)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.00017 (	0.00006)	0.627	0.00037
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000 (	0.00000)	0.001	0.00000
AVERAGE HEAD ON TOP OF LAYER 9	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-0.015 (	0.4594)	-54.69	-0.033

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.46	8929.800
RUNOFF	1.725	6262.5630
DRAINAGE COLLECTED FROM LAYER 2	0.49200	1785.96899
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000007	0.02588
AVERAGE HEAD ON TOP OF LAYER 3	0.052	
MAXIMUM HEAD ON TOP OF LAYER 3	2.165	
DRAINAGE COLLECTED FROM LAYER 8	0.00001	0.02587
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00001
AVERAGE HEAD ON TOP OF LAYER 9	0.000	
MAXIMUM HEAD ON TOP OF LAYER 9	0.004	
SNOW WATER	2.61	9473.1387

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4243

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2100

*** MAXIMUM HEADS ARE COMPUTED USING THE MOUND EQUATION. ***

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	9.1823	0.3826
2	0.0150	0.0751
3	0.0000	0.0000
4	8.2980	0.4610
5	4.1040	0.3420
6	26.2800	0.0730
7	8.9040	0.3710
8	0.0020	0.0100
9	0.0000	0.0000
10	10.2480	0.4270
SNOW WATER	0.000	

****
****

2.2.4 Leachate Collection System Design Calculations

Initial Calculations

25 yr. 24 hr. Storm = 7.2"

Lagoon storage capacity w/2' freeboard = 514,000 gallons based on volume calculations from the as-built drawings.

Discharge pipe (Liner Penetration)= 8" HDPE SDR-17 Pipe ≥ 2% slope

Based on the HELP Model, the average monthly flows for a 5 year period on a per acre basis are as follows:

1. January = 49,969 gallons/acre
2. February = 67,132 gallons/acre
3. March = 65,310 gallons/acre
4. April = 64,878 gallons/acre
5. May = 36,846 gallons/acre
6. June = 6,272 gallons/acre
7. July = 1,344 gallons/acre
8. August = 301 gallons/acre
9. September = 2,430 gallons/acre
10. October = 2,446 gallons/acre
11. November = 19,873 gallons/acre
12. December = 71,767 gallons/acre

Total = 388,568 gallons/acre

Annual Flow based on 10 acres = 3,885,680 gpd

The actual flow rates based on truck loads at 6,000 gallons each of leachate hauled from the landfill to the wastewater plant located in Waynesville is as follows:

1996 - 144 loads = 864,000 gal.
1997 - 194 loads = 1,164,000 gal.
1998 - 131 loads = 786,000 gal.
1999 - 149 loads = 894,000 gal.

This was with rainfall recorded at the landfill in the same time period as follows:

1996 = 66.20 in.
1997 = 53.65 in.
1998 = 58.75 in.
1999 = 36.75 in.

The actual flow rates are considerably less than what is predicted by the HELP Model for approximately the same constructed area. The rainfall is higher for three out of the four years than the average for the 30 year period reported by the National Oceanic and Atmospheric Administration for Waynesville. This data is used in the HELP Model which makes it much more conservative.

The leachate lagoon holds 500,000 gallons of leachate based on the as-built. The largest actual flow occurred in 1997 after the rains of 1996. The HELP Model predicts 3,885,680 gallons of leachate for the five year period. Consequently to be conservative, the actual flow of 1997 and the annual flow for the five year period as predicted by the HELP Model will be used to determine the adequacy of the leachate lagoon.

Flow of 1997 = 1,164,000 gallons/year
HELP Model = 3,885,680 gallons/year
Total = 5,049,680 gallons/year

Based on 5,049,680 gal./yr., the leachate lagoon has to be emptied 10 times a year or once every 1.2 months. Utilizing the actual and the anticipated flows and with the addition of Phase II, the leachate lagoon still has at least 30 days of storage with two feet of freeboard.

Maximum Flow Through 8" pipe @2% (Mannings Equation)

$Q = 1.486/n\ (AR^{2/3}s^{1/2})$ $n = 0.009$
$s = 0.02$ ft/ft
$Q = 1.486/.009(0.311026)(0.157292)^{2/3}(.02)^{1/2}$ $A = 0.311026\ ft^2$
$P = 1.977381$ ft

$Q = 2.1162$ cfs = 949.75 gpm

Leachate Collection System Components

Flow into perforation of pipe	= 662,300 ft^3/yr.
	= 9.42 gpm/ft.
Vertical Flow through Rock Fill	= 441,500 ft^3/ft/yr.
	= 6.28 gpm/ft.
Horizontal Flow through Rock Fill	= 346,500 ft^3/yr.
w/1.0' of Head	= 4.94 gpm

System Performance

The largest area with no garbage will be approximately 2.0 acres.

Q_{25} = (2.0 ac)(43,560 sq.ft./ac)(7.2"/12")(7.48 gal/cu.ft.) = 390,994 gal./day

Q_{25} = 16,291 gal./hr.

Lagoon size = 514,000 gal.

∴ Lagoon will hold 25 yr. 24 hr. storm w/ no garbage in 2.0 acres of exposed cell w/ no evaporation.

<u>Flow Through 8" HDPE SDR-17 pipe @ the penetration</u>

Q_{pipe} = 949.75 gpm
= 1,367,640 gpd

$Q_{25/10\ acres}$ = 1,954,970 gal./day

∴ Penetration pipe will adequately carry the 25 yr. 24 hr. storm out of the landfill if 10 acres are exposed with no garbage in 1.43 days. The pipe at penetration will more than adequately handle the daily peak flow as shown by the HELP Model for a five year period, which is 120,008 gallons.

Factor of Safety = 1,367,640 ÷ 120,008 = 11.40

<u>Flow Through most restrictive component of the leachate collection system (Horizontal Flow Through Rock)</u>

Q_{rock} = 4.94 gpm

Q_{25} = 1,357.62 gpm

∴ The rock will act as a restrictive factor in the horizontal flow of leachate; consequently, the flow will be passed to the pipe through the perforations. There would only need to be 144 ft. of perforated pipe to carry the flow. There are 8,100 total feet of perforated pipe in Phase II.

Leachate Trench Capacity for flow into trench.

25 yr. 24 hr. storm = 7.2"

Assume no evaporation or soil retained water:
- everything is runoff
- assume 7.2" rainfall in first hour of day.

∴ 10.0 acres lined x 43560 ft^2/acres x 7.2"/12"
= 261,360 ft^3 first hour x 7.48 gal/ft^3 ÷ 60 min.
= 32,583 gpm

Vertical flow through Rock Fill = 441,500 ft^3/ft/yr.
= 6.28 gpm/ft.

What length of trench is required to allow the 25 yr. storm to flow through the rock at the surface of the protective cover in 24 hours?

32,583 gpm. ÷ 6.28 gpm/ft = 5,188 ft
Total length of design leachate trench = 8,100 ft.

Factor of Safety = 8,100 ÷ 5,188 = 1.56

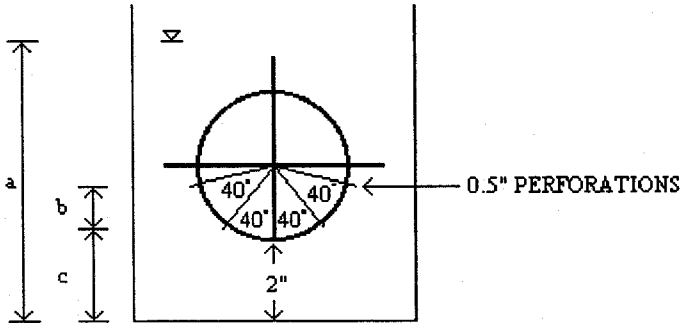
∴ Length O.K.

Total length of leachate trench w/ a flow rate of 6.28 gpm/ft = 8,100 x 6.28
= 50,868 gpm

For total system to collect the 25 yr. 24 hr. storm that fell in 1 hour:

261,360 ft^3 x 7.48 ft^3/gal ÷ 50,868 gpm = 38.43 min.

Assume all water that falls on the site in one hour must go through a leachate trench w/ a pipe and a limit on the head of one foot. How long will it take to drain?



r = Radius, a = 1.0' Head

C = r - rCos40° + 2"

BC = r -rCos80° + 2"

C_6 = 2.70" BC_6 = 4.48"
C_8 = 2.94" BC_8 = 5.31"

∴ Head on the 40° perforation @ 1.0 overall head on liner:
(6") = 12"- 2.70" = 9.30"
(8") = 12" - 2.94" = 9.06"

∴ Head on the 80° perforation @ 1.0 overall head on liner:
(6") = 12"- 4.48" = 7.52"
(8") = 12" - 5.31" = 6.69"

Use the orifice equation to determine the flow into the holes w/ 1.0' of head on the liner.

Q = CAsqrt(2gh) where: C = 0.95 A = 0.0014ft^2 g = 32.2 ft/sec. H = head (ft.)
Q = cfs

$Q_{40°}$

Q_6 = 0.95(0.0014)sqrt(2(32.2)((12-2.70)÷12) = 0.0094 cfs
Q_8 = 0.95(0.0014)sqrt(2(32.2)((12-2.94)÷12) = 0.0093 cfs

$Q_{80°}$

Q_6 = 0.95(0.0014)sqrt(2(32.2)((12-4.48)÷12) = 0.0084 cfs
Q_8 = 0.95(0.0014)sqrt(2(32.2)((12-5.31)÷12) = 0.0080 cfs

Flow per foot of 6" leachate line:
4(0.0094) + 4(0.0084) = .0712 cfs

Flow per foot of 8" leachate line:
4(0.0093) + 4(0.0080) = .0692 cfs

Total leachate trench capacity:
6,550 L.F. of 6" Leachate Line @ 0.0712 cfs/ft.
Total flow capability of 6" line:
6,550 x .0712 = 466.36 cfs = 209,302 gpm

Required 6" Line: 50,868 ÷ (.0712x7.48x60) = 1,592 L.F.
Provided 6,550 L.F. O.K.

Factor of Safety = 6,550 ÷ 1,592 = 4.11

1,550 L.F. of 8" Leachate Line @ 0.0692 cfs/ft.
Total flow capability of 8" line:
1,550 x .0692 = 107.26 cfs = 48,138 gpm

Total flow capability of leachate pipe system:
209,302 gpm + 48,138 gpm = 257,440 gpm
25 yr. 24 hr. storm = 32,583 gpm
Factor of safety = 257,440 gpm ÷ 32,583 gpm = 7.90

∴ Perforations more than adequate to handle the total flow w/ 1.0' of Head.

Leachate pipe separations are 50 ft. Assume the 25 yr. 24 hr. storm falls on a strip 50 ft. by 1 ft.

∴ Total rainfall on strip = 50' x 1' x 7.2/12 = 30 ft^3
Assume this total falls in 1 hr.
∴ 30 ft^3 ÷ 60 min./hr = .50 ft^3/min. = 3.74 gpm

1 ft. of 6" perforated line will drain 0.0712 cfs @ 1.0 ft. of head.

∴ 0.0712 cfs = 31.95 gpm Most extreme case 3.74 gpm.

Factor of safety = 31.95 gpm ÷ 3.74 gpm = 8.54

Assume worst conditions:

7.2" rain on 10.0 acres in one hour and nothing is discharged from the landfill until rain has stopped.

$\therefore$ Volume of water retained = 7.2/12 x 10.0 x 43,560
= 261,360 ft^3
= 1,954,973 gallons

The most restrictive component in the system is the 8" sewer line which is designed w/ a slope of 2%. Consequently, the maximum water that can be discharged is through this pipe.

Maximum Flow Through 8" pipe @10% (Mannings Equation)

$$Q = \frac{1.486\,(AR^{2/3}s^{1/2})}{n}$$

$$Q = \frac{1.486\,(.3110)(.1573)^{2/3}(.02)^{1/2}}{0.009}$$

$Q = 2.12$ cfs = 950 gpm

n = 0.009
s = 0.10 ft/ft
A= 0.3110 ft^2
P= 1.9774 ft

Volume to Discharge = 1,954,973 gals.

1,954,973 gals ÷ 950 gpm = 2,058 min.

= 34.3 hours

This is an extreme condition that cannot happen because of storm water diversion and the storm event would be discharged as it was occurring and not after it happened.

2.2.5 Strength of Pipe

Trench Installation

Given:

Z = 2'-2"	H_f = 250' waste fill
B_d = 1'-6"	w_f = 60 pcf
$K_{\mu'}$ = 0.19	w = 125 pcf

pipe diameter = 6"

Determine: Required pipe strength/SDR

Step 1 - Determine the maximum vertical pressures σv (psf) acting on the top of the pipe.

$\frac{Z}{B_d} = \frac{2.17}{1.50} = 1.45$ $\quad f = (w_f)H_f = 250(60) = 15000$ psf

$C_{\mu s} = e^{-2K\mu'(Z/B_d)} = 0.58$

$C_d = 1.1$

then $\sigma_v = (w)(B_d)(C_d) + (q_f)(C_{\mu s})$

$= (125)(1.5)(1.1) + (15000)(0.58)$

$= 8906.25$ psf $= 61.85$ psi $= \sigma_v$ max.

Step 2 - Select the appropriate modulus of passive soil resistance E' (psi). For crushed rock bedding use 3000 psi.

$$\% \Delta/D = \frac{DB\sigma_v(100)}{[2E/3\ (DR-1)^3] + 0.061E'}$$

Where: $D_1 = 1.5$

$E = 130{,}000$ (Modulus of Elasticity for HDPE)

$K = 0.1$ $\quad \sigma_v = 61.85$ psi

$E' = 3000$ = the modulus of the soil reaction of gravel

B = Bedding Constant 0.1 for pipe embedded in gravel

DR = Dimension Ratio

DR = 17.00 (6" SDR 17)

DR = 17.00 (8" SDR17)

DR = 17.00 (10" SDR 17)

$2E/3(DR-1)^3 =$ 21.16 psi (6" SDR 17)

$=$ 21.16 psi (8" SDR 17)

$=$ 21.16 psi (10" SDR 17)

$$\% \Delta/D(6") = \frac{(1.5)(0.1)(61.85)(100)}{21.16 + 0.061\ (3000)} = \frac{927.75}{246.48} = 3.76\%$$

$$\% \Delta/D(8") = \frac{(1.5)(0.1)(61.85)(100)}{21.16 + 0.061\ (3000)} = \frac{927.75}{246.48} = 3.76\%$$

$$\% \Delta/D(10") = \frac{(1.5)(0.1)(61.85)(100)}{21.16 + 0.061\ (3000)} = \frac{927.75}{246.48} = 3.76\%$$

Maximum allowable safe deflection for flexible polyethylene pipe w/ DR 17 is 4.2%
∴ All SDR 17 pipe will work for depths 250 ft. or less.

Live Loads:

Design by wall crushing:

$S_A = ((SDR - 1)/2)P_T$

S_A = Actual Compressive Stress, psi
SDR = Standard Dimension Ratio
P_T = External Pressure, psi

$S_A = ((17-1)/2)61.85 = 494.80$

Compressive yield strength is 1500 psi, O.K.

Design by Wall Buckling:

$P_{cb} = 0.8SQRT(E'xP_c)$

P_{cb} = Critical Buckling soil Pressure at top of pipe.
E' = Soil Modulus in PSI.
P_c = Hydrostatic, Critical-Collapse Differential Pressure, psi

$P_c = 2.32E/(SDR)^3 = 2.32(100,000)/(17)^3 = 47.22$ psi

E = Stress and time dependent tensile modulus of elasticity, psi.
= 100,000 psi for polyethylene

$P_{cb} = 0.8SQRT(3000x47.22) = 301.11$ psi < 1500 psi O.K.

2.2.6 Base Liner Calculations

Reference: Designing w/ Geosynthetics Robert M. Koerner

T_{allow} = $F_u + F_L + 2F_{at}$
T_{allow} = $\sigma_{allow}\, t$
σ_{allow} = the mobilized allowable geomembrane stress = $\sigma_{ult} \div FS$
FS = Factor of Safety
t = Geomembrane Thickness
F_u = the friction force above geomembrane(assumed to be negligible, since the cover soil probably moves along with the liner as it deforms)
q = the surcharge pressure = $d_{cs}\gamma_{cs}$
d_{cs} = the depth of cover soil
γ_{cs} = the unit weight of cover soil
δ = the friction angle between geomembrane and soil or geomembrane and drainage net
L_{RO} = length of runout
F_{AT} = $(\sigma_h)_{ave} \tan \delta (d_{at})$
σ_h = the average horizontal stress in anchor trench = $K_0\sigma_v$
σ_v = γH_{ave}
γ = the unit weight of backfill soil
H_{ave} = the average depth of anchor trench (requires an estimate)
K_0 = $1\text{-}\sin\phi$
ϕ = the angle of shearing resistance of backfill soil
d_{at} = the (unknown) depth of anchor trench

Allowable Stress in Liner

T_{allow} = $\sigma_{allow} t$
σ_{allow} = σ_{ult}/FS
σ_{ult} = 2,100 psi (from N.S.F. 54)

σ_{allow} = $\sigma_{ult} \div FS$ = 2,100 psi ÷ 1.0
$\therefore T_{allow}$ = 2,100 psi x 0.06 in.
= 126 lbs/in.
= 1,512 lbs/ft.

Compute Forces below Liner (F_L)

$F_L = q\tan\delta(L_{ro})$
$L_{ro} = 3.0$ ft.
$d_{cs} = 3.0$ ft.
$\gamma_{cs} = 110$ pcf
$\delta = 25°$ textured liner

$q = d_{cs}\gamma_{cs}$
$= (3.0)(110)$
$= 330$ lbs/ft^2

$\therefore F_L = (330)\tan 25° (3.0)$
= 461.64 lbs/ft.

Compute Forces Due to Anchor Trench (F_{at})

$F_{at} = (\sigma_h)_{ave} \tan\delta (d_{at})$
$= (1-\sin\phi)(\gamma)(H_{ave})\tan\delta (d_{at})$
$\phi = 30°$
$\gamma = 110$ lbs/ft^3
$H_{ave} = 5$ ft.
$\delta = 25°$

$\therefore F_{at} = (1-\sin 30°)(110 \text{ lbs/ft}^3)(5\text{ft})(\tan 25°)(d_{at})$
$= 128.23 d_{at}$

Compute Required Anchor Trench Depth for FML

$T_{allow} = F_u + F_c + 2F_{at}$

1512 lbs/ft = 0 + 461.64 lbs/ft. + 2(128.23 d_{at})
$\therefore d_{at} = (1512.00-461.64)\div 256.46$
= 4.10ft provide anchor 4.0 ft. deep no factor of safety applied.

Check Anchor Trench for Drainage Net

T_{allow} = 168psi ÷ 1.3 x 0.25in F.S. = 1.3
= 32.31 lbs/in
= 387.72 lbs/ft.

Compute Forces Below Drainage Net (F_L)

$F_L = q \tan \delta (L_{ro})$
δ = 24° Friction angle between textured liner and double bonded geonet.
$q = d\gamma = 3'(110 lbs/ft^3)$
= (3.0)(110)(tan24°)(3.0)
= 440.78 lbs/ft.

Compute Forces Due to Anchor Trench

F_{at} = (1-sin30°)(110)(5)(tan24°)(d_{at})
= 122.44 d_{at}

Compute Required Anchor Trench

387.72 lbs./ft. = 0 + 440.78 lbs./ft. +122.24d_{at}
∴ d_{at} = -0.43 ft.

Note: No anchor trench is required for geonet, however, it will be anchored in F.M.L. anchor trench @4.00 ft.

Check Sliding Forces of Soil Cover

F.S. = (tanδ)÷(tanβ)
δ = Friction Angle = 26° for soil to double bonded geonet
β = Slope Angle = 3:1 slope = 18.418°

F.S. = (tanδ)÷(tanβ)
= (tan 26°)÷(tan18.418°)
= 1.46 > 1 ∴ O.K.

Check Stress Due to Placement of Protective Cover

Ref: Giroud and Beech (1989)

$$T = (\gamma_p Z^2_p \div \sin 2\beta)[((2H_p\cos\beta \div Z_p)-1)((\sin(\beta-\phi_{cm})\div\cos\phi_{cm})-(\sin\phi_{pm}\div\cos(\beta+\phi_{pm}))]$$

T = Tension generated by placement of Cover (lbs/in width)
γ_p = unit weight of protective cover (lbs/in^3)
Z_p = thickness of protective cover (in.)
β = Slope angle of the liner (degrees)
H_p = Vertical height of protective cover (in.)
ϕ_{cm} = Critical mobilized interface friction angle of liner (degrees) = 26°
ϕ_{pm} = mobilized internal friction angle of protective cover (degs.) = 30°

Assume worst case of 50 ft deep on a 3:1 slope with a factor of safety of 1.3

$\phi_{cm} = \phi_c \div F.S. = 26° \div 1.3 = 20°$
$\phi_{pm} = \phi_p \div F.S. = 30° \div 1.3 = 23.1°$
γ_p = 0.0637 lbs/in^3.
Z_p = 36 in.
β = 18.418° (for 3:1 slope)
H_p = 600 in.

$$T = (0.0637 \times 36^2) \div \sin (2)18.418°)[((2\times600\cos18.418° \div 36)-1)((\sin(18.418°-20.0°)\div\cos20.0°)-(\sin23.1° \div \cos(18.418°+23.1°))]$$

T = 137.70[(30.63)(-0.03)-0.52]
= 137.70(-092) - 0.52
= -127.20 lb/in. < T_{allow} 50 ft. 3:1 Embankment O.K.

Conclusion: Highest and steepest slope can have protective cover installed during the construction of the cell. Therefore, any of the other slopes will be o.k.

Self-Weight Stress during Construction

Tensile stress due to self-weight of the Smooth 60mil HDPE liner

$$T = \gamma \times H \times L \times (\sin\beta - \cos\beta\tan\delta)$$

T = Tension due to self-weight (lbs/in.)
H = thickness of liner system component (in.)
L = length of liner system component (in.)
β = Slope angle of the liner (degrees)
δ = critical interface friction angle of liner system
γ = unit weight of liner system component (lbs/in^3)
W = weight per square area of membrane (lbs/in^2)

Assume worst condition:

The length of the liner on a 3:1 slope that would induce failure in the liner.

$T = F_p = 126$ lbs/in

Solve for L (Length)

$$L = T \div (\gamma \times H \times (\sin\beta - \cos\beta\tan\delta))$$

γ = W x .06 in = 0.00012 lbs/in^3
H = 0.06 in. (60mil Smooth HDPE)
β = 18.418° (for 3:1 slope)
δ = 17°

$$L = 126 \div ((0.00012 \times 0.06(\sin 18.418° - \cos 18.418° \tan 17°))$$

= 67,628 in.

= 5,636ft. far exceeds any requirement

∴ Self Weight stress is O.K.

Thermal Stress during Construction

$\varepsilon = \Delta L \div L$ = Strain

ε = Strain in the liner system (percent)
ΔL = Change in length of liner due to change in temperature
L = Length of liner before temperature change

$\Delta L = (\alpha)L(\Delta T)$

α = Coefficient of liner thermal expansion ($°F^{-1}$)
ΔL = Change in length of liner due to change in temperature
ΔT = Change in Temperature (°F°)

Assume:

α = Coefficient of liner thermal expansion ($°F^{-1}$) = 6.7×10^{-5} $°F^{-1}$
ΔT = 100°F Conservative assumption
L = 1 ft.

$\varepsilon = \alpha L \Delta T \div L$
$= \alpha \Delta T$
= 0.0067 ft. or 0.67%

Allowable elongation @ yield = 13%
∴ allowable > design thermal stress o.k.

2.2.7 Foundation, Settlement, and Slope Stability Analysis

VAN DER HORST

GEOTECHNICAL ENGINEERING, P.C.

CONSTRUCTION MONITORING

MATERIALS TESTING

EXPLORATORY DRILLING

GEOTECHNICAL EVALUATION REPORT
FOR
HAYWOOD COUNTY LANDFILL PHASE 2 EXPANSION
HAYWOOD COUNTY, NORTH CAROLINA
VNC-99-036

Prepared for:

Municipal Engineering Services Company, P.A.
PO Box 97
Garner, NC 27529

Prepared by:

VAN DER HORST Geotechnical Engineering, P.C.
3101-156 Stonybrook Drive
Raleigh, NC 27604

Submitted:
December 13, 1999

535 Summit Point Drive
Henrietta, NY 14467
716/359-2730
Fax 716/359-9668

3101 Stonybrook Drive, Suite 156
Raleigh, NC 27604
919/876-0405
Fax 919/876-0460

VAN DER HORST

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Attachments

Drawing 1 - Slope Stability Section/Phase 2 Plan
Slope Stability Data - 26 pages (SB-1 through SB-26)
Foundation/Loading Analysis (3 pages)
Settlement Analysis - 25 page (ST-1 through ST-25)
Borings Logs (P1-1S, P1-1D, P1-2S, P1-2D, P1-3, P1-4, P1-5S, P1-5D P1-6, P1-7S, P1-7D P1-8S, P1-8D, P2-1, P2-2, P-10, P-12, P-13)

VAN DER HORST
GEOTECHNICAL ENGINEERING, P.C.
CONSTRUCTION MONITORING
MATERIALS TESTING
EXPLORATORY DRILLING

Introduction

VAN DER HORST Geotechnical Engineering, P.C. (VAN DER HORST) is pleased to present our geotechnical evaluation report for the Haywood County Landfill Expansion Phase 2. Our services are based on our proposal dated November 10, 1999. The landfill is located in Haywood County, North Carolina. Phase 2 will be constructed adjacent to the south west quadrant of the existing phase 1 landfill cell. Phase 2 is approximately 12 acres in plan. All site geometry and proposed construction was determined from drawings and subsurface boring logs provided by MESCO. The following list of drawings and borings were provided:

Drawings

	Drawing	Date	Title	Comments
1.	E-1	8/30/99	"Existing Conditions"	Stamped Preliminary
2.	E-2	8/30/99	"Subbase"	Stamped Preliminary
3.	P4	10/08/99	"Phase 2 Final Fill"	Stamped Preliminary
4.	P6	10/11/99	"Miscellaneous Details"	Stamped Preliminary
5.	P7	10/11/99	"Alt. Liner System Details"	Stamped Preliminary
6.	F4	08/27/99	"Facility Plan - Final Fill"	Stamped Preliminary

Boring Logs

Copies of all boring logs presented on Drawing E-1 which are located in the phase 2 footprint were provided for analysis, and groundwater elevation summary (Table 1).

Scope of Services

Our scope of services to be provided for this project include:

1. Evaluate the slope stability for the proposed new landfill phase 2.
2. Evaluate the landfill foundation soils with respect to bearing capacity.
3. Evaluate settlement potential as a result of the consolidation of underlying strata caused by applied loads during the landfill construction and operation.

535 Summit Point Drive
Henrietta, NY 14467
716/359-2730
Fax 716/359-9668

3101 Stonybrook Drive, Suite 156
Raleigh, NC 27604
919/876-0405
Fax 919/876-0460

Summary of Analysis

The following is a summary of our analysis.

1. The slope stability analysis of the proposed slopes for the Haywood County Landfill Phase 2 expansion project indicates satisfactory factors of safety against mass slope failure and shallow surface failures.

2. The in-situ proposed subgrade (foundation) soils, and properly placed and compacted on-site silty sands used to establish final subgrades are acceptable and have sufficient strength for support of the proposed landfill construction

3. We estimate the landfill foundation soils could settle up to 13 inches under the proposed loads, during the construction of phase 2. The total settlement when phases 2 thru phase 7 are completed and the landfill is closed, the estimated settlement is calculated at 23 inches. This makes the total differential settlement in phase 2 across between the piezometer P1-1D and the sump location to be 18 inches. This estimated differential and total settlement will occur gradually over time as the proposed loads are applied and could continue up to 20 years after closure of the landfill.

Proposed Development

Phase 2 of the landfill will be approximately 12 acres in plan. The landfill construction will consist of a clay soil liner, geocomposite, select fill/protective cover, compacted municipal solid waste (MSW), intermediate cover, impermeable soil liner (cover) and protective/vegetative cover, there is also a Geosynthetic Clay Liner Alternate liner system that has been modeled. Based on the drawings provided all finished slopes are proposed to be 3 horizontal to 1 vertical (3H:1V).
Perimeter slopes outside of the phase 2 cell are proposed to be 2 horizontal to 1 vertical(2H:1V), on the west and south sides of phase 2 will be cut slopes (sloping downward toward the phase 2 perimeter) or will meet existing grades. The sump of phase 2 will have an perimeter embankment with a 2H:1V slope to the outside of phase 2.

The site will require some cut/fill. The sump at the center of the north end of phase 2 will require approximately 10 to 16 feet of fill and west side of the phase 2 expansion will require approximately 25 to 35 feet of cut. The south east portion of phase 2 will require approximately 10 to 20 feet of cut. At boring location P-12, approximately 90 feet of compacted MSW is proposed at the completion of phase 2, there will be approximately 193 feet of compacted MSW at the sump in phase 2 when all seven phases are completed and the landfill is closed.

Subsurface Conditions

A total of 18 test borings were provided to VAN DER HORST by MESCO. All borings were reviewed by VAN DER HORST to determine the general site subsurface conditions and to determine the depth condition and surface grade of the underlying bedrock. For our analysis of settlement, slope stability and bearing capacity only those borings inside of phase 2 were analyzed. Surface elevations, proposed subgrades, proposed cut/fills and existing top of rock are summarized in Table 1. For brevity, only the more critical test borings were listed in Table 1. The subsurface conditions typically consist of loose to very compact silty sand and weathered rock. Underlying the soil stratum, fractured gneissic bedrock was encountered.

Table 1

Boring (Group)	Location	Existing Surface Elev. (ft.)	Proposed Subgrade Elev. (Ft)	Proposed Subgrade Cut/Fill	Existing top of Rock Elev. (ft	Fill Height Elev. of Trash (ft.)	Proposed Height of Trash (ft.)	Overburden Description	Limiting N value of Overburden
P1-1	See Drawing 1	2625	2595	-30'	2556	2675	80	Firm to Compact Silty Sand (SM)	19-64
P1-8	See Drawing 1	2534	2550	+16'	2492	2720	170	Compacted Fill to 95% of Stnd. Proctor MDD over Loose to Firm Silt(ML)/Sandy Silt(SM)	3-18
P-12	See Drawing 1	2555	2565	+10'	2538	2665	100	Compacted Fill to 95% Stnd. Proctor MDD over Loose to Firm Silty Clay(CL)/Silty Sand(SM)	7-12
P-10	See Drawing 1	2580	2555	-25	N/A	2760	205	Firm to Very Compact Sandy Silt(SM)	18-38
P2-2	See Drawing 1	2574	2580	+6'	2543	2690	110	Compacted Fill to 95% Stnd. Proctor MDD over Loose to Firm Silt(ML)/Silty Sandy (SM)	5-29

Groundwater was encountered at a depth of 64.5 feet below the ground surface at P1-1D, and 2.62 feet below the ground surface at P1-8D. Groundwater was encountered at a depth of 49.3 feet below the ground surface at P-10, and 5.83 feet below the ground surface at P-12. Detailed subsurface conditions are provided on the individual boring logs. A copy of the borings logs used in this analysis are provided with this report

Engineering Evaluation

Our slope stability evaluation is based on final loaded conditions, the following structural components and parameters.

	Friction Angle (ϕ)	Cohesion (psf)	Total Unit Weight (pcf)
Subgrade - Insitu soil or compacted on site soil	30	100	130
Clay Liner System			
1. 2.0' thick cohesive soil liner	20*	400	135
2. 60 mil HDPE flexible membrane liner Geocomposite	20*	0	63
3. 1.0' thick select backfill protective cover	30	100	130
4. 2.0' thick backfill protective cover	30	100	130
Rubbish - Compacted Trash	25	0	65
Alternate - GCL Liner system			
1. 1.5' thick cohesive soil liner	20*	400	135
2. Geosynthetic Clay Liner	18	500	63
3. 60 mil HDPE flexible membrane liner Grocomposite	20*	0	63
4. 1.0' thick select backfill protective cover	30	100	130
5. 2.0' thick backfill protective cover	30	100	130
MSW - compacted trash	25	0	65
Landfill Cover			
1. 1.0' thick intermediate cover	30	100	130
2. 1.5' thick cohesive soil liner	20*	400	135
3. 40 mil LLDPE cover HDPE Drainage Net	20*	0	62
4. 2.0' thick erosive layer.	30	100	130

* VAN DER HORST recommends the material for cohesive soil liner has a minimum friction angle of 20 degrees when tested in accordance with ASTM 3080. We also recommended a minimum interface friction angle of 20 between the cohesive soil liner/cover and 60 mil HDPE/40 mil LLDPE membrane as tested in accordance with ASTM D5321.

Evaluation and Analysis

Foundation Soil Evaluation

The landfill foundation will consist of in-situ soils or compacted on-site fill. The on-site soils are predominately silts and silty sands and weathered rock overlying fractured gneiss bedrock with zones of weathered saprolite. Based on the Standard Penetration Test (SPT) N-values presented on the boring logs, the overburden soils vary in consistency and relative density. The soils generally become moderately dense to very dense with depth.

It was determined that the full load induced by the final closed landfill structure will be approximately 3.6 to 6.9 TSF ,the lower value represents the highest loading at the completion of phase 2, which would be at the location of P-12, the higher value represents the highest loading anticipated, at the sump of phase 2, which would be at the final completion of phases 2 thru 7. The proposed subgrade which is to consist of compacted fills has an allowable bearing capacity of 5.5 TSF, due to the completed final anticipated loading being greater than the allowable bearing capacity, the final height of garbage has to be lowered by 43.5 feet. The final maximum height of MSW (phase 2 thru 7) should be 2692, and the final height of finished cover (phase 2 thru 7) should be 2696.5.

Prior to placement of the clay liner or subgrade fill, the subgrade soils should be proofrolled to determine weak or unsuitable zones. . Areas which exhibit excessive pumping or movement should stabilized with repeated compactive effort or undercut and replaced with stable material of a similar nature to that which was removed. Due to the large amount of fill in the areas that exhibit the lower blow counts (i.e. at P1-8 and P2-2) undercuts in the range of 5 to 8 feet deep may be necessary, the compacted fill should be suitable to meet the required bearing. All undercuts must be filled with a controlled fill that is placed in 8 inch loose lift thickness, compacted to 98% of standard proctor at -2 to +1 percent of optimum moisture , must meet USCS classification of SW, SP, SM, SC or ML, and the plasticisty Index (PI) should be less than 20.

Settlement Evaluation

The foundation substrata will consolidate over time due to the relatively slow application of the loading to the landfill (20+ years). The total settlement of phase 2 at the completion of phase 2 will be approximately 13 inches, which is near the highest point of MSW in phase 2 (at well P-12). The differential settlement at the completion of phase 2 would be approximately 11-12 inches due to the large cut and the reduced loading toward the west side of the perimeter of phase 2.

However due to the relatively slow application of the overall applied loads to the landfill foundation soils, the relatively dense sandy silt and weathered rock substrata we anticipate overall settlement in phase 2 at the completion of phases 2 thru 7 to be 23 to 24 inches at the sump in phase 2.

At the completion of phase 2 thru phase 7, there is a large anticipated differential settlement of 18 inches due to the large cut along the west side of phase 2. At location P1-1D, the 25 to 30 feet of cut along the west side of the site will bring the proposed subgrades to an elevation where firm to very compact Silty Sands and weathered rock, were encountered, Gneiss bedrock will be at 40 feet below the finished subgrades. The anticipated settlement at P1-1D is approximately 5 inches, due to the compact nature of the soil. When phases 2 thru 7 are complete the settlement at P1-8D, including the 16 feet of fill that has to be placed for the proposed subgrades, over the existing loose to firm Sandy Silts where bedrock was encountered at a final subgrade depth of 54 feet, the calculated maximum settlement is approximately 23 to 24 inches. The difference between these two points gives a differential settlement of 18 to 19 inches. The liner system (i.e. HDPE and GCL liners) should be designed to withstand these anticipated differential settlements. A better estimate of liner and soil settlement at the highest lift of the MSW would be possible if there were test boring data available at the proposed sump location.

It may take 10 to 20 years for full consolidation and settlement to be reached. In the absence of test data providing index testing, void ratios and consolidation coefficients, and considering the variability in substrata thickness it is only practical to provide a range of expected settlement. Using SPTSET a settlement analysis software. A 24 inch thick liner system was used in the settlement calculations, if the alternate GCL liner system is used the settlement of the 18 inch clay liner would be approximately ⅜ to ½ inches less than the aforementioned settlements. The analysis was perform considering a continuous foundation with exaggerated width. In this case a foundation width of 99 feet was used. The SPTSET software uses the Boussinesq load theory.

Slope Stability Analysis

Our slope stability analysis was aided by the use of SB-SLOPE software program developed by Von Gunten Engineering Software. SB-SLOPE is a comprehensive slope stability program which follows the limiting equilibrium failure surfaces method (Simplified Bishop Method of Slices) to determine the factor of safety for earth slopes. Based on the 1993 BOCA building code figure 1612.1.3(2) contour map of effective peak acceleration coefficient, we used a seismic coefficient of 0.10 in our analysis. The effects of earth quake loading were taken into account during our analysis. Earthquake coefficients are considered to affect the driving term by affecting the external forces and the slice weights. Groundwater surfaces were not used in the slope stability models.

Drawing 1 attached shows the locations of cross sections that were used in our slope stability analysis. Based on the proposed grades and landfill components section A-A models the highest fill for phase 2. Section B-B models the finished permanent slope of phase 2 that will not change greatly when phases 3 thru 7 are completed. Section C-C models the sump area and 2H:1V perimeter berm. The minimum factor of safety for the different liner systems that were modeled are given in the following table;

Table 2 - Slope Stability Minimum Factors of Safety

Cross Section No.	24" Clay Liner System	Alternate GCL Liner System
A-A	1.359	1.359
B-B	1.377	1.377
C-C	1.377	1.377

Note: If cohesionless material is used in the construction of the 2H:1V berm in section C-C, a slope stability failure could occur (ie Fs_{min}= 0.98 to 1.05).
If the slope is graded to a slope of 3H:1V the minimum factor of safety is increased to 1.407.

The critical failure surfaces do not fall across a large enough section of the liner and cover materials to make noticeable differences in the calculated minimum Factor of Safety for the two proposed liner systems. The critical failure surfaces (minimum FS) for sections A-A and B-B fall in the MSW, and in section C-C the critical failure surface falls in the base material (on-site fill) of the 2:1 slope area.

There was no data for subsurface conditions available at the sump or extending into phase 3 along section C-C, therefore the base material in-situ conditions, such as material types, density, bedrock elevations and ground water surfaces could not be included in the slope stability model. The model for section C-C could not be accurately used to simulate large mass failure surfaces through loose or saturated materials at depth, should they be present. The test borings that were presented do not indicate loose material at depth. In sections A-A and B-B the ground profiles at the toe of the slopes are at approximately the same level or have an upward slope extending away from the perimeter of the landfill, therefore these sections would be confined at the toe, and large deep slope stability failures for these sections (A-A & B-B) would not be likely to occur.

All slope stability calculations were made using the proposed phase 2 operational plan final height profiles. The height of MSW in phase 2 should not be raised above the proposed elevation contours (found on drawing P-4) until additional phases have been constructed and the height of MSW in the adjacent phases is above the perimeter elevation of phase 2.

Closing

VAN DER HORST is pleased to provide our professional services for this project. Our services were performed for the exclusive use of Municipal Engineering for the Haywood County Landfill Phase 2 expansion project. Generally accepted soils mechanics and soils engineering practices were used in our analysis. We conducted our services in a manner consistent with that level and skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, expressed or implied is made.

We appreciate the opportunity to be of service to you on this project. If you have any questions regarding this report, or if we can be of further assistance, please do not hesitate to contact our office.

Respectfully submitted,
VAN DER HORST Geotechnical Engineering, P.C.

William M. Lupi

William M. Lupi, E.I.T.
Geotechnical Staff Engineer

Robert F. van der Horst

Robert F. van der Horst, P.E.
President

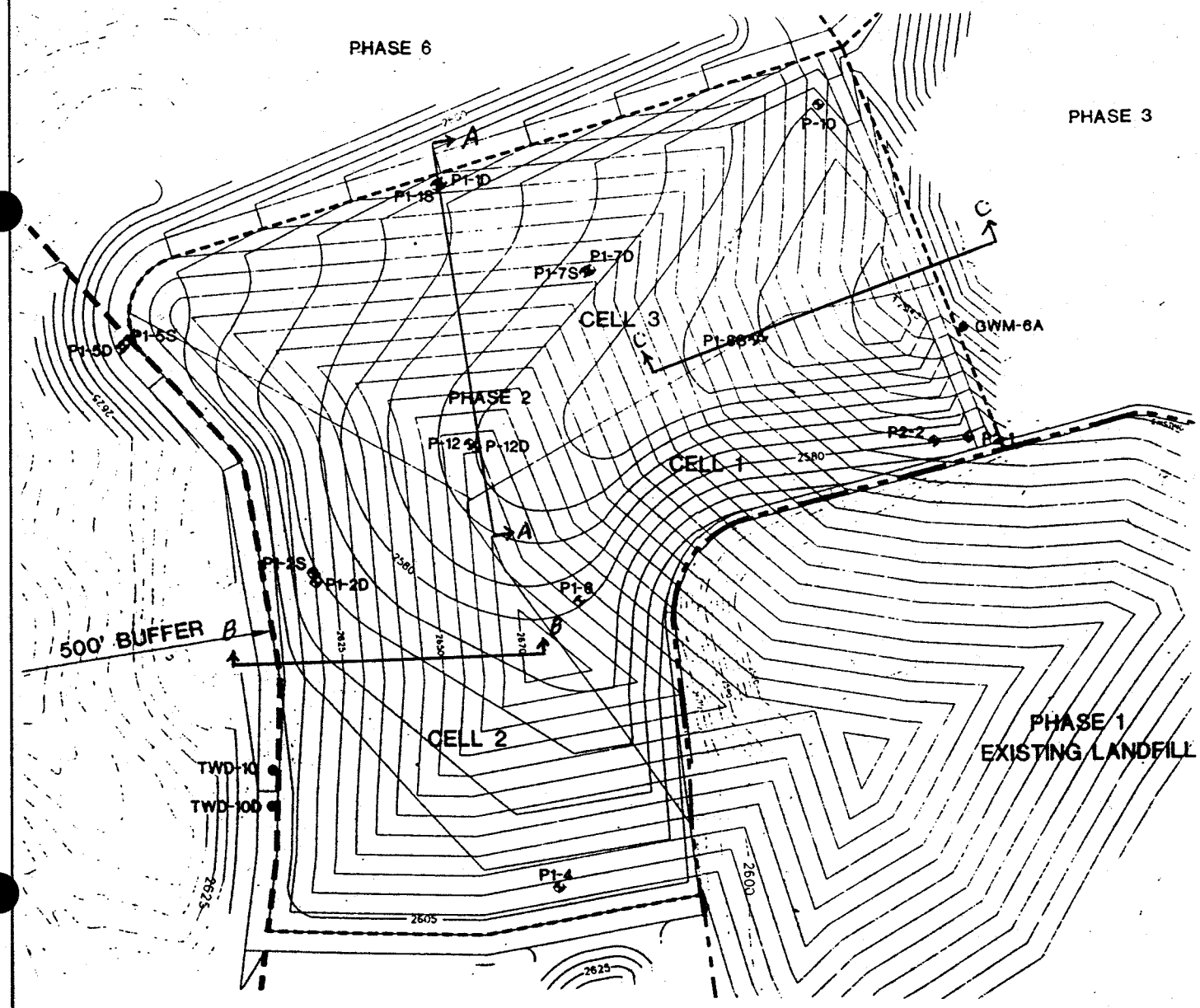
NORTH CAROLINA PROFESSIONAL SEAL 022323 ENGINEER Robert F. van der Horst

12-10-99

VAN DER HORST
GEOTECHNICAL ENGINEERING, P.C.
3101 Stonybrook Drive, Suite 156
Raleigh, North Carolina 27604
Phone: (919) 876-0405 Fax: (919) 876-0460

JOB Haywood County Landfill Expansion Ph. 2
SHEET NO. Drawing 1 OF
CALCULATED BY WML DATE 11/22/99
CHECKED BY DATE
SCALE

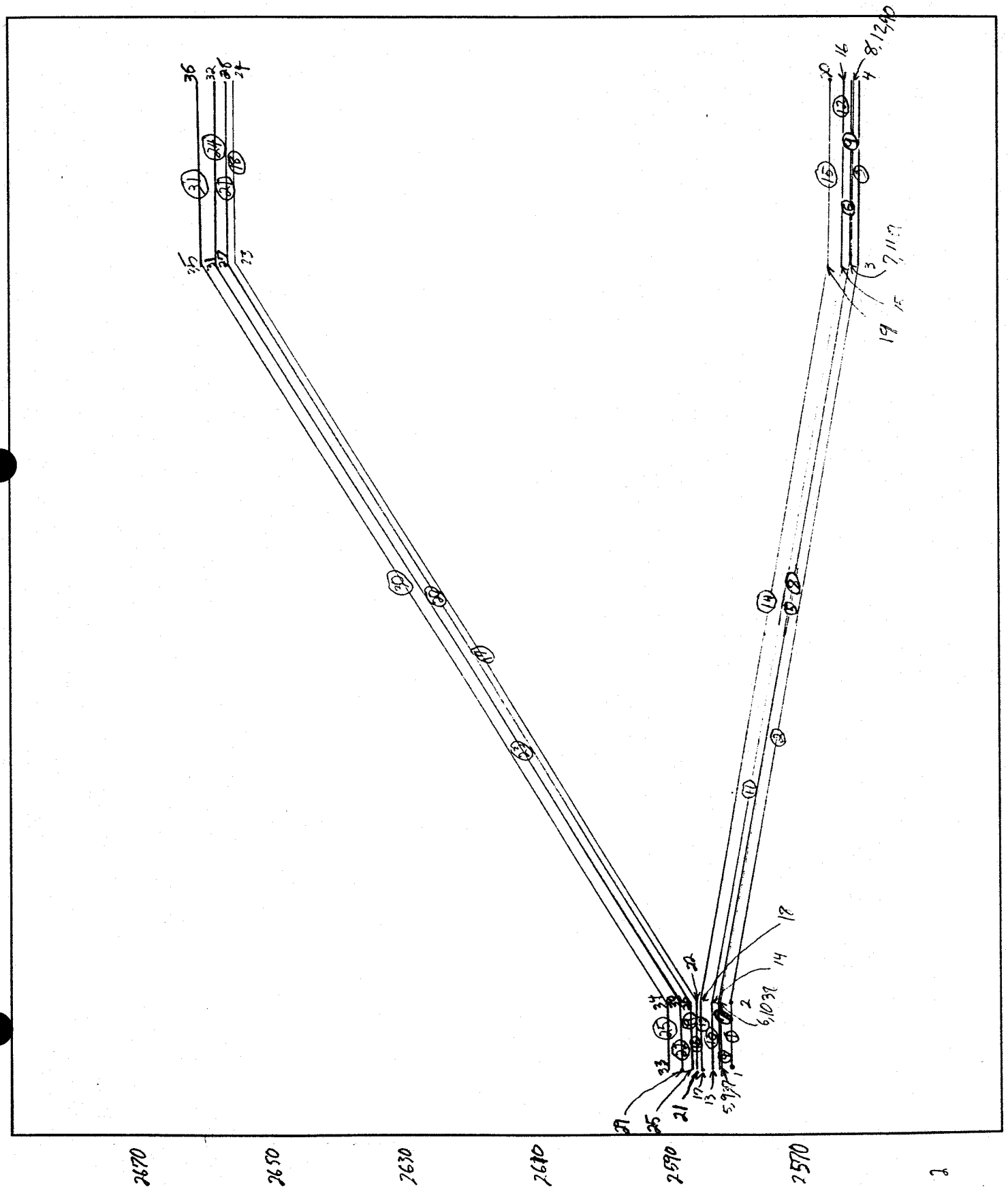
Slope Stability Cross Sections



JD-1

VAN DER HORST
GEOTECHNICAL ENGINEERING, P.C.
3101 Stonybrook Drive, Suite 156
Raleigh, North Carolina 27604
Phone: (919) 876-0405 Fax: (919) 876-0460

JOB Haywood Co Landfill Expansion Phase
SHEET NO. SECTION A-A OF
CALCULATED BY WML DATE 11/22/99
CHECKED BY DATE
SCALE



GEOSYSTEM SLOPE STABILITY PROGRAM
SB-SLOPE

PROJECT DATA:
Project: Haywood County Landfill Expansion Phase 2 Sec. AA w/ clay liner
Location: Haywood County, North Carolina
Filename: 99036B Description: Haywood Co. Landfill - Bill's X-section

ANALYSIS DATA:

Point No.	Coordinates X	Coordinates Y
1	0.0	30.3
2	10.0	30.3
3	290.0	9.8
4	360.0	9.8
5	0.0	32.4
6	10.0	32.4
7	290.0	11.9
8	360.0	11.9
9	0.0	32.5
10	10.0	32.5
11	290.0	12.0
12	360.0	12.0
13	0.0	33.5
14	10.0	33.5
15	290.0	13.0
16	360.0	13.0
17	0.0	35.4
18	10.0	35.4
19	290.0	15.0
20	360.0	15.0
21	0.0	35.5
22	10.0	35.5
23	290.0	105.5
24	360.0	105.5
25	0.0	36.5
26	10.0	36.5
27	290.0	106.5
28	360.0	106.5
29	0.0	38.0
30	10.0	38.0
31	290.0	108.0
32	360.0	108.0
33	0.0	40.0
34	10.0	40.0
35	290.0	110.0
36	360.0	110.0
37	0.0	32.3
38	10.0	32.3
39	290.0	11.8
40	360.0	11.8
41	0.0	38.1
42	10.0	38.1
43	290.0	108.1
44	360.0	108.1

Line No.	Left Point	Right Point	Soil No.
1	1	2	1
2	2	3	1
3	3	4	1
4	37	38	2
5	38	39	2
6	39	40	2
7	5	6	3
8	6	7	3
9	7	8	3
10	9	10	4
11	10	11	4
12	11	12	4
13	13	14	5
14	14	15	5
15	15	16	5
16	17	18	6
17	18	19	6
18	19	20	6
19	21	22	7
20	22	23	7
21	23	24	7
22	25	26	8
23	26	27	8
24	27	28	8
25	29	30	9
26	30	31	9
27	31	32	9
28	41	42	10
29	42	43	10
30	43	44	10
31	33	34	11
32	34	35	11
33	35	36	11

Soil No.	Density pcf	Cohesion psf	Phi Deg
1	130.0	100	30.0
2	135.0	400	20.0
3	63.0	0	20.0
4	63.0	0	20.0
5	130.0	100	30.0
6	130.0	100	30.0
7	65.0	0	25.0
8	130.0	100	30.0
9	135.0	400	20.0
10	62.0	0	20.0
11	130.0	100	30.0

Seismic coefficient, horizontal = 0.100
vertical = 0.100

```
Grid search;  initial parameters:
    initial   final   increment
 x     0.0    100.0       5.0
 y   400.0    700.0       5.0
 r                        2.0
 minimum perpendicular depth is   3.0
 limit at elevation -50.0
OVERALL MINIMUM: x =  30.0, y = 590.0, r = 549.7, FS = 1.360

Automatic search;  initial parameters:
    initial   increment
 x    30.0        0.2
 y   590.0        0.2
 r                0.2
 minimum perpendicular depth is   3.0
 limit at elevation -50.0
OVERALL MINIMUM: x =  29.2, y = 589.8, r = 550.1, FS = 1.359

Automatic search;  initial parameters:
    initial   increment
 x    30.0        0.2
 y   590.0        0.2
 r                0.2
 minimum perpendicular depth is   3.0
 limit at elevation -50.0
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- ERROR: 5 best starting points tried
- ERROR: 5 best starting points tried
- ERROR: 5 best starting points tried
- ERROR: 5 best starting points tried
- ERROR: 5 best starting points tried
OVERALL MINIMUM: x =  29.2, y = 589.8, r = 550.1, FS = 1.359, theta = 17.03
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GEOSYSTEM SLOPE STABILITY PROGRAM
SB-SLOPE

PROJECT DATA:
Project: Haywood County Landfill Expansion Phase 2 Sec. AA w/ GCL liner
Location: Haywood County, North Carolina
Filename: 99036B Description: Haywood Co. Landfill - Bill's X-section

ANALYSIS DATA:

Point No.	Coordinates X	Y	Line No.	Left Point	Right Point	Soil No.
1	0.0	30.3	1	1	2	1
2	10.0	30.3	2	2	3	1
3	290.0	9.8	3	3	4	1
4	360.0	9.8	4	37	38	2
5	0.0	32.4	5	38	39	2
6	10.0	32.4	6	39	40	2
7	290.0	11.9	7	5	6	3
8	360.0	11.9	8	6	7	3
9	0.0	32.5	9	7	8	3
10	10.0	32.5	10	9	10	4
11	290.0	12.0	11	10	11	4
12	360.0	12.0	12	11	12	4
13	0.0	33.5	13	13	14	5
14	10.0	33.5	14	14	15	5
15	290.0	13.0	15	15	16	5
16	360.0	13.0	16	17	18	6
17	0.0	35.4	17	18	19	6
18	10.0	35.4	18	19	20	6
19	290.0	15.0	19	21	22	7
20	360.0	15.0	20	22	23	7
21	0.0	35.5	21	23	24	7
22	10.0	35.5	22	25	26	8
23	290.0	105.5	23	26	27	8
24	360.0	105.5	24	27	28	8
25	0.0	36.5	25	29	30	9
26	10.0	36.5	26	30	31	9
27	290.0	106.5	27	31	32	9
28	360.0	106.5	28	41	42	10
29	0.0	38.0	29	42	43	10
30	10.0	38.0	30	43	44	10
31	290.0	108.0	31	33	34	11
32	360.0	108.0	32	34	35	11
33	0.0	40.0	33	35	36	11
34	10.0	40.0				
35	290.0	110.0				
36	360.0	110.0				
37	0.0	32.3				
38	10.0	32.3				
39	290.0	11.8				
40	360.0	11.8				
41	0.0	38.1				
42	10.0	38.1				
43	290.0	108.1				
44	360.0	108.1				

Soil No.	Density pcf	Cohesion psf	Phi Deg
1	130.0	100	30.0
2	135.0	400	20.0
3	63.0	0	20.0
4	63.0	500	18.0
5	130.0	100	30.0
6	130.0	100	30.0
7	65.0	0	25.0
8	130.0	100	30.0
9	135.0	400	20.0
10	62.0	0	20.0
11	130.0	100	30.0

Seismic coefficient, horizontal = 0.100
vertical = 0.100

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Grid search;  initial parameters:
    initial    final    increment
 x     0.0     100.0        5.0
 y   400.0     700.0        5.0
 r                          2.0
 minimum perpendicular depth is   3.0
 limit at elevation -50.0
OVERALL MINIMUM: x =  20.0, y = 630.0, r = 590.0, FS = 1.359

Automatic search;  initial parameters:
    initial   increment
 x    20.0        0.2
 y   630.0        0.2
 r                0.2
 minimum perpendicular depth is   2.0
 limit at elevation -50.0
OVERALL MINIMUM: x =  19.6, y = 630.4, r = 590.4, FS = 1.359

Automatic search;  initial parameters:
    initial   increment
 x    20.0        0.2
 y   630.0        0.2
 r                0.2
 minimum perpendicular depth is   2.0
 limit at elevation -50.0
OVERALL MINIMUM: x =  19.6, y = 630.4, r = 590.4, FS = 1.359, theta = 17.50
```
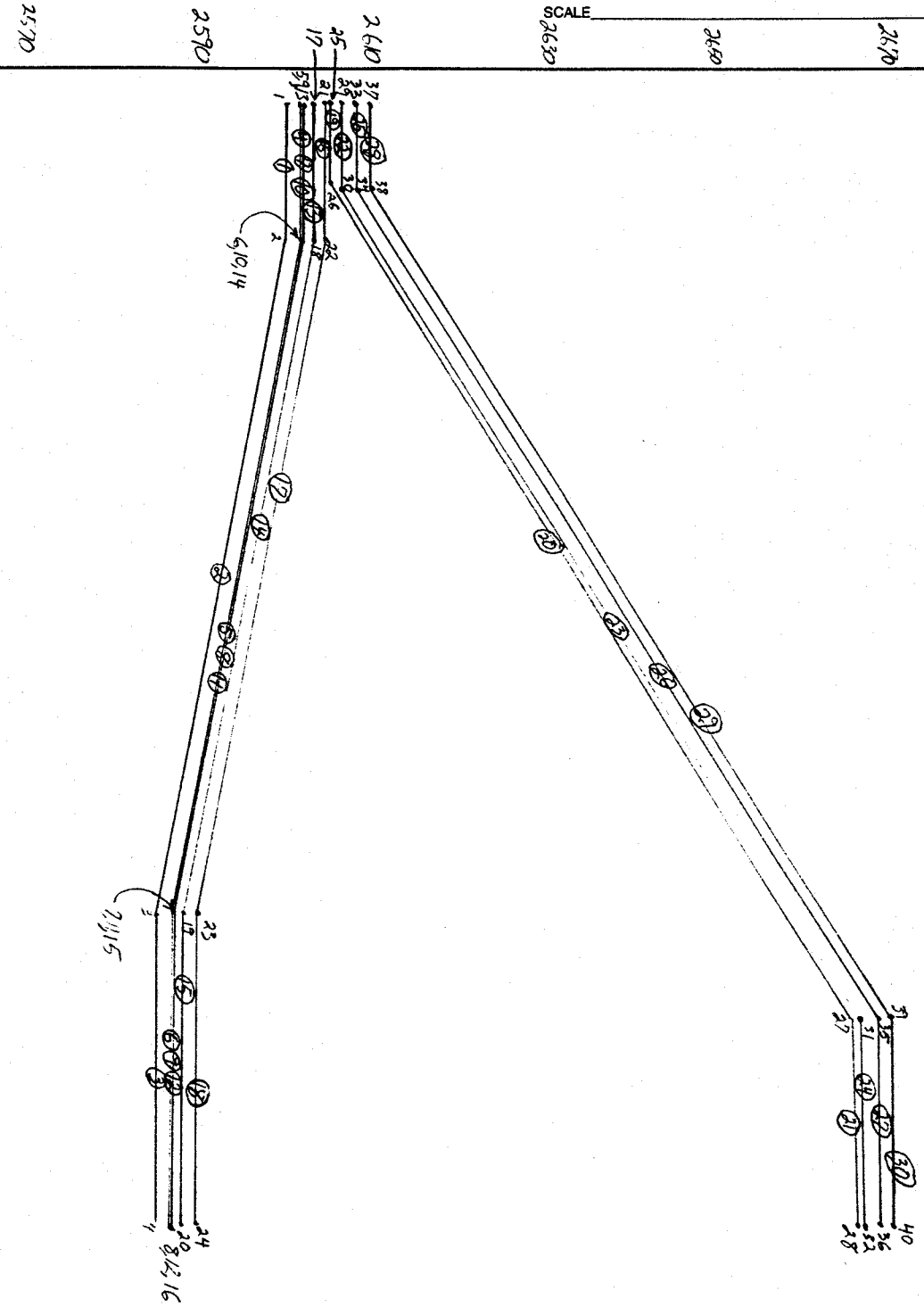

VAN DER HORST
GEOTECHNICAL ENGINEERING, P.C.
3101 Stonybrook Drive, Suite 156
Raleigh, North Carolina 27604
Phone: (919) 876-0405 Fax: (919) 876-0460

JOB Haywod Co Landfill Expansion Phase II
SHEET NO. Section BB OF
CALCULATED BY WML DATE 11/24
CHECKED BY DATE
SCALE



GEOSYSTEM SLOPE STABILITY PROGRAM
SB-SLOPE

PROJECT DATA:
Project: Haywood County Landfill Expansion Phase 2 Sec BB w/clay liner
Location: Haywood County, NC
Filename: 99036C Description: Haywood County,NC - Section B-B

ANALYSIS DATA:

Point No.	Coordinates X	Coordinates Y
1	-10.0	20.2
2	25.0	20.2
3	220.0	5.0
4	310.0	5.0
5	-10.0	22.2
6	25.0	22.2
7	220.0	7.0
8	310.0	7.0
9	-10.0	22.3
10	25.0	22.3
11	220.0	7.1
12	310.0	7.1
13	-10.0	22.4
14	25.0	22.4
15	220.0	7.2
16	310.0	7.2
17	-10.0	23.4
18	25.0	23.4
19	220.0	8.2
20	310.0	8.2
21	-10.0	25.4
22	25.0	25.4
23	220.0	10.2
24	310.0	10.2
25	-10.0	25.5
26	10.0	25.5
27	250.0	85.5
28	310.0	85.5
29	-10.0	26.5
30	10.0	26.5
31	250.0	86.5
32	310.0	86.5
33	-10.0	28.0
34	10.0	28.0
35	250.0	88.0
36	310.0	88.0
37	-10.0	28.1
38	10.0	28.1
39	250.0	88.1
40	310.0	88.1
41	-10.0	30.1
42	10.0	30.1
43	250.0	90.1
44	310.0	90.1

Line No.	Left Point	Right Point	Soil No.
1	1	2	1
2	2	3	1
3	3	4	1
4	5	6	2
5	6	7	2
6	7	8	2
7	9	10	3
8	10	11	3
9	11	12	3
10	13	14	4
11	14	15	4
12	15	16	4
13	17	18	5
14	18	19	5
15	19	20	5
16	21	22	6
17	22	23	6
18	23	24	6
19	25	26	7
20	26	27	7
21	27	28	7
22	29	30	8
23	30	31	8
24	31	32	8
25	33	34	9
26	34	35	9
27	35	36	9
28	37	38	10
29	38	39	10
30	39	40	10
31	41	42	11
32	42	43	11
33	43	44	11

Soil No.	Density pcf	Cohesion psf	Phi Deg
1	130.0	100	30.0
2	135.0	400	20.0
3	63.0	0	20.0
4	63.0	0	20.0
5	130.0	100	30.0
6	130.0	100	30.0
7	65.0	0	25.0
8	130.0	100	30.0
9	135.0	400	20.0
10	62.0	0	20.0
11	130.0	100	30.0

Seismic coefficient, horizontal = 0.100
vertical = 0.100

```
Grid search;  initial parameters:
    initial   final   increment
 x     5.0    250.0       5.0
 y    25.0    650.0       5.0
 r                        1.0
 minimum perpendicular depth is   3.0
 limit at elevation -100.0
OVERALL MINIMUM: x =  30.0, y = 490.0, r = 460.3, FS = 1.377

Automatic search;  initial parameters:
    initial   increment
 x    30.0        0.2
 y   490.0        0.2
 r                0.2
 minimum perpendicular depth is   1.0
 limit at elevation -25.0
OVERALL MINIMUM: x =  30.0, y = 490.0, r = 460.3, FS = 1.377

Automatic search;  initial parameters:
    initial   increment
 x    30.0        0.2
 y   490.0        0.2
 r                0.2
 minimum perpendicular depth is   1.0
 limit at elevation -25.0
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JD-17

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OVERALL MINIMUM: x =  30.0, y = 490.0, r = 460.3, FS = 1.377, theta = 15.13
```

GEOSYSTEM SLOPE STABILITY PROGRAM
SB-SLOPE

PROJECT DATA:
Project: Haywood County Landfill Expansion Phase 2 Sec BB w/GCL
Location: Haywood County, NC
Filename: 99036C Description: Haywood County,NC - Section B-B

ANALYSIS DATA:

Point No.	Coordinates X	Y	Line No.	Left Point	Right Point	Soil No.
1	-10.0	20.2	1	1	2	1
2	25.0	20.2	2	2	3	1
3	220.0	5.0	3	3	4	1
4	310.0	5.0	4	5	6	2
5	-10.0	22.2	5	6	7	2
6	25.0	22.2	6	7	8	2
7	220.0	7.0	7	9	10	3
8	310.0	7.0	8	10	11	3
9	-10.0	22.3	9	11	12	3
10	25.0	22.3	10	13	14	4
11	220.0	7.1	11	14	15	4
12	310.0	7.1	12	15	16	4
13	-10.0	22.4	13	17	18	5
14	25.0	22.4	14	18	19	5
15	220.0	7.2	15	19	20	5
16	310.0	7.2	16	21	22	6
17	-10.0	23.4	17	22	23	6
18	25.0	23.4	18	23	24	6
19	220.0	8.2	19	25	26	7
20	310.0	8.2	20	26	27	7
21	-10.0	25.4	21	27	28	7
22	25.0	25.4	22	29	30	8
23	220.0	10.2	23	30	31	8
24	310.0	10.2	24	31	32	8
25	-10.0	25.5	25	33	34	9
26	10.0	25.5	26	34	35	9
27	250.0	85.5	27	35	36	9
28	310.0	85.5	28	37	38	10
29	-10.0	26.5	29	38	39	10
30	10.0	26.5	30	39	40	10
31	250.0	86.5	31	41	42	11
32	310.0	86.5	32	42	43	11
33	-10.0	28.0	33	43	44	11
34	10.0	28.0				
35	250.0	88.0				
36	310.0	88.0				
37	-10.0	28.1				
38	10.0	28.1				
39	250.0	88.1				
40	310.0	88.1				
41	-10.0	30.1				
42	10.0	30.1				
43	250.0	90.1				
44	310.0	90.1				

Soil No.	Density pcf	Cohesion psf	Phi Deg
1	130.0	100	30.0
2	135.0	400	20.0
3	63.0	0	20.0
4	63.0	500	18.0
5	130.0	100	30.0
6	130.0	100	30.0
7	65.0	0	25.0
8	130.0	100	30.0
9	135.0	400	20.0
10	62.0	0	20.0
11	130.0	100	30.0

Seismic coefficient, horizontal = 0.100
vertical = 0.100

```
Grid search;  initial parameters:
    initial   final   increment
 x    5.0    100.0       5.0
 y   25.0    600.0       5.0
 r                       1.0
 minimum perpendicular depth is   3.0
 limit at elevation -100.0
OVERALL MINIMUM: x =  30.0, y = 490.0, r = 460.3, FS = 1.377

Automatic search;  initial parameters:
    initial   increment
 x    30.0        0.2
 y   490.0        0.2
 r                0.2
 minimum perpendicular depth is   3.0
 limit at elevation -25.0
OVERALL MINIMUM: x =  30.0, y = 490.0, r = 460.3, FS = 1.377

Automatic search;  initial parameters:
    initial   increment
 x    30.0        0.2
 y   490.0        0.2
 r                0.2
 minimum perpendicular depth is   1.0
 limit at elevation -25.0
 - ERROR: 5 best starting points tried
 - ERROR: 5 best starting points tried
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OVERALL MINIMUM: x =  30.0, y = 490.0, r = 460.3, FS = 1.377, theta = 14.15
```
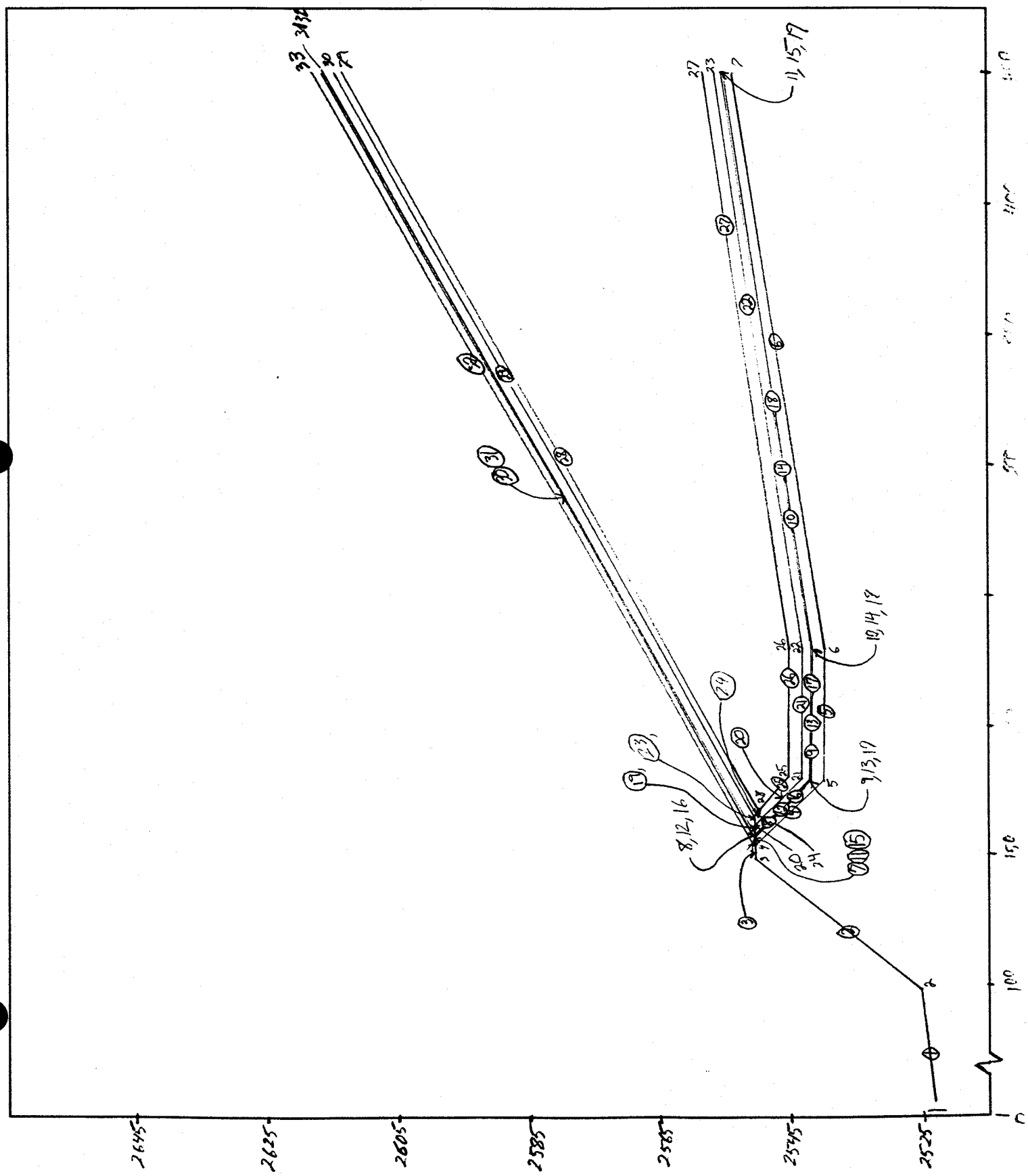

VAN DER HORST
GEOTECHNICAL ENGINEERING, P.C.
3101 Stonybrook Drive, Suite 156
Raleigh, North Carolina 27604
Phone: (919) 876-0405 Fax: (919) 876-0460

JOB Haywood Landfill Phase 2C
SHEET NO. Section C-C OF
CALCULATED BY WML DATE 12/8/99
CHECKED BY DATE
SCALE



GEOSYSTEM SLOPE STABILITY PROGRAM
SB-SLOPE

PROJECT DATA:
Project: Haywood County Landfill Phase 2 Section CC 24" clay liner w/cover
Location: Haywood County, NC
Filename: 99036F Description: Haywood County CC with cover

ANALYSIS DATA:

Point No.	Coordinates X	Coordinates Y	Line No.	Left Point	Right Point	Soil No.
1	0.0	-15.0	1	1	2	1
2	100.0	0.0	2	2	3	1
3	150.0	25.0	3	3	4	1
4	155.0	25.0	4	4	5	1
5	180.0	15.3	5	5	6	1
6	230.0	15.3	6	6	7	1
7	450.0	28.3	7	4	8	2
8	158.8	25.0	8	8	9	2
9	180.0	16.8	9	9	10	2
10	230.0	16.8	10	10	11	2
11	450.0	29.8	11	8	12	3
12	158.9	25.0	12	12	13	3
13	180.0	16.9	13	13	14	3
14	230.0	16.9	14	14	15	3
15	450.0	29.9	15	12	16	4
16	159.0	25.0	16	16	17	4
17	180.0	17.0	17	17	18	4
18	230.0	17.0	18	18	19	4
19	450.0	30.0	19	16	20	5
20	161.0	25.0	20	20	21	5
21	180.0	18.0	21	21	22	5
22	230.0	18.0	22	22	23	5
23	450.0	31.0	23	20	24	6
24	165.0	25.0	24	24	28	6
25	180.0	20.0	25	28	25	6
26	230.0	20.0	26	25	26	6
27	450.0	33.0	27	26	27	6
28	166.5	24.0	28	28	29	7
29	450.0	89.0	29	24	30	8
30	450.0	90.0	30	16	31	9
31	450.0	91.5	31	12	32	10
32	450.0	91.6	32	4	33	11
33	450.0	93.6				

Soil No.	Density pcf	Cohesion psf	Phi Deg
1	130.0	100	30.0
2	135.0	400	20.0
3	63.0	0	20.0
4	63.0	0	20.0
5	130.0	100	30.0
6	130.0	100	30.0
7	65.0	0	25.0
8	130.0	100	30.0
9	135.0	400	20.0
10	63.0	0	20.0
11	130.0	100	30.0

Seismic coefficient, horizontal = 0.100
vertical = 0.100

```
Grid search;  initial parameters:
    initial    final    increment
 x    25.0     250.0        5.0
 y    25.0     300.0        5.0
 r                         5.0
 minimum perpendicular depth is   1.0
 limit at elevation -50.0
OVERALL MINIMUM: x =  90.0, y =  95.0, r =  95.4, FS = 1.381

Automatic search;  initial parameters:
    initial   increment
 x    90.0        0.1
 y    95.0        0.1
 r                0.1
 minimum perpendicular depth is   1.0
 limit at elevation -50.0

Automatic search;  initial parameters:
    initial   increment
 x    90.0        0.1
 y    95.0        0.1
 r                0.1
 minimum perpendicular depth is   1.0
 limit at elevation -50.0
OVERALL MINIMUM: x =  90.1, y =  94.9, r =  95.4, FS = 1.377

Automatic search;  initial parameters:
    initial   increment
 x    90.0        0.1
 y    95.0        0.1
 r                0.1
 minimum perpendicular depth is   1.0
 limit at elevation -35.0
OVERALL MINIMUM: x =  90.1, y =  94.9, r =  95.4, FS = 1.377, theta = 29.07
```

GEOSYSTEM SLOPE STABILITY PROGRAM
SB-SLOPE

PROJECT DATA:
Project: Haywood County Landfill Phase 2 Section CC GCL liner w/cover
Location: Haywood County, NC
Filename: 99036G Description: Haywood County CC with cover

ANALYSIS DATA:

Point No.	Coordinates X	Coordinates Y	Line No.	Left Point	Right Point	Soil No.
1	0.0	-15.0	1	1	2	1
2	100.0	0.0	2	2	3	1
3	150.0	25.0	3	3	4	1
4	155.0	25.0	4	4	5	1
5	180.0	15.3	5	5	6	1
6	230.0	15.3	6	6	7	1
7	450.0	28.3	7	4	8	2
8	158.8	25.0	8	8	9	2
9	180.0	16.8	9	9	10	2
10	230.0	16.8	10	10	11	2
11	450.0	29.8	11	8	12	3
12	158.9	25.0	12	12	13	3
13	180.0	16.9	13	13	14	3
14	230.0	16.9	14	14	15	3
15	450.0	29.9	15	12	16	4
[illegible]	159.0	25.0	16	16	17	4
17	180.0	17.0	17	17	18	4
18	230.0	17.0	18	18	19	4
19	450.0	30.0	19	16	20	5
20	161.0	25.0	20	20	21	5
21	180.0	18.0	21	21	22	5
22	230.0	18.0	22	22	23	5
23	450.0	31.0	23	20	24	6
24	165.0	25.0	24	24	28	6
25	180.0	20.0	25	28	25	6
26	230.0	20.0	26	25	26	6
27	450.0	33.0	27	26	27	6
28	166.5	24.0	28	28	29	7
29	450.0	89.0	29	24	30	8
30	450.0	90.0	30	16	31	9
31	450.0	91.5	31	12	32	10
32	450.0	91.6	32	4	33	11
33	450.0	93.6				

Soil No.	Density pcf	Cohesion psf	Phi Deg
1	130.0	100	30.0
2	135.0	400	20.0
3	63.0	0	20.0
4	63.0	500	18.0
5	130.0	100	30.0
6	130.0	100	30.0
7	65.0	0	25.0
8	130.0	100	30.0
9	135.0	400	20.0
10	63.0	0	20.0
11	130.0	100	30.0

Seismic coefficient, horizontal = 0.100
vertical = 0.100

```
Grid search;  initial parameters:
    initial   final   increment
 x    25.0    200.0       5.0
 y    35.0    250.0       5.0
 r                        5.0
 minimum perpendicular depth is   1.0
 limit at elevation -50.0

Automatic search;  initial parameters:
    initial   increment
 x    90.0        0.1
 y    95.0        0.1
 r                0.1
 minimum perpendicular depth is   1.0
 limit at elevation -50.0
OVERALL MINIMUM: x =  90.1, y =  94.9, r =  95.4, FS = 1.377

Automatic search;  initial parameters:
    initial   increment
 x    90.0        0.1
 y    95.0        0.1
 r                0.1
 minimum perpendicular depth is   1.0
 limit at elevation -35.0
OVERALL MINIMUM: x =  90.1, y =  94.9, r =  95.4, FS = 1.377, theta = 29.07
```

GEOSYSTEM SLOPE STABILITY PROGRAM
SB-SLOPE

PROJECT DATA:
Project: Haywood Co. Landfill Expansion - phase 2 @ Sump
Location:
Filename: 99036D Description: Haywood co phase 2 sump

ANALYSIS DATA:

Point No.	Coordinates X	Y	Line No.	Left Point	Right Point	Soil No.
1	0.0	-15.0	1	1	2	1
2	100.0	0.0	2	2	3	1
3	150.0	25.0	3	3	4	1
4	155.0	25.0	4	4	5	1
5	180.0	15.3	5	5	6	1
6	230.0	15.3	6	6	7	1
7	450.0	28.3	7	4	8	2
8	158.8	25.0	8	8	9	2
9	180.0	16.8	9	9	10	2
10	230.0	16.8	10	10	11	2
11	450.0	29.8	11	8	12	3
12	158.9	25.0	12	12	13	3
13	180.0	16.9	13	13	14	3
14	230.0	16.9	14	14	15	3
15	450.0	29.9	15	12	16	4
[illegible]	159.0	25.0	16	16	17	4
[illegible]	180.0	17.0	17	17	18	4
18	230.0	17.0	18	18	19	4
19	450.0	30.0	19	16	20	5
20	161.0	25.0	20	20	21	5
21	180.0	18.0	21	21	22	5
22	230.0	18.0	22	22	23	5
23	450.0	31.0	23	20	24	6
24	165.0	25.0	24	24	28	6
25	180.0	20.0	25	28	25	6
26	230.0	20.0	26	25	26	6
27	450.0	33.0	27	26	27	6
28	166.5	23.5	28	28	29	7
29	450.0	89.0	29	24	30	8
30	450.0	90.0				

Soil No.	Density pcf	Cohesion psf	Phi Deg
1	130.0	20	30.0
2	135.0	400	20.0
3	63.0	250	20.0
4	63.0	500	18.0
5	130.0	100	30.0
6	130.0	100	30.0
7	65.0	0	25.0
8	130.0	100	30.0

Seismic coefficient, horizontal = 0.100
vertical = 0.100

```
Grid search;  initial parameters:
    initial    final    increment
 x    25.0     250.0       5.0
 y    25.0     350.0       5.0
 r                        5.0
 minimum perpendicular depth is   1.0
 limit at elevation -100.0
OVERALL MINIMUM: x =  95.0, y =  80.0, r =  79.8, FS = 1.059 - low FS
```

Grid Searc
Bishop Metho

```
Automatic search;  initial parameters:
    initial   increment
 x    95.0        0.1
 y    80.0        0.1
 r                0.2
 minimum perpendicular depth is   1.0
 limit at elevation -25.0
OVERALL MINIMUM: x =  91.5, y =  83.2, r =  83.6, FS = 1.051 - low FS
```

Automatic Sear
Bishop
Method

Automatic Search
Spencer Method

```
Automatic search;  initial parameters:
    initial   increment
 x    95.0        0.2
 y    80.0        0.2
 r                0.2
 minimum perpendicular depth is   1.0
 limit at elevation -25.0
OVERALL MINIMUM: x =  90.4, y =  85.0, r =  85.5, FS = 1.050 - low FS, theta = 3
```

Section C-C

2:1 slope at sump

Low Cohesion in Base Material for Embankmen

GEOSYSTEM SLOPE STABILITY PROGRAM
SB-SLOPE

PROJECT DATA:
Project: Haywood Co. Landfill Expansion - phase 2 @ Sump
Location:
Filename: 99036D Description: Haywood co phase 2 sump

ANALYSIS DATA:

Point No.	Coordinates X	Coordinates Y	Line No.	Left Point	Right Point	Soil No.
1	0.0	-9.0	1	1	2	1
2	75.0	0.0	2	2	3	1
3	150.0	25.0	3	3	4	1
4	155.0	25.0	4	4	5	1
5	180.0	15.3	5	5	6	1
6	230.0	15.3	6	6	7	1
7	450.0	28.3	7	4	8	2
8	158.8	25.0	8	8	9	2
9	180.0	16.8	9	9	10	2
10	230.0	16.8	10	10	11	2
11	450.0	29.8	11	8	12	3
12	158.9	25.0	12	12	13	3
13	180.0	16.9	13	13	14	3
14	230.0	16.9	14	14	15	3
15	450.0	29.9	15	12	16	4
16	159.0	25.0	16	16	17	4
17	180.0	17.0	17	17	18	4
18	230.0	17.0	18	18	19	4
19	450.0	30.0	19	16	20	5
20	161.0	25.0	20	20	21	5
21	180.0	18.0	21	21	22	5
22	230.0	18.0	22	22	23	5
23	450.0	31.0	23	20	24	6
24	165.0	25.0	24	24	28	6
25	180.0	20.0	25	28	25	6
26	230.0	20.0	26	25	26	6
27	450.0	33.0	27	26	27	6
28	166.5	23.5	28	28	29	7
29	450.0	89.0	29	24	30	8
30	450.0	90.0				

Soil No.	Density pcf	Cohesion psf	Phi Deg
1	130.0	20	30.0
2	135.0	400	20.0
3	63.0	250	20.0
4	63.0	500	18.0
5	130.0	100	30.0
6	130.0	100	30.0
7	65.0	0	25.0
8	130.0	100	30.0

Seismic coefficient, horizontal = 0.100
vertical = 0.100

```
Grid search;  initial parameters:
    initial    final    increment
 x    25.0     150.0       5.0
      25.0     200.0       5.0
 r                         5.0
 minimum perpendicular depth is   1.0
 limit at elevation -50.0
OVERALL MINIMUM: x =  70.0, y = 145.0, r = 145.1, FS = 1.408
```

Grid Search
Bishop Method

```
Automatic search;  initial parameters:
    initial    increment
 x    70.0        0.2
 y   145.0        0.2
 r                0.2
 minimum perpendicular depth is   1.0
 limit at elevation -25.0
OVERALL MINIMUM: x =  70.2, y = 145.0, r = 145.1, FS = 1.407
```

Automatic Search
Bishop Method

```
Automatic search;  initial parameters:
    initial    increment
 x    70.2        0.2
 y   145.0        0.2
 r                0.2
 minimum perpendicular depth is   1.0
 limit at elevation -25.0
OVERALL MINIMUM: x =  70.2, y = 145.0, r = 145.1, FS = 1.407, theta =  0.00
```

Automatic Search
Spencer Method

Section C-C
3:1 Slope at Sump
Low Cohesion in Embankment Material

VAN DER HORST
GEOTECHNICAL ENGINEERING, P.C.
3101 Stonybrook Drive, Suite 156
Raleigh, North Carolina 27604
Phone: (919) 876-0405 Fax: (919) 876-0460

JOB Haywood Co. Landfill Expansion Ph.
SHEET NO. _____ OF _____
CALCULATED BY WML DATE 12/11/99
CHECKED BY _____ DATE _____
SCALE _____

Bearing Capicity Evaluation

Soil Type: Sandy Silts, Silts (SM/ML) Generally Firm To Compact

Anticipated Loadings at highest Point of MSW in Phase 2 (P-12)

Layer	Thickness (ft)	γ_{total}	Load psf
Erosive Soil Layer	2.0	130.0	260
Clay Cover	1.5	135.0	202.5
Int. Soil Cover	1.0	130.0	130.0
MSW (Refuse)	90.0	65.0	5850
Protective Soil	2.0	130.0	260
Select fill	1.0	130.0	130
Clay liner	2.0	135.0	270

Total Load = 7102.5 psf

= 3.6 TSF

Due To the large ammount of fill/undercut required To get Loose Areas to the Subrade Elevation. Therefore from NAVFAC DM 7.2 Table 1 Recommended Value for Bearing Pressures for Spread foundations for Inorganic Silts and Sandy Silts

very Stiff To Hard 6 TSF

use $\boxed{5.5 \text{ TSF}}$ Bearing Capicity for Compacted fill To 98-100% Compaction of Standard Proctor.

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3101 Stonybrook Drive, Suite 156
Raleigh, North Carolina 27604
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JOB Haywood Co Landfill Evaluation Ph.
SHEET NO. _____ OF _____
CALCULATED BY WML DATE 11/29/99
CHECKED BY _____ DATE _____
SCALE _____

ANTicipated Loadings (Phase 2 Thru Phase 7 complete)

Layer	at Sump Thickness	at Sump γ_{TOT} (pcf)	at Sump Load	at P1-1D Thickness	at P1-1D γ_{TOT} (pcf)	at P1-1D Load
Erosive Soil Layer	2.0	130.0	260.0	2.0	130.0	260.0
Clay Cover	1.5	135.0	202.5	1.5	135.0	202.5
Int. Cover Soil	1.0	130.0	130.0	1.0	130.0	130.0
Refuse	192.5	65.0	12,512.5	75.5	65	4907.5
Protective Soil	2.0	130.0	260.0	2.0	130.0	260.0
Inlet Fill	1.0	130.0	130.0	1.0	130.0	130.0
Clay Liner	2.0	135.0	270.0	2.0	135.0	270.0
Total			13,765.0 psf			6160 psf
			= 6.9 Tsf			3.08 Tsf

Location P1-1D is the closest to Rock with a 30 ft cut to Sand. The sump location has the highest fill (refuse) with a 10 ft fill for subgrade. Location P-12 will require 4 ft of fill (for subgrade)

Calculate Settlement at all 3 Locations To Determine Differential when Phases 2 Thru 7 are complete.

Location	Sump	P1-1D	P-12
Total Settlement	22.89	5.28	8.84
Soil Settlement	20.25	3.06	6.55

Largest Differential Settlement = 22.89 - 5.28
= 17.61 inches
use 18 inches

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JOB Haywood County Landfill Phase 2
SHEET NO. _____ OF _____
CALCULATED BY WML DATE 12/11/99
CHECKED BY _____ DATE _____
SCALE _____

Bearing Capicity — Completion of Phase 2 Thru 7

Bearing Capicity of compacted on-site soils
= 5.5 TSF

The Anticipated Loading at The Sump = 6.9 TSF

Loading Excess = 6.9 - 5.5 TSF = 1.4 TSF = 2800 psf

Height of Garbage must be lowered By

$$\frac{2800 \text{ psf}}{65 \text{ pcf}} = \boxed{43.1 \text{ ft}}$$

Height of Garbage above Sump = 192.5 ft - 43.1 ft = 149.4 ft

Use 149 ft

MSW Elevation above Sump at completion of Phase 2 → 7 =

= Sump Elev. + Max. Height of MSW

Max MSW Elev @ Sump = 2543 + 149 ft = $\boxed{2692}$

Max Elevation of finished Cover = 2692 + 1 + 1.5 + 2.0

" " " " " = $\boxed{2696.5}$

CONE PENETROMETER
SETTLEMENT ANALYSIS

DATE 11-30-1999 TIME 17:02:30

JOB NAME: Haywood Co. Landfill phase 2 - @ P1-8D
JOB NUMBER:99036

FOUNDATION CHARACTERISTICS
FOUNDATION SHAPE CIRCULAR FOUNDATION DEPTH= 0 FT.
FOUNDATION BEARING PRESSURE=13765.0 PSF
FOUNDATION DIAMETER= 99.0 FT. (EQUIV. WIDTH= 87.7 FT)

SOIL CHARACTERISTICS
SOIL DRY UNIT WEIGHT: NONCOHESIVE= 120.0 PCF COHESIVE= 110.0 PCF
SUB. UNIT WEIGHT: NONCOHESIVE= 75.6 PCF COHESIVE= 69.3 PCF
GROUND WATER DEPTH= 18.5 FT.
TIME TO SETTLEMENT= 20.00 YEARS VALUE OF Nc=10
CPT SOUNDING NUMBER:99036d

LOAD THEORY FOR COHESIVE SOILS:BOUSSINESQ

SLICE TOP (FT)	SLICE BASE (FT)	CONE qc (TSF)	P'ov MIDPT (PSF)	IZ	DELTAh SAND (IN)	SU CLAY (PSF)	SU / P'ov	CLAY CONSIS-TENCY	CC / 1+e1	I FACT	DELTA PRESS (PSF)	DELTAH CLAY (IN)
0.0	0.5	20	28			3997	145.4	V.STIFF	0.05	1.00	13765	0.8101
0.5	1.0	20	83			3992	48.4	V.STIFF	0.05	1.00	13765	0.6675
1.0	1.5	20	138			3986	29.0	V.STIFF	0.05	1.00	13765	0.6014
1.5	2.0	20	193			3981	20.7	V.STIFF	0.05	1.00	13764	0.5581
2.0	2.5	70	250	0.13	0.0448							
2.5	3.0	70	310	0.14	0.0470							
3.0	3.5	70	370	0.14	0.0493							
3.5	4.0	70	430	0.15	0.0516							
4.0	4.5	70	490	0.16	0.0539							
4.5	5.0	70	550	0.16	0.0562							
5.0	5.5	70	610	0.17	0.0585							
5.5	6.0	70	670	0.18	0.0608							
6.0	6.5	70	730	0.18	0.0631							
6.5	7.0	70	790	0.19	0.0653							
7.0	7.5	70	850	0.20	0.0676							
7.5	8.0	70	910	0.20	0.0699							
8.0	8.5	70	970	0.21	0.0722							
8.5	9.0	70	1030	0.22	0.0745							
9.0	9.5	70	1090	0.22	0.0768							
9.5	10.0	70	1150	0.23	0.0791							
10.0	10.5	70	1210	0.24	0.0814							
10.5	11.0	70	1270	0.24	0.0837							
11.0	11.5	70	1330	0.25	0.0859							
11.5	12.0	70	1390	0.26	0.0882							
12.0	12.5	70	1450	0.26	0.0905							
12.5	13.0	70	1510	0.27	0.0928							
13.0	13.5	70	1570	0.28	0.0951							
13.5	14.0	70	1630	0.28	0.0974							
14.0	14.5	70	1690	0.29	0.0997							

14.5	15.0	70	1750	0.30	0.1020
15.0	15.5	70	1810	0.30	0.1042
15.5	16.0	70	1870	0.31	0.1065
16.0	16.5	70	1930	0.32	0.1088
[illegible].5	17.0	70	1990	0.32	0.1111
17.0	17.5	70	2050	0.33	0.1134
17.5	18.0	70	2110	0.34	0.1157
18.0	18.5	20	2170	0.34	0.4129
18.5	19.0	20	2219	0.35	0.4209
19.0	19.5	20	2257	0.36	0.4289
19.5	20.0	20	2294	0.36	0.4369
20.0	20.5	20	2332	0.37	0.4449
20.5	21.0	20	2370	0.38	0.4530
21.0	21.5	72	2408	0.38	0.1280
21.5	22.0	72	2446	0.39	0.1303
22.0	22.5	72	2483	0.40	0.1325
22.5	23.0	72	2521	0.40	0.1347
23.0	23.5	72	2559	0.41	0.1369
23.5	24.0	72	2597	0.42	0.1392
24.0	24.5	72	2634	0.42	0.1414
24.5	25.0	72	2672	0.43	0.1436
25.0	25.5	72	2710	0.44	0.1458
25.5	26.0	72	2748	0.44	0.1481
26.0	26.5	72	2786	0.45	0.1503
26.5	27.0	72	2823	0.46	0.1525
27.0	27.5	72	2861	0.46	0.1547
27.5	28.0	72	2899	0.47	0.1570
28.0	28.5	72	2937	0.48	0.1592
28.5	29.0	72	2974	0.48	0.1614
[illegible].0	29.5	72	3012	0.49	0.1636
29.5	30.0	72	3050	0.50	0.1659
30.0	30.5	72	3088	0.50	0.1681
30.5	31.0	72	3126	0.51	0.1703
31.0	31.5	72	3163	0.52	0.1725
31.5	32.0	72	3201	0.52	0.1748
32.0	32.5	72	3239	0.53	0.1770
32.5	33.0	72	3277	0.53	0.1792
33.0	33.5	72	3314	0.54	0.1814
33.5	34.0	72	3352	0.55	0.1837
34.0	34.5	72	3390	0.55	0.1859
34.5	35.0	72	3428	0.56	0.1881
35.0	35.5	72	3466	0.57	0.1903
35.5	36.0	72	3503	0.57	0.1926
36.0	36.5	72	3541	0.58	0.1948
36.5	37.0	72	3579	0.59	0.1970
37.0	37.5	72	3617	0.59	0.1992
37.5	38.0	72	3654	0.60	0.2015
38.0	38.5	72	3692	0.61	0.2037
38.5	39.0	72	3730	0.61	0.2059
39.0	39.5	72	3768	0.62	0.2081
39.5	40.0	72	3806	0.63	0.2104
40.0	40.5	72	3843	0.63	0.2126
40.5	41.0	72	3881	0.64	0.2148
41.0	41.5	72	3919	0.65	0.2170
41.5	42.0	72	3957	0.65	0.2193
[illegible]2.0	42.5	72	3994	0.66	0.2215
42.5	43.0	72	4032	0.67	0.2237
43.0	43.5	72	4070	0.67	0.2259
43.5	44.0	72	4108	0.68	0.2282
44.0	44.5	72	4146	0.68	0.2280

44.5	45.0	72	4183	0.68	0.2271
45.0	45.5	72	4221	0.68	0.2263
45.5	46.0	72	4259	0.67	0.2254
46.0	46.5	72	4297	0.67	0.2245
[illegible].5	47.0	72	4334	0.67	0.2237
47.0	47.5	72	4372	0.67	0.2228
47.5	48.0	72	4410	0.66	0.2219
48.0	48.5	72	4448	0.66	0.2211
48.5	49.0	72	4486	0.66	0.2202
49.0	49.5	72	4523	0.65	0.2193
49.5	50.0	72	4561	0.65	0.2185
50.0	50.5	72	4599	0.65	0.2176
50.5	51.0	72	4637	0.65	0.2167
51.0	51.5	72	4674	0.64	0.2159
51.5	52.0	72	4712	0.64	0.2150
52.0	52.5	72	4750	0.64	0.2141
52.5	53.0	72	4788	0.64	0.2132
53.0	53.5	72	4826	0.63	0.2124
53.5	54.0	72	4863	0.63	0.2115
54.0	54.5	72	4901	0.63	0.2106
54.5	55.0	72	4939	0.63	0.2098
55.0	55.5	72	4977	0.62	0.2089
55.5	56.0	72	5014	0.62	0.2080
56.0	56.5	72	5052	0.62	0.2072
56.5	57.0	72	5090	0.62	0.2063
57.0	57.5	72	5128	0.61	0.2054
57.5	58.0	72	5166	0.61	0.2046
58.0	58.5	%1188	5203	0.61	0.0123
58.5	59.0	%1188	5241	0.61	0.0123
[illegible].0	59.5	%1188	5279	0.60	0.0122
59.5	60.0	%1188	5317	0.60	0.0122
60.0	60.5	%1188	5354	0.60	0.0121
60.5	61.0	%1188	5392	0.60	0.0121
61.0	61.5	%1188	5430	0.59	0.0120
61.5	62.0	%1188	5468	0.59	0.0120
62.0	62.5	%1188	5506	0.59	0.0119
62.5	63.0	%1188	5543	0.58	0.0119
63.0	63.5	%1188	5581	0.58	0.0118
63.5	64.0	%1188	5619	0.58	0.0118
64.0	64.5	%1188	5657	0.58	0.0117
64.5	65.0	%1188	5694	0.57	0.0117
65.0	65.5	%1188	5732	0.57	0.0116
65.5	66.0	%1188	5770	0.57	0.0116
66.0	66.5	%1188	5808	0.57	0.0115
66.5	67.0	%1188	5846	0.56	0.0114
67.0	67.5	%1188	5883	0.56	0.0114
67.5	68.0	%1188	5921	0.56	0.0113
68.0	68.5	%1188	5959	0.56	0.0113
68.5	69.0	%1188	5997	0.55	0.0112
69.0	69.5	%1188	6034	0.55	0.0112
69.5	70.0	%1188	6072	0.55	0.0111
70.0	70.5	%1188	6110	0.55	0.0111
70.5	71.0	%1188	6148	0.54	0.0110
71.0	71.5	%1188	6186	0.54	0.0110
71.5	72.0	%1188	6223	0.54	0.0109
[illegible]2.0	72.5	%1188	6261	0.54	0.0109
72.5	73.0	%1188	6299	0.53	0.0108
73.0	73.5	%1188	6337	0.53	0.0108
73.5	74.0	%1188	6374	0.53	0.0107
74.0	74.5	%1188	6412	0.53	0.0107

74.5	75.0	%1188	6450	0.52	0.0106								
75.0	75.5	%1188	6488	0.52	0.0106								
75.5	76.0	%1188	6526	0.52	0.0105								
76.0	76.5	%1188	6563	0.51	0.0104								
76.5	77.0	%1188	6601	0.51	0.0104								
77.0	77.5	%1188	6639	0.51	0.0103								
77.5	78.0	%1188	6677	0.51	0.0103								
78.0	78.5	%1188	6714	0.50	0.0102								
78.5	79.0	%1188	6752	0.50	0.0102								
79.0	79.5	%1188	6790	0.50	0.0101								
79.5	80.0	%1188	6828	0.50	0.0101								
80.0	80.5	%1188	6866	0.49	0.0100								
80.5	81.0	%1188	6903	0.49	0.0100								
81.0	81.5	%1188	6941	0.49	0.0099								
81.5	82.0	%1188	6979	0.49	0.0099								
82.0	82.5	%1188	7017	0.48	0.0098								
82.5	83.0	%1188	7054	0.48	0.0098								
83.0	83.5	%1188	7092	0.48	0.0097								
83.5	84.0	%1188	7130	0.48	0.0097								
84.0	84.5	%1188	7168	0.47	0.0096								
84.5	85.0	%1188	7206	0.47	0.0096								
85.0	85.5	%1188	7243	0.47	0.0095								
85.5	86.0	%1188	7281	0.47	0.0094								
86.0	86.5	%1188	7319	0.46	0.0094								
86.5	87.0	%1188	7357	0.46	0.0093								
87.0	87.5	%1188	7394	0.46	0.0093								
87.5	88.0	%1188	7432	0.46	0.0092								
88.0	88.5	%1188	7470	0.45	0.0092								
88.5	89.0	%1188	7508	0.45	0.0091								
89.0	89.5	%1188	7546	0.45	0.0091								
89.5	90.0	%1188	7583	0.44	0.0090								
90.0	90.5	%1188	7621	0.44	0.0090								
90.5	91.0	%1188	7659	0.44	0.0089								
91.0	91.5	%1188	7697	0.44	0.0089								
91.5	92.0	%1188	7734	0.43	0.0088								
92.0	92.5	%1188	7772	0.43	0.0088								
92.5	93.0	%1188	7810	0.43	0.0087								
93.0	93.5	%1188	7848	0.43	0.0087								
93.5	94.0	%1188	7886	0.42	0.0086								
94.0	94.5	%1188	7923	0.42	0.0086								
94.5	95.0	%1188	7961	0.42	0.0085								
95.0	95.5	%1188	7999	0.42	0.0084								
95.5	96.0	%1188	8037	0.41	0.0084								
96.0	96.5	%1188	8074	0.41	0.0083								
96.5	97.0	%1188	8112	0.41	0.0083								
97.0	97.5	%1188	8150	0.41	0.0082								
97.5	98.0	%1188	8188	0.40	0.0082								
98.0	98.5	%1188	8226	0.40	0.0081								
98.5	99.0	%1188	8263	0.40	0.0081								

SUM= 20.25 SUM= 2.64

Po= 0 PSF
DELTA P= 13765 PSF
Izp DEPTH= %44.000 FT
Izp= 0.683
C1= 1.0000
C2= 1.4602

X VALUE= 2.50

ESTIMATED TOTAL SETTLEMENT= 22.89 INCHES

CONE PENETROMETER
SETTLEMENT ANALYSIS

DATE 11-29-1999 TIME 15:58:21

JOB NAME: Haywood County Landfill Expansion Phase 2
JOB NUMBER:99036a

FOUNDATION CHARACTERISTICS
FOUNDATION SHAPE CONTINUOUS/STRIP FOUNDATION DEPTH= 0 FT.
FOUNDATION BEARING PRESSURE= 6160.0 PSF
FOUNDATION WIDTH= 99.0 FT.

SOIL CHARACTERISTICS
SOIL DRY UNIT WEIGHT: NONCOHESIVE= 120.0 PCF COHESIVE= 110.0 PCF
SUB. UNIT WEIGHT: NONCOHESIVE= 75.6 PCF COHESIVE= 69.3 PCF
GROUND WATER DEPTH= 36.5 FT.
TIME TO SETTLEMENT= 20.00 YEARS VALUE OF Nc=10
CPT SOUNDING NUMBER:99036a

LOAD THEORY FOR COHESIVE SOILS:BOUSSINESQ

SLICE TOP (FT)	SLICE BASE (FT)	CONE qc (TSF)	P'ov MIDPT (PSF)	IZ	DELTAh SAND (IN)	SU CLAY (PSF)	SU / P'ov	CLAY CONSIS-TENCY	CC / 1+e1	I FACT	DELTA PRESS (PSF)	DELTAH CLAY (IN)
0.0	0.5	20	28			3997	145.4	V.STIFF	0.05	1.00	6160	0.7057
0.5	1.0	20	83			3992	48.4	V.STIFF	0.05	1.00	6160	0.5637
1.0	1.5	20	138			3986	29.0	V.STIFF	0.05	1.00	6160	0.4983
1.5	2.0	20	193			3981	20.7	V.STIFF	0.05	1.00	6160	0.4556
2.0	2.5	70	250	0.21	0.0230							
2.5	3.0	70	310	0.21	0.0232							
3.0	3.5	70	370	0.21	0.0234							
3.5	4.0	70	430	0.21	0.0236							
4.0	4.5	70	490	0.22	0.0238							
4.5	5.0	70	550	0.22	0.0240							
5.0	5.5	70	610	0.22	0.0243							
5.5	6.0	70	670	0.22	0.0245							
6.0	6.5	70	730	0.22	0.0247							
6.5	7.0	70	790	0.23	0.0249							
7.0	7.5	70	850	0.23	0.0251							
7.5	8.0	70	910	0.23	0.0253							
8.0	8.5	70	970	0.23	0.0255							
8.5	9.0	70	1030	0.23	0.0258							
9.0	9.5	228	1090	0.24	0.0080							
9.5	10.0	228	1150	0.24	0.0081							
10.0	10.5	228	1210	0.24	0.0081							
10.5	11.0	228	1270	0.24	0.0082							
11.0	11.5	228	1330	0.24	0.0083							
11.5	12.0	228	1390	0.25	0.0083							
12.0	12.5	30	1450	0.25	0.0636							
12.5	13.0	30	1510	0.25	0.0641							
13.0	13.5	30	1570	0.25	0.0646							
13.5	14.0	30	1630	0.25	0.0650							
14.0	14.5	30	1690	0.26	0.0655							

14.5	15.0	30	1750	0.26	0.0660
15.0	15.5	30	1810	0.26	0.0665
15.5	16.0	30	1870	0.26	0.0670
16.0	16.5	30	1930	0.26	0.0675
16.5	17.0	30	1990	0.26	0.0680
17.0	17.5	30	2050	0.27	0.0685
17.5	18.0	30	2110	0.27	0.0690
18.0	18.5	30	2170	0.27	0.0695
18.5	19.0	30	2230	0.27	0.0700
19.0	19.5	30	2290	0.27	0.0705
19.5	20.0	30	2350	0.28	0.0710
20.0	20.5	30	2410	0.28	0.0715
20.5	21.0	30	2470	0.28	0.0720
21.0	21.5	30	2530	0.28	0.0725
21.5	22.0	30	2590	0.28	0.0730
22.0	22.5	30	2650	0.29	0.0735
22.5	23.0	30	2710	0.29	0.0740
23.0	23.5	30	2770	0.29	0.0745
23.5	24.0	30	2830	0.29	0.0750
24.0	24.5	30	2890	0.29	0.0755
24.5	25.0	30	2950	0.30	0.0760
25.0	25.5	30	3010	0.30	0.0765
25.5	26.0	30	3070	0.30	0.0770
26.0	26.5	30	3130	0.30	0.0775
26.5	27.0	30	3190	0.30	0.0780
27.0	27.5	900	3250	0.31	0.0026
27.5	28.0	900	3310	0.31	0.0026
28.0	28.5	900	3370	0.31	0.0026
28.5	29.0	900	3430	0.31	0.0027
29.0	29.5	900	3490	0.31	0.0027
29.5	30.0	900	3550	0.31	0.0027
30.0	30.5	900	3610	0.32	0.0027
30.5	31.0	900	3670	0.32	0.0027
31.0	31.5	900	3730	0.32	0.0027
31.5	32.0	900	3790	0.32	0.0028
32.0	32.5	900	3850	0.32	0.0028
32.5	33.0	900	3910	0.33	0.0028
33.0	33.5	900	3970	0.33	0.0028
33.5	34.0	900	4030	0.33	0.0028
34.0	34.5	900	4090	0.33	0.0028
34.5	35.0	900	4150	0.33	0.0029
35.0	35.5	900	4210	0.34	0.0029
35.5	36.0	900	4270	0.34	0.0029
36.0	36.5	900	4330	0.34	0.0029
36.5	37.0	900	4379	0.34	0.0029
37.0	37.5	900	4417	0.34	0.0029
37.5	38.0	900	4454	0.35	0.0030
38.0	38.5	900	4492	0.35	0.0030
38.5	39.0	900	4530	0.35	0.0030
39.0	39.5	900	4568	0.35	0.0030
39.5	40.0	900	4606	0.35	0.0030
40.0	40.5	900	4643	0.36	0.0030
40.5	41.0	900	4681	0.36	0.0031
41.0	41.5	900	4719	0.36	0.0031
41.5	42.0	900	4757	0.36	0.0031
42.0	42.5	900	4794	0.36	0.0031
42.5	43.0	900	4832	0.37	0.0031
43.0	43.5	900	4870	0.37	0.0031
43.5	44.0	900	4908	0.37	0.0032
44.0	44.5	900	4946	0.37	0.0032

44.5	45.0	900	4983	0.37	0.0032
45.0	45.5	900	5021	0.37	0.0032
45.5	46.0	900	5059	0.38	0.0032
46.0	46.5	900	5097	0.38	0.0032
46.5	47.0	900	5134	0.38	0.0033
47.0	47.5	900	5172	0.38	0.0033
47.5	48.0	900	5210	0.38	0.0033
48.0	48.5	900	5248	0.39	0.0033
48.5	49.0	900	5286	0.39	0.0033
49.0	49.5	900	5323	0.39	0.0033
49.5	50.0	900	5361	0.39	0.0034
50.0	50.5	900	5399	0.39	0.0034
50.5	51.0	900	5437	0.40	0.0034
51.0	51.5	900	5474	0.40	0.0034
51.5	52.0	900	5512	0.40	0.0034
52.0	52.5	900	5550	0.40	0.0034
52.5	53.0	900	5588	0.40	0.0035
53.0	53.5	900	5626	0.41	0.0035
53.5	54.0	900	5663	0.41	0.0035
54.0	54.5	900	5701	0.41	0.0035
54.5	55.0	900	5739	0.41	0.0035
55.0	55.5	900	5777	0.41	0.0035
55.5	56.0	900	5814	0.42	0.0036
56.0	56.5	900	5852	0.42	0.0036
56.5	57.0	900	5890	0.42	0.0036
57.0	57.5	900	5928	0.42	0.0036
57.5	58.0	900	5966	0.42	0.0036
58.0	58.5	900	6003	0.42	0.0036
58.5	59.0	900	6041	0.43	0.0037
59.0	59.5	900	6079	0.43	0.0037
59.5	60.0	900	6117	0.43	0.0037
60.0	60.5	900	6154	0.43	0.0037
60.5	61.0	900	6192	0.43	0.0037
61.0	61.5	900	6230	0.44	0.0037
61.5	62.0	900	6268	0.44	0.0038
62.0	62.5	900	6306	0.44	0.0038
62.5	63.0	900	6343	0.44	0.0038
63.0	63.5	900	6381	0.44	0.0038
63.5	64.0	900	6419	0.45	0.0038
64.0	64.5	900	6457	0.45	0.0038
64.5	65.0	900	6494	0.45	0.0039
65.0	65.5	900	6532	0.45	0.0039
65.5	66.0	900	6570	0.45	0.0039
66.0	66.5	900	6608	0.46	0.0039
66.5	67.0	900	6646	0.46	0.0039
67.0	67.5	900	6683	0.46	0.0039
67.5	68.0	900	6721	0.46	0.0040
68.0	68.5	900	6759	0.46	0.0040
68.5	69.0	900	6797	0.47	0.0040
69.0	69.5	900	6834	0.47	0.0040
69.5	70.0	900	6872	0.47	0.0040
70.0	70.5	900	6910	0.47	0.0040
70.5	71.0	900	6948	0.47	0.0041
71.0	71.5	900	6986	0.48	0.0041
71.5	72.0	900	7023	0.48	0.0041
72.0	72.5	900	7061	0.48	0.0041
72.5	73.0	900	7099	0.48	0.0041
73.0	73.5	900	7137	0.48	0.0041
73.5	74.0	900	7174	0.48	0.0042
74.0	74.5	900	7212	0.49	0.0042

74.5	75.0	900	7250	0.49	0.0042							
75.0	75.5	900	7288	0.49	0.0042							
75.5	76.0	900	7326	0.49	0.0042							
76.0	76.5	900	7363	0.49	0.0042							
76.5	77.0	900	7401	0.50	0.0043							
77.0	77.5	900	7439	0.50	0.0043							
77.5	78.0	900	7477	0.50	0.0043							
78.0	78.5	900	7514	0.50	0.0043							
78.5	79.0	900	7552	0.50	0.0043							
79.0	79.5	900	7590	0.51	0.0043							
79.5	80.0	900	7628	0.51	0.0044							
80.0	80.5	900	7666	0.51	0.0044							
80.5	81.0	900	7703	0.51	0.0044							
81.0	81.5	900	7741	0.51	0.0044							
81.5	82.0	900	7779	0.52	0.0044							
82.0	82.5	900	7817	0.52	0.0044							
82.5	83.0	900	7854	0.52	0.0045							
83.0	83.5	900	7892	0.52	0.0045							
83.5	84.0	900	7930	0.52	0.0045							
84.0	84.5	900	7968	0.53	0.0045							
84.5	85.0	900	8006	0.53	0.0045							
85.0	85.5	900	8043	0.53	0.0045							
85.5	86.0	900	8081	0.53	0.0046							
86.0	86.5	900	8119	0.53	0.0046							
86.5	87.0	900	8157	0.54	0.0046							
87.0	87.5	900	8194	0.54	0.0046							
87.5	88.0	900	8232	0.54	0.0046							
88.0	88.5	900	8270	0.54	0.0046							
88.5	89.0	900	8308	0.54	0.0046							
89.0	89.5	900	8346	0.54	0.0047							
89.5	90.0	900	8383	0.55	0.0047							
90.0	90.5	900	8421	0.55	0.0047							
90.5	91.0	900	8459	0.55	0.0047							
91.0	91.5	900	8497	0.55	0.0047							
91.5	92.0	900	8534	0.55	0.0047							
92.0	92.5	900	8572	0.56	0.0048							
92.5	93.0	900	8610	0.56	0.0048							
93.0	93.5	900	8648	0.56	0.0048							
93.5	94.0	900	8686	0.56	0.0048							
94.0	94.5	900	8723	0.56	0.0048							
94.5	95.0	900	8761	0.57	0.0048							
95.0	95.5	900	8799	0.57	0.0049							
95.5	96.0	900	8837	0.57	0.0049							
96.0	96.5	900	8874	0.57	0.0049							
96.5	97.0	900	8912	0.57	0.0049							
97.0	97.5	900	8950	0.58	0.0049							
97.5	98.0	900	8988	0.58	0.0049							
98.0	98.5	900	9026	0.58	0.0050							
98.5	99.0	900	9063	0.58	0.0050							

SUM= 3.06 SUM= 2.22

P= 0 PSF
DELTA P= 6160 PSF
Izp DEPTH= %99.000 FT
Izp= 0.582
C1= 1.0000
C2= 1.4602

VALUE= 3.50

ESTIMATED TOTAL SETTLEMENT= 5.28 INCHES

CONE PENETROMETER SETTLEMENT ANALYSIS

DATE 11-29-1999 TIME 10:29:42

JOB NAME: Haywood County Landfill Expansion Phase 2
JOB NUMBER:99036

FOUNDATION CHARACTERISTICS
FOUNDATION SHAPE CIRCULAR FOUNDATION DEPTH= 0 FT.
FOUNDATION BEARING PRESSURE= 7102.5 PSF
FOUNDATION DIAMETER= 99.0 FT. (EQUIV. WIDTH= 87.7 FT)

SOIL CHARACTERISTICS
SOIL DRY UNIT WEIGHT: NONCOHESIVE= 120.0 PCF COHESIVE= 110.0 PCF
SUB. UNIT WEIGHT: NONCOHESIVE= 75.6 PCF COHESIVE= 69.3 PCF
GROUND WATER DEPTH= 14.0 FT.
TIME TO SETTLEMENT= 30.00 YEARS VALUE OF Nc=10
CPT SOUNDING NUMBER:99036b

LOAD THEORY FOR COHESIVE SOILS:BOUSSINESQ

SLICE TOP (FT)	SLICE BASE (FT)	CONE qc (TSF)	P'ov MIDPT (PSF)	IZ	DELTAh SAND (IN)	SU CLAY (PSF)	SU / P'ov	CLAY CONSIS-TENCY	CC / 1+e1	I FACT	DELTA PRESS (PSF)	DELTAH CLAY (IN)
0.0	0.5	20	28			3997	145.4	V.STIFF	0.05	1.00	7102	0.7241
0.5	1.0	20	83			3992	48.4	V.STIFF	0.05	1.00	7102	0.5820
1.0	1.5	20	138			3986	29.0	V.STIFF	0.05	1.00	7102	0.5164
1.5	2.0	20	193			3981	20.7	V.STIFF	0.05	1.00	7102	0.4736
2.0	2.5	70	250	0.13	0.0232							
2.5	3.0	70	310	0.13	0.0243							
3.0	3.5	70	370	0.14	0.0254							
3.5	4.0	70	430	0.15	0.0265							
4.0	4.5	70	490	0.15	0.0276							
4.5	5.0	70	550	0.16	0.0287							
5.0	5.5	70	610	0.16	0.0299							
5.5	6.0	70	670	0.17	0.0310							
6.0	6.5	18	730	0.18	0.1247							
6.5	7.0	18	790	0.18	0.1290							
7.0	7.5	18	850	0.19	0.1334							
7.5	8.0	18	910	0.19	0.1377							
8.0	8.5	18	970	0.20	0.1420							
8.5	9.0	18	1030	0.21	0.1463							
9.0	9.5	18	1090	0.21	0.1506							
9.5	10.0	18	1150	0.22	0.1549							
10.0	10.5	18	1210	0.22	0.1592							
10.5	11.0	18	1270	0.23	0.1636							
11.0	11.5	18	1330	0.24	0.1679							
11.5	12.0	18	1390	0.24	0.1722							
12.0	12.5	18	1450	0.25	0.1765							
12.5	13.0	18	1510	0.26	0.1808							
13.0	13.5	18	1570	0.26	0.1851							
13.5	14.0	18	1630	0.27	0.1894							
14.0	14.5	18	1679	0.27	0.1937							

14.5	15.0	18	1717	0.28	0.1981
15.0	15.5	18	1754	0.29	0.2024
15.5	16.0	18	1792	0.29	0.2067
16.0	16.5	18	1830	0.30	0.2110
16.5	17.0	18	1868	0.30	0.2153
17.0	17.5	18	1906	0.31	0.2196
17.5	18.0	18	1943	0.32	0.2239
18.0	18.5	42	1981	0.32	0.0978
18.5	19.0	42	2019	0.33	0.0997
19.0	19.5	42	2057	0.33	0.1015
19.5	20.0	42	2094	0.34	0.1034
20.0	20.5	42	2132	0.35	0.1052
20.5	21.0	42	2170	0.35	0.1071
21.0	21.5	42	2208	0.36	0.1089
21.5	22.0	42	2246	0.37	0.1108
22.0	22.5	42	2283	0.37	0.1126
22.5	23.0	42	2321	0.38	0.1145
23.0	23.5	900	2359	0.38	0.0054
23.5	24.0	900	2397	0.39	0.0055
24.0	24.5	900	2434	0.40	0.0056
24.5	25.0	900	2472	0.40	0.0057
25.0	25.5	900	2510	0.41	0.0058
25.5	26.0	900	2548	0.41	0.0059
26.0	26.5	900	2586	0.42	0.0059
26.5	27.0	900	2623	0.43	0.0060
27.0	27.5	900	2661	0.43	0.0061
27.5	28.0	900	2699	0.44	0.0062
28.0	28.5	900	2737	0.44	0.0063
28.5	29.0	900	2774	0.45	0.0064
29.0	29.5	900	2812	0.46	0.0065
29.5	30.0	900	2850	0.46	0.0065
30.0	30.5	900	2888	0.47	0.0066
30.5	31.0	900	2926	0.47	0.0067
31.0	31.5	900	2963	0.48	0.0068
31.5	32.0	900	3001	0.49	0.0069
32.0	32.5	900	3039	0.49	0.0070
32.5	33.0	900	3077	0.50	0.0071
33.0	33.5	900	3114	0.51	0.0072
33.5	34.0	900	3152	0.51	0.0072
34.0	34.5	900	3190	0.52	0.0073
34.5	35.0	900	3228	0.52	0.0074
35.0	35.5	900	3266	0.53	0.0075
35.5	36.0	900	3303	0.54	0.0076
36.0	36.5	900	3341	0.54	0.0077
36.5	37.0	900	3379	0.55	0.0078
37.0	37.5	900	3417	0.55	0.0078
37.5	38.0	900	3454	0.56	0.0079
38.0	38.5	900	3492	0.57	0.0080
38.5	39.0	900	3530	0.57	0.0081
39.0	39.5	900	3568	0.58	0.0082
39.5	40.0	900	3606	0.58	0.0083
40.0	40.5	900	3643	0.59	0.0084
40.5	41.0	900	3681	0.60	0.0084
41.0	41.5	900	3719	0.60	0.0085
41.5	42.0	900	3757	0.61	0.0086
42.0	42.5	900	3794	0.61	0.0087
42.5	43.0	900	3832	0.62	0.0088
43.0	43.5	900	3870	0.63	0.0089
43.5	44.0	900	3908	0.63	0.0090
44.0	44.5	900	3946	0.63	0.0090

44.5	45.0	900	3983	0.63	0.0089
45.0	45.5	900	4021	0.63	0.0089
45.5	46.0	900	4059	0.63	0.0089
46.0	46.5	900	4097	0.62	0.0088
46.5	47.0	900	4134	0.62	0.0088
47.0	47.5	900	4172	0.62	0.0088
47.5	48.0	900	4210	0.62	0.0087
48.0	48.5	900	4248	0.61	0.0087
48.5	49.0	900	4286	0.61	0.0087
49.0	49.5	900	4323	0.61	0.0086
49.5	50.0	900	4361	0.61	0.0086
50.0	50.5	900	4399	0.60	0.0085
50.5	51.0	900	4437	0.60	0.0085
51.0	51.5	900	4474	0.60	0.0085
51.5	52.0	900	4512	0.60	0.0084
52.0	52.5	900	4550	0.59	0.0084
52.5	53.0	900	4588	0.59	0.0084
53.0	53.5	900	4626	0.59	0.0083
53.5	54.0	900	4663	0.59	0.0083
54.0	54.5	900	4701	0.58	0.0083
54.5	55.0	900	4739	0.58	0.0082
55.0	55.5	900	4777	0.58	0.0082
55.5	56.0	900	4814	0.58	0.0082
56.0	56.5	900	4852	0.57	0.0081
56.5	57.0	900	4890	0.57	0.0081
57.0	57.5	900	4928	0.57	0.0081
57.5	58.0	900	4966	0.57	0.0080
58.0	58.5	900	5003	0.57	0.0080
58.5	59.0	900	5041	0.56	0.0080
59.0	59.5	900	5079	0.56	0.0079
59.5	60.0	900	5117	0.56	0.0079
60.0	60.5	900	5154	0.56	0.0079
60.5	61.0	900	5192	0.55	0.0078
61.0	61.5	900	5230	0.55	0.0078
61.5	62.0	900	5268	0.55	0.0078
62.0	62.5	900	5306	0.55	0.0077
62.5	63.0	900	5343	0.54	0.0077
63.0	63.5	900	5381	0.54	0.0077
63.5	64.0	900	5419	0.54	0.0076
64.0	64.5	900	5457	0.54	0.0076
64.5	65.0	900	5494	0.53	0.0076
65.0	65.5	900	5532	0.53	0.0075
65.5	66.0	900	5570	0.53	0.0075
66.0	66.5	900	5608	0.53	0.0075
66.5	67.0	900	5646	0.52	0.0074
67.0	67.5	900	5683	0.52	0.0074
67.5	68.0	900	5721	0.52	0.0074
68.0	68.5	900	5759	0.52	0.0073
68.5	69.0	900	5797	0.51	0.0073
69.0	69.5	900	5834	0.51	0.0073
69.5	70.0	900	5872	0.51	0.0072
70.0	70.5	900	5910	0.51	0.0072
70.5	71.0	900	5948	0.50	0.0072
71.0	71.5	900	5986	0.50	0.0071
71.5	72.0	900	6023	0.50	0.0071
72.0	72.5	900	6061	0.50	0.0070
72.5	73.0	900	6099	0.50	0.0070
73.0	73.5	900	6137	0.49	0.0070
73.5	74.0	900	6174	0.49	0.0069
74.0	74.5	900	6212	0.49	0.0069

74.5	75.0	900	6250	0.49	0.0069							
75.0	75.5	900	6288	0.48	0.0068							
75.5	76.0	900	6326	0.48	0.0068							
76.0	76.5	900	6363	0.48	0.0068							
76.5	77.0	900	6401	0.48	0.0067							
77.0	77.5	900	6439	0.47	0.0067							
77.5	78.0	900	6477	0.47	0.0067							
78.0	78.5	900	6514	0.47	0.0066							
78.5	79.0	900	6552	0.47	0.0066							
79.0	79.5	900	6590	0.46	0.0066							
79.5	80.0	900	6628	0.46	0.0065							
80.0	80.5	900	6666	0.46	0.0065							
80.5	81.0	900	6703	0.46	0.0065							
81.0	81.5	900	6741	0.45	0.0064							
81.5	82.0	900	6779	0.45	0.0064							
82.0	82.5	900	6817	0.45	0.0064							
82.5	83.0	900	6854	0.45	0.0063							
83.0	83.5	900	6892	0.44	0.0063							
83.5	84.0	900	6930	0.44	0.0063							
84.0	84.5	900	6968	0.44	0.0062							
84.5	85.0	900	7006	0.44	0.0062							
85.0	85.5	900	7043	0.43	0.0062							
85.5	86.0	900	7081	0.43	0.0061							
86.0	86.5	900	7119	0.43	0.0061							
86.5	87.0	900	7157	0.43	0.0061							
87.0	87.5	900	7194	0.43	0.0060							
87.5	88.0	900	7232	0.42	0.0060							
88.0	88.5	900	7270	0.42	0.0060							
88.5	89.0	900	7308	0.42	0.0059							
89.0	89.5	900	7346	0.42	0.0059							
89.5	90.0	900	7383	0.41	0.0059							
90.0	90.5	900	7421	0.41	0.0058							
90.5	91.0	900	7459	0.41	0.0058							
91.0	91.5	900	7497	0.41	0.0058							
91.5	92.0	900	7534	0.40	0.0057							
92.0	92.5	900	7572	0.40	0.0057							
92.5	93.0	900	7610	0.40	0.0056							
93.0	93.5	900	7648	0.40	0.0056							
93.5	94.0	900	7686	0.39	0.0056							
94.0	94.5	900	7723	0.39	0.0055							
94.5	95.0	900	7761	0.39	0.0055							
95.0	95.5	900	7799	0.39	0.0055							
95.5	96.0	900	7837	0.38	0.0054							
96.0	96.5	900	7874	0.38	0.0054							
96.5	97.0	900	7912	0.38	0.0054							
97.0	97.5	900	7950	0.38	0.0053							
97.5	98.0	900	7988	0.37	0.0053							
98.0	98.5	900	8026	0.37	0.0053							
98.5	99.0	900	8063	0.37	0.0052							

SUM= 6.55 SUM= 2.30

PO= 0 PSF
DELTA P= 7103 PSF
Izp DEPTH= %44.000 FT
Izp= 0.634
C1= 1.0000
C2= 1.4954

X VALUE= 2.50

ESTIMATED TOTAL SETTLEMENT= 8.84 INCHES

CONE PENETROMETER SETTLEMENT ANALYSIS

DATE 11-19-1999 TIME 14:46:55

JOB NAME: Haywood County Landfill Evaluation
JOB NUMBER:VNC-99-035

FOUNDATION CHARACTERISTICS
FOUNDATION SHAPE CONTINUOUS/STRIP FOUNDATION DEPTH= 0 FT.
FOUNDATION BEARING PRESSURE= 6800.0 PSF
FOUNDATION WIDTH= 99.0 FT.

SOIL CHARACTERISTICS
SOIL DRY UNIT WEIGHT: NONCOHESIVE= 115.0 PCF COHESIVE= 105.0 PCF
SUB. UNIT WEIGHT: NONCOHESIVE= 72.4 PCF COHESIVE= 66.1 PCF
GROUND WATER DEPTH= 30.0 FT.
TIME TO SETTLEMENT= 20.00 YEARS VALUE OF Nc=10
CPT SOUNDING NUMBER:99035a

LOAD THEORY FOR COHESIVE SOILS:BOUSSINESQ

SLICE TOP (FT)	SLICE BASE (FT)	CONE qc (TSF)	P'ov MIDPT (PSF)	IZ	DELTAh SAND (IN)	SU CLAY (PSF)	SU / P'ov	CLAY CONSIS-TENCY	CC / 1+e1	I FACT	DELTA PRESS (PSF)	DELTAH CLAY (IN)
0.0	0.5	10	26			1997	76.1	STIFF	0.05	1.00	6800	0.7245
0.5	1.0	10	79			1992	25.3	STIFF	0.05	1.00	6800	0.5824
1.0	1.5	10	131			1987	15.1	STIFF	0.05	1.00	6800	0.5168
1.5	2.0	10	184			1982	10.8	STIFF	0.05	1.00	6800	0.4740
2.0	2.5	6	239	0.21	0.2963							
2.5	3.0	6	296	0.21	0.2991							
3.0	3.5	6	354	0.21	0.3019							
3.5	4.0	6	411	0.21	0.3046							
4.0	4.5	8	469	0.22	0.2306							
4.5	5.0	8	526	0.22	0.2327							
5.0	5.5	8	584	0.22	0.2348							
5.5	6.0	8	641	0.22	0.2369							
6.0	6.5	8	699	0.22	0.2390							
6.5	7.0	8	756	0.23	0.2410							
7.0	7.5	8	814	0.23	0.2431							
7.5	8.0	8	871	0.23	0.2452							
8.0	8.5	8	929	0.23	0.2473							
8.5	9.0	8	986	0.23	0.2494							
9.0	9.5	12	1044	0.24	0.1677							
9.5	10.0	12	1101	0.24	0.1691							
10.0	10.5	12	1159	0.24	0.1705							
10.5	11.0	12	1216	0.24	0.1719							
11.0	11.5	12	1274	0.24	0.1733							
11.5	12.0	12	1331	0.25	0.1747							
12.0	12.5	12	1389	0.25	0.1761							
12.5	13.0	12	1446	0.25	0.1775							
13.0	13.5	12	1504	0.25	0.1789							
13.5	14.0	12	1561	0.25	0.1802							
14.0	14.5	26	1619	0.26	0.0838							

14.5	15.0	26	1676	0.26	0.0845
15.0	15.5	26	1734	0.26	0.0851
15.5	16.0	26	1791	0.26	0.0858
16.0	16.5	26	1849	0.26	0.0864
[illegible].5	17.0	26	1906	0.27	0.0871
17.0	17.5	26	1964	0.27	0.0877
17.5	18.0	26	2021	0.27	0.0883
18.0	18.5	26	2079	0.27	0.0890
18.5	19.0	26	2136	0.27	0.0896
19.0	19.5	22	2194	0.28	0.1067
19.5	20.0	22	2251	0.28	0.1075
20.0	20.5	22	2309	0.28	0.1082
20.5	21.0	22	2366	0.28	0.1090
21.0	21.5	22	2424	0.28	0.1097
21.5	22.0	22	2481	0.29	0.1105
22.0	22.5	22	2539	0.29	0.1113
22.5	23.0	22	2596	0.29	0.1120
23.0	23.5	22	2654	0.29	0.1128
23.5	24.0	22	2711	0.29	0.1136
24.0	24.5	36	2769	0.30	0.0699
24.5	25.0	36	2826	0.30	0.0703
25.0	25.5	36	2884	0.30	0.0708
25.5	26.0	36	2941	0.30	0.0713
26.0	26.5	36	2999	0.30	0.0717
26.5	27.0	36	3056	0.31	0.0722
27.0	27.5	36	3114	0.31	0.0727
27.5	28.0	36	3171	0.31	0.0731
28.0	28.5	36	3229	0.31	0.0736
28.5	29.0	36	3286	0.31	0.0740
[illegible].0	29.5	198	3344	0.32	0.0135
29.5	30.0	198	3401	0.32	0.0136
30.0	30.5	198	3448	0.32	0.0137
30.5	31.0	198	3484	0.32	0.0138
31.0	31.5	198	3521	0.32	0.0139
31.5	32.0	198	3557	0.33	0.0140
32.0	32.5	198	3593	0.33	0.0141
32.5	33.0	198	3629	0.33	0.0141
33.0	33.5	198	3665	0.33	0.0142
33.5	34.0	198	3702	0.33	0.0143
34.0	34.5	198	3738	0.33	0.0144
34.5	35.0	198	3774	0.34	0.0145
35.0	35.5	198	3810	0.34	0.0146
35.5	36.0	198	3846	0.34	0.0146
36.0	36.5	198	3883	0.34	0.0147
36.5	37.0	198	3919	0.34	0.0148
37.0	37.5	198	3955	0.35	0.0149
37.5	38.0	198	3991	0.35	0.0150
38.0	38.5	198	4027	0.35	0.0151
38.5	39.0	198	4064	0.35	0.0152
39.0	39.5	198	4100	0.35	0.0152
39.5	40.0	198	4136	0.36	0.0153
40.0	40.5	198	4172	0.36	0.0154
40.5	41.0	198	4208	0.36	0.0155
41.0	41.5	198	4245	0.36	0.0156
41.5	42.0	198	4281	0.36	0.0157
[illegible]2.0	42.5	198	4317	0.37	0.0157
42.5	43.0	198	4353	0.37	0.0158
43.0	43.5	198	4389	0.37	0.0159
43.5	44.0	198	4426	0.37	0.0160
44.0	44.5	198	4462	0.37	0.0161

44.5	45.0	198	4498	0.38	0.0162
45.0	45.5	198	4534	0.38	0.0163
45.5	46.0	198	4570	0.38	0.0163
46.0	46.5	198	4607	0.38	0.0164
46.5	47.0	198	4643	0.38	0.0165
47.0	47.5	198	4679	0.39	0.0166
47.5	48.0	198	4715	0.39	0.0167
48.0	48.5	198	4751	0.39	0.0168
48.5	49.0	198	4788	0.39	0.0168
49.0	49.5	198	4824	0.39	0.0169
49.5	50.0	198	4860	0.40	0.0170
50.0	50.5	198	4896	0.40	0.0171
50.5	51.0	198	4932	0.40	0.0172
51.0	51.5	198	4969	0.40	0.0173
51.5	52.0	198	5005	0.40	0.0174
52.0	52.5	198	5041	0.41	0.0174
52.5	53.0	198	5077	0.41	0.0175
53.0	53.5	198	5113	0.41	0.0176
53.5	54.0	198	5150	0.41	0.0177
54.0	54.5	198	5186	0.41	0.0178
54.5	55.0	198	5222	0.42	0.0179
55.0	55.5	198	5258	0.42	0.0179
55.5	56.0	198	5295	0.42	0.0180
56.0	56.5	198	5331	0.42	0.0181
56.5	57.0	198	5367	0.42	0.0182
57.0	57.5	198	5403	0.43	0.0183
57.5	58.0	198	5439	0.43	0.0184
58.0	58.5	198	5476	0.43	0.0185
58.5	59.0	198	5512	0.43	0.0185
59.0	59.5	198	5548	0.43	0.0186
59.5	60.0	198	5584	0.44	0.0187
60.0	60.5	198	5620	0.44	0.0188
60.5	61.0	198	5657	0.44	0.0189
61.0	61.5	198	5693	0.44	0.0190
61.5	62.0	198	5729	0.44	0.0190
62.0	62.5	198	5765	0.45	0.0191
62.5	63.0	198	5801	0.45	0.0192
63.0	63.5	198	5838	0.45	0.0193
63.5	64.0	198	5874	0.45	0.0194
64.0	64.5	198	5910	0.45	0.0195
64.5	65.0	198	5946	0.45	0.0196
65.0	65.5	198	5982	0.46	0.0196
65.5	66.0	198	6019	0.46	0.0197
66.0	66.5	198	6055	0.46	0.0198
66.5	67.0	198	6091	0.46	0.0199
67.0	67.5	198	6127	0.46	0.0200
67.5	68.0	198	6163	0.47	0.0201
68.0	68.5	198	6200	0.47	0.0201
68.5	69.0	198	6236	0.47	0.0202
69.0	69.5	198	6272	0.47	0.0203
69.5	70.0	198	6308	0.47	0.0204
70.0	70.5	198	6344	0.48	0.0205
70.5	71.0	198	6381	0.48	0.0206
71.0	71.5	198	6417	0.48	0.0207
71.5	72.0	198	6453	0.48	0.0207
72.0	72.5	198	6489	0.48	0.0208
72.5	73.0	198	6525	0.49	0.0209
73.0	73.5	198	6562	0.49	0.0210
73.5	74.0	198	6598	0.49	0.0211
74.0	74.5	198	6634	0.49	0.0212

74.5	75.0	198	6670	0.49	0.0212							
75.0	75.5	198	6706	0.50	0.0213							
75.5	76.0	198	6743	0.50	0.0214							
76.0	76.5	198	6779	0.50	0.0215							
76.5	77.0	198	6815	0.50	0.0216							
77.0	77.5	198	6851	0.50	0.0217							
77.5	78.0	198	6887	0.51	0.0218							
78.0	78.5	198	6924	0.51	0.0218							
78.5	79.0	198	6960	0.51	0.0219							
79.0	79.5	198	6996	0.51	0.0220							
79.5	80.0	198	7032	0.51	0.0221							
80.0	80.5	198	7069	0.52	0.0222							
80.5	81.0	198	7105	0.52	0.0223							
81.0	81.5	198	7141	0.52	0.0223							
81.5	82.0	198	7177	0.52	0.0224							
82.0	82.5	198	7213	0.52	0.0225							
82.5	83.0	198	7250	0.53	0.0226							
83.0	83.5	198	7286	0.53	0.0227							
83.5	84.0	198	7322	0.53	0.0228							
84.0	84.5	198	7358	0.53	0.0229							
84.5	85.0	198	7394	0.53	0.0229							
85.0	85.5	198	7431	0.54	0.0230							
85.5	86.0	198	7467	0.54	0.0231							
86.0	86.5	198	7503	0.54	0.0232							
86.5	87.0	198	7539	0.54	0.0233							
87.0	87.5	198	7575	0.54	0.0234							
87.5	88.0	198	7612	0.55	0.0234							
88.0	88.5	198	7648	0.55	0.0235							
88.5	89.0	198	7684	0.55	0.0236							
89.0	89.5	198	7720	0.55	0.0237							
89.5	90.0	198	7756	0.55	0.0238							
90.0	90.5	198	7793	0.56	0.0239							
90.5	91.0	198	7829	0.56	0.0240							
91.0	91.5	198	7865	0.56	0.0240							
91.5	92.0	198	7901	0.56	0.0241							
92.0	92.5	198	7937	0.56	0.0242							
92.5	93.0	198	7974	0.57	0.0243							
93.0	93.5	198	8010	0.57	0.0244							
93.5	94.0	198	8046	0.57	0.0245							
94.0	94.5	198	8082	0.57	0.0245							
94.5	95.0	198	8118	0.57	0.0246							
95.0	95.5	198	8155	0.58	0.0247							
95.5	96.0	198	8191	0.58	0.0248							
96.0	96.5	198	8227	0.58	0.0249							
96.5	97.0	198	8263	0.58	0.0250							
97.0	97.5	198	8299	0.58	0.0251							
97.5	98.0	198	8336	0.58	0.0251							
98.0	98.5	198	8372	0.59	0.0252							
98.5	99.0	198	8408	0.59	0.0253							

SUM= 10.75 SUM= 2.30

P0= 0 PSF
DELTA P= 6800 PSF
Izp DEPTH= %99.000 FT
Izp= 0.590
C1= 1.0000
C2= 1.4602

(VALUE= 3.50

ESTIMATED TOTAL SETTLEMENT= 13.05 INCHES

CONE PENETROMETER
SETTLEMENT ANALYSIS

DATE 11-17-1999 TIME 14:23:24

JOB NAME: Haywood County Landfill Evaluation
JOB NUMBER:VNC-99-035

FOUNDATION CHARACTERISTICS
FOUNDATION SHAPE CONTINUOUS/STRIP FOUNDATION DEPTH= 0 FT.
FOUNDATION BEARING PRESSURE= 5800.0 PSF
FOUNDATION WIDTH= 99.0 FT.

SOIL CHARACTERISTICS
SOIL DRY UNIT WEIGHT: NONCOHESIVE= 120.0 PCF COHESIVE= 110.0 PCF
SUB. UNIT WEIGHT: NONCOHESIVE= 75.6 PCF COHESIVE= 69.3 PCF
GROUND WATER DEPTH= 30.0 FT.
TIME TO SETTLEMENT= 20.00 YEARS VALUE OF Nc=10
CPT SOUNDING NUMBER:99035a

LOAD THEORY FOR COHESIVE SOILS:BOUSSINESQ

SLICE TOP (FT)	SLICE BASE (FT)	CONE qc (TSF)	P'ov MIDPT (PSF)	IZ	DELTAh SAND (IN)	SU CLAY (PSF)	SU / P'ov	CLAY CONSIS-TENCY	CC / 1+e1	I FACT	DELTA PRESS (PSF)	DELTAH CLAY (IN)
0.0	0.5	10	28			1997	72.6	STIFF	0.05	1.00	5800	0.6978
0.5	1.0	10	83			1992	24.1	STIFF	0.05	1.00	5800	0.5559
1.0	1.5	10	138			1986	14.4	STIFF	0.05	1.00	5800	0.4906
1.5	2.0	10	193			1981	10.3	STIFF	0.05	1.00	5800	0.4480
2.0	2.5	6	250	0.21	0.2525							
2.5	3.0	6	310	0.21	0.2548							
3.0	3.5	6	370	0.21	0.2571							
3.5	4.0	6	430	0.21	0.2594							
4.0	4.5	8	490	0.22	0.1963							
4.5	5.0	8	550	0.22	0.1981							
5.0	5.5	8	610	0.22	0.1998							
5.5	6.0	8	670	0.22	0.2016							
6.0	6.5	8	730	0.22	0.2033							
6.5	7.0	8	790	0.23	0.2051							
7.0	7.5	8	850	0.23	0.2068							
7.5	8.0	8	910	0.23	0.2086							
8.0	8.5	8	970	0.23	0.2103							
8.5	9.0	8	1030	0.23	0.2121							
9.0	9.5	12	1090	0.24	0.1425							
9.5	10.0	12	1150	0.24	0.1437							
10.0	10.5	12	1210	0.24	0.1449							
10.5	11.0	12	1270	0.24	0.1460							
11.0	11.5	12	1330	0.24	0.1472							
11.5	12.0	12	1390	0.25	0.1484							
12.0	12.5	12	1450	0.25	0.1495							
12.5	13.0	12	1510	0.25	0.1507							
13.0	13.5	12	1570	0.25	0.1519							
13.5	14.0	12	1630	0.25	0.1530							
14.0	14.5	26	1690	0.25	0.0712							

14.5	15.0	26	1750	0.26	0.0717
15.0	15.5	26	1810	0.26	0.0722
15.5	16.0	26	1870	0.26	0.0728
16.0	16.5	26	1930	0.26	0.0733
[illegible].5	17.0	26	1990	0.26	0.0738
17.0	17.5	26	2050	0.27	0.0744
17.5	18.0	26	2110	0.27	0.0749
18.0	18.5	26	2170	0.27	0.0755
18.5	19.0	26	2230	0.27	0.0760
19.0	19.5	22	2290	0.27	0.0905
19.5	20.0	22	2350	0.28	0.0911
20.0	20.5	22	2410	0.28	0.0917
20.5	21.0	22	2470	0.28	0.0924
21.0	21.5	22	2530	0.28	0.0930
21.5	22.0	22	2590	0.28	0.0936
22.0	22.5	22	2650	0.29	0.0943
22.5	23.0	22	2710	0.29	0.0949
23.0	23.5	22	2770	0.29	0.0955
23.5	24.0	22	2830	0.29	0.0962
24.0	24.5	36	2890	0.29	0.0592
24.5	25.0	36	2950	0.30	0.0595
25.0	25.5	36	3010	0.30	0.0599
25.5	26.0	36	3070	0.30	0.0603
26.0	26.5	36	3130	0.30	0.0607
26.5	27.0	36	3190	0.30	0.0611
27.0	27.5	36	3250	0.30	0.0615
27.5	28.0	36	3310	0.31	0.0619
28.0	28.5	36	3370	0.31	0.0623
28.5	29.0	36	3430	0.31	0.0627
[illegible].0	29.5	198	3490	0.31	0.0115
[illegible].5	30.0	198	3550	0.31	0.0115
30.0	30.5	198	3599	0.32	0.0116
30.5	31.0	198	3637	0.32	0.0117
31.0	31.5	198	3674	0.32	0.0117
31.5	32.0	198	3712	0.32	0.0118
32.0	32.5	198	3750	0.32	0.0119
32.5	33.0	198	3788	0.33	0.0120
33.0	33.5	198	3826	0.33	0.0120
33.5	34.0	198	3863	0.33	0.0121
34.0	34.5	198	3901	0.33	0.0122
34.5	35.0	198	3939	0.33	0.0122
35.0	35.5	198	3977	0.34	0.0123
35.5	36.0	198	4014	0.34	0.0124
36.0	36.5	198	4052	0.34	0.0125
36.5	37.0	198	4090	0.34	0.0125
37.0	37.5	198	4128	0.34	0.0126
37.5	38.0	198	4166	0.35	0.0127
38.0	38.5	198	4203	0.35	0.0127
38.5	39.0	198	4241	0.35	0.0128
39.0	39.5	198	4279	0.35	0.0129
39.5	40.0	198	4317	0.35	0.0129
40.0	40.5	198	4354	0.35	0.0130
40.5	41.0	198	4392	0.36	0.0131
41.0	41.5	198	4430	0.36	0.0132
41.5	42.0	198	4468	0.36	0.0132
[illegible]2.0	42.5	198	4506	0.36	0.0133
42.5	43.0	198	4543	0.36	0.0134
43.0	43.5	198	4581	0.37	0.0134
43.5	44.0	198	4619	0.37	0.0135
44.0	44.5	198	4657	0.37	0.0136

44.5	45.0	198	4694	0.37	0.0137
45.0	45.5	198	4732	0.37	0.0137
45.5	46.0	198	4770	0.38	0.0138
46.0	46.5	198	4808	0.38	0.0139
[illegible]5	47.0	198	4846	0.38	0.0139
47.0	47.5	198	4883	0.38	0.0140
47.5	48.0	198	4921	0.38	0.0141
48.0	48.5	198	4959	0.39	0.0141
48.5	49.0	198	4997	0.39	0.0142
49.0	49.5	198	5034	0.39	0.0143
49.5	50.0	198	5072	0.39	0.0144
50.0	50.5	198	5110	0.39	0.0144
50.5	51.0	198	5148	0.40	0.0145
51.0	51.5	198	5186	0.40	0.0146
51.5	52.0	198	5223	0.40	0.0146
52.0	52.5	198	5261	0.40	0.0147
52.5	53.0	198	5299	0.40	0.0148
53.0	53.5	198	5337	0.41	0.0149
53.5	54.0	198	5374	0.41	0.0149
54.0	54.5	198	5412	0.41	0.0150
54.5	55.0	198	5450	0.41	0.0151
55.0	55.5	198	5488	0.41	0.0151
55.5	56.0	198	5526	0.41	0.0152
56.0	56.5	198	5563	0.42	0.0153
56.5	57.0	198	5601	0.42	0.0153
57.0	57.5	198	5639	0.42	0.0154
57.5	58.0	198	5677	0.42	0.0155
58.0	58.5	198	5714	0.42	0.0156
58.5	59.0	198	5752	0.43	0.0156
[illegible].0	59.5	198	5790	0.43	0.0157
59.5	60.0	198	5828	0.43	0.0158
60.0	60.5	198	5866	0.43	0.0158
60.5	61.0	198	5903	0.43	0.0159
61.0	61.5	198	5941	0.44	0.0160
61.5	62.0	198	5979	0.44	0.0161
62.0	62.5	198	6017	0.44	0.0161
62.5	63.0	198	6054	0.44	0.0162
63.0	63.5	198	6092	0.44	0.0163
63.5	64.0	198	6130	0.45	0.0163
64.0	64.5	198	6168	0.45	0.0164
64.5	65.0	198	6206	0.45	0.0165
65.0	65.5	198	6243	0.45	0.0165
65.5	66.0	198	6281	0.45	0.0166
66.0	66.5	198	6319	0.46	0.0167
66.5	67.0	198	6357	0.46	0.0168
67.0	67.5	198	6394	0.46	0.0168
67.5	68.0	198	6432	0.46	0.0169
68.0	68.5	198	6470	0.46	0.0170
68.5	69.0	198	6508	0.46	0.0170
69.0	69.5	198	6546	0.47	0.0171
69.5	70.0	198	6583	0.47	0.0172
70.0	70.5	198	6621	0.47	0.0173
70.5	71.0	198	6659	0.47	0.0173
71.0	71.5	198	6697	0.47	0.0174
71.5	72.0	198	6734	0.48	0.0175
[illegible]2.0	72.5	198	6772	0.48	0.0175
72.5	73.0	198	6810	0.48	0.0176
73.0	73.5	198	6848	0.48	0.0177
73.5	74.0	198	6886	0.48	0.0177
74.0	74.5	198	6923	0.49	0.0178

74.5	75.0	198	6961	0.49	0.0179							
75.0	75.5	198	6999	0.49	0.0180							
75.5	76.0	198	7037	0.49	0.0180							
76.0	76.5	198	7074	0.49	0.0181							
[illegible].5	77.0	198	7112	0.50	0.0182							
77.0	77.5	198	7150	0.50	0.0182							
77.5	78.0	198	7188	0.50	0.0183							
78.0	78.5	198	7226	0.50	0.0184							
78.5	79.0	198	7263	0.50	0.0185							
79.0	79.5	198	7301	0.51	0.0185							
79.5	80.0	198	7339	0.51	0.0186							
80.0	80.5	198	7377	0.51	0.0187							
80.5	81.0	198	7414	0.51	0.0187							
81.0	81.5	198	7452	0.51	0.0188							
81.5	82.0	198	7490	0.51	0.0189							
82.0	82.5	198	7528	0.52	0.0189							
82.5	83.0	198	7566	0.52	0.0190							
83.0	83.5	198	7603	0.52	0.0191							
83.5	84.0	198	7641	0.52	0.0192							
84.0	84.5	198	7679	0.52	0.0192							
84.5	85.0	198	7717	0.53	0.0193							
85.0	85.5	198	7754	0.53	0.0194							
85.5	86.0	198	7792	0.53	0.0194							
86.0	86.5	198	7830	0.53	0.0195							
86.5	87.0	198	7868	0.53	0.0196							
87.0	87.5	198	7906	0.54	0.0197							
87.5	88.0	198	7943	0.54	0.0197							
88.0	88.5	198	7981	0.54	0.0198							
88.5	89.0	198	8019	0.54	0.0199							
[illegible].0	89.5	198	8057	0.54	0.0199							
[illegible].5	90.0	198	8094	0.55	0.0200							
90.0	90.5	198	8132	0.55	0.0201							
90.5	91.0	198	8170	0.55	0.0201							
91.0	91.5	198	8208	0.55	0.0202							
91.5	92.0	198	8246	0.55	0.0203							
92.0	92.5	198	8283	0.56	0.0204							
92.5	93.0	198	8321	0.56	0.0204							
93.0	93.5	198	8359	0.56	0.0205							
93.5	94.0	198	8397	0.56	0.0206							
94.0	94.5	198	8434	0.56	0.0206							
94.5	95.0	198	8472	0.56	0.0207							
95.0	95.5	198	8510	0.57	0.0208							
95.5	96.0	198	8548	0.57	0.0209							
96.0	96.5	198	8586	0.57	0.0209							
96.5	97.0	198	8623	0.57	0.0210							
97.0	97.5	198	8661	0.57	0.0211							
97.5	98.0	198	8699	0.58	0.0211							
98.0	98.5	198	8737	0.58	0.0212							
98.5	99.0	198	8774	0.58	0.0213							

SUM= 9.11 SUM= 2.19

Po= 0 PSF
[illegible]LTA P= 5800 PSF
Izp DEPTH= %99.000 FT
Izp= 0.581
C1= 1.0000
C2= 1.4602

X VALUE= 3.50

ESTIMATED TOTAL SETTLEMENT= 11.31 INCHES

LOG OF BORING: P1-1D

19 Borings

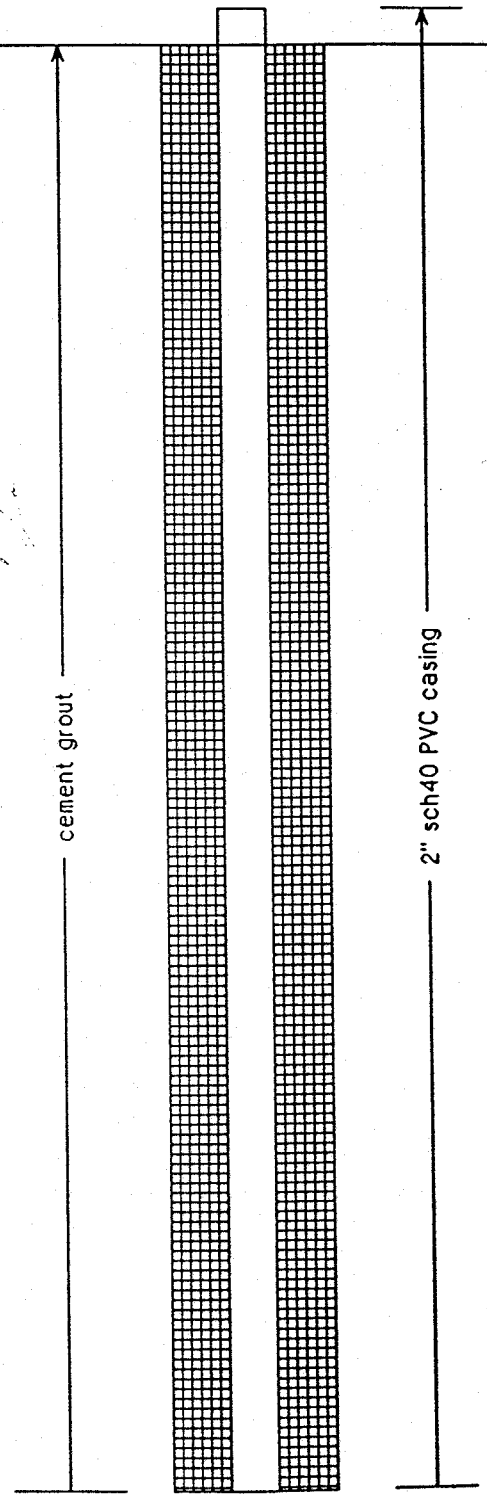
Project: Haywood County
Project No. G98010.6
Type: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2625.52ft
Top of Casing: 2627.68ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	6		X	CLAY (CL); red-brown, trace silt and sand, micaceous, some root debris and topsoil
5	11		X	SILT (ML); pink, with sand, relict structure, rust and iron staining, micaceous
10	16		X	-grades light brown to pink, relict structure, iron and rust staining on thin fractures, micaceous
15	23		X	-grades red, with zones of orange and yellow, some sand, trace clay, relict foliations
20	35		X	-grades tan to light red, weathered gneissic structure
25	18		X	-grades dark, trace sand, schistose structure, iron stained fracture
30	19		X	SILTY SAND (SM); brown to reddish orange, relict foliation at 30 degrees, white mottles
35	64		X	-grades dark brown with rust staining, zones of white silt, relict gneissic structure
40	77		X	SAND (SM); with silt, gray, relict structure

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 100.0 ft
DATE: 3/31/99

Depth to Water: 50.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____
Signature of Field Agent

LOG OF BORING: P1-1D

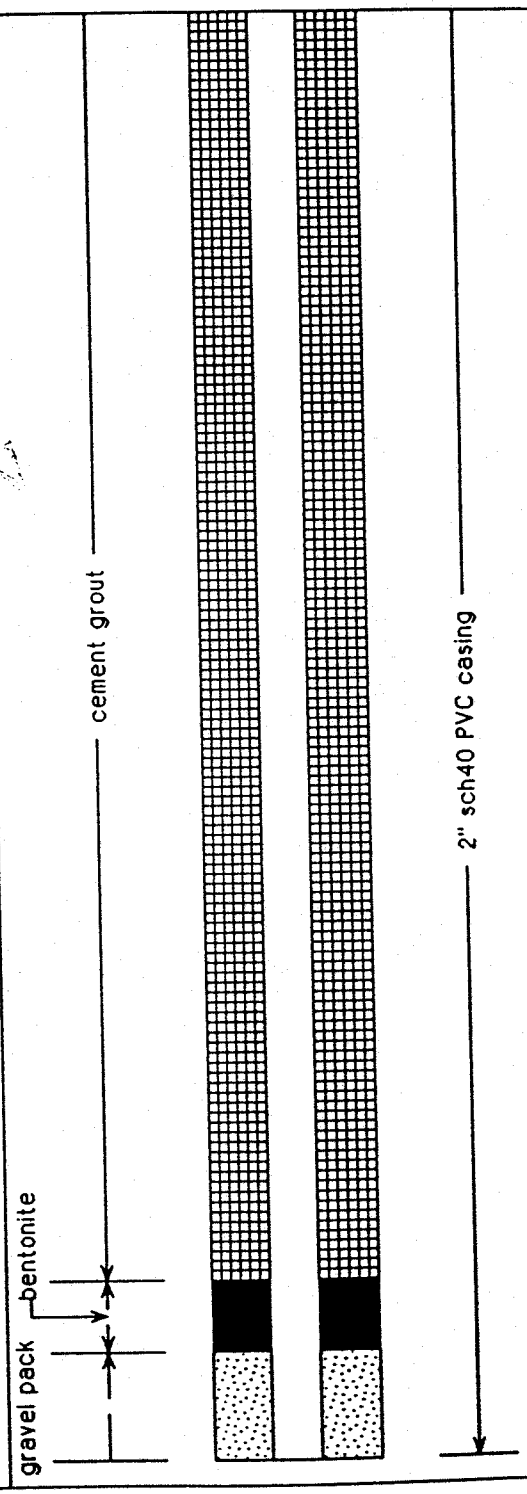
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2625.52ft
Top of Casing: 2627.68ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
				PARTIALLY WEATHERED ROCK; relict structure, hard drilling
45	ref/5.5			-grades light tan, coarse sand and rock fragments, felsic gneiss
50	50/4			-weathered gneiss, rust stained zones, coarse sand, metacrystalline structure, wet
55	50/5			-dark brown, heavily weathered mica zone, iron and rust staining, relict foliation
				SILTY SAND (SM); orange, white and black mottles, zones of fine mica, relict structure
60	36			
65	20			-gray and white weathered gneissic structure, quartz vein
				Air Rotary Bit Refusal at 70 feet
70				
				REC=94.3% RQD=28.8% light-colored w/ zones of gneissic bandings foliated meta-granitic structure, zonal variation, highly fractured w/ iron deposit
75				
80				

PIEZOMETER DIAGRAM



Completion Depth: 100.0 ft
DATE: 3/31/99

Depth to Water: 50.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

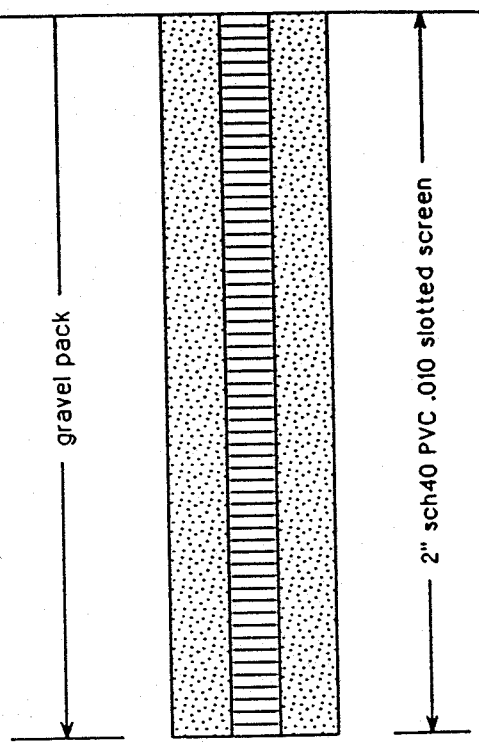
LOG OF BORING: P1-1D

Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2625.52ft
Top of Casing: 2627.68ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	PIEZOMETER DIAGRAM
85					
90					
95					
100				End of Boring at 100.0 feet	
105					
110					
115					
120					



PRELIMINARY

Completion Depth: 100.0 ft
DATE: 3/31/99

Depth to Water: 50.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Stevens Jr
Signature of Field Agent

LOG OF BORING: PT-15

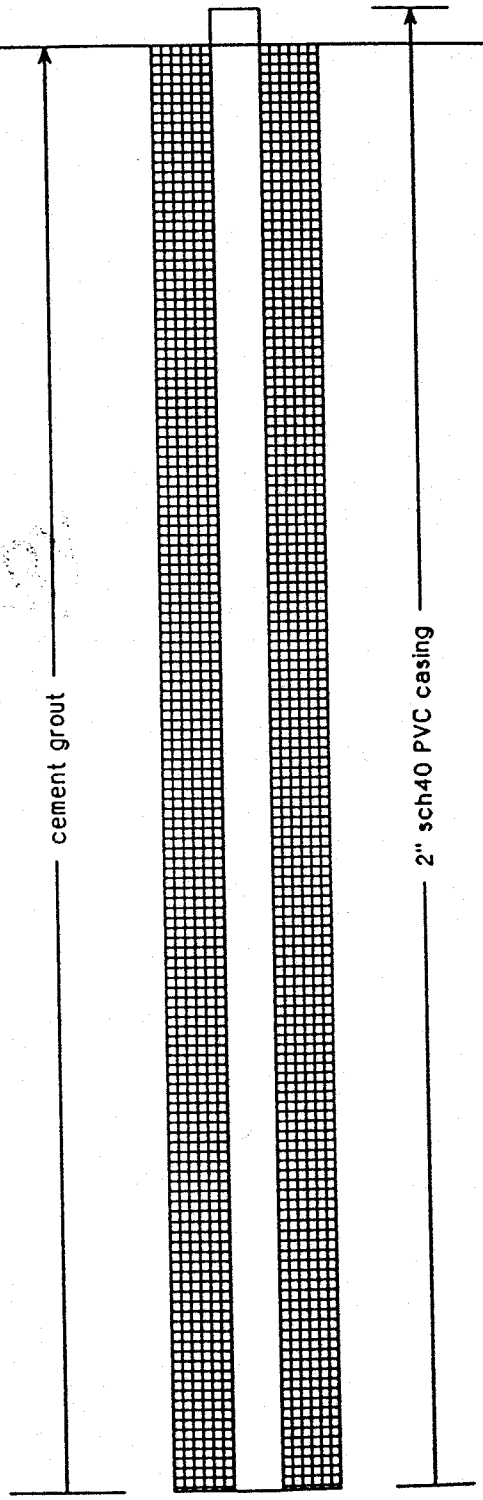
Project: Haywood County
Project No. G98010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2626.20ft
Top of Casing: 2628.07ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	6		X	CLAY (CL); red-brown, trace silt and sand, micaceous, some root debris and topsoil
5	11		X	SILT (ML); pink, with sand, relict structure, rust and iron staining, micaceous
10	16		X	-grades light brown to pink, relict structure, iron and rust staining on thin fractures, micaceous
15	23		X	-grades red, with zones of orange and yellow, some sand, trace clay, relict foliations
20	35		X	-grades tan to light red, weathered gneissic structure
25	18		X	-grades dark, trace sand, schistose structure, iron stained fracture
30	19		X	SILTY SAND (SM); brown to reddish orange, relict foliation at 30 degrees, white mottles
35	64		X	-grades dark brown with rust staining, zones of white silt, relict gneissic structure
40	77		X	SAND (SM); with silt, gray, relict structure

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 68.0 ft
DATE: 3/30/99

Depth to Water: 50.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P1-15

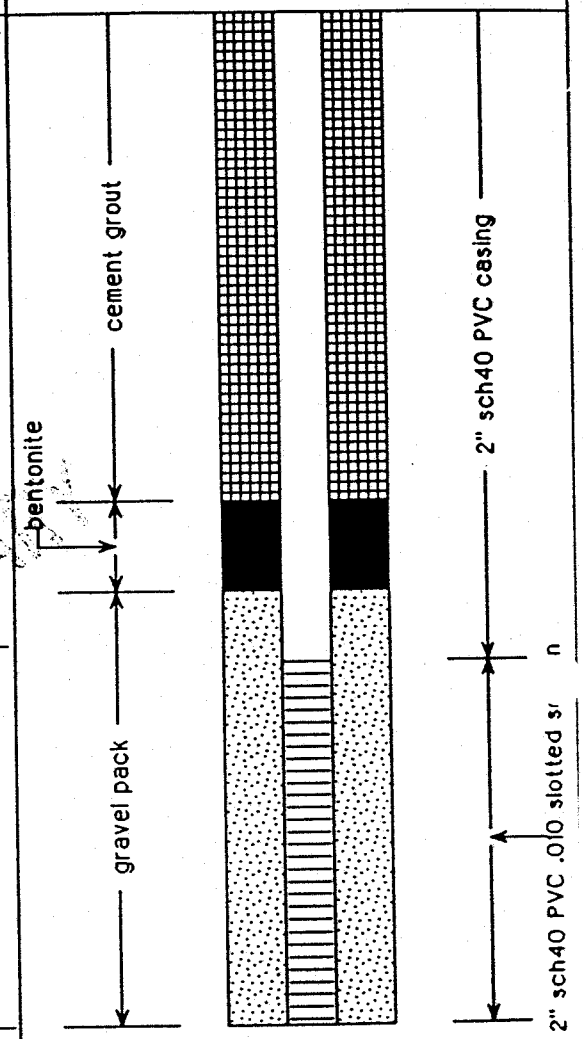
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2626.20ft
Top of Casing: 2628.07ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
				PARTIALLY WEATHERED ROCK; relict structure, hard drilling
45	ref/5.5			-grades light tan, coarse sand and rock fragments, felsic gneiss
50	50/4			-weathered gneiss, rust stained zones, coarse sand, metacrystalline structure, wet
55	50/5			-dark brown, heavily weathered mica zone, iron and rust staining, relict foliation
				SILTY SAND (SM); orange, white and black mottles, zones of fine mica, relict structure
60	36			
65	20			-gray and white weathered gneissic structure, quartz vein
				End of Boring at 68.0
70				
75				
80				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 68.0 ft
DATE: 3/30/99

Depth to Water: 50.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Skinner Jr
Signature of Field Agent

LOG OF BORING: P1-2D

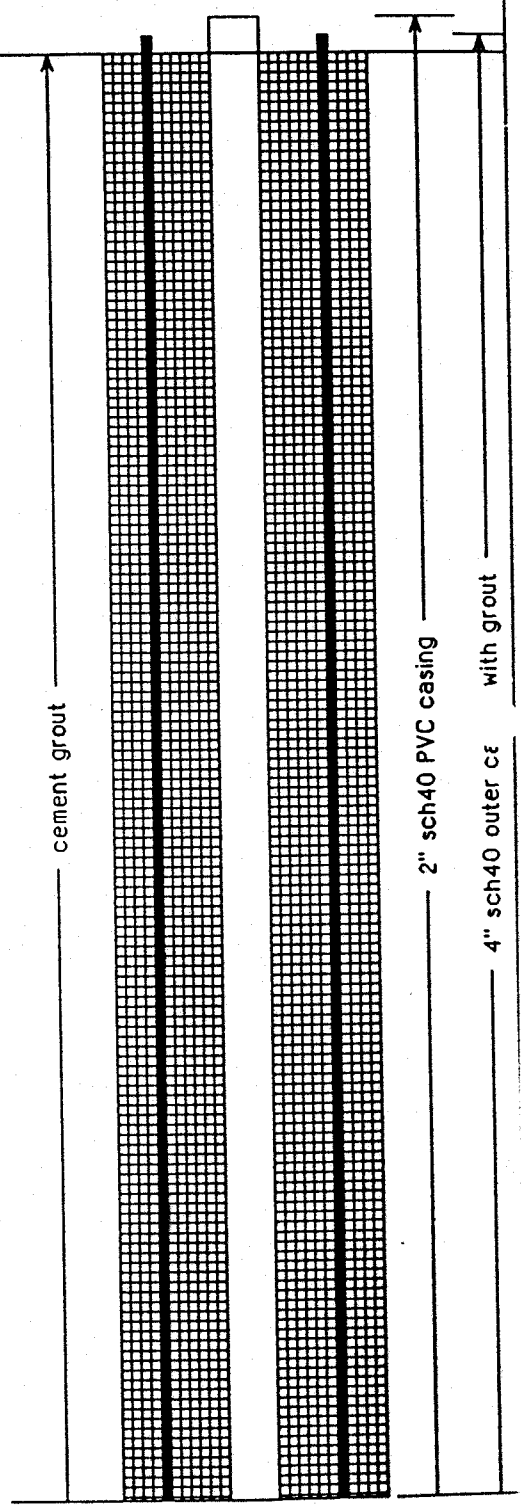
Project: Haywood County
Project No. G98010.6
Type: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2603.09ft
Top of Casing: 2604.98ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	9		X	Sandy Silt (ML); FILL MATERIAL, medium brown, no structure, few fragments
5	11		X	-FILL MATERIAL
10	15		X	-FILL MATERIAL
15	14		X	-FILL MATERIAL
20	13		X	-FILL MATERIAL
25	11		X	-FILL MATERIAL
30	13		X	-FILL MATERIAL, moist
35	10		X	-FILL MATERIAL
				SILT (ML), dark brown to black, some root debris, original ground elevation
40	4		X	-medium brown, little structure, wet

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 79.25 ft
DATE: 4/7/99

Depth to Water: 39.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P1-2D

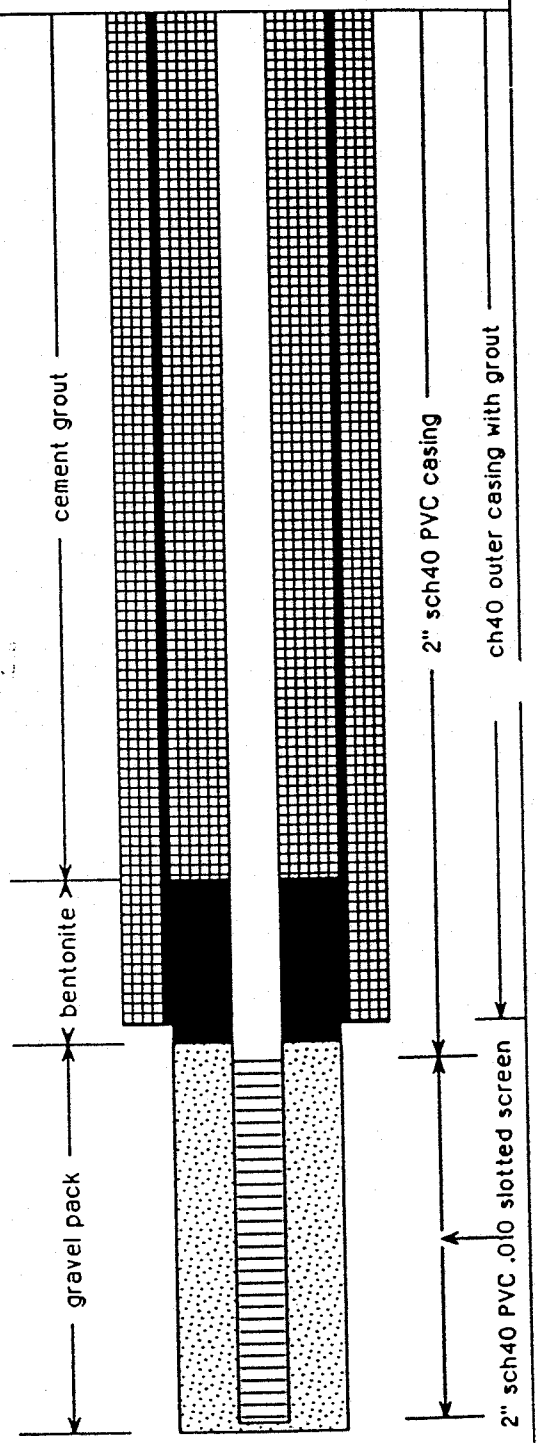
Project: Haywood County
Project No. G98010.6
Type: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2603.09ft
Top of Casing: 2604.98ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
45	8			
				SANDY SILT (ML); brown to gray, faint structure, abundant rust staining, small vertical fracture, some dark mica, wet
50	12			
55	24			-red-brown to gray, thinly layered weathered gneiss, some heavy rust staining, fine mica foliations
				-rocky zone
60	13			
65	17			
				Air Rotary Bit Refusal at 69.25 feet
70				REC=84.2% RQD=56.0% Gneiss; white, meta-granitic structure, weathered toward top, angled foliation
75				-zone of weathered saprolite, brown to yellow
80				End of Boring at 79.25 feet

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 79.25 ft
DATE: 4/7/99

Depth to Water: 39.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Shumer Jr
Signature of Field Agent

LOG OF BORING: PP 23

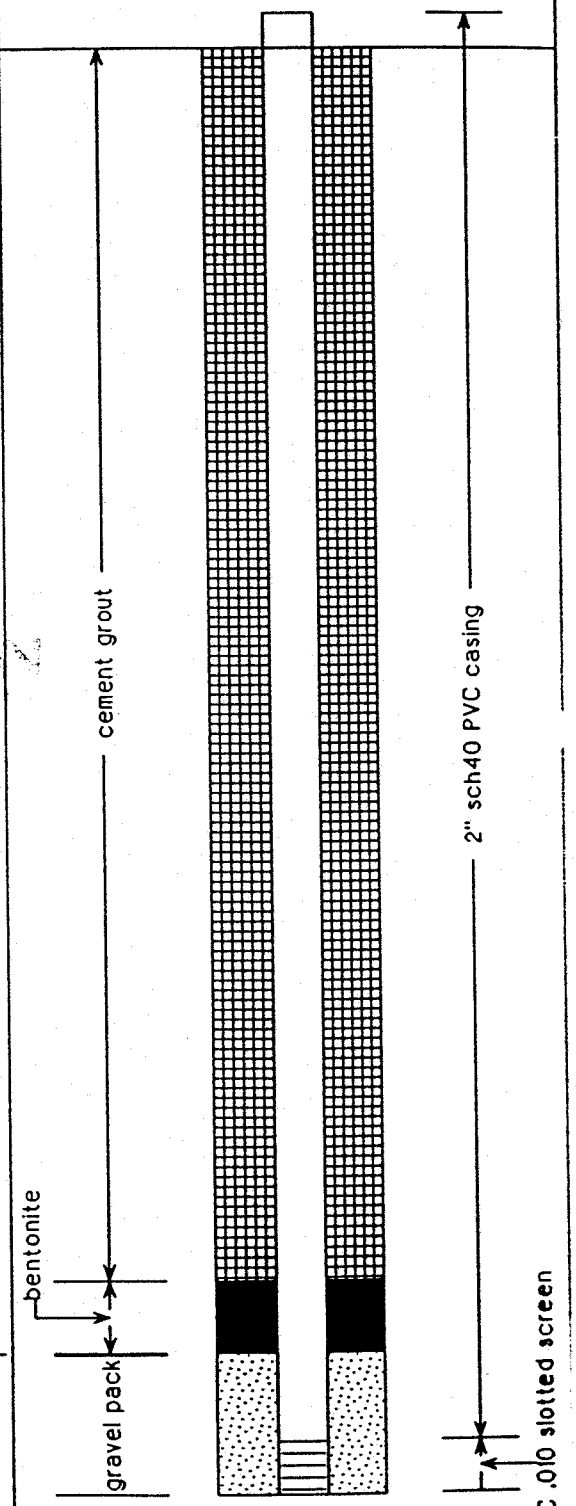
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2602.48ft
Top of Casing: 2604.01ft

DEPTH	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	9		X	Sandy Silt (ML); FILL MATERIAL, medium brown, no structure, few fragments
5	11		X	-FILL MATERIAL
10	15		X	-FILL MATERIAL
15	14		X	-FILL MATERIAL
20	13		X	-FILL MATERIAL
25	11		X	-FILL MATERIAL
30	13		X	-FILL MATERIAL
35	10		X	-FILL MATERIAL
				SILT (ML), dark brown to black, some root debris, original ground elevation
40	4		X	-medium brown, little structure, wet

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 48.5 ft
DATE: 4/7/99

Depth to Water: 40.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: Jon
Signature of Field Agent

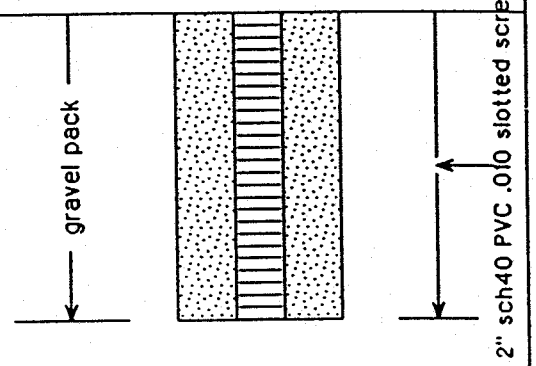
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2602.48ft
Top of Casing: 2604.01ft

DEPTH	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	8			-rocky zone from 40-41 feet
45				
				SANDY SILT (ML); brown to gray, faint structure, abundant rust staining, small vertical fracture, some dark mica, wet
50				End of Boring at 48.5 feet
55				
60				
65				
70				
75				
80				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 48.5 ft
DATE: 4/7/99

Depth to Water: 40.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Skinner Jr
Signature of Field Agent

LOG OF BORING: P1-3

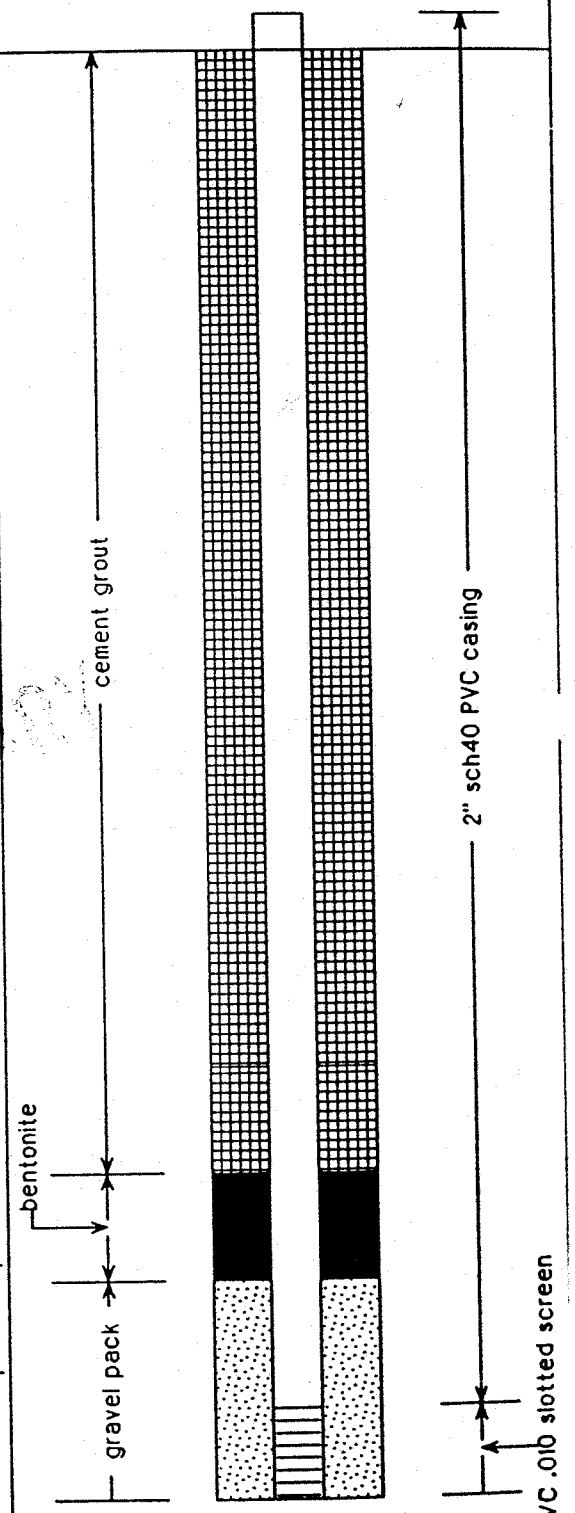
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2609.67ft
Top of Casing: 2612.35ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	4			CLAYEY SILT (ML); medium brown-red, relict structure, some root debris and mica, few rock fragments
5	22			SANDY SILT (SM); tan and pink, zones of medium-grained mica, thinly layered, saprolite of metacrystalline parent material
10	18			-thickly layered mica and white sand-silt, heavy iron staining, some rust staining
15	18			-faint layering, trace mica, relict fractures with good iron staining, rust staining abundant
20	50/5.5"			PARTIALLY WEATHERED ROCK; dark gray-green weathered schist, red clay and iron staining on relict foliations and fractures
25	50/2"			-layered mica, saturated
30	29			SANDY SILT (SM); medium brown, faint relict structure, wet
35	ref/0			PARTIALLY WEATHERED ROCK Air Rotary Bit Refusal at 36.0 feet
40				REC=80.4% RQD=34.7% grey w/regional white bandings, abundunt fractures typically parallel to foliation, highly weathered w/abundunt iron staining in upper 2 ft. of core sample

PIEZOMETER DIAGRAM



Completion Depth: 47.5 ft
DATE: 4/13/99

-noticable weathering

Depth to Water: 24 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P1-3

Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2609.67ft
Top of Casing: 2612.35ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	PIEZOMETER DIAGRAM
45				-fracture parpendicular to foliation w/iron staining	gravel pack; 2"sch40 PVC .010 slotted screen
				End of Boring at 75.0 feet	
50					
55					
60					
65					
70					
75					
80					

PRELIMINARY

Completion Depth: 47.5 ft
DATE: 4/13/99

Depth to Water: 24 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Skinner Jr.
Signature of Field Agent

LOG OF BORING: P1-4

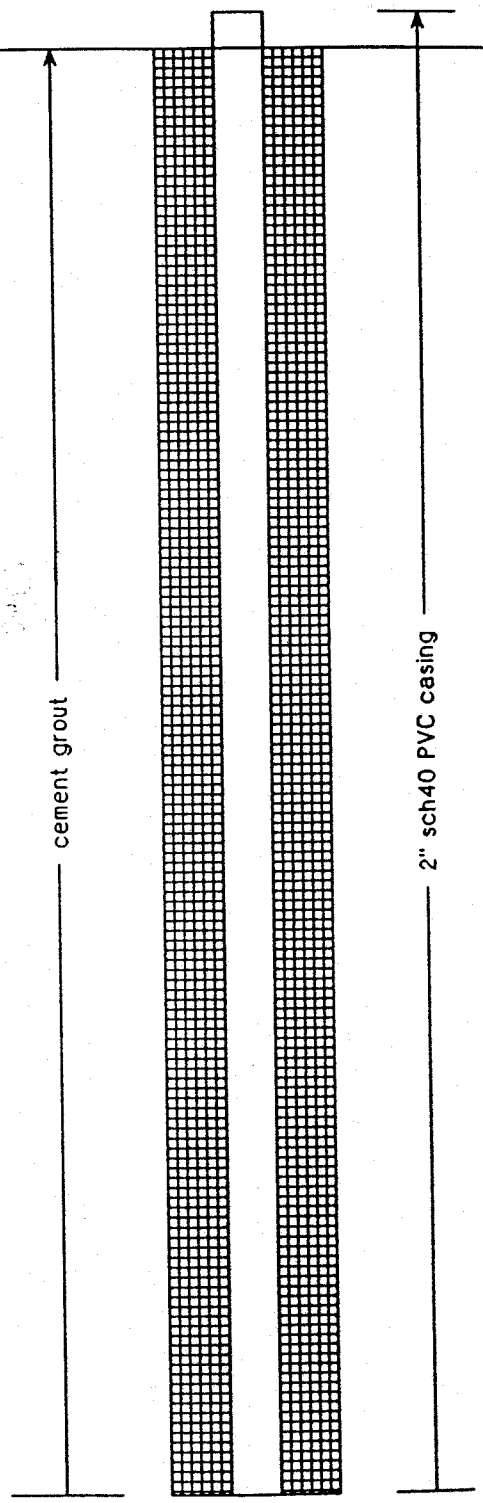
Project: Haywood County
Project No. G98010.6
pe: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2610.78ft
Top of Casing: 2613.42ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	4		X	SILT (ML): medium to dark brown, some medium and coarse sand, faint gneissic structure
	11		X	SANDY SILT (SM): tan to gray, some coarse sand, zonated with white silt and fine sand, faint relict structure
5				
	40		X	-tan to white, thin fracture with iron staining, zones of weathered mica schist
10				
	49		X	-dark brown, fine to medium sand, near vertical relict fractures with rust staining, weathered schist texture
15				
	28		X	-weathered massive metacrystalline, faint layering
20				
	46		X	-thick layered schist with iron and rust stains, zones of white medium sand and silt, moist
25				
	60		X	-some coarse sand, trace clay, moist
30				
	54		X	-less layering, moist
35				
	27		X	
40				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 72.0 ft
DATE: 4/12/99

Depth to Water: 39.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P1-4

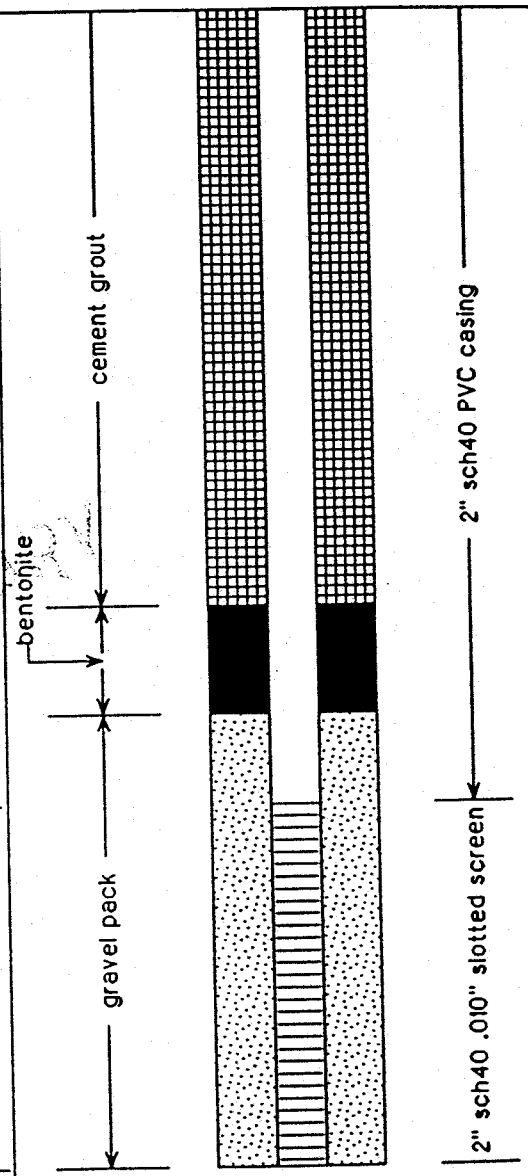
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2610.78ft
Top of Casing: 2613.42ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
				-rocky zone form 40-41 feet
	ref/4"			-few fragments, weathered gneiss
45				
50				
55				
60				Air Rotary Bit Refusal at 62.0 feet
				REC=100% RQD=70.0% gneiss; light-colored meta-granitic structure, angled micaceous foliation, mixture of lateral and angled fractures
65				-weathering w/trace amount of iron staining
				-high-angled fracture w/iron staining
70				
				End of Boring at 72.0 feet
75				
80				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 72.0 ft
DATE: 4/12/99

Depth to Water: 39.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Skaggs Jr
Signature of Field Agent

LOG OF BORING: P1-5D

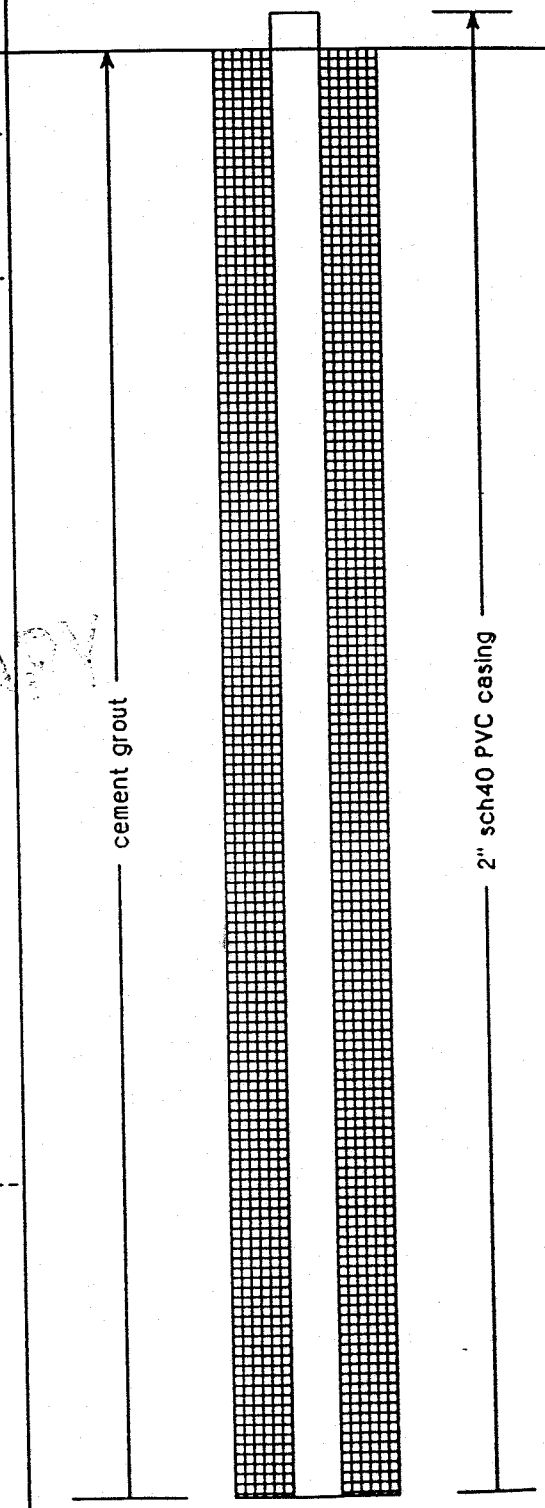
Project: Haywood County
Project No. G98010.6
Type: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2633.21ft
Top of Casing: 2635.45ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	5		X	CLAY (CL); red, with silt, some root debris, no structure
	9		X	SILT (ML); pink and white, with fine sand, trace clay, very faint relict structure
5				
	10		X	SAND (SM); white and gray, fine to medium grained, trace coarse, rust stained pits, faint gneissic structure
10				
	20		X	-grades with white sand, relict vein apparent, no structure
15				
				-hard drilling from 18-20 feet, rock fragments of metacrystalline and thick, fractured quartz
20				
	26		X	-white to yellow, medium to coarse grained, with trace rock fragments, grades to brown sand and silt with relict schistosity
25				
	91		X	-relict foliations at 30 to 45 degrees
30				
	19		X	SILT (ML); dark brown to yellow, rust staining throughout, faint relict structure, relict fracture at 45 degrees with iron and rust staining
35				
	71		X	-quartz vein from 39-41 feet
40				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 78.5 ft
DATE: 3/24/99

Depth to Water: 49.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____
Signature of Field Agent

LOG OF BORING: P1-5D

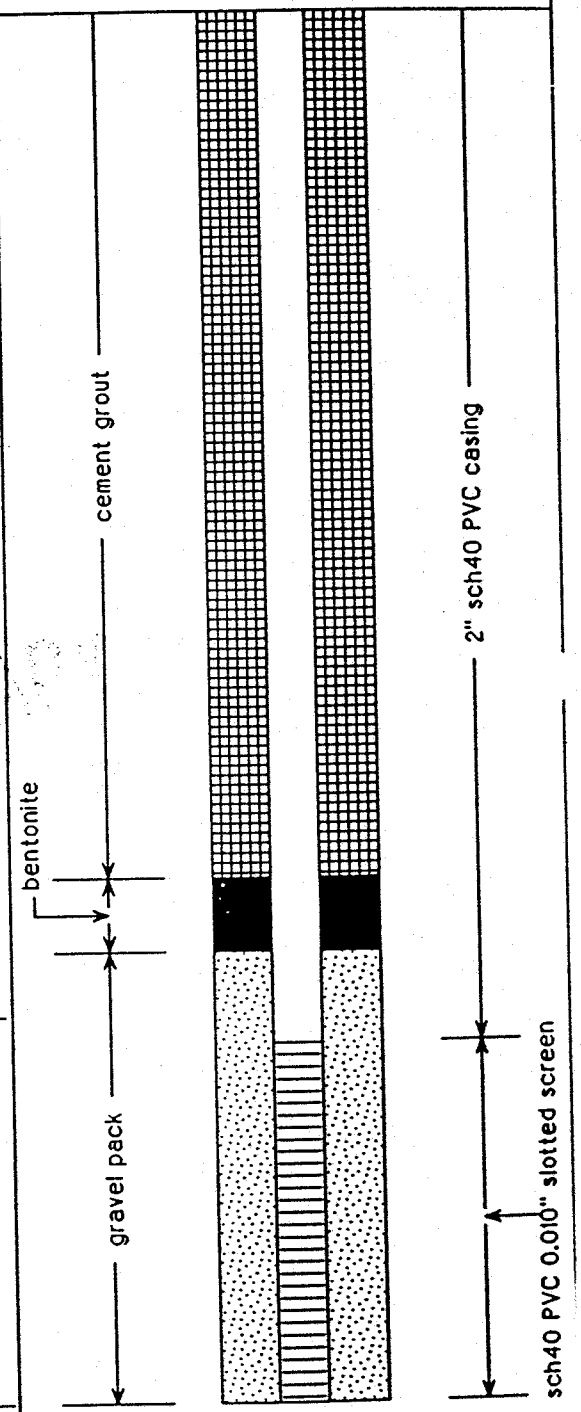
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2633.21ft
Top of Casing: 2635.45ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
45	27			
	50/5"			-white to gray, dense, trace mica and fine sand, faint structure, wet
50				Air Rotary Bit Refusal at 51.0 feet
				-PWR, A/H irregular
55				-compentent rock, A/H constant
				-PWR, A/H irregular, with rust stained quart fragments
60				-competent rock, A/H constant
65				-quartz vein with rust staining
70				REC=73.3% RQD=31.8% Gneiss; white w/regional grey layerings, zonal variation, meta-granitic structure, angled fractures throughout, heavily weathered in upper 2 ft.
				-dark-colored, zone of schist and gneiss w/thin foliation
75				-angled fractures w/iron staining
				-dark-colored, zone of shist and gneiss w/thin foliation
80				End of Boring at 78.50 feet

PIEZOMETER DIAGRAM



Completion Depth: 78.5 ft
DATE: 3/24/99

Depth to Water: 49.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P1-5S

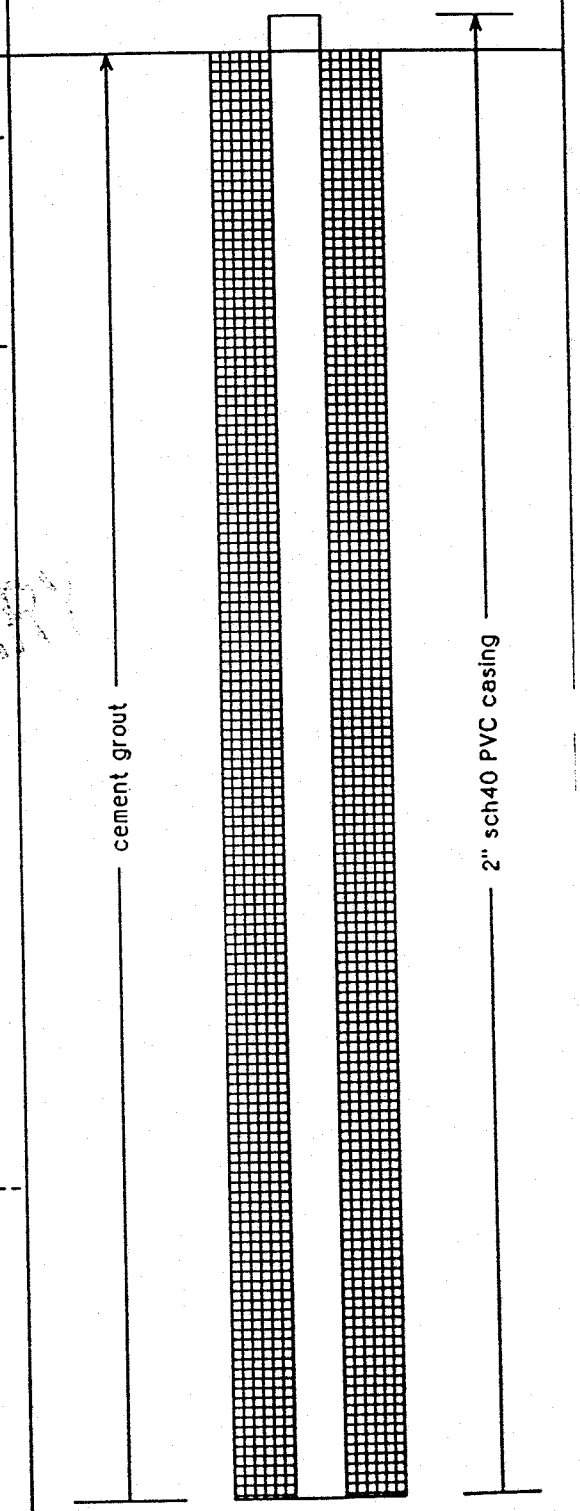
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2633.21ft
Top of Casing: 2636.07ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	5		X	CLAY (CL); red, with silt, some root debris, no structure
	9		X	SILT (ML); pink and white, with fine sand, trace clay, very faint relict structure
5				-hard drilling, rock fragments of metacrystalline and white quartz
	10		X	SAND (SM);white and gray, fine to medium grained, trace coarse, rust stained pits, faint gneissic structure
10				
	20		X	-grades with white sand, relict vein apparent, no structure
15				
				-hard drilling from 18-20 feet, rock fragments of metacrystalline and thick, fractured quartz
20				
	26		X	-white-yellow, medium to coarse grained, with trace rock fragments, grades to brown sand and silt with relict schistosity
25				
	91		X	-relict foliations at 30 to 45 degrees
30				
	19		X	SILT (ML); dark brown to yellow, rust staining throughout, faint relict structure, relcit fracture at 45 degrees with iron and rust staining
35				
	71		X	-quartz vein from 39-41 feet
40				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 58.0 ft
DATE: 3/25/99

Depth to Water: 49.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P1-5S

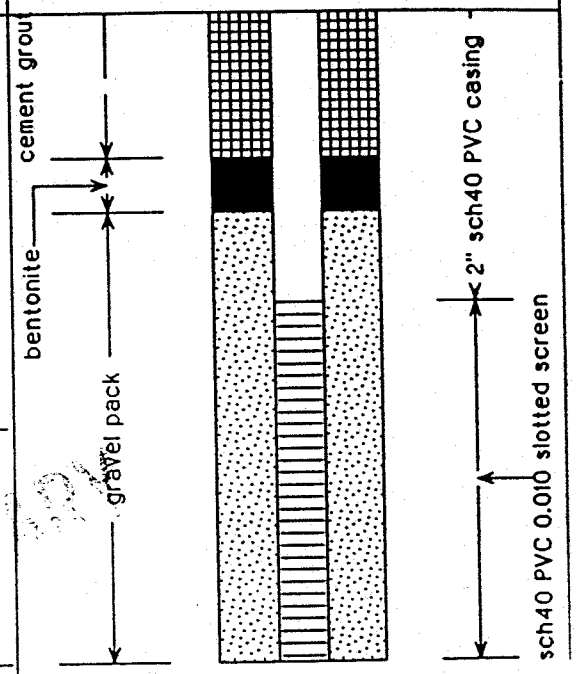
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2633.21ft
Top of Casing: 2636.07ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
45	27			
50	50/5"			-white to gray, dense, trace mica and fine sand, faint structure, wet
				-Air Rotary Bit Refusal at 51.0 feet
				-PWR, A/H irregular
55				-competent rock, A/H constant
				End of Boring at 58.0 feet
60				
65				
70				
75				
80				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 58.0 ft
DATE: 3/25/99

Depth to Water: 49.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Skinner Jr
Signature of Field Agent

LOG OF BORING: P1-6

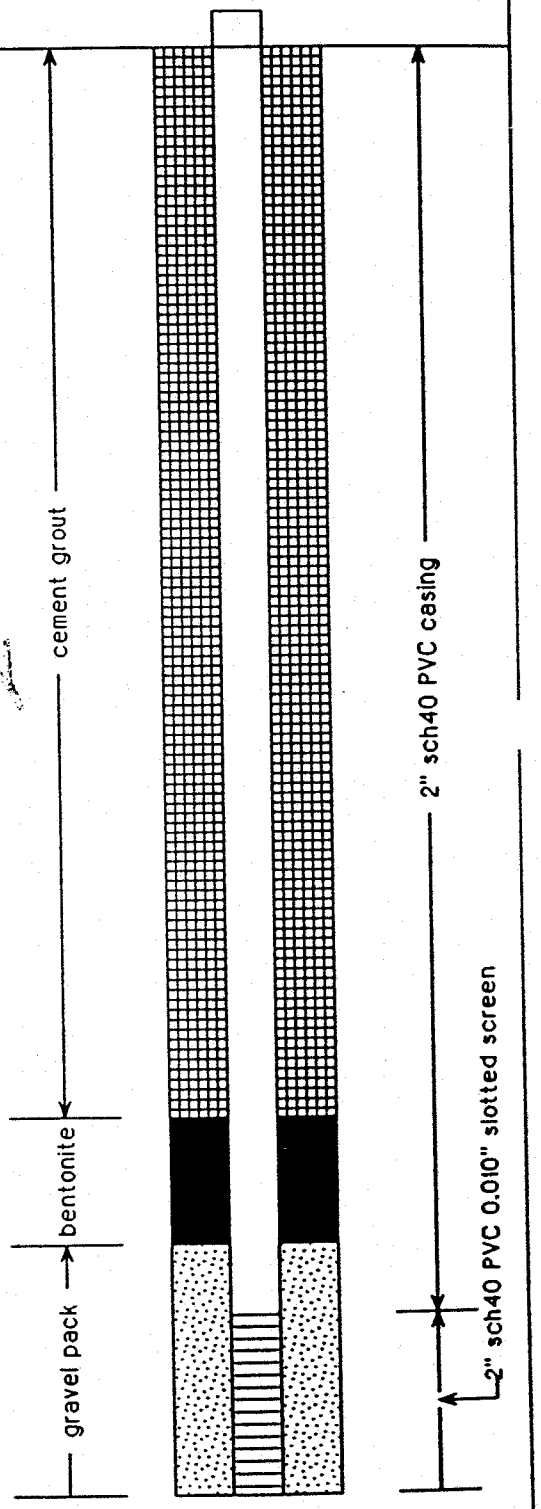
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2589.77ft
Top of Casing: 2592.18ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	7		X	SANDY SILT (SM); medium brown, some coarse grains, trace clay, no apparent structure, FILL MATERIAL
5	10		X	-FILL MATERIAL
10	10		X	-FILL MATERIAL
15	15		X	-dark brown to black, no structure, root debris apparent, original land surface
20	13		X	SILT (ML); red-brown, with sand, medium and fine-grained mica, weathered massive texture, relict foliations, abundant rust staining
25	11		X	SILTY SAND (SM); brown, some fine mica, metacrystalline texture, zone of white silt and coarse quartz sand, relict crystals, rust staining
30	11		X	-more zonal variation, gneissic texture
35	11		X	-weathered crystals replaced with fine, brown mica, wet
40	25		X	

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 45.0 ft
DATE: 4/9/99

Depth to Water: 34.5 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P1-6

Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2589.77ft
Top of Casing: 2592.18ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	PIEZOMETER DIAGRAM
45				End of Boring at 45.0 feet Air Rotary Bit Refusal > 45.9 feet	gravel pack 2" sch40 PVC 0.010" slotted screen
50					
55					
60					
65					
70					
75					
80					

PRELIMINARY

Completion Depth: 45.0 ft
DATE: 4/9/99

Depth to Water: 34.5 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Skinner Jr
Signature of Field Agent

LOG OF BORING: P1-7D

Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,SS

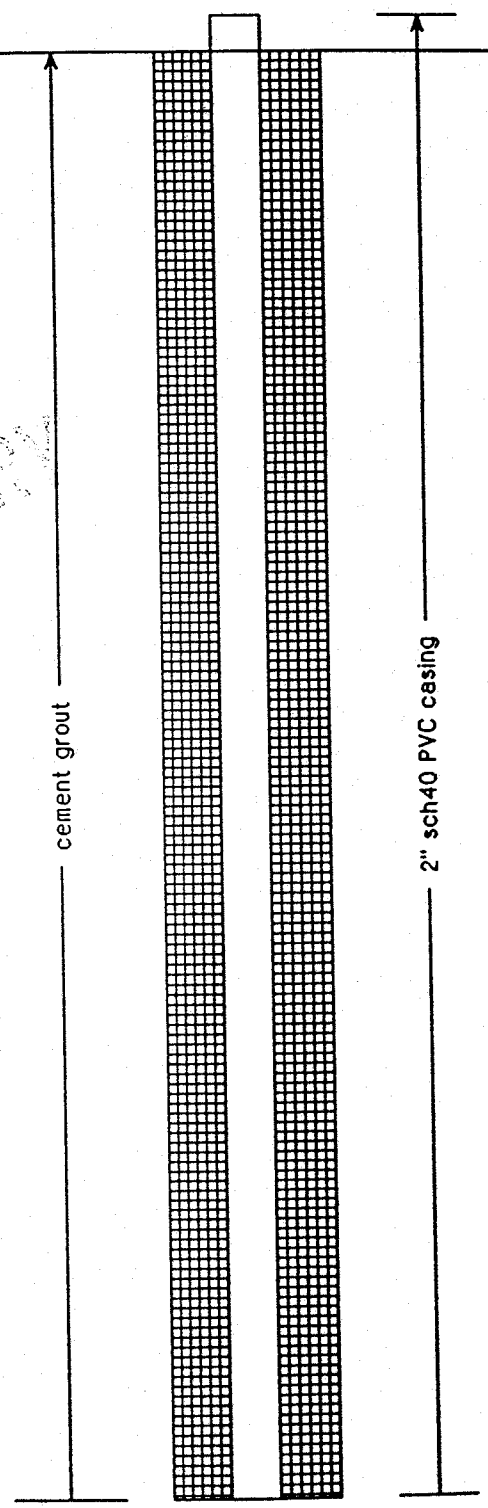
Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2575.00ft
Top of Casing: 2575.97ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	6			CLAY (CL); red-brown clay, with silt and fine sand, very faint relict structure, trace root debris
5	10			SANDY SILT (SM); medium brown to orange, micaceous, relict crstals, good relict structure, saprolite of layered schist and gneiss
				-hard drilling 7.5 to 8.5 feet
10	9			-weathered metacrystalline texture, some rust and iron staining
				Air Rotary Bit Refusal at 13.0 feet
15				GNEISS, A/H constant, fractured gniessic boulder
				-A/H irregular, brown soil and rock fragments
20				-A/H constant
				-A/H irregular
25	50/4"			-A/H constant
30				-fracture
35				
40				-fracture

PRELIMINARY

PIEZOMETER DIAGRAM



Completion Depth: 54.0 ft
DATE: 4/5/99

Depth to Water: 41.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P1-7D

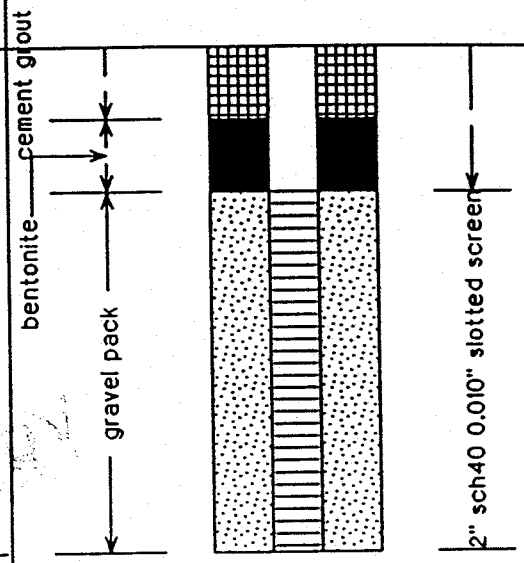
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2575.00ft
Top of Casing: 2575.97ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
				-water bearing fracture set
				-fracture set
45				-fracture
50				
55				End of Boring at 54.0 feet
60				
65				
70				
75				
80				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 54.0 ft
DATE: 4/5/99

Depth to Water: 41.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Stevens Jr
Signature of Field Agent

LOG OF BORING: P1-7S

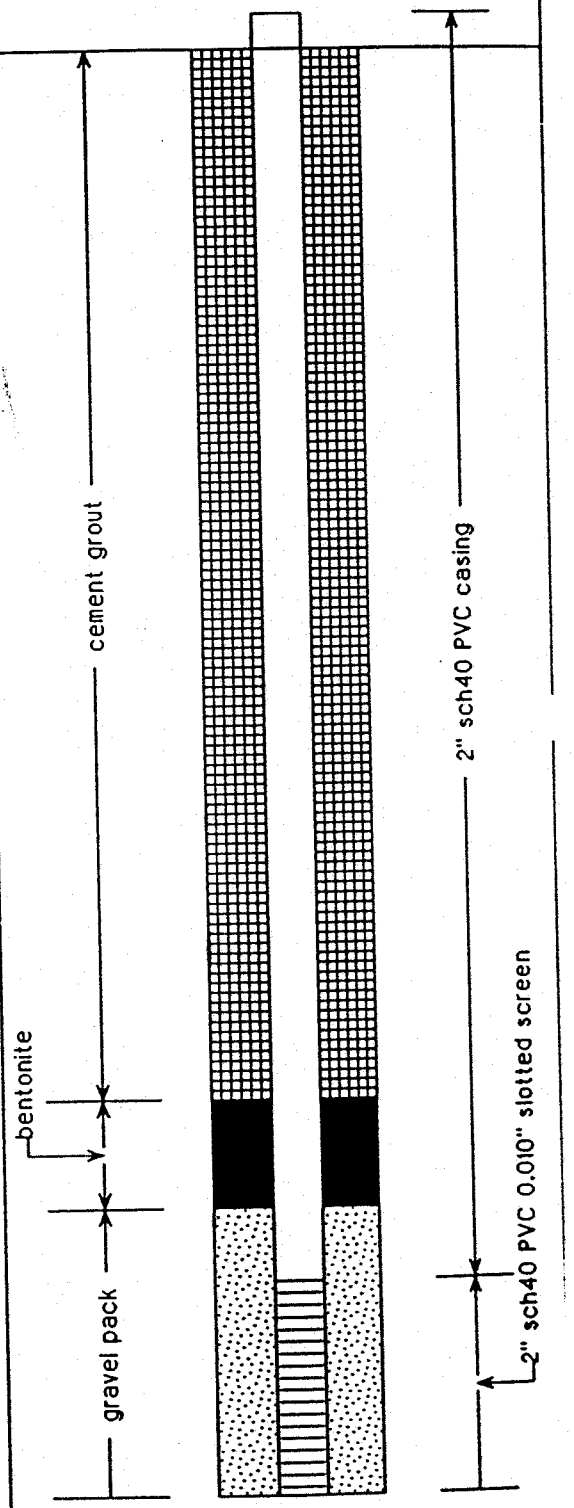
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2575.00ft
Top of Casing: 2576.76ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	6		X	CLAY (CL); red-brown clay, with silt and fine sand, very faint relict structure, trace root debris
5	10		X	SANDY SILT (SM); medium brown to orange, micaceous, relict crstals, good relict structure, saprolite of layered schist and gneiss
				-hard drilling 7.5 to 8.5 feet
10	9		X	-weathered metacrystalline texture, some rust and iron staining
				Air Rotary Bit Refusal at 13.0 feet
15				GNEISS, A/H constant, fractured gniessic boulder
				-A/H irregular, brown soil and rock fragments
20				-A/H constant
				-A/H irregular
25	50/4"		X	-A/H constant
30				-fracture
35				
40				-fracture

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 44.0 ft
DATE: 3/31/99

Depth to Water: 41.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P1-7S

Project: Haywood County
Project No. G98010.6
Type: A/R,A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2575.00ft
Top of Casing: 2576.76ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	PIEZOMETER DIAGRAM
				-water bearing fracture set	gravel pack; 2" sch40 PVC 0.010" slotted scree
45				End of Boring at 44.0 feet	
50					
55					
60					
65					
70					
75					
80					

PRELIMINARY

Completion Depth: 44.0 ft
DATE: 3/31/99

Depth to Water: 41.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Skinner
Signature of Field Agent

LOG OF BORING: P1-8D

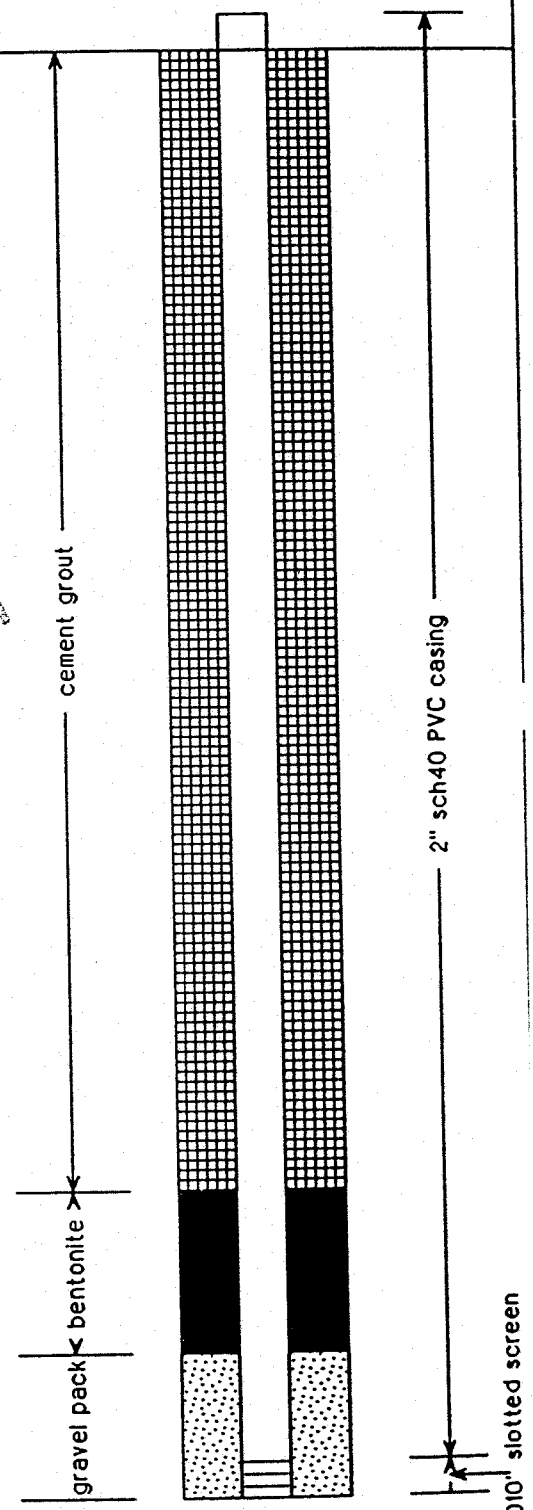
Project: Haywood County
Project No. G98010.6
Type: A/R.A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2533.52ft
Top of Casing: 2534.65ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	5		X	SILT (ML): dark brown, some organics, with sand, few fragments of weathered metagranite
5	3		X	SANDY SILT (SM): orange to gray, weathered metcrystalline rock, wet
10	4		X	-good relict metacrystlline structure, abundant rust staining, trace fine mica
15	6		X	-yellow to white with gray micaceous weathered crystals, iron and rust staining throughout, saturated
20	13		X	-dark brown and black, relict structure highly weathered gneiss and schist, zones of weathered quartz, saturated
25	11		X	-tan to gray, micaceous, zones of white weathered quartz, medium sand, trace coarse, faint relict foliation,
30	18		X	-little recovery, quartz with rust staining
35				-no sample taken due to collapsing annular
40				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 52.0 ft
DATE: 4/6/99

Depth to Water: 2.5 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: PT-8D

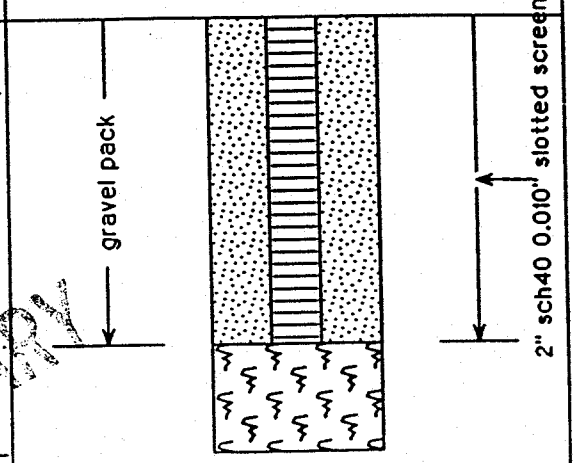
Project: Haywood County
Project No. 698010.6
Type: A/R.A/H,NX/NQ,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2533.52ft
Top of Casing: 2534.65ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
				Air Rotary Bit Refusal at 42.0 feet
45				REC=89.2% RQD=63.1% Gneiss, zonal variation, angled foliation w/zones of weathered saprolite, mixture of lateral and angled fractures some of which are accompanied by iron staining
				—brown to yellow, weathered saprolite to heavily fractured gneiss w/iron deposit
50				Annular space collapsed up to 49.0 feet
				—yellowish heavily weathered saprolite
				End of Boring at 52 feet
55				
60				
65				
70				
75				
80				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 52.0 ft
DATE: 4/6/99

Depth to Water: 2.5 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Skinner Jr.
Signature of Field Agent

LOG OF BORING: PT-85

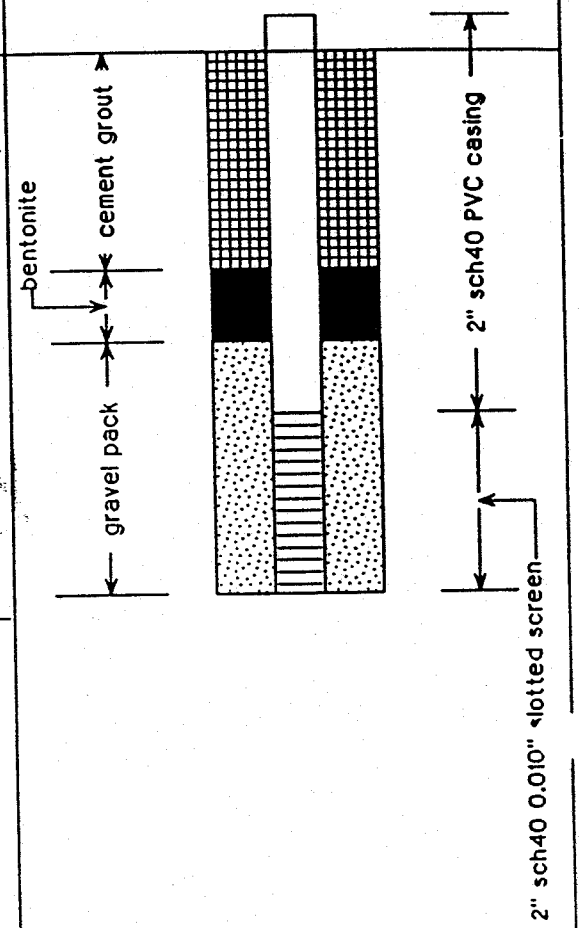
Project: Haywood County
Project No. 698010.6
Type: A/R.A/H,SS

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2534.02ft
Top of Casing: 2536.11ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	5		X	SILT (ML); dark brown, some oragnics, with sand, few fragments of weathered metagranite
	3		X	SANDY SILT (SM); orange to gray, weathered metcrystalline rock, wet
5				
	4		X	-good relict metacrystlline structure, abundant rust staining, trace fine mica
10				
	8		X	-yellow-white with gray micaceous weathered crystals, iron and rust staining throughout, saturated
15				End of Boring at 15.0 feet
20				
25				
30				
35				
40				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 15.0 ft
DATE: 4/5/99

Depth to Water: 2.5 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Skinner Jr
Signature of Field Agent

LOG OF BORING: 271

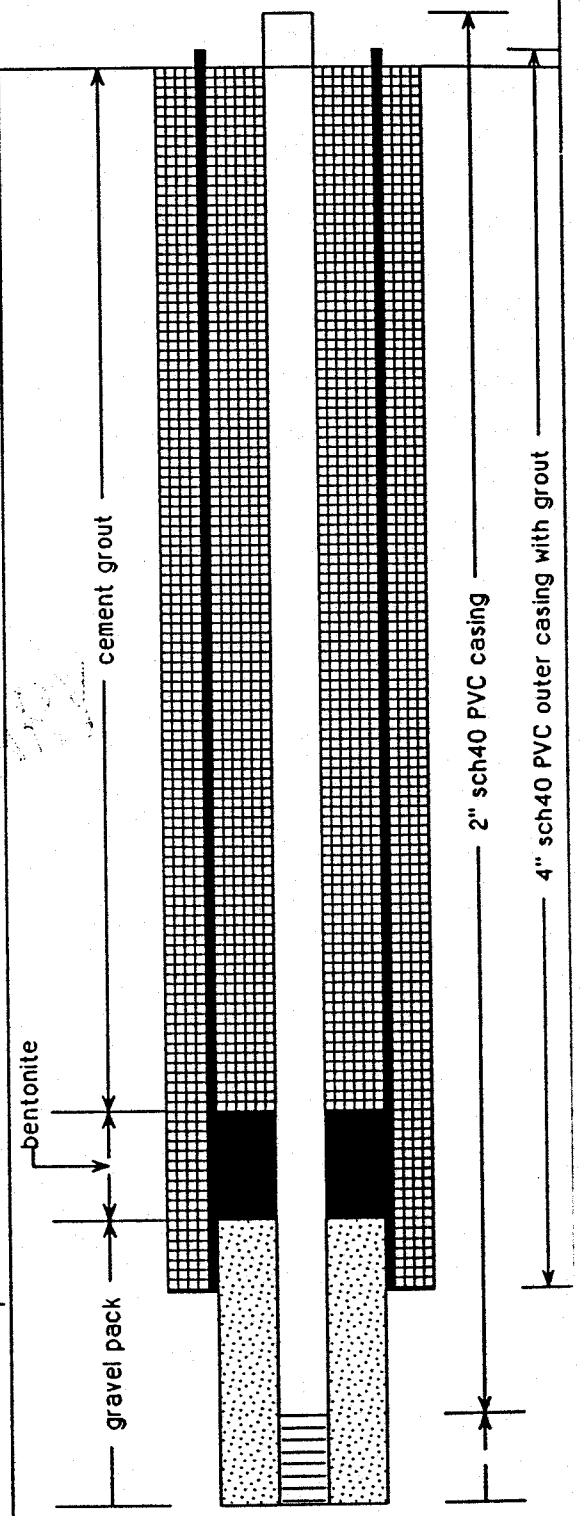
Project: Haywood County
Project No. 698010.5
Type: HSA SS NQ AH

Drilling Contractor: Graham & Currie
Registration Number: 537

Surface Elevation: 2572.74ft
Top of Casing: 2576.93ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	6			SILTY SAND (SM); brown to dark brown, some clay, root debris
5	7			-brown, with medium grained sand, some mica and trace clay, some root debris
10	11			-grades stiff, with medium to coarse grained sand and mica
15	24			-red to brown, very stiff, grades with more coarse grained sand, relict foliations, zones of clayey sand
20	26			-grades with less sand, trace clay
				-grades olive brown, silty, some clay
25	39			-salt and pepper color, dense, medium to coarse grained, some gravel, near vertical clay-filled fracture, saprolite
30	57			-grades very dense, rock fragments, gneissic structure, grades to orange weathered rock, quartz grains with sand and silt, biotite layer
				Auger Refusal at 34.0 feet
35				GNEISS; quartz, plagioclase, and mafic minerals, faint banding fractures at 30 degrees, REC=92%, RQD=79%
				-highly weathered zone, REC=59%, RQD=0%
40				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 52.5 ft
DATE: 5/21/98

Depth to Water: 37 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____
Signature of Field Agent

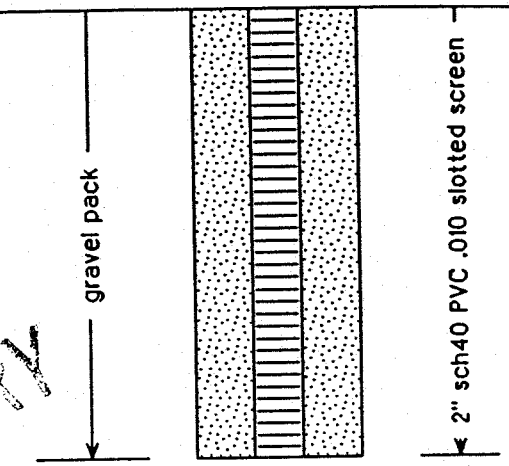
LOG OF BORING: 2-1

Project: Haywood County
Project No. G98010.5
Type: HSA SS NQ AH

Drilling Contractor: Graham & Currie
Registration Number: 537

Surface Elevation: 2572.74ft
Top of Casing: 2576.93ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	PIEZOMETER DIAGRAM
				-REC=85%, RQD=52%	
45				-slightly weathered, fractures parallel to banding at 30 degrees REC=100%, RQD=92%	gravel pack; 2" sch40 PVC .010 slotted screen
50					
				End of Boring at 52.5 feet	
55					
60					
65					
70					
75					
80					



PRELIMINARY

Completion Depth: 52.5 ft
DATE: 5/21/98

Depth to Water: 37 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P2-2

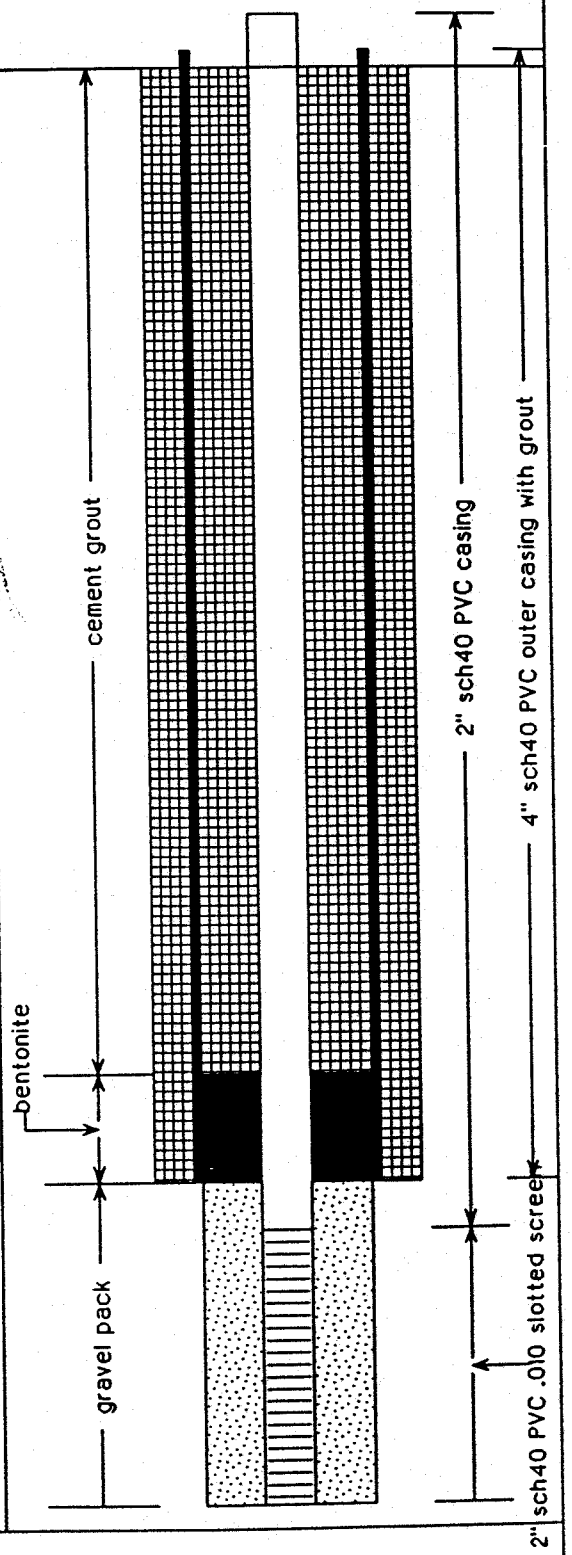
Project: Haywood County
Project No. G98010.5
Type: HSA SS AH

Drilling Contractor: Graham & Currie
Registration Number: 537

Surface Elevation: 2573.66ft
Top of Casing: 2574.13ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	5			SILT (ML); tan to brown, firm, with medium to coarse grained sand, root debris
5				SILTY SAND (SM); olive brown to brown, little clay
10	10			SAND (SP); black/white, medium dense, fine to coarse grained; rock fragments, relict foliation, with quartz and biotite; iron stains
15	24			SANDY SILT (ML); tan-orange, medium dense, fine sand with some coarse grains, relict foliation, vertical fracture with iron mineralization, micaceous
20	20			SILTY SAND (SM); dark brown and black, medium dense, rust staining, highly weathered quartz grains, relict foliatioin at 45 degrees with iron staining
25	29			-grades black and white with yellow stains, coarse quartz grains, micaceous iron staining, relict foliation
30	50/5			SAND (SP); white-yellow, very dense, medium to coarse grained, with gravel, relict foliation Auger Refusal at 31.0 feet
35				GNEISS
40				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 47.3 ft
DATE: 5/21/98

Depth to Water: 33 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____
Signature of Field Agent

LOG OF BORING: P2-2

Project: Haywood County
Project No. G98010.5
Type: HSA SS AH

Drilling Contractor: Graham & Currie
Registration Number: 537

Surface Elevation: 2573.66ft
Top of Casing: 2574.13ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	PIEZOMETER DIAGRAM
45					gravel pack; 2" sch40 PVC .010 slotted screen
				End of Boring at 47.3 feet	
50					
55					
60					
65					
70					
75					
80					

PRELIMINARY

Completion Depth: 47.3 ft
DATE: 5/21/98

Depth to Water: 33 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____
Signature of Field Agent

LOG OF BORING: P-10

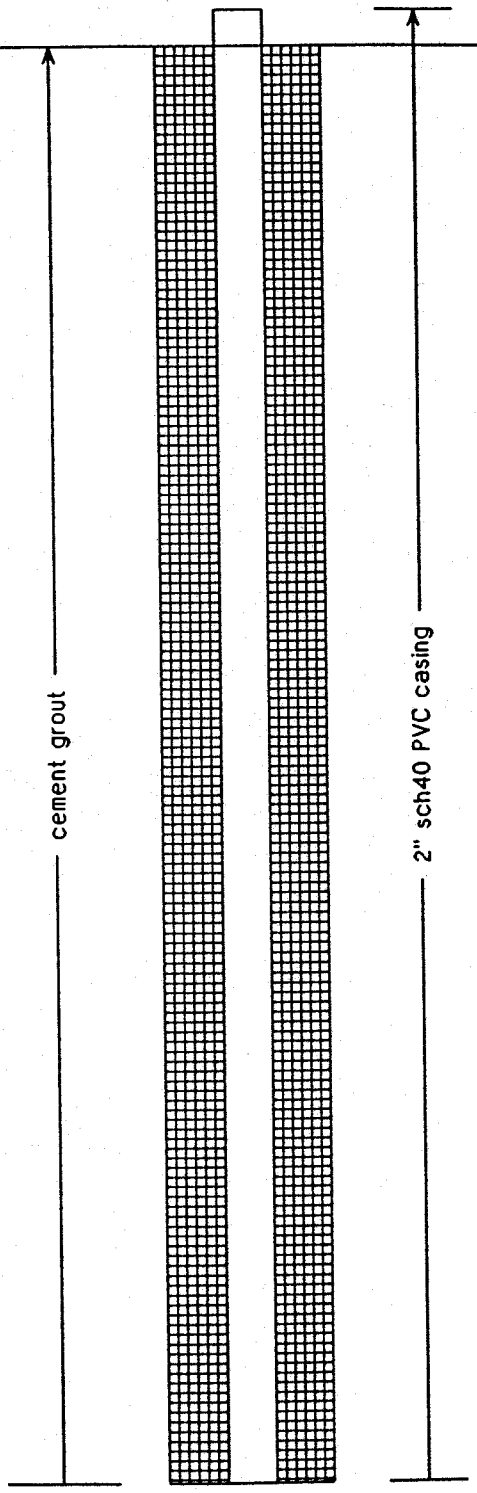
Project: Haywood County
Project No. G98010.5
Type: HSA SS

Drilling Contractor: Graham & Currie
Registration Number: 537

Surface Elevation: 2579.49ft
Top of Casing: 2581.86ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	5		X	SILT (ML); pink-brown, firm, with sand and clay, trace mica, relict structure
5	7		X	-grades with weathered zones of biotite
	12		X	SANDY SILT (ML); olive green to brown, medium dense, fine to coarse sand, relict structure, weathered relict crystals, some mica
10	17		X	SILT (ML); brown to white, very stiff, trace fine sand and rock fragments, layers of mica
15	26		X	SANDY SILT (ML); red to brown, medium dense, sand medium grained, zones of muscovite
20	32		X	-grades brown, dense, fine sand, rock fragments, iron stained, relict gneissic layering
25	31		X	-grades brown to rust colored, poorly sorted sand, rock fragments relict structure
30	34		X	-grades with rock fragments
35	50/4		X	-grades very dense, relict gneissic structure, rust staining
40				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 73.0 ft
DATE: 3/19/98

Depth to Water: 52 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____
Signature of Field Agent

LOG OF BORING: P-10

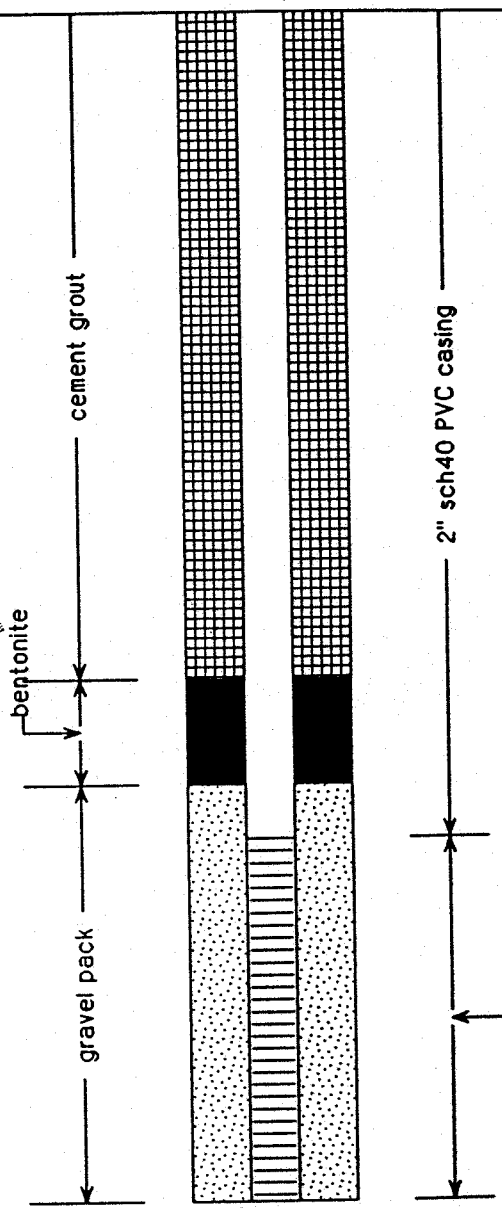
Project: Haywood County
Project No. G98010.5
Type: HSA SS

Drilling Contractor: Graham & Currie
Registration Number: 537

Surface Elevation: 2579.49ft
Top of Casing: 2581.86ft

DEPTH	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
45	38		X	-grades moist, dense, gneissic structure, trace coarse sand, some mica
50	18		X	-grades medium dense, with mica and trace clay, iron stained relict fracture
55	27		X	-grades wet
60	25		X	-grades with more clay
65	50/4		X	-grades very dense, relict foliation near vertical
70	50/5		X	-grades with black and white relict layering
75				End of Boring at 73.0 feet
80				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 73.0 ft
DATE: 3/19/98

Depth to Water: 52 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____ Signature of Field Agent

LOG OF BORING: P-12

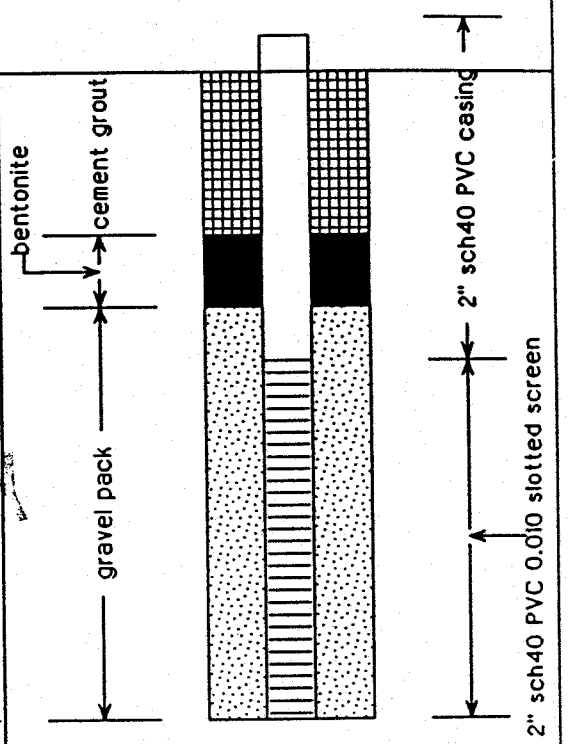
Project: Haywood County
Project No. G98010.5
Type: HSA,SS

Drilling Contractor: Graham & Currie
Registration Number: 537

Surface Elevation: 2555.29ft
Top of Casing: 2557.56ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	7		X	SILTY CLAY (CL); Dark brown, damp, firm, some coarse sand, trace fine mica
5	12		X	SILT (ML); Tan to brown, moist, stiff, faint relict structure, some fine mica and coarse sand, trace clay
10	8		X	-grades medium to dark brown, saturated, firm, with medium and coarse sand, 1" layer of gravel at 8'
15	12		X	SILTY SAND (SM); brown with yellow-orange mottles, saturated, stiff, relict gneissic banding, coarse grained
20				End of Boring at Auger Refusal 18.0 feet
25				
30				
35				
40				

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 18.0 ft
DATE: 3/13/98

Depth to Water: 8.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____
Signature of Field Agent

LOG OF BORING: P-12D

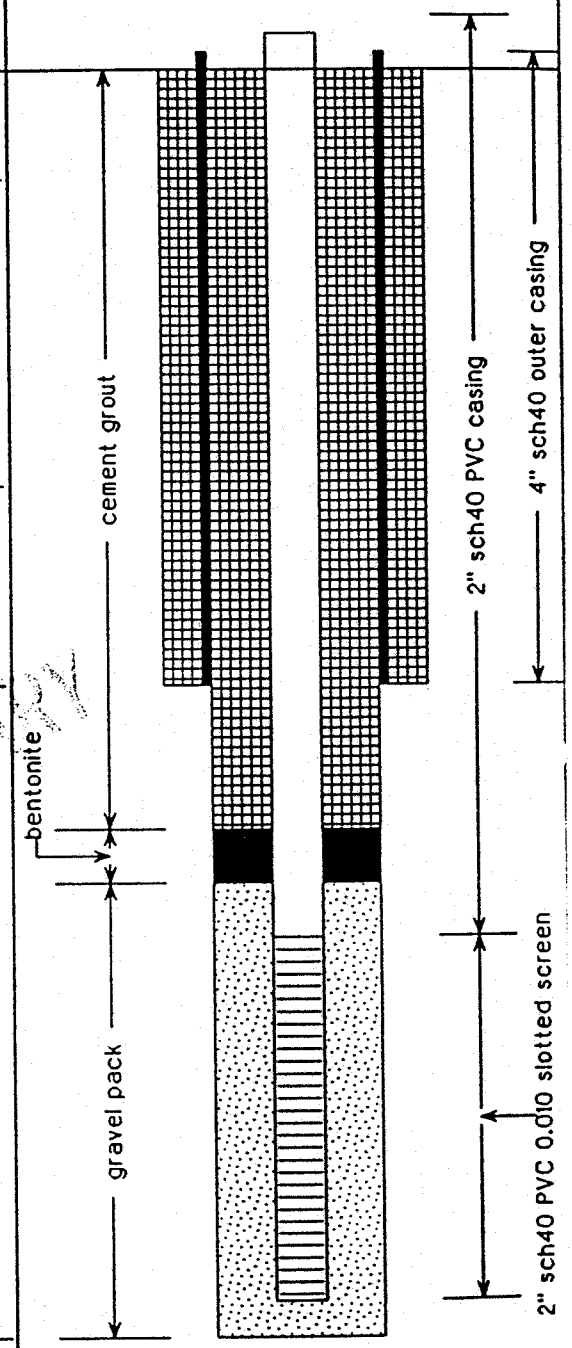
Project: Haywood County
Project No. 698010.6
Type: A/R,A/H

Drilling Contractor: Engineering Tectonics
Registration Number: 835

Surface Elevation: 2554.58ft
Top of Casing: 2555.83ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	7			SILTY CLAY (CL); Dark brown, damp, firm, some coarse sand, trace fine mica
5	12			SILT (ML); Tan to brown, moist, stiff, faint relict structure, some fine mica and coarse sand, trace clay
10	8			-grades medium to dark brown, saturated, firm, with medium and coarse sand, 1" layer of gravel at 8 feet
15	12			SILTY SAND (SM); brown with yellow-orange mottles, saturated, stiff, relict gneissic banding, coarse grained
				Air Rotary Bit Refusal at 17.0 feet
20				GNEISS, meta-granitic texture, slightly weathered, some iron deposit on surface
				-A/H irregular, saprolite and weathered fracture zone
25				-A/H irregular, saprolite and weathered fracture zone
30				
35				End of Boring at 35.0 feet
40				

PIEZOMETER DIAGRAM



Completion Depth: 35.0 ft
DATE: 4/6/99

Depth to Water: 8.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: James A. Skynner Jr
Signature of Field Agent

LOG OF BORING: P-13

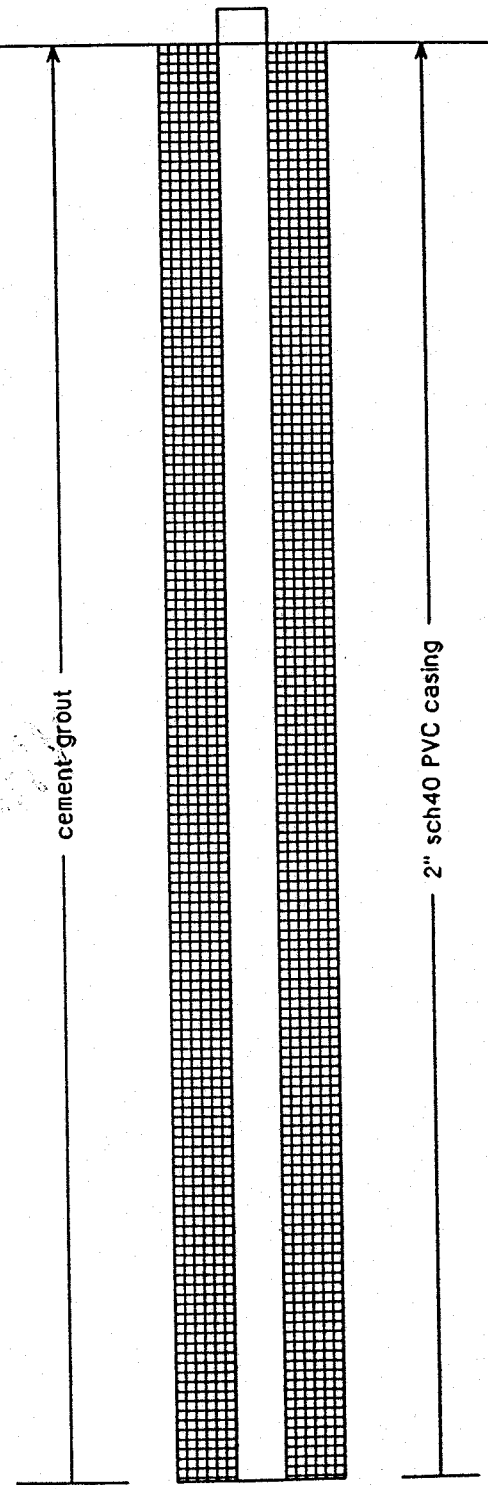
Project: Haywood County
Project No. 698010.5
Type: HSA SS

Drilling Contractor: Graham & Currie
Registration Number: 537

Surface Elevation: 2671.66ft
Top of Casing: 2675.69ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
	9		X	SILT (ML), red, stiff, with mica, relict iron mineralization
5	12		X	-red to purple, relict foliation, trace mica and fine to medium sand
10	13		X	-grades with white mottles, relict foliation
15	18		X	-grades with black mottles, very stiff
20	30		X	-grades with zones of orange coarse sand
25	26		X	SANDY SILT (ML); tan to pink, black and white rock fragments, medium dense
30	44		X	-grades dense, with coarse grains and small rock fragments
35	34		X	SILT (ML); purple to brownish red, hard, saprolite, some mica
40	41		X	SANDY SILT (ML); dark red with white and black mottles,

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 96.0 ft
DATE: 4/21/98

Depth to Water: 84.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____
Signature of Field Agent

LOG OF BORING: P-13

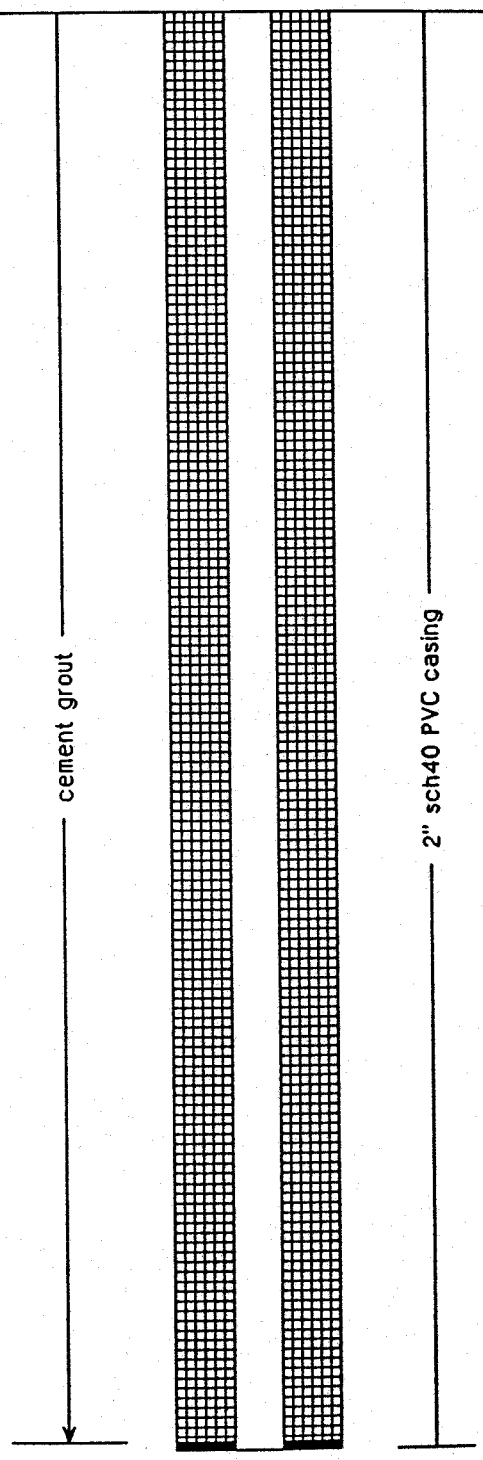
Project: Haywood County
Project No. G98010.5
Type: HSA SS

Drilling Contractor: Graham & Currie
Registration Number: 537

Surface Elevation: 2671.66ft
Top of Casing: 2675.69ft

DEPTH (ft)	BLOWS PER FOOT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL
			X	saprolite, medium to coarse grained sand, iron mineralization on relict foliation
45	30		X	-grades with mica, rust staining on mica surfaces
50	51		X	-grades with quartz fragments and coarse sand
55	29		X	-grades with fine sand and rust stained schistose layers
60	68		X	-grades with medium grained sand and biotite, relict foliation
65	27		X	-grades with fine grained sand and trace coarse sand
70	29		X	-grades dark brown with trace clay
75	31		X	-grades with fine sand, less clay, lighter color, relict foliation
80	69		X	

PIEZOMETER DIAGRAM



PRELIMINARY

Completion Depth: 96.0 ft
DATE: 4/21/98

Depth to Water: 84.0 ft WD

MUNICIPAL ENGINEERING SERVICES COMPANY, P.A.

I acknowledge that this record is true to the best of my knowledge: _____
Signature of Field Agent

2.2.8 Technical References

1. "Lining of Waste Impoundment and Disposal Facilities", (U.S.) Environmental Protection Agency, March 1983.

2. "NSF International (NSF) Standard 54 Flexible Membrane Liner", The NSF Joint Committee on Flexible Membrane Liners, 1991.

3. "Geosynthetic Design Guidance for Hazardous Waste Landfill Cells and Surface Impoundments", S & M E Inc. for the USEPA, December 1987, pgs EPA III-21 to EPA III-49.

4. James K. Mitchell, Raymond B. Seed, and H. Bolton Seed, "Kettleman Hill Waste Landfill Slope Failure I: Liner-System Properties" in Journal of Geotechnical Engineering, April 1 1990, pgs 647-668.

5. Joseph E. Bowls, Foundation Analysis and Design, 4th ed, 1988, Page 141, Table 3-4.

6. Soil Dynamics, Deep Stabilization, and Special Geotechnical Construction, NAVFACS, Design Manual 7.3, April 1983, Page 7.3-78.

7. Design, Construction and Monitoring of Landfills, Second Edition, Amalendu Bagchi, Wisconsin Department of Natural Resources, Pages 178-238.

2.2.9 Applicable Location Restriction Demonstrations

All location restrictions were handled in the site study with the exception of the seismic impact zone which is covered in the Hydrogeologic Study.

2.3 Engineering Drawings

SECTION 3.0

MATERIALS AND CONSTRUCTION PRACTICES

All tests indicated in this section are described in Section 4.0 Construction Quality Assurance Plan. Tests mentioned in this section are the same tests indicated in Section 4.0.

3.1 Construction Sequence

1. Clear all areas necessary for construction of Riser Basins.
2. Construct Riser Basins.
3. Permanently seed all disturbed areas.
4. Clear all areas necessary for construction of Diversion Ditches.
5. Construct Diversion Ditches.
6. Permanently seed all disturbed areas.
7. Prepare Subbase.
8. Construct Base Liner System.
9. Construct Penetrations.
10. Construct Protective cover over the Base Liner System.
11. Excavate the Leachate Trenches.
12. Construct Leachate Collection System.
13. Construct the Sewer Line From Leachate Collection System to the Lagoon.
14. Permanently seed any disturbed areas

3.2 Subbase

The fill subgrade will be placed in 8" loose lifts and compacted to at least 95% of maximum dry density and near optimum moisture contents; as determined by Standard Proctor Compaction Test (ASTM D698)' in 6" compacted lifts. Each compacted lift will be tested at one test per six inch (6") lift for each 200 linear feet or fraction thereof of compacted berm(s) less than 50 feet in base width and one test per six (6) inch lift for each 10,000 square feet or fraction thereof of compacted mass fill. If an area fails, it shall be recompacted, reworked or replaced and retested.

Before beginning construction of the base liner system, the project engineer shall visually inspect the exposed surface to evaluate the suitability of the subgrade and document that the surface is properly prepared and that the elevations are consistent with the Division approved engineering plans. The elevations will be verified from survey data based on a 50 foot grid across the subbase.

At a minimum, the subgrade shall be proof-rolled at cut sections utilizing a fully loaded tandem dump truck or equivalent. If movement of the subbase is observed under the tires, the section of movement will be removed and replaced with suitable fill material. This newly placed fill material will then be tested for proper density and moisture.

3.3 Cohesive Soil Liner

3.3.1 Materials and Construction Practices

All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

The soil for the cohesive soil liner shall consist of the red, orange, clayey silt on site if the mica content is less than 0.5 percent by weight passing the No. 200 Sieve and a permeability of 1.0×10^{-7} cm/sec or less for the base liner system or 1.0×10^{-5} cm/sec or less for the alternate base liner, is achieved. Off-site cohesive soils may be used if approved by the Engineer and provides a permeability of 1.0×10^{-7} cm/sec or lower for the base liner system or 1.0×10^{-5} cm/sec for the alternate base liner system or lower. Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil liner. The window is developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

A test strip of compacted cohesive soil liner shall be prepared to create a permeability "window" prior to general installation of the cohesive soil liner. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil liner. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 125 ft. The test strip shall consist of at least four compacted 6 inch lifts of cohesive soil liner. The test strip may be used as an integral part of the overall cohesive soil liner if it meets the required specification for the liner.

After the test strip passes, soil will be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift. A sheepsfoot roller or approved alternative may be used to compact the soil liner provided the compaction and permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil liner shall be screened, disked, or prepared using any other, approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. The clay liner must be a minimum of 2.0 feet thick. No additional

construction shall proceed on the soil layers at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved. If the soil for the cohesive soil liner is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory.

The thickness and grade of the clay liner will be verified by the engineer before placement of the geomembrane liner. The thickness and grade will be verified by surveying the clay at 50' grid points where the elevations of the subbase will be checked with the top of clay liner to verify 2.0 feet of clay liner. The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil liner shall have no sudden sharp or abrupt changes in grade. The Contractor shall protect the cohesive soil liner from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil liner until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions will be replaced or reworked by the contractor to remove these defects.

The anchor trench shall be excavated by the Contractor to lengths and widths shown on the design drawings prior to geomembrane placement. Anchor trenches excavated in clay soils susceptible to desiccation cracks should be excavated only the distance required for that days liner placement to minimize the potential of desiccation cracking of the clay soils. Corners in the anchor trench shall be slightly rounded where the geomembrane adjoins the trench to minimize sharp bends in the geomembrane.

Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil liner and the surface shall remain the responsibility of the contractor.

3.4 Flexible Membrane Liner

3.4.1 Materials and Construction Practices

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

60 mil High Density Polyethylene (HDPE) - National Sanitation Foundation (NSF) Standard Number 54 is to be placed in direct contact with moist cohesive soil liner. The Landfill itself is single lined and will only have a Textured Geomembrane. The extrusion rods and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner.

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project. Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture. The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds. The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface. No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane. Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas. The geomembrane will be deployed in a manner to minimize wrinkles. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed. In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a

minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

The flexible membrane liner will be welded together by fusion and extrusion fillet welding methods. Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge. Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets.

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can effect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will effect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams may substantiate the decision made by the Project Superintendent to seam on any given day. Fusion Welding is done by first overlapping panels of geomembrane approximately four (4) inches, next clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding. Next, adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths". A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

Extrusion Welding is done by overlapping panels of geomembrane a minimum of three (3) inches and temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane. Next grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area. Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind. Purge the extruder prior to beginning the seam to remove all heat-degraded extrudate from the barrel. Keep welding rod clean and off the ground.

Test seams shall be performed at the beginning of each seaming period and at least once each four (4) hours for each seaming apparatus used that day. Test seams shall be made on fragment

pieces of the geomembrane liner and under the same conditions as actual seams. The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width. Visually inspect the seam for squeeze out, footprint, pressure and general appearance. Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated. If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved. After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam identification number, welder's name, temperature control setting and test results. Passing test results records shall be maintained.

Seaming shall extend to the outside edge of panels to be placed in the anchor trench. While welding a seam, monitor and maintain the proper overlap. Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind. While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly. Align wrinkles at the seam overlap to allow welding through the wrinkle. Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions. All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane. All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind two (2) inches minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

Air pressure testing will be conducted. The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time. An air pump with rubber hose and sharp hollow needle (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi will be used to test the seam. Seal both ends of the seam to be tested. Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld. Inflate the test channel to a pressure between 27 to 30 psi, close valve, and observe initial pressure after approximately 2 minutes. For the 60 mil HDPE liner the seam has to have a minimum initial pressure of 27 psi and a maximum initial pressure of 30 psi. Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize. Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used.

If loss of pressure exceeds 3 psi or if the pressure does not stabilize, locate faulty area and repair. At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected. Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

In the event of a Non-Complying Air Pressure Test, check the seam end seals and retest seams. If non-compliance with specified maximum pressure differential re-occurs, cut one (1) inch samples from each end of the seam and additional samples. Perform destructive peel tests on the samples using the field tensiometer. If all samples pass destructive testing, remove the overlap left by the wedge welder and vacuum test the entire length of seam. If a leak is located by the vacuum test, repair by extrusion welding. Test the repair by vacuum testing. If no leak is discovered by vacuum testing, the seam will pass non-destructive testing. If one or more samples fail the peel tests, additional samples will be taken. When two (2) passing samples are located, the seam between these two (2) locations will be considered non-complying. Capping or removal are the only two (2) acceptable methods of repairing failed seams. Non-destruct test the entire length of the repaired seam.

Vacuum testing will be conducted when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

Vacuum box assembly consists of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, a vacuum gauge, vacuum pump assembly equipped with a pressure controller and pipe connection, a rubber pressure/vacuum hose with fittings and connections, a bucket and means to apply a soapy solution.

The procedure for Vacuum Testing is to trim excess overlap from seam, if any. Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi. Apply a generous amount of a solution of strong liquid detergent and water to the area to be tested. Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner. Close the bleed valve and open the vacuum valve. Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box. Ensure that a leak tight seal is created. For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles. If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process. The procedure for Non-Complying Testis to mark all areas where soap bubbles appear and repair the marked areas. Retest repaired areas.

The procedure for Destructive Testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane. All destructive tests will be done according to ASTM D4437. The sample should be twelve (12) inches wide with a

seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications. A one (1) inch sample shall be cut from each end of the test seam for field testing. The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the liner tears before any part of the seam does the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing. Destructive samples will be taken every 500 ft. of seam.

In the event of Destructive Test Failure, cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing. All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered. If the laboratory samples pass then reconstruct the seam between the two (2) passing samples locations. Heat tack the overlap along the length of the seam to be reconstructed and extrusion weld. Vacuum test the extrusion weld. If either of the samples fail, then additional samples are taken in accordance with the above procedure until two (2) passing samples are found to establish the zone in which the seam should be reconstructed. All passing seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken. In cases of reconstructed seams exceeding 150 feet, a destructive sample must be taken and pass destructive testing from within the zone in which the seam has been reconstructed.

The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation. All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely matter to protect the moist cohesive soil liner and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil liner such as a temporary cover. If cohesive soil liner is damaged, it must be reworked. Procedures available for repair are (1)Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of the defect and all corners of patches shall be rounded, (2) Grinding and welding - used to repair sections of extruded seams, (3) Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws, (4) Capping - used to repair lengths of failed extruded seams, (5) Removal of a bad seam and replacement with a strip of new material seamed into place.

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as-built drawing.

3.5 HDPE Double Bonded Drainage Net

3.5.1 Materials and Construction Practices

The geonets will be handled in such a manner as to ensure the geonets are not damaged in any way. On slopes, the geonets will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geonet sheet in tension. If necessary, the geonet will be positioned by hand after being unrolled to minimize wrinkles. Geonets can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1).

Geonets will not be welded to the geomembrane. Geonets will be cut using approved cutters,(i.e., hook blade, scissors, etc.) Care should be taken to prevent damage to underlying layers. Care must be taken not to entrap dirt in the geonet that could cause clogging of the drainage system, and or stones that could damage the adjacent geomembrane.

Adjacent rolls of geonet will be overlapped by at least four inches and securely tied. Tying can be achieved by plastic fasteners. Tying devices will be white or yellow for easy inspection. Metallic devices are not allowed. Tying will be five to ten feet along the bottom of the slope. Tying will be every five feet along the slope, every two feet across the slope and at the top of the berm. Tying in the anchor trench will be done in one foot intervals. In the corners of the side slopes where overlaps between perpendicular geonet strips are required, an extra layer of geonet will be unrolled along the slope, on top of the previously installed geonets, from the top to bottom of the slope.

Any holes or tears in the geonet will be repaired by placing a patch extending two feet beyond edges of the hole or tear. The patch will be secured to the original geonet by tying every twelve inches. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area will be cut out and the two portions of the geonet will be joined.

3.6 Protective Cover

3.6.1 Materials and Construction Practices

The soil for the select site backfill shall consist of suitable site soil free of debris, roots, rocks and organics. The soil shall contain no particles or objects greater than 3/4 inch in largest dimension, which has been screened. No permeability, grain size, or other tests are required for this material. This material is not being used as a drainage media, leachate collection lines are installed every fifty feet and designed to collect water flowing on top of the protective cover.

The soil for backfill shall consist of suitable site soil free of debris, roots, rocks, and organics. There are no permeability, grain size, or any other test required for this material. This material is not being used as a drainage media, leachate collection lines are installed every fifty feet and designed to collect water flowing on top of the protective cover.

Installation of the protective cover shall be the responsibility of the contractor. Before proceeding with placement of the protective cover over the liner, the Contractor shall furnish to the Engineer with the manufacturer's certification that the lining has been satisfactorily installed in accordance with the manufacturer's recommendations.

The protective cover shall be composed of select backfill and backfill. The cover shall be installed using low ground pressure equipment such as a Caterpillar D6H LGP, or approved equal, with ground pressure not exceeding 4.71 psi until the depth of cover exceeds three feet.

A minimum of 12 inches of cover between low ground pressure equipment such as the Caterpillar D6H LGP, or approved equal, and the liner is required at all times. Roadways for entering and for transporting material over slopes and floor shall have a minimum depth of four feet. Avoid undue stress on the liner at all times. Cover material must be pushed up side slopes, never down to help minimize wrinkles. A worker must walk along side earth moving equipment and remove all rocks, stones, roots or other debris that could cause damage to the liner. Material must be placed to minimize wrinkles, wrinkles in excess of two feet in height are unacceptable. If a wrinkle is more than two feet in height, soil will be placed on top of the wrinkle to decrease the height. Equipment operators must avoid sharp turns or quick stops that could pinch and tear the liner. If damage does occur, report it to the Project Manager immediately so that repairs can be performed without needless delay. Cover shall be placed and maintained in a uniform thickness, free of ruts and irregularities. Do not work wet cover material that cannot support equipment. Equipment operators and all other personnel must be qualified and must exercise good judgment and common sense at all times.

3.7 Leachate Collection System

3.7.1 Materials and Construction Practices

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications, or shall be the product of the listed manufacturers, or similar and equal; thereto, as approved by the Engineer.

The Leachate Collection System consists of No. 5 stone, 4.5 oz. Non-woven Geotextile fabric, and 8" SDR 17 HDPE pipe will be used in the construction of the Leachate Collection System.

A 2' wide by 3' deep trench will be dug out of the protective cover as indicated on the operation drawings located in section 5 of this document. Excavation for the leachate collection shall be done only after the three foot of protective cover has been installed over the flexible membrane liner. Mechanical equipment can be used for the first two and one-half feet of excavation. The remaining one-half foot or whatever protective cover remains above the flexible membrane liner shall be excavated by hand so as to not damage the liner. If damage occurs to the liner the Engineer or Owner shall be notified immediately and the repair shall take place shortly thereafter.

The 4.5oz non-woven geotextile fabric will be placed in the trench such that it can completely surround the trench. No. 5 stone will be placed at a depth of 2" in the whole length of the trench. Next the butt fused perforated SDR 17 6" or 8" HDPE pipe will be placed on top of the 2" thick stone and then covered with the No. 5 stone. After the placement of the stone the 4.5oz geotextile will be closed over top of the trench. All the leachate collection pipe, as shown on the operation drawings, is connected in a way such that all leachate runs to the low spot in the landfill where it will be gravity fed into the sewer line.

Butt Fusion for HDPE pipe. Clean pipe ends inside and outside with a clean cloth to remove dirt, water, grease and other foreign materials. Square (face) the pipe ends using facing tool of the fusion machine. Check line-up of pipe ends in fusion machine to see that pipe ends meet squarely and completely over the entire surface to be fused. This is commonly referred to as "adjusting high-low". It is advisable at this point to make sure the clamps are tight so that the pipe does not slip during the fusion process. Insert clean heater plate between aligned ends, and bring ends firmly in contact with plate, but do not apply pressure while achieving melt pattern. Carefully move the pipe ends away from the heater plate and remove the plate. (If the softened material sticks to the heater plate, discontinue the joint. Clean heater plate, re-square pipe ends and start over.)
Note: One pipe end usually moves away from the heater plate first. It is good practice to "bump" the plate away from the other side and then lift it out. Never drag or slide it over the melted pipe end.

Bring melted ends together rapidly. Do not slam. Apply enough pressure to form a double roll back to the body of the pipe brad around the entire circumference of the pipe about 1/8" to 3/16" wide. Pressure is necessary to cause the heated material to flow together. Allow the joint to cool and solidify properly. This occurs when the brad feels hard and your finger can remain comfortably on the brad. Remove the pipe from the clamps and inspect the joint appearance.

Knife Gate Valves will be placed in several places to control stormwater and leachate as indicated in the operation drawings.

3.8 Sewer Line

3.8.1 Materials and Construction Practices

The sewer line consists of a SDR 17 HDPE dual containment pipe, 8" carrier by 12" containment, Polyethylene manholes are placed along the sewer line. The sewer line runs to the Leachate Lagoon where it is aerated as needed, recirculated or pumped to its appropriate location.

All Gravity Flow Pipeline shall be installed using a laser for control of vertical and horizontal alignment. The Contractor shall follow accepted practices in the utilization of the laser. A certified laser operator shall be present on the job at all times. Care shall be exercised to assure that the alignment control range of the instrument is not exceeded; but in no case, shall the range exceed 500 feet. Care shall be taken to prevent vibration of or direct sunlight on the instrument. Where present, a blower shall be provided to purge glue vapors from the pipe. An air velocity meter shall be provided so that the velocity of air in the pipe will not be great enough to cause the light beam to be distorted. The Contractor shall coordinate the work to minimize the number of take downs and set ups at each point. Periodic checks of the laser shall be made to assure that alignment is maintained.

Each pipe shall be laid on an even, firm bed, so that no uneven strain will come to any part of the pipe. Before each piece of pipe is lowered into the trench, it shall be thoroughly inspected to insure its being clean. Each piece of pipe shall be lowered separately. No piece of pipe or fitting which is known to be defective, shall be laid or placed in the lines. If any defective pipe or fitting shall be discovered after the pipe is laid it shall be removed and replaced with a satisfactory pipe or fitting without additional charge. In case a length of pipe is cut to fit in a line, it shall be so cut as to leave a smooth end at right angles to the longitudinal axis of the pipe.

Butt Fusion for HDPE pipe. Clean pipe ends inside and outside with a clean cloth to remove dirt, water, grease and other foreign materials. Square (face) the pipe ends using facing tool of the fusion machine. Check line-up of pipe ends in fusion machine to see that pipe ends meet squarely and completely over the entire surface to be fused. This is commonly referred to as "adjusting high-low". It is advisable at this point to make sure the clamps are tight so that the pipe does not slip during the fusion process. Insert clean heater plate between aligned ends, and bring ends firmly in contact with plate, but do not apply pressure while achieving melt pattern. Carefully move the pipe ends away from the heater plate and remove the plate. (If the softened material sticks to the heater plate, discontinue the joint. Clean heater plate, re-square pipe ends and start over.)

Note: One pipe end usually moves away from the heater plate first. It is good practice to "bump" the plate away from the other side and then lift it out. Never drag or slide it over the melted pipe end.

Bring melted ends together rapidly. Do not slam. Apply enough pressure to form a double roll back to the body of the pipe brad around the entire circumference of the pipe about 1/8" to 3/16" wide. Pressure is necessary to cause the heated material to flow together. Allow the joint to cool and solidify properly. This occurs when the brad feels hard and your finger can remain comfortably on the brad. Remove the pipe from the clamps and inspect the joint appearance.

HDPE Dual Containment Force main - ASTM D3350. All HDPE pipe shall be tested at its rated working pressure. In no case shall there be any visible leakage, nor shall there be leakage between any section of pipe.

3.9 Closure Cohesive Soil Liner

3.9.1 Materials and Construction Practices

All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

The soil for the cohesive soil liner shall consist of the red, orange, clayey silt on site if the mica content is less than 0.5 percent by weight passing the No. 200 Sieve and a permeability of 1.0×10^{-5} cm/sec or less is achieved. Off-site cohesive soils may be used if approved by the Engineer and provides a permeability of 1.0×10^{-5} cm/sec or lower Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil liner. The window is developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

A test strip of compacted cohesive soil liner shall be prepared to create a permeability "window" prior to general installation of the cohesive soil liner. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil liner. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 125 ft. The test strip shall consist of at least four compacted 6 inch lifts of cohesive soil liner. The test strip may be used as an integral part of the overall cohesive soil liner if it meets the required specification for the liner.

After the test strip passes soil will be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift. A sheepsfoot roller or approved alternative may be used to compact the soil liner provided the compaction and

permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil liner shall be screened, disked, or prepared using any other, approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. The clay liner must be a minimum of 2.0 feet thick. No additional construction shall proceed on the soil layers at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved. If the soil for the cohesive soil liner is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory.

The thickness and grade of the clay liner will be verified by the engineer before placement of the geomembrane liner. The thickness and grade will be verified by surveying the clay at 50' grid points where the elevations of the subbase will be checked with the top of clay liner to verify 1.5 feet of clay. The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil liner shall have no sudden sharp or abrupt changes in grade. The Contractor shall protect the cohesive soil liner from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil liner until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions will be replaced or reworked by the contractor to remove these defects.
The anchor trench shall be excavated by the Contractor to lengths and widths shown on the design drawings prior to geomembrane placement. Anchor trenches excavated in clay soils susceptible to desiccation cracks should be excavated only the distance required for that days liner placement to minimize the potential of desiccation cracking of the clay soils. Corners in the anchor trench shall be slightly rounded where the geomembrane adjoins the trench to minimize sharp bends in the geomembrane.

Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil liner and the surface shall remain the responsibility of the contractor.

3.10 Closure Flexible Membrane Liner

3.10.1 Materials and Construction Practices

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

40 mil High Density Polyethylene (HDPE) - National Sanitation Foundation (NSF) Standard Number 54 is to be placed in direct contact with moist cohesive soil liner. The Landfill itself is single lined and will only have a Textured Geomembrane. The extrusion rods and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner.

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project. Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture. The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds. The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface. No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane. Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas. The geomembrane will be deployed in a manner to minimize wrinkles. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed. In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a

minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

The flexible membrane liner will be welded together by fusion and extrusion fillet welding methods. Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge. Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets.

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can effect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will effect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams may substantiate the decision made by the Project Superintendent to seam on any given day. Fusion Welding is done by first overlapping panels of geomembrane approximately four (4) inches, next clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding. Next, adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths". A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

Extrusion Welding is done by overlapping panels of geomembrane a minimum of three (3) inches and temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane. Next grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area. Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind. Purge the extruder prior to beginning the seam to remove all heat-degraded extrudate from the barrel. Keep welding rod clean and off the ground.

Test seams shall be performed at the beginning of each seaming period and at least once each four (4) hours for each seaming apparatus used that day. Test seams shall be made on fragment

pieces of the geomembrane liner and under the same conditions as actual seams. The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width. Visually inspect the seam for squeeze out, footprint, pressure and general appearance. Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated. If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved. After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam identification number, welder's name, temperature control setting and test results. Passing test results records shall be maintained.

Seaming shall extend to the outside edge of panels to be placed in the anchor trench. While welding a seam, monitor and maintain the proper overlap. Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind. While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly. Align wrinkles at the seam overlap to allow welding through the wrinkle. Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions. All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane. All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind two (2) inches minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

Air pressure testing will be conducted. The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time. An air pump with rubber hose and sharp hollow needle (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi will be used to test the seam. Seal both ends of the seam to be tested. Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld. Inflate the test channel to a pressure between 27 to 30 psi, close valve, and observe initial pressure after approximately 2 minutes. For the 60 mil HDPE liner the seam has to have a minimum initial pressure of 27 psi and a maximum initial pressure of 30 psi. Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize. Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used.

If loss of pressure exceeds 3 psi or if the pressure does not stabilize, locate faulty area and repair. At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected. Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

In the event of a Non-Complying Air Pressure Test, check the seam end seals and retest seams. If non-compliance with specified maximum pressure differential re-occurs, cut one (1) inch samples from each end of the seam and additional samples. Perform destructive peel tests on the samples using the field tensiometer. If all samples pass destructive testing, remove the overlap left by the wedge welder and vacuum test the entire length of seam. If a leak is located by the vacuum test, repair by extrusion welding. Test the repair by vacuum testing. If no leak is discovered by vacuum testing, the seam will pass non-destructive testing. If one or more samples fail the peel tests, additional samples will be taken. When two (2) passing samples are located, the seam between these two (2) locations will be considered non-complying. Capping or removal of the non-complying seam are the only two (2) acceptable methods for repairing failed seams. Non-destruct test the entire length of the repaired seam.

Vacuum testing will be conducted when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

Vacuum box assembly consists of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, a vacuum gauge, vacuum pump assembly equipped with a pressure controller and pipe connection, a rubber pressure/vacuum hose with fittings and connections, a bucket and means to apply a soapy solution.

The procedure for Vacuum Testing is to trim excess overlap from seam, if any. Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi gauge. Apply a generous amount of a solution of strong liquid detergent and water to the area to be tested. Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner. Close the bleed valve and open the vacuum valve. Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box. Ensure that a leak tight seal is created. For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles. If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process. The procedure for Non-Complying Testis to mark all areas where soap bubbles appear and repair the marked areas. Retest repaired areas.

The procedure for Destructive Testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane. All destructive tests will be done according to ASTM D4437. The sample should be twelve (12) inches wide with a

seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications. A one (1) inch sample shall be cut from each end of the test seam for field testing. The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the liner tears before any part of the seam does the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing. Destructive samples will be taken every 500 ft. of seam.

In the event of Destructive Test Failure, cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing. All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered. If the laboratory samples pass then reconstruct the seam between the two (2) passing samples locations. Heat tack the overlap along the length of the seam to be reconstructed and extrusion weld. Vacuum test the extrusion weld. If either of the samples fail, then additional samples are taken in accordance with the above procedure until two (2) passing samples are found to establish the zone in which the seam should be reconstructed. All passing seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken. In cases of reconstructed seams exceeding 150 feet, a destructive sample must be taken and pass destructive testing from within the zone in which the seam has been reconstructed.

The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation. All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely matter to protect the moist cohesive soil liner and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil liner such as a temporary cover. If cohesive soil liner is damaged, it must be reworked. Procedures available for repair are (1)Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of the defect and all corners of patches shall be rounded, (2) Grinding and welding - used to repair sections of extruded seams, (3) Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws, (4) Capping - used to repair lengths of failed extruded seams, (5) Removal of a bad seam and replacement with a strip of new material seamed into place.

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as-built drawing.

3.11 Closure HDPE Double Bonded Drainage Net

3.11.1 Materials and Construction Practices

The geonets will be handled in such a manner as to ensure the geonets are not damaged in any way. On slopes, the geonets will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geonet sheet in tension. If necessary, the geonet will be positioned by hand after being unrolled to minimize wrinkles. Geonets can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1).

Geonets will not be welded to the geomembrane. Geonets will be cut using approved cutters,(i.e., hook blade, scissors, etc.) Care should be taken to prevent damage to underlying layers. Care must be taken not to entrap dirt in the geonet that could cause clogging of the drainage system, and or stones that could damage the adjacent geomembrane.

Adjacent rolls of geonet will be overlapped by at least four inches and securely tied. Tying can be achieved by plastic fasteners. Tying devices will be white or yellow for easy inspection. Metallic devices are not allowed. Tying will be five to ten feet along the bottom of the slope. Tying will be every five feet along the slope, every two feet across the slope and at the top of the berm. Tying in the anchor trench will be done in one foot intervals. In the corners of the side slopes where overlaps between perpendicular geonet strips are required, an extra layer of geonet will be unrolled along the slope, on top of the previously installed geonets, from the top to bottom of the slope.

Any holes or tears in the geonet will be repaired by placing a patch extending two feet beyond edges of the hole or tear. The patch will be secured to the original geonet by tying every twelve inches. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area will be cut out and the two portions of the geonet will be joined.

3.12 Closure Protective Cover

3.12.1 Materials and Construction Practices

The soil for the select site backfill shall consist of suitable site soil free of debris, roots, rocks and organics. The soil shall contain no particles or objects greater than 3/4 inch in largest dimension, which has been screened. No permeability, grain size, or other tests are required for this material.

Installation of the protective cover shall be the responsibility of the contractor. Before proceeding with placement of the protective cover over the liner, the Contractor shall furnish to the Engineer with the manufacturer's certification that the lining has been satisfactorily installed in accordance with the manufacturer's recommendations.

The protective cover shall be composed of 24" of select backfill. The cover shall be installed using low ground pressure equipment such as a Caterpillar D6H LGP, or approved equal, with ground pressure not exceeding 4.71 psi until the depth of cover exceeds three feet.

A minimum of 12 inches of cover between low ground pressure equipment such as the Caterpillar D6H LGP, or approved equal, and the liner is required at all times. Roadways for entering and for transporting material over slopes and floor shall have a minimum depth of four feet. Avoid undue stress on the liner at all times. Cover material must be pushed up side slopes, never down to help minimize wrinkles. A worker must walk along side earth moving equipment and remove all rocks, stones, roots or other debris that could cause damage to the liner. Material must be placed to minimize wrinkles, wrinkles in excess of two feet in height are unacceptable. If a wrinkle is more than two feet in height, soil will be placed on top of the wrinkle to decrease the height. Equipment operators must avoid sharp turns or quick stops that could pinch and tear the liner. If damage does occur, report it to the Project Manager immediately so that repairs can be performed without needless delay. Cover shall be placed and maintained in a uniform thickness, free of ruts and irregularities. Do not work wet cover material that cannot support equipment. Equipment operators and all other personnel must be qualified and must exercise good judgment and common sense at all times.

3.13 Closure Methane Venting System

3.13.1 Materials and Construction Practices

The Methane Gas Venting System will consist of No. 5 stone, 8 oz. Geotextile fabric, and 8" PVC pipe will be used in the construction of the Gas venting system.

A 2' wide by 1' deep trench will be dug out of the intermediate cover as indicated on the operation drawings located in section 5 of this document. An 8oz geotextile fabric will be placed inside the trench such that it can completely surround the trench. No. 5 stone will be placed solely in the whole length of the trench except for the first 10' in all directions of the 10" PVC solid walled vent pipe, where 8" PVC pipe shall be placed and covered with the No. 5 stone. After the placement of the stone the 8oz geotextile will be closed over top of the trench.

SECTION 4.0

CONSTRUCTION QUALITY ASSURANCE PLAN

4.1 Introduction

The Division of Solid Waste Management requires that the Engineer certifies the constructed landfill is built according to approved plans and specifications. The Engineer that will accomplish this task is the one who did the planning and has written the specifications.

Before construction can begin a pre-construction meeting will be held and the responsibilities and duties of each party will be discussed.

The Contractor is responsible for following and meeting the requirements set forth in the contract documents. The Contractors will provide to the Owner of the landfill and the Engineer a completed landfill constructed by Division of Solid Waste approved plans and specifications. The Contractor will give the Engineer a schedule for completion of the landfill including dates for expected construction of the clay test pad, base liner system installation, installation of protective cover, installation of leachate collection system, and estimated time for project completion. The contractor is responsible for providing a foreman to remain on site at all times during construction, provide qualified personnel to conduct quality control, scheduling and coordinating the subcontractors, provide progress reports and as-built drawings, and coordinating construction activities with the Engineer. The foreman is responsible for supervising and coordinating with his crew, subcontractors, quality control personnel, attending all meetings and notifying the Engineer's Construction Observer when any discrepancies occur. The Contractor will meet with the Construction Observer on a daily basis to discuss the days construction activities. The results of all tests and any change in schedule shall be given to the Construction Observer as soon they are known by the contractor. The Contractor must be registered in the state of North Carolina.

Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. The Liner Foreman is responsible for coordinating the installation of the geomembrane liner. The Liner Forman will report to the Contractors Foreman, and Engineer's Construction Observer on a daily basis. The Liner Foreman is responsible for obtaining the geomembrane samples needed for field and laboratory testing as indicated in the plans and specifications.

The Engineer is responsible for providing the engineering design, drawings and specifications, contract documents and CQA needed for construction of the landfill. The Engineer is responsible for conduction of the pre-construction meeting, which will lay out the foundation for the project. The engineer will approve any design changes and certify to the Division of Solid Waste Management that the landfill was constructed according to the requirements of Rule .1621 Construction Quality Assurance Plan and .1624 Construction requirements for MSWLF Facilities, and Division approved plans and specifications. This will be accomplished by on site observation, independent laboratory soil testing to test site specific soil properties including permeability and independent material testing laboratories for destructive testing of the flexible membrane liner. The Engineer will be providing Quality Assurance by spot testing along side the contractor, who will be providing the Quality Control. The Engineer will certify that the construction was completed in accordance with the CQA manual. The Engineer must be a professional engineer registered in North Carolina

The Construction Observer (CO) is the Engineer's representative on-site. It is the CO's responsibility to know and interpret the plans and specifications of the project. On a daily basis the CO will coordinate with the Foreman to help ensure a quality product for the Owner. The CO will keep a daily log on the activities of the Contractor, keep notes on all meetings, and handle all quality assurance activities indicated in this document. The CO will keep a log of all material delivered on site and ensure the materials meets or exceeds the specifications indicated in this report. If the need arises additional meetings will be scheduled as seen fit by the CO.

4.2 Inspection Activities and Sampling Strategies

4.2.1 Base Liner System Subbase

The fill subgrade will be placed in 8" loose lifts and compacted to at least 95% of maximum dry density and near optimum moisture contents; as determined by Standard Proctor Compaction Test (ASTM D698) in 6" compacted lifts. No aggregate particles greater than 6" in any direction will be allowed in the subgrade or berm/embankment. Each compacted lift will be tested at one test per six inch (6") lift for each 200 lineal feet or fraction thereof of compacted berm(s) less than 50 feet in base width and one test per six (6) inch lift for each 10,000 square feet or fraction thereof of compacted mass fill. If an area fails, it shall be recompacted, reworked or replaced and retested.

Before beginning construction of the base liner system, the project engineer shall visually inspect the exposed surface to evaluate the suitability of the subgrade and document that the surface is properly prepared and that the elevations are consistent with the Division approved engineering plans. The elevations will be verified from survey data based on a 50 foot grid across the subbase.

At a minimum, the subgrade shall be proof-rolled at cut sections utilizing a fully loaded tandem dump truck or equivalent. If movement of the subbase is observed under the tires, the section of movement will be removed and replaced with suitable fill material. This newly placed fill material will then be tested for proper density and moisture.

4.2.2 Base Liner System Cohesive Soil Liner

All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Cohesive Soil Liner Borrow Material

Test Name	Test Method	Contractor/Engineer Frequency
Moisture/Density	ASTM D698/D1557	1 per 5000 c.y.
Remolded Permeability	ASTM D5084	1 per 5000 c.y.
Atterberg Limits	ASTM D4318	1 per 5000 c.y.
Visual Classification	ASTM D2488	1 per 5000 c.y.
Grain Size Distribution	ASTM D422	1 per 5000 c.y.

Cohesive Soil Liner Test Pad

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	3 per lift
Permeability	ASTM D5084	1 per lift
Remolded Permeability	ASTM D5084	1 per lift
Atterberg Limits	ASTM D4318	1 per lift
Visual Classification	ASTM D2488	1 per lift
Grain Size Distribution	ASTM D422	1 per lift

In-Place Cohesive Soil Liner

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	1 per lift per acre
Permeability	ASTM D5084	1 per lift per acre
Atterberg Limits	ASTM D4318	1 per lift per acre
Visual Classification	ASTM D2488	1 per lift per acre
Grain Size Distribution	ASTM D422	1 per lift per acre

(a) Suitable on-site and/or off-site soils may be used as cohesive soil liner if it can achieve an in-place permeability of 1.0×10^{-7} cm/sec or less for the base liner system or 1.0×10^{-5} cm/sec or less for the alternate base liner system and meets all testing requirements indicated in the material testing paragraph in this section. Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

(b) A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil liner. The window shall be plotted on a semi-log plot with moisture content versus density. Laboratory testing to develop the window shall include a series of remolded samples compacted to various dry densities and moisture contents utilizing the same compactive effort (ASTM D 698 or D 1557). The remolded samples shall be tested for permeability to determine whether or not

the particular soil type will provide the maximum permeability (1.0×10^{-7} cm/sec or 1.0×10^{-5} cm/sec) at various dry densities and moisture contents. The window is then developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

(c) Atterberg limits and grain size distribution shall also be conducted on the bulk samples used to prepare the permeability window ASTM D2488, D4318, D422. These tests can be used as indices on random samples collected from the borrow site during construction to verify the soil type is the same as was used to develop the "window". As a minimum, sufficient visual classifications and Atterberg limits shall be conducted in association with each permeability test to verify that the construction materials meet specifications.

(d) A test strip of compacted cohesive soil liner shall be prepared to verify the permeability "window" prior to general installation of the cohesive soil liner. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil liner. At a minimum, the verification will consist of three moisture density tests, one Atterberg limits test, one grain size distribution test (ASTM D698, ASTM D2488, D4318, and D422), and one Shelby Tube sample for each lift constructed in the test pad. Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil liner after placement and compaction. The permeability must be a maximum of 1.0×10^{-7}cm/sec or 1.0×10^{-5} cm/sec for alternate liner systems. Tests shall be performed in accordance with the ASTM D5084. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 25 ft. The test strip shall consist of at least four compacted 6 inch lifts of cohesive soil liner. Placement and testing of the test strip shall be in conformance with the construction specifications and requirements for general installation of the cohesive soil liner. Test results from the test strip shall be used to guide placement and achievement of the required maximum permeabilities of the cohesive soil liners. The test strip may be used as an integral part of the overall cohesive soil liner if it meets the required specification for the liner. All results shall be given to the Construction Observer.

(e) The soils shall be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift compacted preferably at a moisture content between 0 to 3% above optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698). A sheepsfoot roller or approved alternative may be used to compact the soil liner provided the compaction and permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have

been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil liner shall be screened, disced, or prepared using any other approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. After each lift, the surface shall be scarified prior to the placement of the next lift to provide good bonding from one lift to the next.

(f) The cohesive soil liner shall be tested to evaluate the coefficient of permeability. The coefficient of permeability of the soil liner shall be equal to or less than 1.0×10^{-7} cm/sec (1.0×10^{-5} cm/sec for alternate base liner) after placement and compaction. The soil liner must be a minimum of 2.0 feet thick (1.5 feet thick for alternate base liner).

(g) Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil liner after placement and compaction. The permeability must be a maximum of 1.0×10^{-7} cm/sec (1.0×10^{-5} cm/sec for alternate base liner). Tests shall be performed in accordance with the ASTM D5084 with a hydraulic gradient of 20 and confining pressure of 10 psi.

(h) The soil liner shall be tested a minimum of one soil sample per lift per acre for laboratory permeability. All permeability testing will be on random samples judged by the Engineer to be representative of the most permeable soil conditions for the area being tested. The project engineer shall certify that the materials used in construction were tested according to the Division approved plans. If after placement of the soil liner it fails the required tests, the material will either be reworked or replaced. The soil liner must remain moist at all times, if any section becomes dry, rework the dry area and moisten.

(i) A minimum of two (2) inches of soil shall be removed prior to securing each sample for permeability testing. The sampling tube shall be advanced vertically into the soil with as little soil disturbance as possible and should be pushed using a uniform pressure. The sampling tube (Shelby tube), when extracted, shall be free of dents, and the ends shall not be distorted. A backhoe or approved alternative should be used to advance the sampling tube (Shelby tube) as long as disturbance is minimized. Drive tube samples of the liner may be obtained for permeability testings. If the Engineer judges the sample to be too disturbed, another sample shall be taken. Once an acceptable sample has been secured and properly prepared, all sample excavations shall be backfilled to grade with a 50% mixture of bentonite and similar soils in maximum 3-inch loose lifts and hand tamped with a blunt tool to achieve a tight seal equivalent to the original density.

(j) No additional construction shall proceed on the soil layers at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved.

(k) As a minimum, sufficient visual classifications (ASTM Test Designation D2488), gradation analyses (ASTM Test Designation D422) and Atterberg limits (ASTM Test Designation D4318) shall be conducted in association with each permeability test to verify

that the construction materials meet specifications. The minimum number of tests will be 1 per lift per acre.

(l) If the soil for the cohesive soil liner is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory. Where additives are required, the soil shall be placed in maximum 8-inch thick loose lifts and compacted preferably between 0 to +3% optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698) for the soil-additive mixture. All other compaction procedures for the soil apply.

(m) Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil liner shall have no sudden sharp or abrupt changes in grade.

(n) The Contractor shall protect the cohesive soil liner from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil liner until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions shall be replaced or reworked by the contractor to remove these defects.

(o) The thickness and grade of the soil liner will be verified by the surveyor before placement of the geomembrane liner. The soil liner will be surveyed at 50' grid points where the elevations of the subbase will be checked with the top of soil liner to verify 2.0 feet of soil liner (1.5 feet of soil liner for the alternate base liner). The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

(p) The anchor trench shall be excavated by the Contractor to lengths and widths shown on the design drawings prior to geomembrane placement. Anchor trenches excavated in cohesive soils susceptible to desiccation cracks should be excavated only the distance required for that days liner placement to minimize the potential of desiccation cracking of the cohesive soils. Corners in the anchor trench shall be slightly rounded where the geomembrane adjoins the trench to minimize sharp bends in the geomembrane.

(q) Surface Acceptance. Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil liner and the surface shall remain the responsibility of the contractor.

4.2.3 Base Liner System Flexible Membrane Liner Method of Deployment

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Flexible Membrane Liner Tests

Test Name	Description	Test Method	Frequency
Air Test	Air Test Seams		Every Seam
Vacuum Test	Every welded area		Where air test impossible
Destructive Tests	Seam Strength	ASTM D4437	Every 500' of seam

Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

60 mil High Density Polyethylene (HDPE) - Geosynthetic Research Institute (GRI) GM13 - Is to be placed in direct contact with moist cohesive soil liner. The Landfill itself is single lined and will only have a single Textured Geomembrane. The extrusion rods and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner and shall meet the following minimum properties:

ENGLISH UNITS

Table 1(a) - High Density Polyethylene (HDPE) Geomembrane - Smooth

Property	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness, (min. ave.) • lowest individual of 10 values	D 5199	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	per roll
Density (min.)	D 1505/D792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties *(1)* (min. ave.) • yield stress • break stress • yield elongation • break elongation	D 638 Type IV	63 lb/in. 114 lb/in. 12% 700%	84 lb/in. 152 lb/in. 12% 700%	105 lb/in. 190 lb/in. 12% 700%	126 lb/in. 228 lb/in. 12% 700%	168 lb/in. 304 lb/in. 12% 700%	210 lb/in. 380 lb/in. 12% 700%	252 lb/in. 456 lb/in. 12% 700%	20,000 lb
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	D 4833	54 lb	72 lb	90 lb	108 lb	144 lb	180 lb	216 lb	45,000 lb
Stress Crack Resistance *(2)*	D 5397 (App.)	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	per GRI-GM10
Carbon Black Content (range)	D 1603 *(3)*	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	20,000 lb
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(5)* (a) Standard OIT —or— (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	200,000 lb
Oven Aging at 85°C *(5), (6)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(7)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	GM 11 D 3895 D 5885	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	per each formulation

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 inches

(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(3) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.

(4) Carbon black dispersion for 10 different views:
• all 10 in Categories 1 or 2

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

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ENGLISH UNITS

Table 2(a) - High Density Polyethylene (HDPE) Geomembrane - Textured

Property	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height (min. ave.) *(1)*	GM 12	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	every 2nd roll *(2)*
Density (min. ave.)	D 1505/D792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties (min. ave.) *(3)* • yield stress • break stress • yield elongation • break elongation	D 638 Type IV	63 lb/in. 45 lb/in. 12% 100%	84 lb/in. 60 lb/in. 12% 100%	105 lb/in. 75 lb/in. 12% 100%	126 lb/in. 90 lb/in. 12% 100%	168 lb/in. 120 lb/in. 12% 100%	210 lb/in. 150 lb/in. 12% 100%	252 lb/in. 180 lb/in. 12% 100%	20,000 lb
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	D 4833	45 lb	60 lb	75 lb	90 lb	120 lb	150 lb	180 lb	45,000 lb
Stress Crack Resistance *(4)*	D 5397 (App.)	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	200 hr.	per GRI-GM 10
Carbon Black Content (range)	D 1603 *(5)*	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	2.0 - 3.0%	20,000 lb
Carbon Black Dispersion	D 5596	note *(6)*	note *(6)*	note *(6)*	note*(6)*	note*(6)*	note*(6)*	note *(6)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(7)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	200,000 lb
Oven Aging at 85°C *(7), (8)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(9)* (a) Standard OIT — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(11)*	GM11 D 3895 D 5885	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	 N.R. *(10)* 50%	per each formulation

(1) Of 10 readings; 8 out of 10 must be ≥ 7 mil, and lowest individual reading must be ≥ 5 mil
(2) Alternate the measurement side for double sided textured sheet
(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 inches
(4) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
(5) Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
(6) Carbon black dispersion for 10 different views:
• all 10 in Categories 1 or 2
(7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(8 It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(9) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
(10) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(11) UV resistance is based on percent retained value regardless of the original HP-OIT value.

(1) Preparation for Geomembrane Deployment

(a) Panel Layout

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project.

(b) Identification

Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture.

(c) Verification

The manufacturers certification will be given to the construction observer. The construction observer will inspect all certifications. If the certification does not meet specifications, it will be rejected. Adequate laboratory QA/QC conformance testing shall be performed by the contractor/engineer to verify minimum requirements outlined on Table 2(a) of GM13-9 of 12. QC testing information is for each roll of material delivered to the site. A third party QA lab will test for thickness, density, carbon black content, carbon black dispersion and tensile properties for one roll out of four delivered to the site.

(2) Field Panel Placement

(a) Location

The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

(b) Weather Conditions

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds.

(c) Method of Deployment

(1) The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface.

(2) No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane.

(3) Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas.

(4) The geomembrane will be deployed in a manner to minimize wrinkles. The geomembrane will have no fold overs.

(5) Any damage to a panel of the geomembrane will be repaired. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed.

(3) Field Seaming

(a) Layout

In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

(b) Personnel

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

(c) Equipment

(1) Fusion Welding

Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets

are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge.

(2) Extrusion Fillet Welding

Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets. The extrusion welder is equipped with gauges giving the temperature in the apparatus and the preheat temperature at the nozzle.

(d) Weather Conditions

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can effect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will effect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams substantiate the decision made by the Project Superintendent to seam on any given day.

(4) <u>Seam Preparation</u>

(a) Fusion Welding

(1) Overlap the panels of geomembrane approximately four (4) inches.

(2) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding.

(3) Adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

(4) A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

(b) Extrusion Welding

(1) Overlap the panels of geomembrane a minimum of three (3) inches.

(2) Temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane.

(3) Grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area.

(4) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind.

(5) Purge the extruder prior to beginning the seam to remove all heat-degraded extrudate from the barrel.

(6) Keep welding rod clean and off the ground.

(5) Test Seams

Test seams shall be performed at the beginning of each seaming period and at least once each four (4) hours for each seaming apparatus used that day. Test seams shall be made on fragment pieces of the geomembrane liner and under the same conditions as actual seams.

(a) Test Seam Length

The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width.

(b) Sample Procedure

(1) Visually inspect the seam for squeeze out, footprint, pressure and general appearance.

(2) Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated.

(3) If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved.

(4) After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam identification number, welder's name, temperature control setting and test results.

(5) Passing test results records shall be maintained.

(6) General Seaming Procedures

(a) Seaming shall extend to the outside edge of panels to be placed in the anchor trench.

(b) While welding a seam, monitor and maintain the proper overlap.

(c) Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind.

(d) While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly.

(e) Align wrinkles at the seam overlap to allow welding through the wrinkle.

(f) Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions.

(g) All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane.

(h) All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind ¼ of an inch minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

4.2.4 Base Liner System Flexible Membrane Liner Tests

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

(a) Air Pressure Testing

The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time.

(1) Equipment for Air Testing

An air pump (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi.
A rubber hose with fittings and connections.

A sharp hollow needle, or other approved pressure feed device with a pressure gauge capable of reading and sustaining a pressure between 25 to 30 psi.

(2) Procedure for Air Testing

Seal both ends of the seam to be tested.

Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld.

Inflate the test channel to a pressure between 25 to 30 psi, in accordance with the following schedule, close valve, and observe initial pressure after approximately 2 minutes.

INITIAL PRESSURE SCHEDULE *

Material (Mil)	Min. Psi	Max. Psi
40	25	30
60	27	30
80	30	30
100	30	30

* Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize.

Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used. If loss of pressure exceeds the following or if the pressure does not stabilize, locate faulty area and repair.

MAXIMUM PERMISSIBLE PRESSURE DIFFERENTIAL AFTER 5 MINUTES - HDPE

Material (Mil)	Pressure Diff.
40	4 psi
60	3 psi
80	3 psi
100	3 psi

At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected.

Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

(3) In the event of a Non-Complying Air Pressure Test, the following procedure shall be followed:

Check seam end seals and retest seams.

If non-compliance with specified maximum pressure differential re-occurs, cut one (1) inch samples from each end of the seam and additional samples.

Perform destructive peel tests on the samples using the field tensiometer.

If all samples pass destructive testing, remove the overlap left by the wedge welder and vacuum test the entire length of seam.

If a leak is located by the vacuum test, repair by extrusion welding. Test the repair by vacuum testing.

If no leak is discovered by vacuum testing, the seam will pass non-destructive testing.

If one or more samples fail the peel tests, additional samples will be taken.

When two (2) passing samples are located, the seam between these two (2) locations will be considered non-complying. Capping or removal of the non-complying seam are the only two (2) acceptable methods of repairing failed seams. Non-destruct test the entire length of the repaired seam.

(b) Vacuum Testing

This test is used when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

(1) Equipment for Vacuum Testing

Vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.

Vacuum pump assembly equipped with a pressure controller and pipe connection.

A rubber pressure/vacuum hose with fittings and connections.

A bucket and means to apply a soapy solution.

A soapy solution.

(2) Procedure for Vacuum Testing

Trim excess overlap from seam, if any.

Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi gauge.

Apply a generous amount of a solution of strong liquid detergent and water to the area to be tested.

Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner.

Close the bleed valve and open the vacuum valve.

Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box.

Ensure that a leak tight seal is created.

For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process.

(3) Procedure for Non-Complying Test

Mark all areas where soap bubbles appear and repair the marked areas.

Retest repaired areas.

(c) Destructive Testing

(1) Concept

The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane.

(2) Procedure for Destructive Testing

All Destructive tests will be done according to ASTM D4437. Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one test location every 500 feet of seam length.

Additional destructive tests may be taken in areas of contamination, offset welds, visible crystallinity or other potential cause of faulty welds at the descretion of the Project Superintendent and Engineer.

Sample Size

The sample should be twelve (12) inches wide with a seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications.

A one (1) inch sample shall be cut from each end of the test seam for field testing.

The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the liner tears before any part of the seam does the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing.

(3) Procedure in the event of Destructive Test Failure

Cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing.

If the laboratory samples pass then reconstruct the seam between the two (2) passing samples locations.

Capping or removal of the failed seam are the only two (2) acceptable methods for repairing failed seams.

All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered.

(d) Quality Assurance Laboratory Testing

(1) Destructive samples sent to the laboratory will be tested for "shear strength" and "peel adhesion" (ASTM D4437 as modified by NSF). Five (5) specimens shall be tested for each test method with data recorded. Four (4) out of the five (5) specimens must pass for each test in order for the seam to pass the destructive test.

(2) Defects and Repairs

(a) The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation.

(b) All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

(c) Repair Procedures

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely manner to protect the moist cohesive soil liner and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil liner such as a temporary cover. If cohesive soil liner is damaged, it must be reworked. Procedures available for liner repair:

Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of the defect and all corners of patches shall be rounded.

Reconstruction - used to repair seams bounded by passing destruct samples

Grinding and welding - used to repair sections of extruded seams.

Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws.

Capping - used to repair lengths of failed extruded seams.

Removal of a bad seam and replacement with a strip of new material seamed into place.

(d) Verification of Repairs

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as-built drawing.

4.2.5 Protective Cover for Landfill Construction

HPDE Geocomposite Drainage Netting manufactured by SKAPS Industries, or approved equal. Q/C testing information/certification for each property on geocomposite will be provided by the contractor/manufacture for the rolls delivered.

GEOCOMPOSITE PROPERTIES

PROPERTY	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Thickness	ASTM D 5199	inch	0.305
Transmissivity[1] (15,000 psf)	ASTM D 4716	m^2/sec	$3x10^{-5}$
Ply Adhesion	ASTM D 413 or F 904	lb/in	2.0

COMPONENT PROPERTIES

GEONET	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Polymer Density	ASTM D 1505	g/cm^3	0.94
Carbon Black Content	ASTM D 4218	%	2.0
Thickness	ASTM D 5199	inches	0.200
Mass per unit area	ASTM D 5261	lbs/ft^2	0.162
Transmissivity[1]	ASTM D 4716	m^2/sec	$1x10^{-3}$@ 15,000 psf
Tensile Strength	ASTM D 5035	lbs/in	45

GEOTEXTILE	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Fabric Weight	ASTM D 5261	oz/yd^2	7.1
Thickness	ASTM D 5199	mils	95
Grab Strength	ASTM D 4632	lbs	210
Water Flow Rate	ASTM D 4491	gpm/ft^2	110
Apparent opening size (AOS)	ASTM D 4751	mm (Sieve Size)	0.150 (100)

1. Measured using water @ 20° C (68° F) with a gradient of one, between two steel plates, after one hour. Value may vary, based on dimensions of the transmissivity specimen and specific laboratory.
2. Component properties are tested prior to the lamination process. They cannot be tested on the final product.

The geocompsite will be handled in such a manner as to ensure the geocomposite are not damaged in any way. On slopes, the geocomposite will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite will be positioned by hand after being unrolled to minimize wrinkles. Geocomposite can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1).

Geocomposite will not be welded to the geomembrane. Geocomposite will be cut using approved cutters,(i.e., hook blade, scissors, etc.) Care should be taken to prevent damage to underlying layers. Care must be taken not to entrap dirt in the geocomposite that could cause clogging of the drainage system, and or stones that could damage the adjacent geomembrane.

Adjacent rolls of geocomposite will be overlapped by at least four inches and securely tied. Tying can be achieved by plastic fasteners. Tying devices will be white or yellow for easy inspection. Metallic devices are not allowed. Tying will be five to ten feet along the bottom of the slope. Tying will be every five feet along the slope, every two feet across the slope and at the top of the berm. Tying in the anchor trench will be done in one foot intervals. In the corners of the side slopes where overlaps between perpendicular geocomposite strips are required, an extra layer of geocomposite will be unrolled along the slope, on top of the previously installed geocomposite, from the top to bottom of the slope.

Any holes or tears in the geocomposite will be repaired by placing a patch extending two feet beyond edges of the hole or tear. The patch will be secured to the original geocomposite by tying every twelve inches. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined.

The engineer will visually inspect the drainage layer before placement of the protective soil, if any defects are detected they will be repaired before placement of protective soil.

Select Backfill

The soil for the select backfill shall consist of suitable soil free of debris, roots, rocks and organics. The soil shall contain no particles or objects greater than 3/4 inch in largest dimension, which has been screened. There are no permeability, grain size, or any other test required for this material. This material is not being used as a drainage media; leachate collection lines are installed and designed to collect water flowing on top of the protective cover.

Backfill

The soil for backfill shall consist of suitable soil free of debris, roots, rocks, and organics. There are no permeability, grain size, or any other test required for this material. This material is not being used as a drainage media; leachate collection lines are installed and designed to collect water flowing on top of the protective cover.

Protective Soil Cover

Installation of the protective cover shall be the responsibility of the contractor. Before proceeding with placement of the protective cover over the liner, the Contractor shall furnish to the Engineer with the manufacturer's certification that the lining has been satisfactorily installed in accordance with the manufacturer's recommendations.

The protective cover shall be composed of select backfill and backfill. The cover shall be installed using low ground pressure equipment such as a Caterpillar D6H LGP, or approved equal, with ground pressure not exceeding 4.71 psi until the depth of cover exceeds three feet.

When installing the cover, the contractor shall adhere to the following guidelines:

(1) A minimum of 12 inches of cover between low ground pressure equipment such as the Caterpillar D6H LGP, or approved equal, and the liner is required at all times. Roadways for entering and for transporting material over slopes and floor shall have a minimum depth of four feet.

(2) Avoid undue stress on the liner at all times. Cover material must be pushed up side slopes, never down to help minimize wrinkles. Material must be placed to minimize wrinkles, wrinkles in excess of two feet in height are unacceptable. If a wrinkle is more than two feet in height, soil will be placed on top of the wrinkle to decrease the height. Fold over of the liner will not be allowed. A worker must walk along side earth moving equipment and remove all rocks, stones, roots or other debris that could cause damage to the liner. Equipment operators must avoid sharp turns or quick stops that could pinch and tear the liner.

(3) If damage does occur, report it to the Project Manager immediately so that repairs can be performed without needless delay.

(4) Cover shall be placed and maintained in a uniform thickness, free of ruts and irregularities.

(5) Do not work wet cover material that cannot support equipment.

(6) Equipment operators and all other personnel must be qualified and must exercise good judgment and common sense at all times.

4.2.6 Leachate Collection System

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications, or shall be the product of the listed manufacturers, or similar and equal; thereto, as approved by the Engineer.

(1) High Density Polyethylene Pipe

The polyethylene pipe shall be high performance, ultra-high molecular weight, high density polyethylene pipe, conforming to ASTM D1248 (Type III, Class C, Category 5, Grade P34). Minimum cell classification values shall be 335434C as referenced in ASTM D3350. The pipe shall be SDR 17. The pipe shall contain 2 percent carbon black. The pipe shall be "Driscopipe," as manufactured by Phillips Products Company, or equal.

(2) Stone Surrounding Perforated Collection Piping

Stone for leachate collection system shall meet the requirements of NC DOT aggregate, standard size No. 5 and shall contain no fines. Stone must pass the sieve analysis test for No. 5 stone performed at the quarry.

(3) Geotextile Filter Fabric

Filter fabric surrounding the stone/collection piping shall be non-woven needle punched drainage fabric with the following minimum properties:

1)	Weight	4.5 oz/yd^2	ASTM D-5261
2)	Thickness	60 mils	ASTM D-1777
3)	Grab Strength	125 lbs.	ASTM D-4632
4)	Grab Elongation	60%	ASTM D-4632
5)	Trapezoidal Tear Strength	60 lbs.	ASTM D-4533
6)	Puncture Strength	65 lbs.	ASTM D-4833
7)	Mullen Burst Strength	185 psi	ASTM D-3786
8)	Permittivity	1.8 sec^{-1}	ASTM D-4491
9)	Apparent Opening Size (AOS)	0.212 mm (US sieve size 70)	ASTM D-4751

Filter fabric shall be manufactured by Polyfelt, Mirafi, or approved equal.

(4) Knife Gate Valves

Knife Gate Valves shall be bonnetless, wafer type made with a cast iron body, with several support ribs for a strong flanged connection. All sizes shall have a fabricated stainless steel liner. Standard flange holes will be drilled and tapped. Flange drilling dimensions will meet M.S.C. SP-81 and A.N.S.I. B16.5, Class 125/150 requirements. The raised face flange shall meet M.S.S. SP-81 face-to-face dimensions. Valves shall have all wetted parts of stainless steel. Stainless steel liner shall extend through the valve chest to the top of the packing gland. Both sides of the gate shall be finished ground. The stem shall be stainless steel and shall have double pitch threads. The yoke nut shall be acid-resisting bronze. The valve shall have a raised seat with a relieved area around the seat to prevent jamming. The valve gate shall be suitable for 125 psi pressure differential. Packing gland shall have three (3) layers of fiber packing with a 4th elastomer seal. Resilient seated knife gate valves shall have a round port with a replaceable resilient seat interlocked by a metal retaining ring. The metal ring shall act as a wiper blade to clean the gate before it passes over the seat. The resilient seat shall be captured and locked in place on three (3) sides only exposing one surface for sealing which prevents blowout. Knife gate valves shall be a series 304G as manufactured by Red Valve or equal.

(5) Polyethylene Manholes

Polyethylene manholes shall be produced using polyethylene compounds conforming to the requirement of Type III, Category "3", Class B, as defined and described in ASTM D-1248. Clean reworked material or reprocessed material may be use din the manufacture provided that the manhole components meet all the requirements of the product specification.

Polyethylene manholes shall be produced in the rotational molding process. The manhole will consist of an appropriate combination of base, elevation, and top section based on project requirements. Interior access to all manholes shall be designed so that a portable ladder or permanent step system can be supported by the installed manhole. Manholes may be supplied with factory molded steps. Manway reducers shall be concentric with respect to the larger portion of the manhole. The manhole shall be designed to accept and shall be furnished with concrete filled polyethylene manhole lids weighing not less than 190 pounds and must be compatible with a Dewey Brothers RCR-2001 standard cast iron frame. Manhole segment joints shall be designed to function as a full tongue and grove with the groove portion no less than 2.75 inches in depth, and shall include water tight gaskets and/or sealing compounds as recommended by the manufacturer.

Polyethylene manholes shall have a nominal cylinder internal diameter of 48 inches. The manway reducer nominal inside diameter shall be 27.75 inches. Wall thickness of all components shall be determined in accordance with ASTM D-2122 and shall be a minimum of .330 inches.

(6) Trenching for Leachate Piping

The Engineer shall provide on the Contract Drawings a horizontal layout for the proposed leachate collection system along with a minimum of two (2) bench marks. The Contractor shall be responsible for verifying the accuracy of any and all bench marks prior to use. No claim for extra work will be allowed for alleged inaccuracy for any bench mark. It shall be the Contractor's responsibility to protect the original line and bench marks set by the Engineer. Should this information become destroyed or damaged, the cost of the replacement will be borne by the Contractor.

Excavation for the leachate collection shall be done only after the three foot of protective cover has been installed over the flexible membrane liner.

Mechanical equipment can be used for the first two and one-half feet of excavation. The remaining one-half foot or whatever protective cover remains above the flexible membrane liner shall be excavated by hand so as to not damage the liner. If damage occurs to the liner the Engineer or Owner shall be notified immediately and the repair shall take place shortly thereafter.

(7) Installation of Geotextile Filter Fabric

Geotextile filter fabric shall be installed along the entire length of the trenching or as required by Project Specifications on top of the exposed flexible membrane liner/geocomposite net. This fabric is intended to protect the liner/net from the stone that surrounds the perforated collection piping.

In addition, the fabric shall be installed up the walls of the trench with enough excess at the top so that the stone can be completely covered with filter fabric.

4.2.7 Sewer Line

All HDPE pipe shall be laid in conformance with the ASTM standard for installing flexible thermoplastic pipe ASTM D2321. This specification shall be strictly conformed with unless otherwise noted by the Project Specifications or required by the Engineer on site because of local conditions.

All Dual Containment HDPE PIPE shall confirm to ASTM D3350.

(1) Construction Methods

All Gravity Flow Pipeline shall be installed using a laser for control of vertical and horizontal alignment. The Contractor shall follow accepted practices in the utilization of the laser. A certified laser operator shall be present on the job at all times. Care shall be exercised to assure that the alignment control range of the instrument is not exceeded; but in no case, shall the range exceed 500 feet. Care shall be taken to prevent vibration of or direct sunlight on the instrument. Where present, a blower shall be provided to purge glue vapors from the pipe. An air velocity meter shall be provided so that the velocity of air in the pipe will not be great enough to cause the light beam to be distorted. The Contractor shall coordinate the work to minimize the number of take downs and set ups at each point. Periodic checks of the laser shall be made to assure that alignment is maintained.

Each pipe shall be laid on an even, firm bed, so that no uneven strain will come to any part of the pipe. Before each piece of pipe is lowered into the trench, it shall be thoroughly inspected to insure its being clean. Each piece of pipe shall be lowered separately. No piece of pipe or fitting which is known to be defective, shall be laid or placed in the lines. If any defective pipe or fitting shall be discovered after the pipe is laid it shall be removed and replaced with a satisfactory pipe or fitting without additional charge. In case a length of pipe is cut to fit in a line, it shall be so cut as to leave a smooth end at right angles to the longitudinal axis of the pipe.

(2) Butt Fusion for HDPE pipe

Clean pipe ends inside and outside with a clean cloth to remove dirt, water, grease and other foreign materials.

Square (face) the pipe ends using facing tool of the fusion machine.

Check line-up of pipe ends in fusion machine to see that pipe ends meet squarely and completely over the entire surface to be fused. This is commonly referred to as "adjusting high-low". It is advisable at this point to make sure the clamps are tight so that the pipe does not slip during the fusion process.

Insert clean heater plate between aligned ends, and bring ends firmly in contact with plate, but do not apply pressure while achieving melt pattern. Carefully move the pipe ends away from the heater plate and remove the plate. (If the softened material sticks to the heater plate, discontinue the joint. Clean heater plate, re-square pipe ends and start over.)

Note: One pipe end usually moves away from the heater plate first. It is good practice to "bump" the plate away from the other side and then lift it out. Never drag or slide it over the melted pipe end.

Bring melted ends together rapidly. Do not slam. Apply enough pressure to form a double roll back to the body of the pipe brad around the entire circumference of the pipe about 1/8" to 3/16" wide. Pressure is necessary to cause the heated material to flow together.

Allow the joint to cool and solidify properly. This occurs when the brad feels hard and your finger can remain comfortably on the brad. Remove the pipe from the clamps and inspect the joint appearance.

(3) Tests

HDPE Dual Containment Force main - ASTM D3350. All HDPE pipe shall be tested at its rated working pressure. In no case shall there be any visible leakage, nor shall there be leakage between any section of pipe.

4.2.8 Closure Cap System

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

4.2.9 Closure Cohesive Soil Cap

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Cohesive Soil Cap Borrow Material

Test Name	Test Method	Contractor/Engineer Frequency
Moisture/Density	ASTM D698/D1557	1 per 5000 c.y.
Remolded Permeability	ASTM D5084	1 per 5000 c.y.
Atterberg Limits	ASTM D4318	1 per 5000 c.y.
Visual Classification	ASTM D2488	1 per 5000 c.y.
Grain Size Distribution	ASTM D422	1 per 5000 c.y.

Cohesive Soil Cap Test Pad

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	3 per lift
Permeability	ASTM D5084	1 per lift
Remolded Permeability	ASTM D5084	1 per lift
Atterberg Limits	ASTM D4318	1 per lift
Visual Classification	ASTM D2488	1 per lift
Grain Size Distribution	ASTM D422	1 per lift

In-Place Cohesive Soil Cap

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	1 per lift per acre
Permeability	ASTM D5084	1 per lift per acre
Atterberg Limits	ASTM D4318	1 per lift per acre
Visual Classification	ASTM D2488	1 per lift per acre
Grain Size Distribution	ASTM D422	1 per lift per acre

(a) Suitable on-site and/or off-site soils may be used as cohesive soil cap if it can achieve an in-place permeability of 1.0×10^{-5} cm/sec or less and meets all testing requirements indicated in the material testing paragraph in this section. Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

(b) A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil cap. The window shall be plotted on a semi-log plot with moisture content versus density. Laboratory testing to develop the window shall include a series of remolded samples compacted to various dry densities and moisture contents utilizing the same compactive effort (ASTM D 698 or D 1557). The remolded samples shall be tested for permeability to determine whether or not the particular soil type will provide the maximum permeability (1.0×10^{-5} cm/sec) at various dry densities and moisture contents. The window is then developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

(c) Atterberg limits and grain size distribution shall also be conducted on the bulk samples used to prepare the permeability window ASTM D2488, D4318, D422. These tests can be used as indices on random samples collected from the borrow site during construction to verify the soil type is the same as was used to develop the "window". As a minimum, sufficient visual classifications and Atterberg limits shall be conducted in association with each permeability test to verify that the construction materials meet specifications.

(d) A test strip of compacted cohesive soil cap shall be prepared to verify the permeability "window" prior to general installation of the cohesive soil cap. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil cap. At a minimum, the verification will consist of three moisture density tests, one Atterberg limits test, one grain size distribution test (ASTM D2488, D4318, and D422), and one Shelby Tube sample for each lift constructed in the test pad. Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil cap after placement and compaction. The permeability must be a maximum of 1.0×10^{-5}cm/sec. Tests shall be performed in accordance with the ASTM D5084. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 25 ft. The test strip shall consist of at least three compacted 6 inch lifts of cohesive soil cap. Placement and testing of the test strip shall be in conformance with the construction specifications and requirements for general installation of the cohesive soil cap. Test results from the test strip shall be used to guide placement and achievement of the required maximum permeability of 1.0×10^{-5} cm/sec of the cohesive soil cap. The test strip may be used as an integral part of the overall cohesive soil cap if it meets the required specification for the cap. All results shall be given to the Construction Observer.

(e) The soils shall be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift compacted preferably at a moisture content between 0 to 3% above optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698). A sheepsfoot roller or approved alternative may be used to compact the soil cap provided the compaction and permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil cap shall be screened, disced, or prepared using any other approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. After each lift, the surface shall be scarified prior to the placement of the next lift to provide good bonding from one lift to the next.

(f) The cohesive soil cap shall be tested to evaluate the coefficient of permeability. The coefficient of permeability of the soil cap shall be equal to or less than 1.0×10^{-5} cm/sec after placement and compaction. The soil cap must be a minimum of 1.5 feet thick.

(g) Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil cap after placement and compaction. The permeability must be a maximum of 1.0×10^{-5}cm/sec. Tests shall be performed in accordance with ASTM D5084.

(h) The soil cap shall be tested a minimum of one soil sample per lift per acre for laboratory permeability. All permeability testing will be on random samples judged by the Engineer to be representative of the most permeable soil conditions for the area being tested. The project engineer shall certify that the materials used in construction were tested according to the Division approved plans. If after placement of the soil cap it fails the required tests, the material will either be reworked or replaced. The soil cap must remain moist at all times, if any section becomes dry, rework the dry area and moisten.

(i) A minimum of two (2) inches of soil shall be removed prior to securing each sample for permeability testing. The sampling tube shall be advanced vertically into the soil with as little soil disturbance as possible and should be pushed using a uniform pressure. The sampling tube (Shelby tube), when extracted, shall be free of dents, and the ends shall not be distorted. A backhoe or approved alternative should be used to advance the sampling tube (Shelby tube) as long as disturbance is minimized. Drive tube samples of the cap may be obtained for permeability testings. If the Engineer judges the sample to be too disturbed, another sample shall be taken. Once an acceptable sample has been secured and properly prepared, all sample excavations shall be backfilled to grade with a 50% mixture of bentonite and similar soils in maximum 3-inch loose lifts and hand tamped with a blunt tool to achieve a tight seal equivalent to the original density.

(j) No additional construction shall proceed on the soil layers at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved.

(k) As a minimum, sufficient visual classifications (ASTM Test Designation D2488) , analyses (ASTM Test Designation D422) and Atterberg limits (ASTM Test Designation D4318) shall be conducted in association with each permeability test to verify that the construction materials meet specifications. The minimum number of tests will be 1 per lift per acre.

(l) If the soil for the cohesive soil cap is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory. Where additives are required, the soil shall be placed in maximum 8-inch thick loose lifts and compacted preferably between 0 to +3% optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698) for the soil-additive mixture. All other compaction procedures for the soil apply.

(m) Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil cap shall have no sudden sharp or abrupt changes in grade.

(n) The Contractor shall protect the cohesive soil cap from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil cap until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions shall be replaced or reworked by the contractor to remove these defects.

(o) The thickness and grade of the soil cap will be verified by the surveyor before placement of the geomembrane liner. The soil cap will be surveyed at 100' grid points where the elevations of the top of landfill will be checked with the top of soil cap to verify 1.5 feet of soil cap. The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

(p) Surface Acceptance. Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil cap and the surface shall remain the responsibility of the contractor.

4.2.10 Closure Flexible Membrane Liner Method of Deployment

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Flexible Membrane Liner Tests

Test Name	Description	Test Method	Frequency
Air Test	Air Test Seams		Every Seam
Vacuum Test	Every welded area		Where air test impossible
Destructive Tests	Seam Strength	ASTM D4437	Every 500' of seam

Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

40 mil Linear Low Density Polyethylene (LLDPE) is to be placed in direct contact with moist cohesive soil cap. The extrusion rods and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner and shall meet the following minimum properties:

Smooth 40 mil LLDPE Liner Specifications

Property	Test Method	Test Value	Contractor/Engineer Test Frequency
Thickness (min. avg.)	D5199	nom. (mil)	Per roll
- lowest individual for 8 out of 10 values		-10%.	
Density (max.)	D1505/D792	0.939	200,000 lb
Tensile Properties (1)(min. avg.)	D638 Type IV		20,000 lb
- yield stress lb/in		64	
- break stress lb/in		152	
- yield strain %		13	
- break strain %		800	
2% Modulus - psi (max.)	D5323	30,000	20,000 lb
Tear Resistance- lb/in (min avg.)	D1004	22	45,000 lb
Puncture Resistance- lb/in (min avg.)	D4833	56	45,000 lb
Axi-Symmetric Break Strain- % (min)	D5617	30	200,000 lb
Stress Crack Resistance- hr (2)	D5397 (App.)	n/a	per GRI-GM10
Carbon Black Content- %	D1603 (3)	2.0-3.0	20,000 lb
Carbon Black Dispersion	D5597	note (4)	45,000 lb
Oxidative Induction Time (OIT) (min ave,) (5)			
(a) Standard OIT	D3895	120 min.	
-or-			200,000 lb
(b) High Pressure OIT	D5885	500 min.	
Oven Aging at 85°C (6)	D5721		
(a) Standard OIT (min. ave) -% retained after 90 days	D3895	55	per each formulation
-or-			
(b) High Pressure OIT (min ave) -% retained after 90 days	D5885	80	
UV Resistance (7)			
(a) Standard OIT (min avg.)	D3890	N.R. (8)	
-or-			per each formulation
(b) High Pressure OIT (min avg.) -% retained after 1600 hrs (9)	D5885	50	

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm
(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
(3) Other methods such as D4128 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
(4) Carbon black dispersion for 10 different views:
- all 10 in Categories 1 or 2
(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(7) The condition of the test should be 20 hr UV cycle at 75°C followed by 4hr condensation at 60°C.
(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

(1) Preparation for Geomembrane Deployment

(a) Panel Layout

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project.

(b) Identification

Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture.

(c) Verification

The manufacturers certification will be given to the construction observer. The construction observer will inspect all certifications. If the certification does not meet specifications, it will be rejected. Adequate laboratory QA/QC conformance testing shall be performed by contractor/engineer to verify minimum requirements.

(2) Field Panel Placement

(a) Location

The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

(b) Weather Conditions

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds.

(c) Method of Deployment

(1) The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface.

(2) No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane.

(3) Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas.

(4) The geomembrane will be deployed in a manner to minimize wrinkles. The geomembrane will have no fold overs.

(5) Any damage to a panel of the geomembrane will be repaired. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed.

(3) Field Seaming

(a) Layout

In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

(b) Personnel

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

(c) Equipment

(1) Fusion Welding

Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge.

(2) Extrusion Fillet Welding

Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes

some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets. The extrusion welder is equipped with gauges giving the temperature in the apparatus and the preheat temperature at the nozzle.

(d) Weather Conditions

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can effect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will effect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams substantiate the decision made by the Project Superintendent to seam on any given day.

(4) Seam Preparation

(a) Fusion Welding

(1) Overlap the panels of geomembrane approximately four (4) inches.

(2) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding.

(3) Adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

(4) A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

(b) Extrusion Welding

(1) Overlap the panels of geomembrane a minimum of three (3) inches.

(2) Temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane.

(3) Grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area.

(4) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind.

(5) Purge the extruder prior to beginning the seam to remove all heat-degraded extrudate from the barrel.

(6) Keep welding rod clean and off the ground.

(5) Test Seams

Test seams shall be performed at the beginning of each seaming period and at least once each four (4) hours for each seaming apparatus used that day. Test seams shall be made on fragment pieces of the geomembrane liner and under the same conditions as actual seams.

(a) Test Seam Length

The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width.

(b) Sample Procedure

(1) Visually inspect the seam for squeeze out, footprint, pressure and general appearance.

(2) Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated.

(3) If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved.

(4) After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam identification number, welder's name, temperature control setting and test results.

(5) Passing test results records shall be maintained.

(6) General Seaming Procedures

(a) Seaming shall extend to the outside edge of panels to be anchored.

(b) While welding a seam, monitor and maintain the proper overlap.

(c) Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind.

(d) While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly.

(e) Align wrinkles at the seam overlap to allow welding through the wrinkle.

(f) Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions.

(g) All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane.

(h) All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind ¼ of an inch minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

4.2.11 Closure Flexible Membrane Liner Tests

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

(a) Air Pressure Testing

The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time.

(1) Equipment for Air Testing

An air pump (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi.

A rubber hose with fittings and connections.

A sharp hollow needle, or other approved pressure feed device with a pressure gauge capable of reading and sustaining a pressure between 25 to 30 psi.

(2) Procedure for Air Testing

Seal both ends of the seam to be tested.

Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld.

Inflate the test channel to a pressure between 25 to 30 psi, in accordance with the following schedule, close valve, and observe initial pressure after approximately 2 minutes.

INITIAL PRESSURE SCHEDULE *

Material (Mil)	Min. Psi	Max. Psi
40	25	30
60	27	30
80	30	30
100	30	30

* Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize.

Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used. If loss of pressure exceeds the following or if the pressure does not stabilize, locate faulty area and repair.

MAXIMUM PERMISSIBLE PRESSURE DIFFERENTIAL AFTER 5 MINUTES - LLDPE

Material (Mil)	Pressure Diff.
40	4 psi
60	3 psi
80	3 psi
100	3 psi

At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected.

Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

(3) In the event of a Non-Complying Air Pressure Test, the following procedure shall be followed:

Check seam end seals and retest seams.

If non-compliance with specified maximum pressure differential re-occurs, cut one (1) inch samples from each end of the seam and additional samples.

Perform destructive peel tests on the samples using the field tensiometer.

If all samples pass destructive testing, remove the overlap left by the wedge welder and vacuum test the entire length of seam.

If a leak is located by the vacuum test, repair by extrusion welding. Test the repair by vacuum testing.

If no leak is discovered by vacuum testing, the seam will pass non-destructive testing.

If one or more samples fail the peel tests, additional samples will be taken.

When two (2) passing samples are located, the seam between these two (2) locations will be considered non-complying. Capping or removal of the non-complying seam are the only two (2) acceptable methods for repairing failed seams. Non-destruct test the entire length of the repaired seam.

(b) Vacuum Testing

This test is used when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

(1) Equipment for Vacuum Testing

Vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.

Vacuum pump assembly equipped with a pressure controller and pipe connection.

A rubber pressure/vacuum hose with fittings and connections.

A bucket and means to apply a soapy solution.

A soapy solution.

(2) Procedure for Vacuum Testing

Trim excess overlap from seam, if any.

Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi gauge.

Apply a generous amount of a solution of strong liquid detergent and water to the area to be tested.

Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner.

Close the bleed valve and open the vacuum valve.

Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box.

Ensure that a leak tight seal is created.

For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process.

(3) Procedure for Non-Complying Test

Mark all areas where soap bubbles appear and repair the marked areas.
Retest repaired areas.

(c) Destructive Testing

(1) Concept

The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane.

(2) Procedure for Destructive Testing

All Destructive tests will be done according to ASTM D4437. Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one test location every 500 feet of seam length.

Additional destructive tests may be taken in areas of contamination, offset welds, visible crystallinity or other potential cause of faulty welds at the descretion of the Project Superintendent and Engineer.

Sample Size

The sample should be twelve (12) inches wide with a seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications.

A one (1) inch sample shall be cut from each end of the test seam for field testing.

The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the liner tears before any part of the seam does the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing.

(3) Procedure in the event of Destructive Test Failure

Cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing.

If the laboratory samples pass then reconstruct the seam between the two (2) passing samples locations.

Heat tack the overlap along the length of the seam to be reconstructed and extrusion weld.

Vacuum test the extrusion weld.

If either of the samples fail, then additional samples are taken in accordance with the above procedure until two (2) passing samples are found to establish the zone in which the seam should be reconstructed.

All passing seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken.

In cases of reconstructed seams exceeding 150 feet, a destructive sample must be taken and pass destructive testing from within the zone in which the seam has been reconstructed.

All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered.

(d) Quality Assurance Laboratory Testing

(1) Destructive samples sent to the laboratory will be tested for "shear strength" and "peel adhesion" (ASTM D4437 as modified by NSF). Five (5) specimens shall be tested for each test method with data recorded. Four (4) out of the five (5) specimens must pass for each test in order for the seam to pass the destructive test.

(2) Defects and Repairs

(a) The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation.

(b) All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

(c) Repair Procedures

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely manner to protect the moist cohesive soil liner and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil cap such as a temporary cover. If cohesive soil cap is damaged, it must be reworked. Procedures available for liner repair:

Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of the defect and all corners of patches shall be rounded.

Reconstruction - used to repair seams bounded by passing destruct samples.

Grinding and welding - used to repair sections of extruded seams.

Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws.

Capping - used to repair lengths of failed extruded seams.

Removal of a bad seam and replacement with a strip of new material seamed into place.

(d) Verification of Repairs

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as-built drawing.

4.2.12 Closure Protective Cover

(1) HPDE Geocomposite Drainage Netting manufactured by SKAPS Industries, or approved equal.

GEOCOMPOSITE PROPERTIES

PROPERTY	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Thickness	ASTM D 5199	inch	0.305
Transmissivity[1] (15,000 psf)	ASTM D 4716	m^2/sec	$3x10^{-5}$
Ply Adhesion	ASTM D 413 or F 904	lb/in	2.0

COMPONENT PROPERTIES

GEONET	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Polymer Density	ASTM D 1505	g/cm^3	0.94
Carbon Black Content	ASTM D 4218	%	2.0
Thickness	ASTM D 5199	inches	0.200
Mass per unit area	ASTM D 5261	lbs/ft^2	0.162
Transmissivity[1]	ASTM D 4716	m^2/sec	$1x10^{-3}$@ 15,000 psf
Tensile Strength	ASTM D 5035	lbs/in	45

GEOTEXTILE	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Fabric Weight	ASTM D 5261	oz/yd^2	7.1
Thickness	ASTM D 5199	mils	95
Grab Strength	ASTM D 4632	lbs	210
Water Flow Rate	ASTM D 4491	gpm/ft^2	110
Apparent opening size (AOS)	ASTM D 4751	mm (Sieve Size)	0.150 (100)

1. Measured using water @ 20° C (68° F) with a gradient of one, between two steel plates, after one hour. Value may vary, based on dimensions of the transmissivity specimen and specific laboratory.
2. Component properties are tested prior to the lamination process. They cannot be tested on the final product.

The geocompsite will be handled in such a manner as to ensure the geocomposite are not damaged in any way. On slopes, the geocomposite will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite will be positioned by hand after being unrolled to minimize wrinkles. Geocomposite can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1).

Geocomposite will not be welded to the geomembrane. Geocomposite will be cut using approved cutters,(i.e., hook blade, scissors, etc.) Care should be taken to prevent damage to underlying layers. Care must be taken not to entrap dirt in the geocomposite that could cause clogging of the drainage system, and or stones that could damage the adjacent geomembrane. Adjacent rolls of geocomposite will be overlapped by at least four inches and securely tied. Tying can be achieved by plastic fasteners. Tying devices will be white or yellow for easy inspection. Metallic devices are not allowed. Tying will be five to ten feet along the bottom

of the slope. Tying will be every five feet along the slope, every two feet across the slope and at the top of the berm. Tying in the anchor trench will be done in one foot intervals. In the corners of the side slopes where overlaps between perpendicular geocomposite strips are required, an extra layer of geocomposite will be unrolled along the slope, on top of the previously installed geocomposite, from the top to bottom of the slope.

Any holes or tears in the geocomposite will be repaired by placing a patch extending two feet beyond edges of the hole or tear. The patch will be secured to the original geocomposite by tying every twelve inches. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined.

The engineer will visually inspect the drainage layer before placement of the erosive layer, if any defects are detected they will be repaired before placement of erosive layer.

(2) Erosive Layer

The soil for the erosive layer shall consist of any soils suitable of supporting vegetative growth. The erosive layer shall be installed using low ground pressure equipment such as a Caterpillar D6H LGP, or approved equal, with ground pressure not exceeding 4.71 psi. When installing the erosive layer, the contractor shall adhere to the following guidelines:

(a) A minimum of twelve inches (12") of cover between low ground pressure equipment and the liner is required at all times. Roadways for entering and for transporting material over slopes and capped/lined areas shall have a minimum depth of four feet (4').

(b) Avoid undue stress on the liner at all times. Cover material must be pushed up slopes, never down to help minimize wrinkles. Material must be placed to minimize wrinkles, wrinkles in excess of two feet in height are unacceptable. If a wrinkle is more than two feet in height, soil will be placed on top of the wrinkle to decrease the height. Fold over of the liner will not be allowed. A worker must walk along side earth moving equipment and remove all rocks, stones, roots or other debris that could cause damage to the liner. Equipment operators must avoid sharp turns or quick stops that could pinch and tear the liner.

(c) If damage does occur, report it to the Project Manager immediately so that repairs can be performed without needless delay.

(d) Do not work wet cover material that cannot support equipment.

(e) Equipment operators and all other personnel must be qualified and must exercise good judgment and common sense at all times.

(3) Vegetative Layer

Native vegetation will be used as approved by the Erosion Control Plan.

4.2.13 Closure Methane Venting System

NC.D.O.T. No.5 stone, Geotextile fabric, and 8" and 10" plastic pipes will be used in the construction of the gas venting system.

(1) Stone in Trenches and Surrounding Perforated Collection Piping

Stone for methane collection system shall meet the requirements of NC DOT aggregate, standard size No. 5 and shall contain no fines. Stone must pass the sieve analysis test for No. 5 stone performed at the quarry.

(2) Geotextile Fabric

Geotextile fabric surrounding the stone/piping shall be non-woven needle punched fabric with the following minimum properties:

1)	Weight	8.0 oz/yd^2	ASTM D-3776
2)	Grab Strength	205 lbs.	ASTM D-4632
3)	Grab Elongation	50%	ASTM D-4632
4)	Trapezoidal Tear Strength	85 lbs.	ASTM D-4533
5)	Puncture Strength	100 lbs.	ASTM D-4833
6)	Mullen Burst Strength	320 psi	ASTM D-3786
7)	Permittivity	1.4 sec^{-1}	ASTM D-4491

Geotextile fabric shall be manufactured by Polyfelt , TNS Advanced Technologies, or approved equal.

(3) Plastic Pipe

Plastic gravity sewer pipe and fittings used for methane vent shall be unplasticized polyvinyl chloride (PVC) and conform to the requirements of ASTM Designation D-3034 on ASTM F679, Type PSM, Class 12454-B, SDR-35 with elastomeric gasket joints. PVC pipe and fittings shall be as manufactured by J-M Pipe, Certainteed, H&W Industries or equal. The methane riser pipe shall be a 10 inch solid wall PVC pipe.

4.3 Documentation

At the completion of the contract, it is the Engineer's responsibility to provide to the Owner and eventually to the Division of Solid Waste Management the following:

1. As-built drawings of the subgrade, liner system, leachate collection.
2. Documentation of all subbase standard Proctor tests.
3. Documentation of all cohesive soil liner tests including test pads, permeability, standard Proctor and Atterberg limits.
4. Documentation of all destructive and non-destructive tests, methods and results and repairs.
5. Geomembrane panel layout with test locations and repairs illustrated.
6. Summary from the Project Engineer.
7. Any other pertinent documentation.

The CQA report shall be sealed by the Project Engineer and a certification that construction was completed an accordance with the CQA plan, Conditions of the permit to construct, The requirements of rule .1624 Construction Requirements for MSWLF Facilities, and acceptable engineering practices.

Shop Drawings

Contractor is required to submit to the Engineer a descriptive detail and any shop and setting drawings. On composite liner system, such submission shall include the following:

(1) Flexible Membrane Liner Panel Layout Drawings,
(2) Flexible Membrane Liner Penetration Details,
(3) Flexible Membrane Liner Anchoring Detail,
(4) Flexible Membrane Liner Seaming Detail,
(5) Single Flexible Membrane Liner Anchoring to Structure Detail,
(6) Flexible Membrane Liner Extension Detail, and
(7) Certified experience records for manufacturer, fabricator and installer, listing installations of Flexible Membrane Liners.

SEAM TESTING

Project Name _____ Project Number _____ Superintendent _____

NSC FIELD SEAM NO.	SEAM DATE	SHOP DWGN SEAM NO.	WELDER AND SEAMER ID. NO.	TEST DATE	START		END		AIR TEST RESULTS	COMMENTS	REPAIR DATE	WELDER AND GUN ID. NO.	REPAIR VACUUM TEST DATE	SEAM (INITIAL) (DATE)
					PRESS.	TIME	PRESS.	TIME						

Page _____ of _____

DESTRUCTIVE TEST SAMPLES

Project Name _____ Project Number _____ Supervisor _____

DATE	WELDER ID.	SEAMER	SEAM NO.	LOCATION	SAMPLE ID.

Page ____ of ____

TEST SEAM RECORDS

Project Name _____ Project Number _____ Supervisor _____

TEST DATE	TIME	LBS./IN.	PASS/FAIL	MACHINE NUMBER	TEMP. SETTING	OPERATOR

Page ____ of ____

REPAIR REPORT

Project Name _____ Project Number _____ Supervisor _____

FIELD SEAM #	PANEL #	REPAIR DATE	WELDER AND SEAMER ID. #	LOCATION OF REPAIR	REPAIR VACUUM TEST DATE	REPAIR ACCEPTED (INITIAL) (DATE)

Page ____ of ____

SECTION 5.0

OPERATION PLAN

5.1 Introduction

Haywood County Landfill will only accept Municipal Solid Wastes (MSW) from Haywood County. Haywood County will construct a 10.26 acre Municipal Solid Waste Landfill (Phase 2) according to Subtitle D requirements. The facility will be constructed with 24 inches of cohesive soil (permeability of 1.0×10^{-7} cm/sec), 60 mil High Density Polyethylene liner (HDPE), 36 inches of protective cover over the liner and a leachate collection system which flows to the existing leachate lagoon.

The perimeter of the lined area will be marked off by 3 inch PVC pipe at 100' intervals that will be placed in the anchor trenches. Solid waste will not be placed within four (4) feet of this boundary to assure that it is being placed directly above the liner system so that no leachate can flow outside of this area. The lined area will be divided by a berm that will segregate area for solid waste and where stormwater is to be diverted as runoff.

The diversion of stormwater is accomplished by the installation of a 60 mil HDPE liner connected to the Base Liner next to the main leachate collection lines. This liner acts as its own lagoon and the rain that falls onto the unused portion of the landfill is discharged through a penetration as stormwater. The HDPE stormwater flap keeps leachate from migrating to the cell that is only producing stormwater. This stormwater flap is located inside each cell such that the leachate line separating the cell is located outside the current cell. Each one of these leachate lines has an individual valve. If the valve is left open the stormwater leaves the cell through a penetration. This water never comes in contact with solid waste. When solid waste is placed within a cell the valve is closed and the leachate is sent to the lagoon. Phase 2 is broken up into five (5) cells, divided by these main leachate collection lines.

All stormwater that comes in contact with solid waste will be handled as leachate. The leachate is collected and held in the leachate lagoon. The leachate is gravity fed from the landfill, through a dual containment sewer line and HDPE manholes, then to the lagoon.

Leachate will be treated at the Waste Water Treatment Plant. The leachate will have to be tested according to the pretreatment conditions outlined in the pre-treatment agreement. Tanker trucks will transport the leachate to the treatment plant. In the future there may be a force main constructed to pump the leachate to the treatment plant.

The leachate will be pumped out of the leachate lagoon into either tanker trucks or recirculated into the working face of the landfill. The pumping of leachate will be on an as needed basis. During wet weather, the pump and hauling may have to be done 24 hours a day for several days or until the leachate lagoon levels have been reduced. On the other hand, during dry weather, leachate may not have to be hauled for several days at a time.

Leachate will be recirculated. (See Appendix IV)

The leachate lagoon will be inspected on a monthly basis and a report generated and placed in the landfill records. The report will include the date the liner was inspected, the inspector, general observations since the last inspection, visible abrasions, possible stress cracks, or obvious punctures.

Stress cracks can occur in wrinkles that are generated from heat expansion or contraction due to freezing. Also, the HDPE liner may deteriorate due to ultra violet light and this can appear as an abrasion where material can be scraped away with a hard object. If any damage or possible weak spots due to ultra violet exposure has been detected, a qualified HDPE installation company shall be notified immediately so that a repair patch can be installed. The leachate level shall not be allowed to exceed the depth of the damaged liner until it has been repaired and tested by the liner installation company. Once this has been accomplished all testing documentation shall be placed in the operating records.

Daily cover will be the combination of soil and synthetic cover. The synthetic cover will be used on days that the next days fill will be placed directly on top of the fill. Soil cover will be used when the next day's waste will not be placed directly on top or the synthetic cover is not large enough to cover the entire area. Soil cover will be placed at least once a week. (See cover requirements under operational requirements).

The County has implemented a program at the landfill for detecting and preventing the disposal of hazardous and liquid wastes. The program consists of random inspection of incoming loads at a minimum of 1% of the weekly traffic. Landfill personnel have been trained to recognize hazardous and liquid wastes. Records will be kept on the training and the inspections. (See Section 5.3-Appendix I).

The County of Haywood will monitor for explosive gases at landfill structures and the perimeter of the landfill. The concentration of methane gases generated by the landfill cannot exceed 25 percent of the lower explosive limit for methane in the structures, and it cannot exceed 100 percent of the lower explosive limit for methane of the landfill property boundary. (See Section 5.5-Appendix III) If methane gas is found to exceed the acceptable limits at either the property boundary or landfill structures, it is the County's responsibility to do the following:

1. Immediately take all necessary steps to ensure protection of human health, i.e. no smoking, temporarily abandon the structure and notify the Division of Solid Waste Management.

2. 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

3. 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 of Solid Waste management that the plan has been implemented. The plan will describe the nature and extent of the problem and the proposed remedy.

Off and on site erosion will be controlled through erosion control structures and devices. Provisions for a vegetative ground cover sufficient to restrain erosion will be accomplished within <u>30 working days</u> or <u>120 calendar days</u> upon completion of any phase of landfill development.

The County of Haywood will record and retain at the landfill an operating record of the following information:

(1) Inspection records, waste determination records, and training procedures;
(2) Amounts by weight of solid waste received at the landfill;
(3) Waste determination, Leachate sampling data, leachate levels, meteorological data ;
(4) Gas monitoring results and any remediation plans;
(5) Any demonstration, certification, findings, monitoring, testing or analytical data required for surface and groundwater monitoring;
(6) Any monitoring, testing or analytical data required for closure or post-closure;
(7) Any cost estimates and financial assurance documentation.

All information contained in the operating record will be furnished upon request to the Division of Solid Waste Management or be made available at all reasonable times for inspection by the Division.

Ground and surface water will be sampled and analyzed according to Subtitle D Appendix I detection monitoring requirements. The monitoring frequency for all Appendix I(Section 5.3) detection monitoring constituents will be at least semiannual during the life of the facility (including closure) and the post-closure period. A minimum of four independent samples from each well (background and downgradient) will be collected and analyzed for the Appendix I constituents during the first semiannual sampling event. At least one sample from each well (background and downgradient) will be collected and analyzed during subsequent semiannual sampling events.

If the County of Haywood determines that there is a statistically significant increase over background for one or more of the constituents listed in Appendix I at any monitoring well at the relevant point of compliance, the County will, within 14 days of the finding, report to the Division of Solid Waste and place a notice in the operating record indicating which constituents have shown statistically significant changes from background levels. The County will establish an assessment monitoring program within 90 days. The County may demonstrate that a source other than the landfill caused the contamination or that the statistically significant increase resulted from an error in sampling, analysis, statistical evaluation, or natural variation in ground-water quality. A report documenting these demonstrations will be certified by a Licensed Geologist or Professional Engineer and approved by the Division of Solid Waste. A copy of this report will be placed in the operating record. If a successful demonstration is made, documented, and approved by the Division, the County may continue detection monitoring. If after 90 days, a successful demonstration is not made, the County will initiate an assessment monitoring program.

5.2 Operational Requirements

1. Waste Acceptance and Disposal Requirements

   a. The Municipal Solid Waste Landfill (MSWLF) will only accept those solid wastes which it is permitted to receive. Haywood County will notify the Division within 24 hours of attempted disposal of any waste the landfill is not permitted to receive. Signs are placed at the entrance to the Landfill stating that Hazardous and Liquid wastes are not accepted and that random waste screening is performed.

b. The following wastes are prohibited from disposal at the MSWLF:

i. Hazardous waste as defined within 15A NCAC 13A, to also include hazardous waste from conditionally exempt small quantity generators.

ii. Polychlorinated biphenyls (PCB) wastes as defined in 40 CFR 761.

iii. Bulk or non-containerized liquid waste will not be placed in the landfill unless:

(i) The waste is household waste other than septic waste and waste oil,
(ii) The waste is leachate or gas condensate derived from the landfill.

iv. White Goods, Yard Waste, Tires.

v. Containers holding liquid wastes will not be placed in the landfill unless:

(i) The container is a small container similar in size to that normally found in household waste;
(ii) The container is designed to hold liquids for use other than storage; or
(iii) The waste is household waste.

vi. For the purpose of this paragraph:

(i) Liquid waste means any waste material that is determined to contain "free liquids" as defined by Method 9095 (Paint Filter Liquids Test), S. W. 846.

c. Spoiled foods, animal carcasses, abattoir waste, hatchery waste, and other animal waste delivered to the disposal site will be covered immediately.

d. Asbestos waste will be accepted. The waste will be put in a hole dug out of the existing waste and buried immediately. A 24 hour notice will be given to the Landfill before any asbestos arrives, records will be kept as to whom and type of asbestos buried.

e. Wastewater treatment sludges may be accepted either as a soil conditioner incorporated into or applied onto vegetative growth layer but in no case greater than six inches in depth. Or wastewater treatment sludges may be co-disposed in the lined area.

f. Haywood County will continue a program at the Landfill for detecting and preventing the disposal of hazardous and liquid wastes. (Section 5.3-Appendix I) This program will include, at a minimum:

i. Random inspections of incoming loads or other comparable procedures;

ii. Records of any inspections;

iii. Training of facility personnel to recognize hazardous and liquid wastes.

iv. Development of a contingency plan to properly manage any identified hazardous and liquid wastes. The plan must address identification, removal, storage and final deposition of the waste.

g. Waste placement will be within the areal limits of the base liner system and in a manner consistent with the effective permit.

2. Cover material requirements.

a. Except as in Part (b), Haywood County must cover disposed solid waste with six inches of earthen material at the end of each operating day, or at more frequent intervals if necessary, to control disease vectors, fires, odors blowing litter, and scavenging.

b. Alternative materials such as synthetic cover may be used as daily cover on the working face or until it is necessary to cover with earthen material. The alternative material must be approved by the Division of Solid Waste and applied according to manufacturers recommendations. At a minimum soil cover will be used once a week. (Section 5.4-Appendix II)

c. Areas which will not have additional wastes placed on them for 12 months or more, but where final termination of disposal operations has not occurred, will be covered with a minimum of one foot of intermediate cover.

3. Disease vector control

a. Haywood County will prevent or control on-site populations of disease vectors using techniques appropriate for protection of human health and the environment. At the end of every day, waste will be covered either by synthetic cover or 6" of soil cover. At a minimum soil will be used once a week. Any waste that requires immediate cover, will be covered immediately with soil.

b. "Disease vectors" means any rodents, flies, mosquitoes, or other animals, including insects, capable of transmitting disease to humans.

4. Explosive gases control

a. Haywood County must ensure that:

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

ii. The concentration of methane gas does not exceed 100 percent of the lower explosive limit for methane at the landfill property boundary.

b. Haywood County will implement a routine methane monitoring program to ensure that the standards of 4 (a) are met. (Section 5.5-Appendix III)

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

I. Soil conditions;

II. The hydrogeologic conditions surrounding the facility;

III. The hydraulic conditions surrounding the facility;

IV. The location of facility structures and property boundaries.

ii. The minimum frequency of monitoring will be quarterly.

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

i. Immediately take all necessary steps to ensure protection of human health, i.e. no smoking, temporarily abandon the structure and notify the Division of Solid Waste Management.

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 of Solid Waste Management that the plan has been implemented. The plan will describe the nature and extent of the problem and the proposed remedy.

d. "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.

5. Air Criteria

a. Haywood County will ensure that the landfill does not violate any applicable requirements developed under a State Implementation Plan (SIP) approved or promulgated by the US. EPA Administrator pursuant to Section 110 of the Clean Air Act, as amended.

b. Open burning of solid waste, except for the infrequent burning of land clearing debris generated on site or debris from emergency clean-up operations, is prohibited. Any such infrequent burning will be approved by the Division of Solid Waste Management.

c. Earth moving equipment will be provided to control accidental fires and leachate tank trucks used for water or leachate that would be recirculated can also be used. Arrangements have been made with the local fire department to provide actual fire protection. This Fire department has access at all times to the landfill to provide fire fighting services when needed. Landfill personnel can use soil to isolate the fire so it will not spread any further but actual fighting of the fire should be the responsibility of the trained fire department.

d. Fires that occur at the landfill will be reported to the Division of Solid Waste Management within 24 hours and written notification will be submitted within 15 days.

6. Access and safety requirements

a. The landfill will be adequately secured by means of gates, chains, beams, fences and other security measures approved by the Division of Solid Waste Management to prevent unauthorized entry.

b. An attendant will be on duty at the site at all times while it is open for public use to ensure compliance with operational requirements.

c. The access road to the site will be of all-weather construction and maintained in good condition.

d. Dust control measures will be implemented when necessary. If dust problems should arise, the county will use any reasonable means necessary to reduce it. At a minimum the county will spray water on necessary areas.

e. Signs providing information on tipping or disposal procedures, the hours during which the site is open for pubic use, the permit number and other pertinent information will be posted at the site entrance.

f. Signs will be posted stating that no hazardous or liquid waste can be received.

g. Traffic signs or markers will be provided as necessary to promote an orderly traffic pattern to and from the discharge area and to maintain efficient operating conditions.

h. The removal of solid waste from the landfill will be prohibited unless the County approves and the removal is not performed on the working face.

i. Barrels and drums will not be disposed of unless they are empty and perforated sufficiently to ensure that no liquid or hazardous waste is contained therein, except fiber drums containing asbestos.

7. Erosion and Sedimentation Control Requirements

a. Adequate sediment control measures (structures or devices), will be utilized to prevent silt from leaving the landfill.

b. Adequate sediment control measures (structures or devices), will be utilized to prevent excessive on-site erosion.

c. Provisions for a vegetative ground cover sufficient to restrain erosion will be accomplished within **30 working days** or **120 calendar days** upon completion of any phase of landfill development.

8. Drainage Control and Water Protection Requirements

a. Surface water will be diverted from the operational area.

b. Solid waste will not be disposed of in water.

c. Leachate will be contained on site and properly treated prior to discharge.

d. The landfill will not:

(i) Cause a discharge of pollutants into waters of the United States, including wetlands, that violates any requirements of the Clean Water Act, including, but not limited to, the National Pollutant Discharge Elimination System (NPDES) requirements pursuant to Section 402.

(ii) Cause the discharge of a nonpoint source of pollution to waters of the United States, including wetlands, that violates any requirements of an area-wide or state-wide water quality management plan that has been approved under Section 208 or 319 of the Clean Water Act, as amended.

9. Liquids Restriction

a. Bulk or non-containerized liquid waste will not be placed in the landfill unless:

(i) The waste is household waste other than septic waste and waste oil,

(ii) The waste is leachate or gas condensate derived from the landfill.

b. Containers holding liquid wastes will not be placed in the landfill unless:

(i) The container is a small container similar in size to that normally found in household waste;

(ii) The container is designed to hold liquids for use other than storage; or

(iii) The waste is household waste.

c. For the purpose of this paragraph:

(i) Liquid waste means any waste material that is determined to contain "free liquids" as defined by Method 9095 (Paint Filter Liquids Test), S. W. 846.

d. Test for free liquids:

Sludges or other wastes may be tested for free liquids after previous screening tests have shown that the waster is not hazardous and does not contain PCB's. The specified test to determine whether or not a material is considered to be a liquid is the Paint Filter Test method 9095. The procedure for conducting this test is as follows:

(i) Obtain standard 400- micron paint filter;

(ii) Place a properly-sized, clean, dry funnel in a ring stand or similar device;

(iii) Fold the filter and line the funnel with it;

(iv) Place a 100 ml sample of waste into the funnel;

(v) Place a clean, dry container under the funnel; and,

(vi) Check in exactly 5 minutes to see if any liquid is in the container.

(vii) If any liquid passes through the filter in 5 minutes or less, the waste is considered to be a liquid. The filtrate can be water, oil or any combination of any non-hazardous liquids.

10. Record keeping Requirements

a. Haywood County MSWLF will record and retain at the facility, or an alternative location near the facility approved by the Division of Solid Waste Management, in an operating record the following information as it becomes available.

(i) Inspection records, waste determination records, and training procedures;

(ii) Amounts by weight of solid waste received at the landfill to include source of generation.

(iii) Waste determination, Leachate sampling data, leachate levels, meteorological data ;

(iv) Gas monitoring results and any remediation plans;

(v) Any demonstration, certification, findings, monitoring, testing or analytical data required for surface and groundwater monitoring;

(vi) Any monitoring, testing or analytical data required for closure or post-closure; and,

(vii) Any cost estimates and financial assurance documentation.

b. All information contained in the operating record will be furnished upon request to the Division of Solid Waste Management or be made available at all reasonable times for inspection by the Division.

c. Haywood County will maintain a copy of the operation plan at the landfill.

11. Spreading and Compacting Requirements

a. The initial lift of solid waste will be placed over cell 1 that is bounded by the leachate collection ditch. This lift will be covered with six (6) inches of daily cover. This lift will absorb the rain water and allow some of it to evaporate prior to reaching the leachate collection system. When a heavy rain does occur, the impact on the leachate collection system will not be immediate. Prior to placement of solid waste over any leachate pipe, the geotextile fabric that is covering the stone will be folded back so that solid waste will be in direct contact with the stone. This method will not allow biological growth to develop on the geotextile which could eventually clog the system.

b. The initial lift of solid waste will be placed loosely at a depth of 4 feet. As this lift is being placed, a spotter should be placed in the landfill to assure that the compactor does not drive any long, sharp objects through the protective cover into the liner system. If an object were to penetrate the liner system, the protective cover must be

removed and the penetration repaired. The subsequent lifts can be placed up to final grades or until the diversion berm needs to be moved to cell 2 which will allow for more horizontal space. Heavy landfill equipment including articulating dump trucks, and compactor will only be allowed on areas that have a minimum of 4' of solid waste. Only low pressure equipment such as a D6 LGP Caterpillar will be allowed on the protective cover.

c. The landfill will restrict solid waste into the smallest area feasible, typically 60' x 75' area.

d. Solid waste will be compacted as densely as practical into cells. The compactor should run over an area of solid waste a minimum of 6 times.

e. Appropriate methods such as fencing and diking will be provided within the area to confine solid waste subject to be blown by the wind. At the conclusion of each day of operation, all windblown material resulting from the operation will be collected and returned to the area.

12. Leachate Management Plan

a. Haywood County will periodically maintain the leachate collection system.

b. Haywood County will maintain records for the amount of leachate collected.

c. Haywood County will quality sample their leachate bi-annually for Appendix I (Section 5.3) constituents, pH, BOD, COD, TDS, phosphate, nitrate, and sulfate. The sample will be obtained from the lagoon and sampled the same time as the monitoring wells.

d. The leachate is being treated by the Town of Waynesville Waste Water Treatment Plant.

e. Under extreme operational conditions Haywood has the option of shutting down the flow of leachate to the lagoon by use of a shut off valve. The leachate will be temporarily stored within the MSWLF units until such a time the flow of leachate can continue to the lagoon. If any rain or other event requires storage of leachate or storm water in the cell, the Division of Solid Waste will be notified immediately followed by written communication.

f. Leachate will be recirculated. (See Section 5.6-Appendix IV)

5.3 Appendix I

A. INTRODUCTION

The municipal solid waste stream is made up of wastes from all sectors of society. The waste is often categorized by its source or its characteristics. Terms used include commercial, industrial, residential, biomedical, hazardous, household, solid, liquid, demolition/construction, sludge, etc. Regardless of how one classifies wastes, the bottom line is that wastes are delivered to the landfill and a management decision must be made to either reject or accept them. This responsibility rests with the manager of the landfill. Wastes which are not authorized to be accepted at the landfill create a number of potential problems including: (1) liability due to future releases of contaminants; (2) bad publicity if media learns of unacceptable waste entering the landfill; (3) potential for worker injury; (4) exposure to civil or criminal penalties; (5) damage to landfill environmental control systems.

B. HAZARDOUS WASTE REGULATIONS AND MANAGEMENT

In the United States, hazardous waste is regulated under RCRA, Subtitle C. A waste is hazardous if it is listed as a hazardous waste by the Administrator of the Environmental Protection Agency (EPA) in the Code of Federal Regulations, Title 40, Part 261, or if it meets one or more of the hazardous waste criteria as defined by EPA. These criteria are:

- Ignitability
- Corrosivity
- Reactivity
- Toxicity

1. Ignitability

Ignitable waste is a waste that burns readily, causes a fire by friction under normal circumstances, or is an oxidizer. Any waste having a flash point of <140F falls in this category. Flash point is that temperature at which a liquid gives off vapors that will ignite when an open flame is applied. Under Department of Transportation (DOT) definitions, a flammable liquid has a flash point of >100 F. A combustible liquid has a flash point between 100 and 200 F. Therefore, a flammable liquid is always hazardous while a combustible liquid may or may not be hazardous depending upon its flash point.

2. Corrosivity

A corrosive waste is one having a very high or a very low pH. The pH of a liquid is a measure of how acidic or basic (alkaline) the material is. The pH scale ranges from 0 to 14. High numbers are basic and low numbers are acidic. A substance having a pH ≤ 2.0 or ≥ 12.5 is defined as hazardous under RCRA.

3. Reactivity

A waste is reactive if it is normally unstable: reacts violently with water; forms an explosive mixture with water; contains quantities of cyanide or sulfur that could be released to the air; or can easily be detonated or exploded. These wastes may fall into any one of several DOT categories.

4. Toxicity Characteristic Leaching Procedure (TCLP)

A waste is TCLP toxic if the concentration of any constituent in Table 1 exceeds the standard assigned to that substance. The TCLP is a methodology which attempts to simulate the conditions within a landfill. An acidic solution is passed through a sample of waste and the resultant "leachate" is analyzed for contaminants. The TCLP is designed to detect heavy metals, pesticides and a few other organic and inorganic compounds. The purpose of the test is to prevent groundwater contamination by highly toxic materials. TCLP tests the mobility of 40 different elements and compounds.

Except in certain specified circumstances, regulated quantities of hazardous waste must be disposed of at a permitted hazardous waste disposal facility. In accordance with 40 CFR Part 261.3, **any material contaminated by a hazardous waste is also deemed to be a hazardous waste and must be managed as such.** Hazardous waste from conditionally exempt small quantity generators are to be disposed of in a Hazardous waste disposal facility. RCRA permits are also required to store, transport, and treat hazardous waste.

C. POLYCHLORINATED BIPHENYL'S (PCBs)

1. Introduction

PCBs are nonflammable and conduct heat without conducting electricity. These compounds were most frequently used as an additive to oil or other liquids in situations where heat was involved. The PCBs enhance the heat conducting properties of the liquid and thereby increase the heat dissipation or cooling effect obtained. They have also been used in lubricants and paint. In the United States one of the most common applications was in electric transformers. The only effective method for destroying PCBs is high Temperature incineration which is relatively expensive due to a shortage of PCB incineration capacity.

TABLE 1

T.C.L.P. CONSTITUENTS & REGULATORY LEVELS (mg/L)			
CONSTITUENT	REG LEVEL	CONSTITUENT	REG LEVEL
Arsenic	5.0	Hexachlorobenzene	0.13
Barium	100	Hexachloro-1,3-butadiene	0.5
Benzene	0.5	Hexachloroethane	3.0
Cadmium	1.0	Lead	5.0
Carbon Tetrachloride	0.5	Lindane	0.4
Chlordane	0.03	Mercury	0.2
Chlorobenzene	100	Methoxychlor	10.0
Chloroform	6.0	Methyl ethyl ketone	200
Chromium	5.0	Nitrobenzene	2.0
m-Cresol	200	Pentachlorophenol	100
o-Cresol	200	Pyridine	5.0
p-Cresol	200	Selenium	1.0
Cresol	200	Silver	5.0
1,4-Dichlorobenzene	10.0	Tetrachloroethylene	0.7
1,2-Dichloroethane	0.7	Toxaphene	0.5
1,1-Dichloroethylene	0.5	Trichloroethylene	0.5
2,4-Dichlorophenoxyacetic acid	0.7	2,4,5-Trichlorophenol	400
2,4-Dinitrotoluene	0.13	2,4,6-Trichlorophenol	2.0
Endrin	0.02	2,4,5-TP (Silvex)	1.0
Heptachlor (and its hydroxide)	0.008	Vinyl Chloride	0.2

By law PCB's are no longer used as dielectrics in transformers and capacitors manufactured after 1979. There are many millions of pounds of PCBs still in use or in storage. One example is the ballasts used in fluorescent light fixtures. It has been estimated that there are between 0.5 million and 1.5 billion ballasts currently in use in this country. Due to the long life of these units, about half of these may be of pre-1979 manufacture and contain PCBs. Since each ballast contains about one ounce of nearly pure PCB fluid, there are about **20 to 30 million pounds** of PCBs in existing lighting fixtures. These items are <u>not</u> the subject to RCRA Subtitle D Waste Screening!

Commercial or industrial sources of PCB wastes that should be addressed by the program include:

- Mineral oil and dielectric fluids containing PCBs;
- Contaminated soil, dredged material, sewage sludge, rags, and other debris from a release of PCBs;
- Transformers and other electrical equipment containing dielectric fluids; and
- Hydraulic machines.

2. PCB Regulatory Requirements

As contrasted to hazardous wastes, the Toxic Substance Control Act regulates PCBs based on the concentration of PCBs in the waste rather than the source or characteristic of the waste. The regulations concerning PCB disposal are spelled out in 40 CFR Part 761. Subtitle D of RCRA merely requires that PCB waste not be disposed in a MSW landfill. PCB management requirements include:

Waste containing more than 500 ppm of PCBs must be incinerated. Waste containing from 50 to 500 ppm must be disposed of by incineration, approved burning, or in chemical waste landfill permitted to receive such wastes. The regulations are silent concerning wastes containing less than 50 ppm of PCBs; however, the regulations cannot be circumvented by diluting stronger wastes.

D. FUNDAMENTALS OF WASTE SCREENING

1. Know Your Generators and Haulers

Since the level of sophistication of your waste screening program will be a reflection of the likelihood of hazardous waste and PCB waste being in your incoming waste, **knowledge of the commercial industrial base of your service area is critical.** Some examples are the automotive industry, which generates solvents, paint wastes, lead acid batteries, grease and oil; the dry cleaning industry, which may generate filters containing dry cleaning solvents; metal platers which generate heavy metal wastes; and other industries which generate a variety of undesirable wastes; e.g. chemical and related products, petroleum refining, primary metals, electrical and electronic machinery, etc.

Landfill managers should also know the haulers and trucks serving the businesses in their community which are likely to carry unacceptable wastes.

Some local governments and solid waste management agencies have enacted legislation requiring haulers to provide a manifest showing the customers whose wastes make up that particular load. Such a manifest is an extremely useful tool when a load is found to contain prohibited wastes. It is unwise to accept wastes from unknown, unlicensed, or otherwise questionable haulers.

2. Inspections

An inspection is typically a visual observation of the incoming waste loads by an individual who is trained to identify regulated hazardous or PCB wastes that would not be acceptable for disposal at the MSWLF unit. The training of landfill personnel will be conducted by a local EMS official or a SWANA certification. An inspection is considered satisfactory if the inspector knows the nature of all materials received in the load and is able to discern whether the materials are potentially regulated hazardous wastes or PCB wastes.

Ideally, all loads should be screened; however, it is generally not practical to inspect in detail all incoming loads. Random inspections, therefore, can be used to provide a reasonable means to adequately control the receipt of inappropriate wastes. Random inspections are simply inspections made on less than every load. At a minimum the inspection frequency will not be less than one percent of the waste stream.

The frequency of random inspections may be based on the type and quantity of wastes received daily, and the accuracy and confidence desired in conclusions drawn from inspection observations. Because statistical parameters are not provided in the regulation, a reasoned, knowledge-based approach may be taken. A random inspection program may take many forms such as inspecting every incoming load one day out of every month or inspecting one or more loads from transporters of wastes of unidentifiable nature each day. If these inspections indicate that unauthorized wastes are being brought to the MSWLF site, the random inspection program should be modified to increase the frequency of inspections.

Inspection priority also can be given to haulers with unknown service areas, to loads brought to the facility in vehicles not typically used for disposal of municipal solid waste, and to loads transported by previous would-be offenders. For wastes of unidentifiable nature received from sources other than households (e.g., industrial or commercial establishments), the inspector should question the transporter about the source/composition of the materials.

Loads will be inspected on the tipping floor at the baler facility prior to actual disposal of the waste at the working face of the landfill unit to provide the County the opportunity to refuse or accept the wastes.

An inspection flow chart to identify, accept, or refuse solid waste is provided as Figure 1.

Inspections of materials may be accomplished by discharging the vehicle load in an area designed to contain potentially hazardous wastes that may arrive at the facility. The waste should be carefully spread for observation using a front end loader or other piece of equipment. The Division of Solid Waste recommends that waste should be hand raked to spread the load. Personnel should be trained to identify suspicious wastes. Some indications of suspicious wastes are:

- Hazardous placards or markings;
- Liquids;
- Powders or dusts;
- Sludges;
- Bright or unusual colors;
- Drums or commercial size containers; or
- Chemical odors.

Haywood County will follow these procedures when suspicious wastes are discovered.

- Segregate the wastes;
- Question the driver;
- Review the manifest (if applicable);
- Contact possible source;
- Call the State Solid Waste Management Department;
- Use appropriate protective equipment;
- Contact laboratory support if required; and
- Notify the local Hazardous Material Response Team.

Containers with contents that are not easily identifiable, such as unmarked 55-gallon drums, should be opened only by properly trained personnel. Because these drums could contain hazardous waste, they should be refused whenever possible. Upon verifying that the solid waste is acceptable, it may then be transferred to the working face for disposal.

Testing typically would include the Toxicity Characteristic Leaching Procedure (TCLP) and other tests for characteristics of hazardous wastes including corrositivity, ignitability, and reactivity. Wastes that are suspected of being hazardous should be handled and stored as a hazardous waste until a determination is made.

If the wastes temporarily stored at the site are determined to be hazardous, Haywood County is responsible for the management of the waste. If the wastes are to be transported from the facility, the waste must be: (1) stored at the MSWLF facility in accordance with requirements of a hazardous waste generator, (2) manifested, (3) transported by a licensed Treatment, Storage, or Disposal (TSD) facility for disposal.

E. RECORD KEEPING AND NOTIFICATION REQUIREMENTS

Records must be kept pursuant to an incident where regulated hazardous waste or prohibited waste is found at the landfill. It is also recommended that records be kept of all screening activities and incidents, whether or not, regulated or prohibited wastes are found. This will help prove that the landfill owner/operator has acted in a prudent and reasonable manner.

The best way to prove compliance with this requirement is to document each inspection including:

Date and time of waste detection
Hauler name (company and driver)
Waste(s) detected
Waste generator(s) if able to identify
Action(s) taken to manage or return material(s)
Efforts taken if extreme toxicity or hazard was discovered
Landfill employee in responsible charge

40 CFR Part 258 requires that records should be maintained at or near the landfill site during its active life and as long after as may be required by the appropriate state or local regulations.

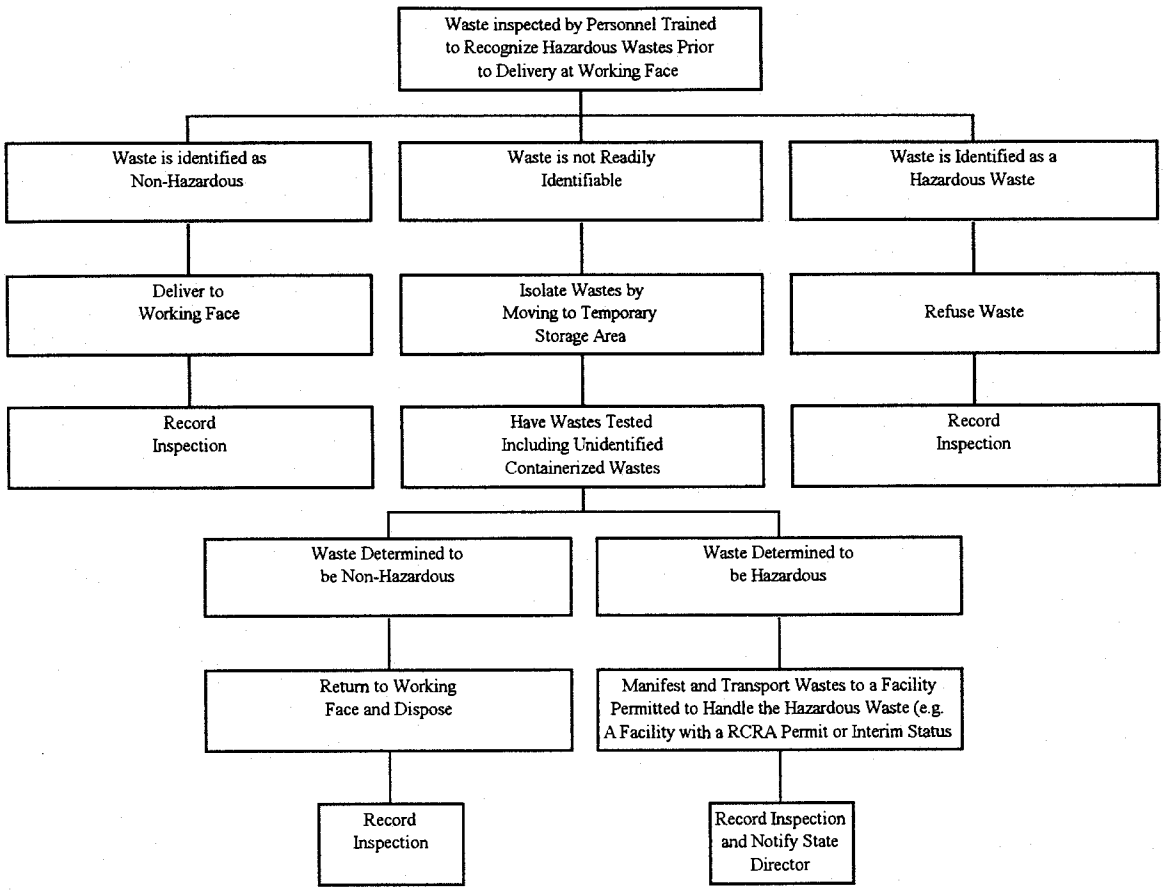


FIGURE 1
Hazardous Waste Inspection Decision Tree
Inspection Prior to Working Face

WASTE SCREENING CHECK LIST

CONTAINERS	YES	NO
FULL	____	____
PARTIALLY FULL	____	____
EMPTY	____	____
CRUSHED	____	____
PUNCTURED	____	____
POWDERS/DUSTS		
IDENTIFIED	____	____
UNKNOWN	____	____
SATURATION	____	____
LABEL/HAZARDOUS	____	____
ODOR/FUMES		
STRONG	____	____
FAINT	____	____
HEAT	____	____
ITEMS FOUND		
BATTERIES	____	____
OIL	____	____
BIOMEDICAL	____	____
RADIOACTIVE	____	____
ASHES/RESIDUE	____	____
SOD/SOIL	____	____
LIQUID	____	____
HAZARDOUS	____	____
PCB'S	____	____

CHECK ALL THAT APPLY

DETAILED SCREENING REPORT

WASTE SOURCE _____
ADDRESS _____
_____
_____

PROBABLE [ ] SUSPECTED [ ] CONFIRMED [ ]

WASTE HAULER _____
ADDRESS _____
_____
_____

DRIVER'S NAME _____
DETAIL _____
_____
_____

NOTIFIED:

WASTE SOURCE [ ] HAULING MANAGEMENT [ ] SITE MANAGEMENT [ ]

STATE [ ] FEDERAL [ ]

_____

NAME _____
WITNESS (IF ANY) _____
DATE _____ TIME _____ AM PM

_____

ACTION REQUIRED

5.4 Appendix II

HAYWOOD COUNTY SYNTHETIC COVER OPERATION PLAN

1. Determine the size of the area to be covered. Be sure to allow for five to ten feet extra on each measurement to ensure that the refuse is completely covered.

2. The synthetic cover is shipped to the landfill site with panels folded accordion-type, then rolled up. Unroll the cover along the working face (depending upon operations), and attach the leading edge of the unrolled panel to existing landfill equipment with ropes(i.e., to the top of the blade).

3. Pull the sewn panels of cover across the compacted trash. The synthetic cover maybe pulled from any direction, which may vary from day to day. Keep the leading edge between the two machines (or people) as high as possible to eliminate drag.

4. Anchor the edges of synthetic cover every 20 feet with tires or sandbags to hold the synthetic cover in place. If it is windy, more anchoring may be required. Make sure a large enough panel has been ordered to completely cover the refuse (base this on the heaviest day to the week). If complete coverage is not possible, cover the exposed refuse with soil; but take care not to place too much dirt on the synthetic cover if it is to be re-used.

5. On the next day of operations, remove the tires and/or sandbags. Simply pull the synthetic cover across itself (to reduce drag) and off the refuse to an area that is inactive. Anchor the edges again to prevent wind from lifting the blanket. At the end of the day, pull the synthetic cover back across the refuse by repeating steps 3 and 4 until a new panel is needed.

Synthetic Cover is designed to be used as landfill daily cover on a working face. For best results, it is recommended that the area to be covered be kept as close to a square shape as possible not to exceed 75' X 75' in size. Not only does this procedure allow for easier coverage, it allows for better management of the working face and saves time at the end of the working day.

Haywood County will use a panel of synthetic cover that is pulled over the working face on a daily basis by two pieces of landfill equipment. At the end of the working day, the panel will be secured in place. This is attained by one of two methods -- the panel may be heavy enough to hold itself in place due to accumulation of soil and is left in that manner; or tires are placed on the panel to secure it in place.

The working face is operated in this manner, brought to an intermediate grade and then covered with the required six (6) inches of soil. The process will continue until a lift is completed. The process is then started over on the next lift until the landfill is filled to final grade and a section is closed. At a minimum six (6) inches of soil cover will be used once a week.

TIPS TO REMEMBER

1. Always pull the fabric across itself during installation and removal to make each panel last as long as possible.

2. Avoid driving on the panel(s); this may cause punctures and tears.

3. Tie the panel(s) to the top of the dozer blade and raise the blade to minimize dragging on refuse.

4. Use tires or sandbags to hold the panel(s) down overnight. Soil can be used if you plan to leave panel(s) in place and cover with refuse.

5. Minimize stress between dozer/compactors while pulling on the panel(s).

5.5 Appendix III

EXPLOSIVE GAS CONTROL PLAN FOR - HAYWOOD COUNTY

Quarterly the Haywood County landfill will monitor the explosive gas at the landfill structures and at or near the landfill boundary. The permanent probes will consist of a plastic stand pipe similar to a piezometer used for groundwater detection. A typical permanent methane probe is detailed in the operation drawings. The permanent probe will be constructed at a depth of six (6) feet. A 6" diameter hole will contain a one (1) inch slotted PVC pipe. The bottom two (2) feet will be backfilled with non-carbonate pea gravel with a bentonite seal one (1) foot thick above it. The remaining three (3) feet will be backfilled with *in situ* soils. The one (1) inch PVC pipe will be approximately three (3) feet above the existing grade. The PVC pipe will be capped with a one (1) inch PVC cap, one quarter (1/4) inch NPT hose barb, and 1" tubing, plugged or capped.

The location and spacing of the methane monitoring probes is somewhat arbitrary. The locations were determined by the relationship of solid waste with property lines and landfill structures. The spacing of the monitoring probes is between 200 and 400 feet. The migration of methane gas is induced by pressure gradients. The methane will move from areas of high pressure to those of low pressure following the path of least resistance. The methane will migrate vertically until it reaches the landfill cap, where it will begin to flow horizontally. This occurs until it finds a pathway out, either by the installed methane collection trenches or migration through the permeable *in situ* soils. Since methane is lighter than air, it wants to escape into the atmosphere. It has been our experience that whenever gas is migrating no matter what the spacing or depth of the monitoring probes, the gas will fill the void created by the monitoring point and an explosive meter will monitor the level. The six foot depth of the monitoring probes is to ensure a stable monitoring point. The only time a shallow monitoring point has not worked is in a very heavy, impermeable clay layer that acts as a seal to the migration of the gas. If a clay layer is encountered during the construction of the monitoring points, it will either be moved beyond the clay or excavated to a depth that is in the conductive zone below the clay.

The permanent probes will surround Phase 2. Haywood County's landfill is designed with a base liner system and cap system, there should be no migration of methane in the permeable *in situ* soils.

The gas can be detected by use of an instrument that reports the percent of lower explosive limit. The instrument being used is the Gas Tech GP 204.

Quarterly, a County employee will visit each monitoring point either the temporary or permanent. The monitoring points consist of all methane probes and leachate collection system cleanouts. Using the detection instrument, he will determine if methane gas has filled the probes. If the probe is near the property line and methane gas is detected at or beyond the lower explosive limit (100% LEL), it must then be determined if the gas is migrating across the landfill boundary. If the probe is on the boundary or methane gas has migrated beyond the boundary , a remediation plan must be completed by Haywood County.

Other points of monitoring will be the landfill structures. Each structure will be monitored for methane using the following methods:

1. All crawl spaces will be monitored;
2. All corners in the structure will be monitored;
3. Any holes, cracks and pipes through the foundation will be monitored

If methane gas is detected beyond 25% of its lower explosive limit in any structure, check the calibration of the monitor and resample. If the reading is still above 25%, evacuate the building and try to find the source of gas. If the source is found try to remove the source. If this fails a remediation plan is stated in the operational requirements.

5.6 Appendix IV

HAYWOOD COUNTY'S RECIRCULATION PLAN

Haywood County does intend to utilize recirculation as a means of disposal of their leachate. The intention is to utilize recirculation as a method by which some relief can be given to the pumping and hauling. This relief will come in the form of evaporation and retention of water within the solid waste. The remaining leachate will be hauled to the Waynesville Waste Water Treatment Plant for disposal. Haywood County must obtain a permit from the Division of Solid Waste before leachate recirculation can begin.

No water that comes in contact with the present surface of solid waste runs off any where other than the leachate collection system.

The County will spread the leachate over the surface of the solid waste, that is at a minimum five feet (5') deep, within the landfill. The spreading will be accomplished by one of two methods. The first method is by simply backing their leachate hauling truck into the landfill. A spreader hose will then be attached to the leachate tank and Haywood County personnel will manually discharge the leachate over the solid waste. The second method will utilize the tank truck except the leachate will be used to wet down solid waste that is piled up from being dumped from a truck or trucks. Once this pile is wet, it will be spread around the working face by the trash compactor.

At a later date, a pump system may be incorporated into the system. The pump system will pump directly from the leachate lagoon and the leachate spread in a manner as it was from the tank truck.

Monthly monitoring will be performed to measure the leachate head at the leachate head detection well and analyze the leachate for BOD, COD, temperature and pH.

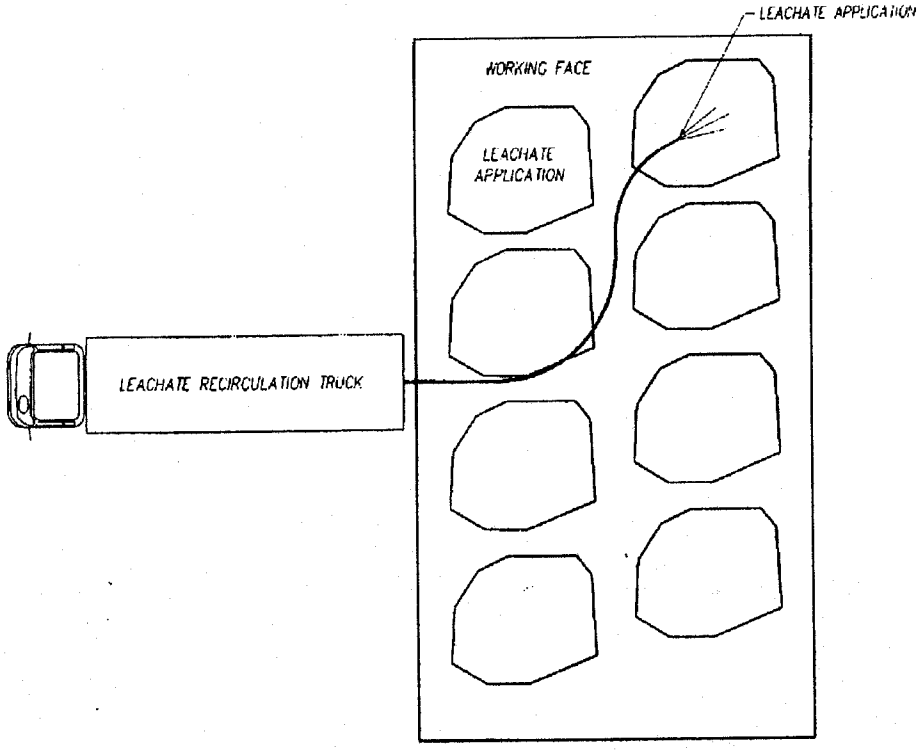
The following conditions will be met by Haywood County:

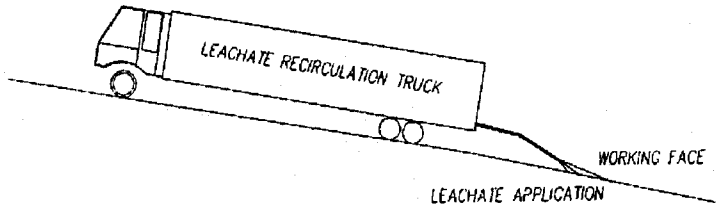
- A rain gauge and thermometer will be placed on site
- A base line sampling of leachate has been performed (See Attachment 1)
- A brief description of the equipment and its associated specifications is submitted (see Attachment 2)
- Weekly record of leachate head measurements (see Attachment 3)
- Weekly record of leachate recirculated and leachate disposed (see Attachment 4)
- Weekly record of visual monitoring log (see Attachment 5)
- Weekly record of rainfall and lagoon depth (see Attachment 6)
- Records will be kept on a weekly basis
- No leachate will be applied on less than one lift (8 feet) of waste
- No leachate will be recirculated when it is raining, or when the waste is too wet
- No run off or side seepage will be allowed
- Odors will be controlled
- Leachate depth will be monitored in the leachate head detection well to ensure that the head on the liner does not exceed one foot for more than 24 hours.
- The application system will be properly maintained and documented
- Leachate will be tested every 30 days and a progress report will be submitted annually

ATTACHMENT 1

BASELINE DATA

TO BE ADDED IN THE FUTURE





ATTACHMENT 2

ATTACHMENT 3

HAYWOOD COUNTY LEACHATE HEAD READINGS

DATE	DEPTH AT HEAD TEST WELL

ATTACHMENT 4

HAYWOOD COUNTY LEACHATE RECIRCULATION DATA

DATE	VOLUME RECIRCULATED	RECIRCULATION AREA (Section of Landfill)	VOLUME HAULED FOR DISPOSAL

ATTACHMENT 5

HAYWOOD COUNTY VISUAL MONITORING LOG

DATE	INDIVIDUAL MONITORING	OBSERVATIONS

ATTACHMENT 6

HAYWOOD COUNTY RAINFALL AND LAGOON DEPTH LOG

DATE	RAINFALL (INCHES)	LAGOON DEPTH (FEET)

5.7 Operation Drawings

CLOSURE PLAN

6.1 Introduction

Haywood County will cap their landfill within 180 days after the final receipt of solid waste. The cap system will consist of 12 inches bridging material (temporary cover), 18 inches of cohesive soil liner with a permeability no greater than 1.0×10^{-5} cm/sec, 40 mil Linear Low Density Polyethylene (LLDPE), drainage layer, 24 inches of protective/erosive layer. The cap contains gas venting system consisting of a series of washed stone trenches below the soil liner that will be vented through 10" diameter PVC pipes that penetrate the cap. The cap system will also include the proper seeding and mulching of the erosive layer and other erosion control devices. The largest area ever needing closure will be 10.26 acres.

Prior to beginning closure, Haywood County shall notify the Division of Solid Waste that a notice of the intent to close the unit has been placed in the operating record. The County shall begin closure activities no later than thirty (30) days after the date on which the landfill receives the final wastes or if the landfill has remaining capacity and there is a reasonable likelihood that the landfill will receive additional wastes, no later than one year after the most recent receipt of wastes. Extensions beyond the one-year deadline for beginning closure may be granted by the Division of Solid Waste if the County demonstrates that the landfill has the capacity to receive additional waste and the County has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the closed landfill.

The County shall complete closure activities in accordance with the closure plan within 180 days following the final receipt of waste. Extensions of the closure period may be granted by the Division of Solid Waste if the County demonstrates that closure will, of necessity, take longer than one hundred eighty (180) days and the County has taken and will continue to take all steps to prevent threats of human health and environment from the enclosed landfill.

Following closure of the landfill, the County shall record a notation on the deed to the landfill property and notify the Division of Solid Waste that the notation has been recorded and a copy has been placed in the operating record. The notation on the deed shall in perpetuity notify any potential purchaser of the property that the land has been used as a landfill and its use is restricted under the closure plan approved by the Division of Solid Waste. The County may request permission from the Division to remove the notation from the deed if all waste are removed from the landfill.

6.2 Closure Cap System

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

6.3 Cohesive Soil Cap

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Cohesive Soil Cap Borrow Material

Test Name	Test Method	Contractor/Engineer Frequency
Moisture/Density	ASTM D698/D1557	1 per 5000 c.y.
Remolded Permeability	ASTM D5084	1 per 5000 c.y.
Atterberg Limits	ASTM D4318	1 per 5000 c.y.
Visual Classification	ASTM D2488	1 per 5000 c.y.
Grain Size Distribution	ASTM D422	1 per 5000 c.y.

Cohesive Soil Cap Test Pad

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	3 per lift
Permeability	ASTM D5084	1 per lift
Remolded Permeability	ASTM D5084	1 per lift
Atterberg Limits	ASTM D4318	1 per lift
Visual Classification	ASTM D2488	1 per lift
Grain Size Distribution	ASTM D422	1 per lift

In-Place Cohesive Soil Cap

Test Name	Test Method	Contractor/Engineer Frequency
Field Moisture/Density	ASTM D1556 (sand cone) ASTM D2922/D3017 (nuclear gauge) ASTM D2937 (drive cylinder)	1 per lift per acre
Permeability	ASTM D5084	1 per lift per acre
Atterberg Limits	ASTM D4318	1 per lift per acre
Visual Classification	ASTM D2488	1 per lift per acre
Grain Size Distribution	ASTM D422	1 per lift per acre

(a) Suitable on-site and/or off-site soils may be used as cohesive soil cap if it can achieve an in-place permeability of 1.0×10^{-5} cm/sec or less and meets all testing requirements indicated in the material testing paragraph in this section. Wyoming bentonite or an approved equivalent may be blended with the soil to lower the soil's permeability.

(b) A permeability "window" shall be developed for each type of soil from the borrow material that will be used for construction of the cohesive soil cap. The window shall be plotted on a semi-log plot with moisture content versus density. Laboratory testing to develop the window shall include a series of remolded samples compacted to various dry densities and moisture contents utilizing the same compactive effort (ASTM D 698 or D 1557). The remolded samples shall be tested for permeability to determine whether or not the particular soil type will provide the maximum permeability (1.0×10^{-5} cm/sec) at various dry densities and moisture contents. The window is then developed from the accepted remolded samples and moisture contents from the semi-log plot. A straight line is typically drawn between the acceptable points on the moisture-density curve to indicate a range of probable acceptable permeability results. The window will be used in the construction of the test strip to verify the laboratory remolded permeability results.

(c) Atterberg limits and grain size distribution shall also be conducted on the bulk samples used to prepare the permeability window ASTM D2488, D4318, D422. These tests can be used as indices on random samples collected from the borrow site during construction to verify the soil type is the same as was used to develop the "window". As a minimum, sufficient visual classifications and Atterberg limits shall be conducted in association with each permeability test to verify that the construction materials meet specifications.

(d) A test strip of compacted cohesive soil cap shall be prepared to verify the permeability "window" prior to general installation of the cohesive soil cap. The test strip will be used to verify the results from the remolded permeabilities from the borrow site utilizing the permeability window(s) for each soil type that is going to be used for construction of the cohesive soil cap. At a minimum, the verification will consist of three moisture density tests, one Atterberg limits test, one grain size distribution test (ASTM D2488, D4318, and D422), and one Shelby Tube sample for each lift constructed in the test pad. Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil cap after placement and compaction. The permeability must be a maximum of 1.0×10^{-5}cm/sec. Tests shall be performed in accordance with the ASTM D5084. The test strip shall be approximately 2,500 sq. ft. in surface area and constructed to conform geometrically to the site topography with a minimum lateral dimension in any direction of 25 ft. The test strip shall consist of at least three compacted 6 inch lifts of cohesive soil cap. Placement and testing of the test strip shall be in conformance with the construction specifications and requirements for general installation of the cohesive soil cap. Test results from the test strip shall be used to guide placement and achievement of the required maximum permeability of 1.0×10^{-5} cm/sec of the cohesive soil cap. The test strip may be used as an integral part of the overall cohesive soil cap if it meets the required specification for the cap. All results shall be given to the Construction Observer.

(e) The soils shall be placed to the total thickness shown on the plans in maximum 8-inch thick loose lifts with a maximum 6" compacted lift compacted preferably at a moisture content between 0 to 3% above optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698). A sheepsfoot roller or approved alternative may be used to compact the soil cap provided the compaction and permeability requirements can be achieved. Each lift shall be tested for permeability, moisture content, particle size distribution analysis, Atterberg limits, moisture-density-permeability relation, and if needed percent bentonite admixed with soil, prior to the placement of the succeeding lift and visually inspected to confirm that all soil clods have been broken and that the surface is sufficiently scarified so that adequate bonding can be achieved. Soils for cohesive soil cap shall be screened, disced, or prepared using any other approved method as necessary to obtain a homogeneous cohesive soil with clod sizes in a soil matrix no larger than about 1.5 inches in maximum diameter. After each lift, the surface shall be scarified prior to the placement of the next lift to provide good bonding from one lift to the next.

(f) The cohesive soil cap shall be tested to evaluate the coefficient of permeability. The coefficient of permeability of the soil cap shall be equal to or less than 1.0×10^{-5} cm/sec after placement and compaction. The soil cap must be a minimum of 1.5 feet thick.

(g) Laboratory permeability tests shall be performed on tube (Shelby or drive tubes) samples of the cohesive soil cap after placement and compaction. The permeability must be a maximum of 1.0×10^{-5}cm/sec. Tests shall be performed in accordance with ASTM D5084.

(h) The soil cap shall be tested a minimum of one soil sample per lift per acre for laboratory permeability. All permeability testing will be on random samples judged by the Engineer to be representative of the most permeable soil conditions for the area being tested. The project engineer shall certify that the materials used in construction were tested according to the Division approved plans. If after placement of the soil cap it fails the required tests, the material will either be reworked or replaced. The soil cap must remain moist at all times, if any section becomes dry, rework the dry area and moisten.

(i) A minimum of two (2) inches of soil shall be removed prior to securing each sample for permeability testing. The sampling tube shall be advanced vertically into the soil with as little soil disturbance as possible and should be pushed using a uniform pressure. The sampling tube (Shelby tube), when extracted, shall be free of dents, and the ends shall not be distorted. A backhoe or approved alternative should be used to advance the sampling tube (Shelby tube) as long as disturbance is minimized. Drive tube samples of the cap may be obtained for permeability testings. If the Engineer judges the sample to be too disturbed, another sample shall be taken. Once an acceptable sample has been secured and properly prepared, all sample excavations shall be backfilled to grade with a 50% mixture of bentonite and similar soils in maximum 3-inch loose lifts and hand tamped with a blunt tool to achieve a tight seal equivalent to the original density.

(j) No additional construction shall proceed on the soil layers at the area being tested until the Engineer has reviewed the results of the tests and judged the desired permeability is being achieved.

(k) As a minimum, sufficient visual classifications (ASTM Test Designation D2488) , analyses (ASTM Test Designation D422) and Atterberg limits (ASTM Test Designation D4318) shall be conducted in association with each permeability test to verify that the construction materials meet specifications. The minimum number of tests will be 1 per lift per acre.

(l) If the soil for the cohesive soil cap is incapable of achieving the required permeability when compacted, bentonite or approved alternative may be mixed with the soils to decrease the permeability. The amount of additive required must be determined in the laboratory. Where additives are required, the soil shall be placed in maximum 8-inch thick loose lifts and compacted preferably between 0 to +3% optimum moisture content to 95% standard Proctor maximum dry density (ASTM Test Designation D698) for the soil-additive mixture. All other compaction procedures for the soil apply.

(m) Surfaces to be lined shall be smooth and free of debris, roots, and angular or sharp rocks larger than three-eight (3/8) inches in diameter to a depth of six (6) inches. The cohesive soil cap shall have no sudden sharp or abrupt changes in grade.

(n) The Contractor shall protect the cohesive soil cap from desiccation, flooding and freezing. Protection, if required, may consists of a thin plastic protective cover, (or other material as approved by the engineer) installed over the completed cohesive soil cap until such time as the placement of flexible membrane liner begins. Areas found to have any desiccation cracks or which exhibit swelling, heaving or other similar conditions shall be replaced or reworked by the contractor to remove these defects.

(o) The thickness and grade of the soil cap will be verified by the surveyor before placement of the geomembrane liner. The soil cap will be surveyed at 100' grid points where the elevations of the top of landfill will be checked with the top of soil cap to verify 1.5 feet of soil cap. The grade will then be verified with the surveyed information. The survey will be performed by NC licensed surveyors.

(p) Surface Acceptance. Upon request, the Flexible Membrane Liner manufacturer installer shall provide the Engineer with a written acceptance of the surface prior to commencing installation. Subsequent repairs to the cohesive soil cap and the surface shall remain the responsibility of the contractor.

6.4 Closure Flexible Membrane Liner Method of Deployment

All materials and equipment shall be furnished by an established and reputable manufacturer or supplier. All materials and equipment shall be new and shall be of first class ingredients and construction, designed and guaranteed to perform the service required and shall conform with the following standard specifications or shall be the product of the listed manufacturers or similar and equal thereto as approved by the Engineer.

Flexible Membrane Liner Tests

Test Name	Description	Test Method	Frequency
Air Test	Air Test Seams		Every Seam
Vacuum Test	Every welded area		Where air test impossible
Destructive Tests	Seam Strength	ASTM D4437	Every 500' of seam

Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

40 mil Linear Low Density Polyethylene (LLDPE) is to be placed in direct contact with moist cohesive soil cap. The extrusion rods and/or brads used in seaming the rolls together shall be derived from the same base resin as the liner and shall meet the following minimum properties:

Smooth 40 mil LLDPE Liner Specifications

Property	Test Method	Test Value	Contractor/Engineer Test Frequency
Thickness (min. ave.)	D5199	nom. (mil)	Per roll
- lowest individual for 8 out of 10 values		-10%.	
Density (max.)	D1505/D792	0.939	200,000 lb
Tensile Properties (1)(min. ave.)	D638 Type IV		20,000 lb
- yield stress lb/in		64	
- break stress lb/in		152	
- yield strain %		13	
- break strain %		800	
2% Modulus - psi (max.)	D5323	30,000	20,000 lb
Tear Resistance- lb/in (min ave.)	D1004	22	45,000 lb
Puncture Resistance- lb/in (min ave.)	D4833	56	45,000 lb
Axi-Symmetric Break Strain- % (min)	D5617	30	200,000 lb
Stress Crack Resistance- hr (2)	D5397 (App.)	n/a	per GRI-GM10
Carbon Black Content- %	D1603 (3)	2.0-3.0	20,000 lb
Carbon Black Dispersion	D5597	note (4)	45,000 lb
Oxidative Induction Time (OIT) (min ave.) (5)			
(a) Standard OIT	D3895	120 min.	
-or-			200,000 lb
(b) High Pressure OIT	D5885	500 min.	
Oven Aging at 85°C (6)	D5721		
(a) Standard OIT (min. ave) -% retained after 90 days	D3895	55	per each formulation
-or-			
(b) High Pressure OIT (min ave) -% retained after 90 days	D5885	80	
UV Resistance (7)			
(a) Standard OIT (min ave)	D3890	N.R. (8)	
-or-			per each formulation
(b) High Pressure OIT (min ave) -% retained after 1600 hrs (9)	D5885	50	

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm

(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.
(3) Other methods such as D4128 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
(4) Carbon black dispersion for 10 different views:
- all 10 in Categories 1 or 2
(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(7) The condition of the test should be 20 hr UV cycle at 75°C followed by 4hr condensation at 60°C.
(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

(1) Preparation for Geomembrane Deployment

(a) Panel Layout

Prior to commencement of liner deployment, layout drawings shall be produced to indicate the panel configuration and location of seams for the project.

(b) Identification

Each panel used for the installation shall be given a numeric or alpha-numeric identification number consistent with the layout drawing. This identification number shall be related to manufacturing roll number that identifies the resin type, batch number and date of manufacture.

(c) Verification

The manufacturers certification will be given to the construction observer. The construction observer will inspect all certifications. If the certification does not meet specifications, it will be rejected. Adequate laboratory QA/QC conformance testing shall be performed by contractor/engineer to verify minimum requirements.

(2) Field Panel Placement

(a) Location

The Flexible Membrane Liner Manufacturer/Installer shall install field panels at the location indicated on the layout drawing. If the panels are deployed in a location other than that indicated on the layout drawings, the revised location shall be noted in the field on a layout drawing which will be modified at the completion of the project to reflect actual panel locations.

(b) Weather Conditions

Geomembrane deployment shall not be carried out during any precipitation, nor in the presence of excessive moisture (i.e. fog, dew), in an area of standing water, or during high winds.

(c) Method of Deployment

(1) The method and equipment used to deploy the panels must not damage the geomembrane or the supporting subgrade surface.

(2) No personnel working on the geomembrane will smoke, wear shoes that can damage the geomembrane, or engage in actions which could result in damage to the geomembrane.

(3) Adequate temporary loading and/or anchoring, (i.e. sandbags, tires), which will not damage the geomembrane, will be placed to prevent uplift of the geomembrane by wind. If uplift occurs, additional sandbags will be placed in necessary areas.

(4) The geomembrane will be deployed in a manner to minimize wrinkles. The geomembrane will have no fold overs.

(5) Any damage to a panel of the geomembrane will be repaired. Any area of a panel seriously damaged (torn, twisted, or crimped) will be marked, cut out and removed from the work area with resulting seaming and/or repairs performed.

(3) Field Seaming

(a) Layout

In general, seams shall be oriented parallel to the slope, i.e., oriented along, not across the slope. Whenever possible, horizontal seams should be located not less than five (5) feet from the toe of the slope. Each seam made in the field shall be numbered in a manner that is compatible with the panel layout drawing for documentation of seam testing results.

(b) Personnel

All personnel performing seaming operations shall be trained in the operation of the specific seaming equipment being used and will qualify by successfully welding a test seam. The project foreman will provide direct supervision of all personnel seaming to verify proper welding procedures are followed. Qualified liner installers, seamers, and the liner foreman shall meet a minimum requirement of 1,000,000 square feet of geomembrane installation. There are no other minimum qualifications needed by other parties.

(c) Equipment

(1) Fusion Welding

Fusion Welding consists of placing a heated wedge, mounted on a self propelled vehicular unit, between two (2) overlapped sheets such that the surface of both sheets are heated above the polyethylene's melting point. After being heated by the wedge, the overlapped panels pass through a set of preset pressure wheels which compress the two (2) panels together so that a continuous homogeneous fusion weld is formed. The fusion welder is equipped with a temperature readout device which continuously monitors the temperature of the wedge.

(2) Extrusion Fillet Welding

Extrusion fillet welding consists of introducing a ribbon of molten resin along the edge of the seam overlap of the two (2) sheets to be welded. The molten polymer causes

some of the material of each sheet to be liquefied resulting in a homogeneous bond between the molten weld bead and the surfaces of the sheets. The extrusion welder is equipped with gauges giving the temperature in the apparatus and the preheat temperature at the nozzle.

(d) Weather Conditions

The Flexible Membrane Liner Manufacturer/Installer will rely on the experience of the Project Superintendent and the results of test seams to determine seaming restrictions by weather. Many factors, such as ambient temperature, humidity, wind, sunshine, etc., can effect the integrity of field seams and must be taken into account when deciding whether or not seaming should proceed. Responsibility for monitoring these conditions shall lie with the Project Superintendent; however, the Engineer may suspend any seaming operation which is, in his opinion, at the risk of providing the Owner with a quality product. Test seams are required prior to daily production seaming to determine if the weather conditions will effect the Flexible Membrane Liner System's ability to produce quality seams. Additional non-destructive and destructive testing of production seams substantiate the decision made by the Project Superintendent to seam on any given day.

(4) Seam Preparation

(a) Fusion Welding

(1) Overlap the panels of geomembrane approximately four (4) inches.

(2) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, debris of any kind. No grinding is required for fusion welding.

(3) Adjust the panels so that seams are aligned with the fewest possible number of wrinkles and "fishmouths".

(4) A movable protective layer may be used, at the discretion of the Flexible Geomembrane Liner System Project Superintendent, directly below the overlap of geomembrane that is to be seamed to prevent build-up of moisture between the panels.

(b) Extrusion Welding

(1) Overlap the panels of geomembrane a minimum of three (3) inches.
(2) Temporarily bond the panels of geomembrane to be welded taking care not to damage the geomembrane.

(3) Grind seam overlap prior to welding within one (1) hour of welding operation in a manner that does not damage the geomembrane. Limit grinding to ¼" outside of the extrusion weld area.

(4) Clean the seam area prior to seaming to assure the area is clean and free of moisture, dust, dirt, and debris of any kind.

(5) Purge the extruder prior to beginning the seam to remove all heat-degraded extrudate from the barrel.

(6) Keep welding rod clean and off the ground.

(5) Test Seams

Test seams shall be performed at the beginning of each seaming period and at least once each four (4) hours for each seaming apparatus used that day. Test seams shall be made on fragment pieces of the geomembrane liner and under the same conditions as actual seams.

(a) Test Seam Length

The test seam shall be at least three (3) feet long and should be made by joining two (2) pieces of geomembrane at least 9" in width.

(b) Sample Procedure

(1) Visually inspect the seam for squeeze out, footprint, pressure and general appearance.

(2) Two random samples one (1) inch wide shall be cut from the test seam. The specimens shall then be tested in peel using a field tensiometer and shall not fail in the seam. If a specimen fails the entire procedure shall be repeated.

(3) If any of the second set of specimens fail, the seaming apparatus shall not be accepted and shall not be used for seaming until the deficiencies are corrected and a passing test seam is achieved.

(4) After completion of these tests, the remaining portion of test seam can be discarded. Documentation of the test seams will be maintained listing seam identification number, welder's name, temperature control setting and test results.

(5) Passing test results records shall be maintained.

(6) General Seaming Procedures

(a) Seaming shall extend to the outside edge of panels to be anchored.

(b) While welding a seam, monitor and maintain the proper overlap.

(c) Inspect seam area to assure area is clean and free of moisture, dust, dirt, debris of any kind.

(d) While welding a seam, monitor temperature gauges to assure proper settings are maintained and that the seaming apparatus is operating properly.

(e) Align wrinkles at the seam overlap to allow welding through the wrinkle.

(f) Fishmouths or wrinkles at seam and overlaps that cannot be welded through shall be cut along the ridge in order to achieve a flat overlap. The cut fishmouth or wrinkle shall be seamed. Any portion where the overlap is inadequate shall be patched with an oval or round patch of the same geomembrane extending a minimum of six (6) inches beyond the cut in all directions.

(g) All cross/butt seams between two (2) rows of seamed panels shall be welded during the coolest time of the day to allow for contraction of the geomembrane.

(h) All "T" joints shall have the overlap from the wedge welder seam trimmed back to allow an extrusion fillet weld. Then grind ¼ of an inch minimum on either side of the wedge seam, then extrusion weld all of the area prepared by grinding.

6.5 Flexible Membrane Liner Tests

The installation crews will non-destructively test all field seams over their full length using air pressure testing, vacuum testing or other approved methods, to verify the continuity and integrity of the seams.

(a) Air Pressure Testing

The welded seam created by double hot-wedge fusion welding process is composed of two distinct welded seams separated by an unwelded channel approximately 3/8 of an inch between the two welded seams permits the double hot-wedge fusion seams to be tested by inflating the sealed channel with air to a predetermined pressure, and observing the stability of the pressurized channel over time.

(1) Equipment for Air Testing

An air pump (manual or motor driven) capable of generating and sustaining a pressure between 25 to 30 psi.

A rubber hose with fittings and connections.

A sharp hollow needle, or other approved pressure feed device with a pressure gauge capable of reading and sustaining a pressure between 25 to 30 psi.

(2) Procedure for Air Testing

Seal both ends of the seam to be tested.

Insert needle or other approved pressure feed device into the sealed channel created by the fusion weld.

Inflate the test channel to a pressure between 25 to 30 psi, in accordance with the following schedule, close valve, and observe initial pressure after approximately 2 minutes.

INITIAL PRESSURE SCHEDULE *

Material (Mil)	Min. Psi	Max. Psi
40	25	30
60	27	30
80	30	30
100	30	30

* Initial pressure settings are read after a two minute "relaxing period". The purpose of this "relaxing period" is to permit the air temperature and pressure to stabilize.

Observe and record the air pressure five (5) minutes after "relaxing period" ends and when initial pressure setting is used. If loss of pressure exceeds the following or if the pressure does not stabilize, locate faulty area and repair.

MAXIMUM PERMISSIBLE PRESSURE DIFFERENTIAL AFTER 5 MINUTES - LLDPE

Material (Mil)	Pressure Diff.
40	4 psi
60	3 psi
80	3 psi
100	3 psi

At the conclusion of the pressure test the end of the seam opposite the pressure gauge is cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will have to be repeated after the blockage is corrected.

Remove needle or other approved pressure feed device and seal resulting hole by extrusion welding.

(3) In the event of a Non-Complying Air Pressure Test, the following procedure shall be followed:

Check seam end seals and retest seams.
If non-compliance with specified maximum pressure differential re-occurs, cut one (1) inch samples from each end of the seam and additional samples.

Perform destructive peel tests on the samples using the field tensiometer.

If all samples pass destructive testing, remove the overlap left by the wedge welder and vacuum test the entire length of seam.

If a leak is located by the vacuum test, repair by extrusion welding. Test the repair by vacuum testing.

If no leak is discovered by vacuum testing, the seam will pass non-destructive testing.

If one or more samples fail the peel tests, additional samples will be taken.

When two (2) passing samples are located, the seam between these two (2) locations will be considered non-complying. Capping or removal of the non-complying seam are the only two (2) acceptable methods for repairing failed seams. Non-destruct test the entire length of the repaired seam.

(b) Vacuum Testing

This test is used when the geometry of the weld makes air pressure testing impossible or impractical or when attempting to locate the precise location of a defect believed to exist after air pressure testing. The penetration will be tested using this method.

(1) Equipment for Vacuum Testing
Vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.

Vacuum pump assembly equipped with a pressure controller and pipe connection.

A rubber pressure/vacuum hose with fittings and connections.

A bucket and means to apply a soapy solution.

A soapy solution.

(2) Procedure for Vacuum Testing

Trim excess overlap from seam, if any.

Turn on the vacuum pump to reduce the vacuum box to approximately 5 inch of mercury, i.e., 5 psi gauge.

Apply a generous amount of a solution of strong liquid detergent and water to the area to be tested.

Place the vacuum box over the area to be tested and apply sufficient downward pressure to "seat" the seal strip against the liner.

Close the bleed valve and open the vacuum valve.

Apply a minimum of 5 in. Hg vacuum to the area as indicated by the gauge on the vacuum box.

Ensure that a leak tight seal is created.

For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

If no bubbles appear after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 in. overlap, and repeat the process.

(3) Procedure for Non-Complying Test

Mark all areas where soap bubbles appear and repair the marked areas.

Retest repaired areas.

(c) Destructive Testing

(1) Concept

The purpose of destructive testing is to determine and evaluate seam strength. These tests require direct sampling and thus subsequent patching. Therefore destructive testing should be held to a minimum to reduce the amount of repairs to the geomembrane.

(2) Procedure for Destructive Testing

All Destructive tests will be done according to ASTM D4437. Destructive test samples shall be marked and cut out randomly at a minimum average frequency of one test location every 500 feet of seam length.

Additional destructive tests may be taken in areas of contamination, offset welds, visible crystallinity or other potential cause of faulty welds at the descretion of the Project Superintendent and Engineer.

Sample Size

The sample should be twelve (12) inches wide with a seam fourteen (14) inches long centered lengthwise in the sample. The sample may be increased in size to accommodate independent laboratory testing by the owner at the owner's request or by specific project specifications.

A one (1) inch sample shall be cut from each end of the test seam for field testing.

The two (2), one (1) inch wide samples shall be tested in the field in a tensiometer for peel ASTM D4437. Tensile strength is essentially a measurement of the greatest tension stress a substance can bear without tearing. If the liner tears before any part of the seam does the test is successful. If any field sample fails to pass, it will be assumed the sample fails destructive testing.

(3) Procedure in the event of Destructive Test Failure

Cut additional field samples for testing. In the case of a field production seam, the samples must lie a minimum of ten (10) feet in each direction from the location of the failed sample. Perform a field test for peel strength. If these field samples pass, then laboratory samples can be cut and forwarded to the laboratory for full testing.

If the laboratory samples pass then reconstruct the seam between the two (2) passing samples locations.

Heat tack the overlap along the length of the seam to be reconstructed and extrusion weld.

Vacuum test the extrusion weld.

If either of the samples fail, then additional samples are taken in accordance with the above procedure until two (2) passing samples are found to establish the zone in which the seam should be reconstructed.

All passing seams must be bounded by two (2) locations from which samples passing laboratory destructive tests have been taken.

In cases of reconstructed seams exceeding 150 feet, a destructive sample must be taken and pass destructive testing from within the zone in which the seam has been reconstructed.

All destructive seam samples sent to the Flexible Membrane Liner System's laboratory shall be numbered.

(d) Quality Assurance Laboratory Testing

(1) Destructive samples sent to the laboratory will be tested for "shear strength" and "peel adhesion" (ASTM D4437 as modified by NSF). Five (5) specimens shall be tested for each test method with data recorded. Four (4) out of the five (5) specimens must pass for each test in order for the seam to pass the destructive test.

(2) Defects and Repairs

(a) The Project Superintendent shall conduct a detailed walk through and visually check all seams and non-seam areas of the geomembrane for defects, holes, blisters and signs of damage during installation.

(b) All other installation personnel shall, at all times, be on the lookout for any damaged areas. Damaged areas shall be marked and repaired.

(c) Repair Procedures

Any portion of the geomembrane showing a flaw or failing a destructive or non-destructive test shall be repaired. Several procedures exist for repair and the decision as to the appropriate repair procedure shall be made by the Project Superintendent. Repairs need to be made in a timely manner to protect the moist cohesive soil liner and flexible membrane liner. If inclement weather is approaching, steps need to be made to protect the cohesive soil cap such as a temporary cover. If cohesive soil cap is damaged, it must be reworked. Procedures available for liner repair:

Patching - used to repair large holes, tears and destructive sample locations. All patches shall extend at least six (6) inches beyond the edges of the defect and all corners of patches shall be rounded.

Reconstruction - used to repair seams bounded by passing destuct samples.

Grinding and welding - used to repair sections of extruded seams.

Spot welding or seaming - used to repair small tears, pinholes or other minor localized flaws.

Capping - used to repair lengths of failed extruded seams.

Removal of a bad seam and replacement with a strip of new material seamed into place.

(d) Verification of Repairs

Every repair shall be non-destructively tested. Repairs which pass the non-destructive test shall be deemed adequate. Large repairs may require a destructive test. Repair test results shall be logged. The repair location shall be recorded on an as-built drawing.

6.6 Protective Cover

(1) HPDE Geocomposite Drainage Netting manufactured by SKAPS Industries, or approved equal.

GEOCOMPOSITE PROPERTIES

PROPERTY	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Thickness	ASTM D 5199	inch	0.305
Transmissivity[1] (15,000 psf)	ASTM D 4716	m^2/sec	$3x10^{-5}$
Ply Adhesion	ASTM D 413 or F 904	lb/in	2.0

COMPONENT PROPERTIES

GEONET	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Polymer Density	ASTM D 1505	g/cm^3	0.94
Carbon Black Content	ASTM D 4218	%	2.0
Thickness	ASTM D 5199	inches	0.200
Mass per unit area	ASTM D 5261	lbs/ft^2	0.162
Transmissivity[1]	ASTM D 4716	m^2/sec	$1x10^{-3}$@ 15,000 psf
Tensile Strength	ASTM D 5035	lbs/in	45

GEOTEXTILE	TEST	UNITS	MINIMUM AVERAGE ROLL VALUE
Fabric Weight	ASTM D 5261	oz/yd^2	7.1
Thickness	ASTM D 5199	mils	95
Grab Strength	ASTM D 4632	lbs	210
Water Flow Rate	ASTM D 4491	gpm/ft^2	110
Apparent opening size (AOS)	ASTM D 4751	mm (Sieve Size)	0.150 (100)

1. Measured using water @ 20° C (68° F) with a gradient of one, between two steel plates, after one hour. Value may vary, based on dimensions of the transmissivity specimen and specific laboratory.
2. Component properties are tested prior to the lamination process. They cannot be tested on the final product.

The geocomposite will be handled in such a manner as to ensure the geocomposite are not damaged in any way. On slopes, the geocomposite will be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geocomposite sheet in tension. If necessary, the geocomposite will be positioned by hand after being unrolled to minimize wrinkles. Geocomposite can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., where extra layers are required or where slope is less than 10:1).

Geocomposite will not be welded to the geomembrane. Geocomposite will be cut using approved cutters,(i.e., hook blade, scissors, etc.) Care should be taken to prevent damage to underlying layers. Care must be taken not to entrap dirt in the geocomposite that could cause clogging of the drainage system, and or stones that could damage the adjacent geomembrane.

Adjacent rolls of geocomposite will be overlapped by at least four inches and securely tied. Tying can be achieved by plastic fasteners. Tying devices will be white or yellow for easy inspection. Metallic devices are not allowed. Tying will be five to ten feet along the bottom of the slope. Tying will be every five feet along the slope, every two feet across the slope and at the top of the berm. Tying in the anchor trench will be done in one foot intervals. In the corners of the side slopes where overlaps between perpendicular geocomposite strips are required, an extra layer of geocomposite will be unrolled along the slope, on top of the previously installed geocomposite, from the top to bottom of the slope.

Any holes or tears in the geocomposite will be repaired by placing a patch extending two feet beyond edges of the hole or tear. The patch will be secured to the original geocomposite by tying every twelve inches. If the hole or tear width across the roll is more than 50% the width of the roll, the damaged area will be cut out and the two portions of the geocomposite will be joined.

The engineer will visually inspect the drainage layer before placement of the erosive layer, if any defects are detected they will be repaired before placement of erosive layer.

(2) Erosive Layer

The soil for the erosive layer shall consist of any soils suitable of supporting vegetative growth. The erosive layer shall be installed using low ground pressure equipment such as a Caterpillar D6H LGP, or approved equal, with ground pressure not exceeding 4.71 psi. When installing the erosive layer, the contractor shall adhere to the following guidelines:

(a) A minimum of twelve inches (12") of cover between low ground pressure equipment and the liner is required at all times. Roadways for entering and for transporting material over slopes and capped/lined areas shall have a minimum depth of four feet (4').

(b) Avoid undue stress on the liner at all times. Cover material must be pushed up slopes, never down to help minimize wrinkles. Material must be placed to minimize wrinkles, wrinkles in excess of two feet in height are unacceptable. If a wrinkle is more than two feet in height, soil will be placed on top of the wrinkle to decrease the height. Fold over of the liner will not be allowed. A worker must walk along side earth moving equipment and remove all rocks, stones, roots or other debris that could cause damage to the liner. Equipment operators must avoid sharp turns or quick stops that could pinch and tear the liner.

(c) If damage does occur, report it to the Project Manager immediately so that repairs can be performed without needless delay.

(d) Do not work wet cover material that cannot support equipment.

(e) Equipment operators and all other personnel must be qualified and must exercise good judgment and common sense at all times.

(3) Vegetative Layer

Native vegetation will be used as approved by the Erosion Control Plan.

6.7 Methane Venting System

Gas Venting System

NC.D.O.T. No.5 stone, Geotextile fabric, and 8" and 10" plastic pipes will be used in the construction of the Gas venting system.

(1) Stone in Trenches and Surrounding Perforated Collection Piping

Stone for methane collection system shall meet the requirements of NC DOT aggregate, standard size No. 5 and shall contain no fines. Stone must pass the sieve analysis test for No. 5 stone performed at the quarry.

(2) Geotextile Fabric

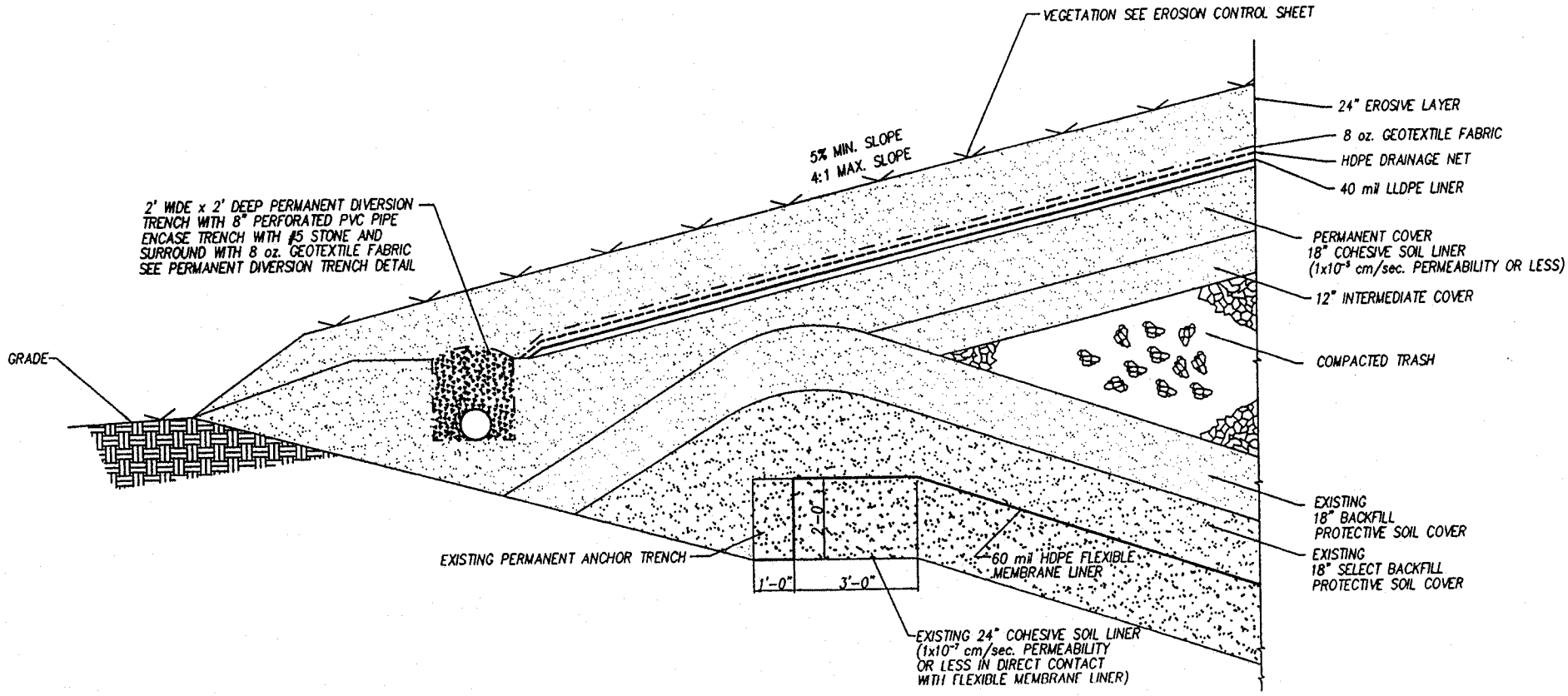
Geotextile fabric surrounding the stone/piping shall be non-woven needle punched fabric with the following minimum properties:

1)	Weight	8.0 oz/yd^2	ASTM D-3776
2)	Grab Strength	205 lbs.	ASTM D-4632
3)	Grab Elongation	50%	ASTM D-4632
4)	Trapezoidal Tear Strength	85 lbs.	ASTM D-4533
5)	Puncture Strength	100 lbs.	ASTM D-4833
6)	Mullen Burst Strength	320 psi	ASTM D-3786
7)	Permittivity	1.4 sec^{-1}	ASTM D-4491

Geotextile fabric shall be manufactured by Polyfelt , TNS Advanced Technologies, or approved equal.

(3) Plastic Pipe

Plastic gravity sewer pipe and fittings used for methane vent shall be unplasticized polyvinyl chloride (PVC) and conform to the requirements of ASTM Designation D-3034 on ASTM F679, Type PSM, Class 12454-B, SDR-35 with elastomeric gasket joints. PVC pipe and fittings shall be as manufactured by J-M Pipe, Certainteed, H&W Industries or equal. The methane riser pipe shall be a 10 inch solid wall PVC pipe.



TYPICAL CLOSURE DETAIL AT PERMANENT ANCHOR TRENCH

NOT TO SCALE

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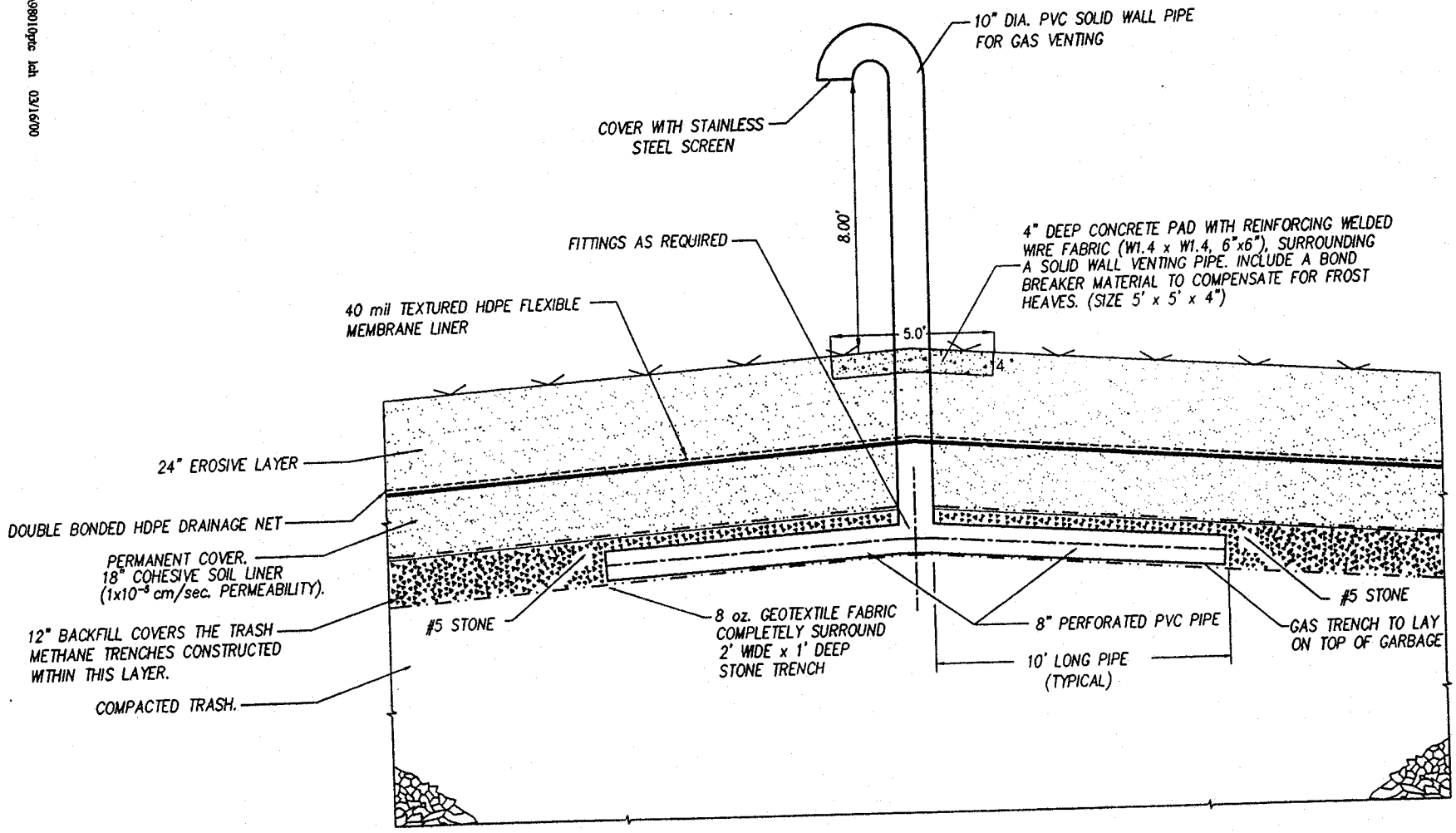

TYPICAL METHANE GAS COLLECTION TRENCH CLOSURE DETAIL AND CAP COVER DETAIL

N.T.S.

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6.8 Closure Costs

The largest area to be closed within the permitted life will be phase 2 (10.3 Ac.) as well as phase 1. The estimated costs shown below are only for phase 2. Post Closure will be 30 years after closure.

Closure Costs:

Closure will consist of the following which costs are estimated as being done by a third party.

1. 18" of $1x10^{-5}$ cm/sec. soil cover;
2. 40 Mil LLDPE Liner and Drainage net;
3. Erosion Control Devices;
4. 24" Erosive layer;
5. Seeding and Mulching;
6. Mobilization/Demobilization;
7. Labor Costs; and
8. Stone for methane gas collection.
9. Geotextile for methane gas collection.
10. Vent pipes for methane gas collection.
11. Engineering Costs and QA/QC of the Composite liner and certification of closure.

Estimate of Probable Costs:

1. **18" of $1x10^{-5}$ cm/sec. soil cover for 10.3 acres:**

   Total yardage + 15% = 28,700 yd^3 @ a cost of \$3.60/yd^3
   ∴ Cost = $103,320.00

2. **40 Mil LLDPE Liner and Drainage net for 10.3 acres**

   Total Footage + 15% = 516,000 ft^2 @ a cost of .72/ft^2
   ∴ Cost = $371,520.00

3. **Erosion Control devices**

   Estimated costs @ $42,000.00
   ∴ Cost = $42,000.00

4. **24" Erosive soil layer for 10.3 acres.**

   Total yardage + 15% = 38,300 yd^3 @ a cost of \$2.70/yd^3
   ∴ Cost = $103,410

5. **Seeding and Mulching for 10.3 acres.**

Estimated cost of $1,800.00/acre
∴ Cost = $18,540.00

6. **Mobilization/Demobilization.**

Estimated cost of $18,000.00

7. **Labor Costs.**

Estimated cost of $96,000.00
∴ Cost = $96,000.00

8. **Stone for methane gas collection.**

Total estimated linear feet =2,600 ft.
Total estimated volume for a 2'x1' trench = 5,200 ft^3
with a density of 120 lbs/ft^3 total weight =312 tons @ a cost of $18.00/ton
∴ Cost = $5,616.00

9. **Geotextile for methane gas collection.**

Total estimated linear feet = 2,600 ft.
Total estimated perimeter for a 2'x1' trench = (2,600 ft × 6 ft)@ a cost of $0.20/ ft^2
∴ Cost = $3,120.00

10. **Vent pipes for methane gas collection.**

Estimated cost @ $600.00 each.
∴ Cost = $3,600.00

11. **Engineering Costs and QA/QC of the Composite liner and certification of closure.**

Estimated cost = $120,000.00
∴ Cost = $120,000.00

Total of Estimated Phase 2 Closure Costs:

1. $ 103,320.00
2. $ 371,520.00
3. $ 42,000.00
4. $ 103,410.00
5. $ 18,540.00
6. $ 18,000.00
7. $ 96,000.00
8. $ 5,616.00
9. $ 3,120.00
10. $ 3,600.00
11. $ 120,000.00

Total: $885,126.00 (Phase 2 only)

The current closure cost for the existing Municipal Solid Waste Landfill in Haywood County (Permit #4407) is $1,498,440.00.

SECTION 7.0

POST-CLOSURE PLAN

7.1 Introduction

CONTACTS:

Name:	Jack Horton
Title:	County Manager
Phone No.:	(828) 452-6625
Address:	215 N. Main Street Waynesville, NC 28786

DESCRIPTION OF USE:

Haywood County has no future use planned for their landfill at this time.

DESCRIPTION OF MAINTENANCE ACTIVITIES:

The Haywood County Landfill will be monitored quarterly for evidence of settlement, subsidence and ponding in the cap system. The entire site will be monitored quarterly for evidence and effects of erosion. The erosion control plan will be preserved. Annually in the Spring, the vegetative cover will be monitored to assure a good stand of vegetation, and where needed, it will be reseeded. These maintenance activities will take place over the entire post closure period of thirty years.

The leachate collection system will be monitored annually and flushed out if necessary. Leachate will be collected and treated until the generation of leachate has stopped due to capping.

DESCRIPTION OF MONITORING ACTIVITIES:

The Haywood County Landfill will monitor and analyze ground and surface water semi-annually for (Subtitle D Appendix I) constituents for a period of thirty years. The County will also monitor methane gas at landfill structures and the boundary quarterly for the thirty-year period.

COMPLETION OF POST-CLOSURE CARE

Following completion of the post-closure care period for each MSWLF unit, the owner or operator will notify the Division of Solid Waste 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.

CLOSURE OF LEACHATE STORAGE FACILITIES

Haywood County will close the leachate lagoon within 180 days after liquid collection has ceased.

All solid waste will be removed from the leachate lagoon, connecting sewer lines, and manholes. All solid waste removed will be properly handled and disposed of according to federal and State requirements. All connecting lines will be disconnected and securely capped or plugged.

All waste residues, contaminated system components (composite liner system), contaminated subsoils, structures and equipment contaminated with waste will be removed and appropriately disposed. If the groundwater surrounding the impoundment is contaminated, other corrective actions to remediate a contaminant plume may be required by the Department. If the groundwater surrounding the lagoon is found not to be contaminated, the liner system may remain in place if drained, cleaned to remove all traces of waste, and both liners punctured so that drainage is allowed. The lagoon is to be backfilled and regraded to the surrounding topography.

7.2 Post Closure Costs

The largest closed area to be monitored within the post closure life will be phase 1 (11.9 Ac.) and phase 2 (10.3 Ac.). The estimated costs shown below are for phase 2 only.

Post Closure Costs:

Methane gas and ground and surface will be monitored for 30 years after closure. The cap will also have to be monitored for the 30 year period. All costs include reports, data analysis, and certifications.

1. **Ground and Surface Water monitoring semiannually for 30 years for appendix I constituents and statistical analysis.**

   Estimated cost/sample = $840.00/sample
   Total annual samples = 2(18 wells + 3 surface) = 42 samples/year
   Estimated cost = 30 years x 42 samples/year x $840.00/sample
   = $1,058,400.00

   ∴ Cost = $1,058,400.00

2. **Methane Gas monitoring quarterly for 30 years.**

   Estimate $600.00/quarter = $2,400.00/year
   Estimated cost = 30 year x $2,400.00 = $72,000.00

   ∴ Cost = $72,000.00

3. **Cap Monitoring and repairing any problems.**

Estimate $120,000.00 for the 30 years.

∴ Cost = $120,000.00

4. **Closure of sedimentation and erosion control devices.**

Estimate $24,000.00 for closure

∴ Cost = $24,000.00

5. **Leachate Management.**

Estimate $300,000.00 for the 30 years.

∴ Cost = $300,000.00

6. **Closure of leachate lagoon.**

Estimate $28,800.00 for Closure.

Total of Estimated Phase 2 Post Closure Costs:

1. $1,058,400.00
2. $ 72,000.00
3. $ 120,000.00
4. $ 24,000.00
5. $ 28,800.00
6. $ 300,000.00

Total: $1,603,200.00 (Phase 2 only)

The current post closure cost for the existing Haywood County Municipal Solid Waste Landfill (Permit #4407) is $3,435,706.00.

SECTION 8.0

FINANCIAL ASSURANCES

TO BE SUBMITTED AT A LATER DATE

HAYWOOD COUNTY
MUNICIPAL SOLID WASTE
LANDFILL
OPERATION PLAN
PERMIT RENEWAL PHASE 2

BOARD OF COMMISSIONERS

CHAIRMAN - Jim Stevens
VICE-CHAIRMAN - Robert Forga
COMMISSIONNERS:
Mary Ann Enloe
Carlyle Ferguson
Wade Francis

COUNTY MANAGER

JACK HORTON

SOLID WASTE MANAGER

JOE WALKER

Engineer
Municipal Engineering Services Company, P.A.
Garner, N.C. Boone, N.C.

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODLIE

3/20/2000

by _____
Professional Engineer

Municipal Engineering Services Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529
P.O. BOX 349 BOONE, N.C. 28607

SCALE:	NTS
DATE:	3/10/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	T1
SHEET NO.	1 of 1

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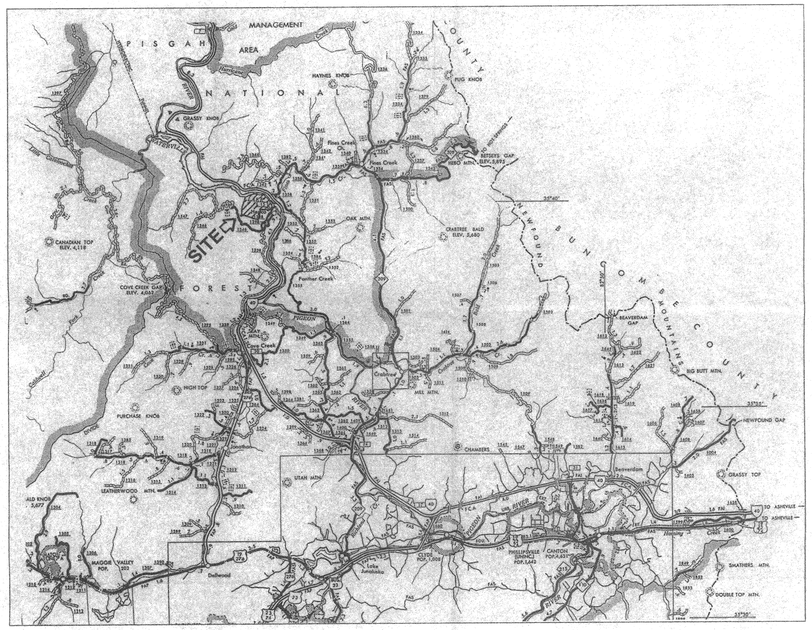
INDEX

SHEET NO.	DRAWING NO.	DESCRIPTION
01	T1	TITLE SHEET
02	T2	INDEX
03	P1	FACILITY OPERATIONS
04	P2	1st CELL TRANSITION CONTOURS
05	P3	2nd CELL TRANSITION CONTOURS
06	P4	3rd CELL TRANSITION CONTOURS
07	P5	4th CELL TRANSITION CONTOURS
08	P6	PHASE 2 FINAL FILL
09	P7	METHANE GAS COLLECTION
10	P8	OPERATION DETAILS
11	P9	EROSION CONTROL PLAN
12	P10	EROSION CONTROL DETAILS



Municipal Services Engineering Company, P.A.

P.O. BOX 97, GARNER, N.C. 27529 (919) 772-5393

P.O. BOX 549 BOONE, N.C. 28607 (704) 262-1767

NORTH CAROLINA PROFESSIONAL SEAL 4262 ENGINEER JIMMY D. WOODIE

3/20/2000

SCALE:	NTS
DATE:	3/10/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	T2
SHEET NO.	2 of 12

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LEGEND:

EIP = EXISTING IRON PIPE OR PIN
IPS = IRON PIPE OR PIN SET
R/R SPIKE = RAILROAD SPIKE SET
FC = FENCE CORNER
MH = MAN HOLE
WM = WATER METER
PP = POWER SERVICE POLE
— P — = AERIAL POWER LINE
DB = DEED BOOK
PG = PAGE
= EXISTING GROUNDWATER MONITOR
= EXISTING PIEZOMETER
= PROPOSED CONTOURS
= 300' BUFFER
= PROPOSED ANCHOR TRENCH
= PROPOSED PHASELIMITS
= EXISTING LANDFILL
= EXISTING CONTOURS
= WETLANDS

PHASE 5
PHASE 4
PHASE 3
PHASE 2
PHASE 1
EXISTING LANDFILL
CELL 1
CELL 2
CELL 3
CELL 4
CELL 5
500' BUFFER
EXISTING LAGOON
CLEAN OUT
SUMP AREA (SEE DETAIL SHEET 8 OF 12)
STORMWATER PENETRATION
INV. IN = 2543.5'
INV. OUT = 2542.0'
KNIFE VALVES (2 TOTAL)
EXISTING LANDFILL ANCHOR TRENCH
8" HDPE SDR 17 DUAL CONTAINMENT
8" CARRIER BY 12" CONTAINMENT
(FOR PROFILE AND INVERT ELEVATIONS SEE SHEET 9 OF 12)
EX. MANHOLE #1
INV. IN 2556.63
INV. OUT 2556.53
EX. MANHOLE #2
INV. IN 2543.13
INV. OUT 2543.03
EX. MANHOLE #3
INV. IN 2524.81
INV. OUT 2524.81
EX. MANHOLE #4
INV. IN 2503.80
INV. OUT 2495.70
EX. MANHOLE #5
INV. IN 2471.20
INV. OUT 2471.10
EX. MANHOLE
INV. IN 2468.1
INV. OUT 2465.4
EX. MANHOLE
INV. IN 2464.70
INV. OUT 2464.00
EX. FLOW M.H.
INV. IN 2461.40
INV. OUT 2458.70
EX. MANHOLE
INV. IN 2454.00
INV. OUT 2453.60
CONCRETE
7+68.70

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER TIMMY D. WOODIE
3/20/2000

Municipal Services Engineering Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY NORTH CAROLINA

OPERATION PLAN

DATE	BY	REV.	DESCRIPTION

SCALE:	1"= 60'
DATE:	3/10/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	P1
SHEET NO.	3 OF

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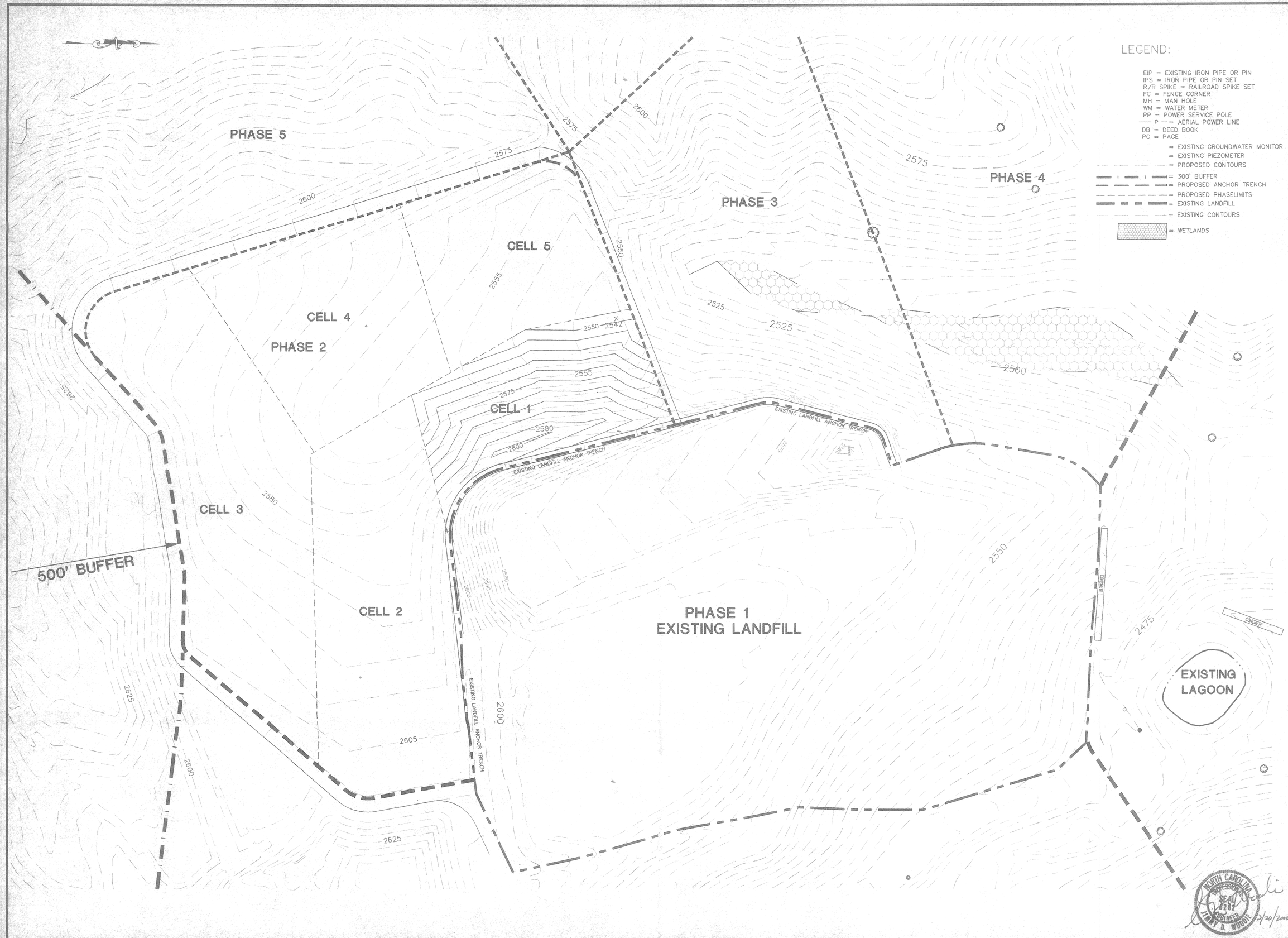

Municipal Engineering Services Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY

OPERATION PLAN

DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 60'
DATE: 3/10/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. P2
SHEET 4 OF

NORTH CAROLINA PROFESSIONAL SEAL 8282 ENGINEER JIMMY D. WOODIE
3/20/2000

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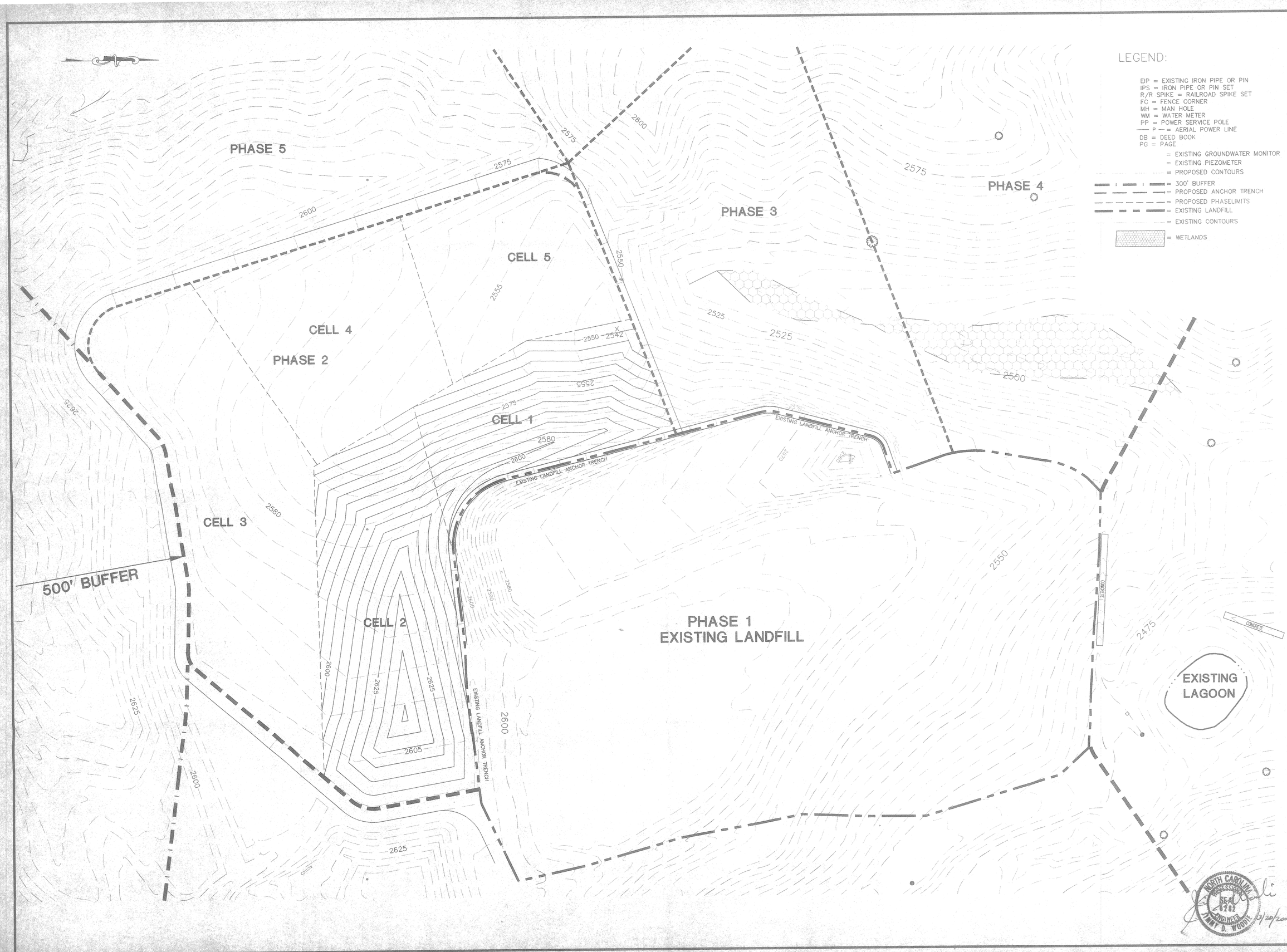


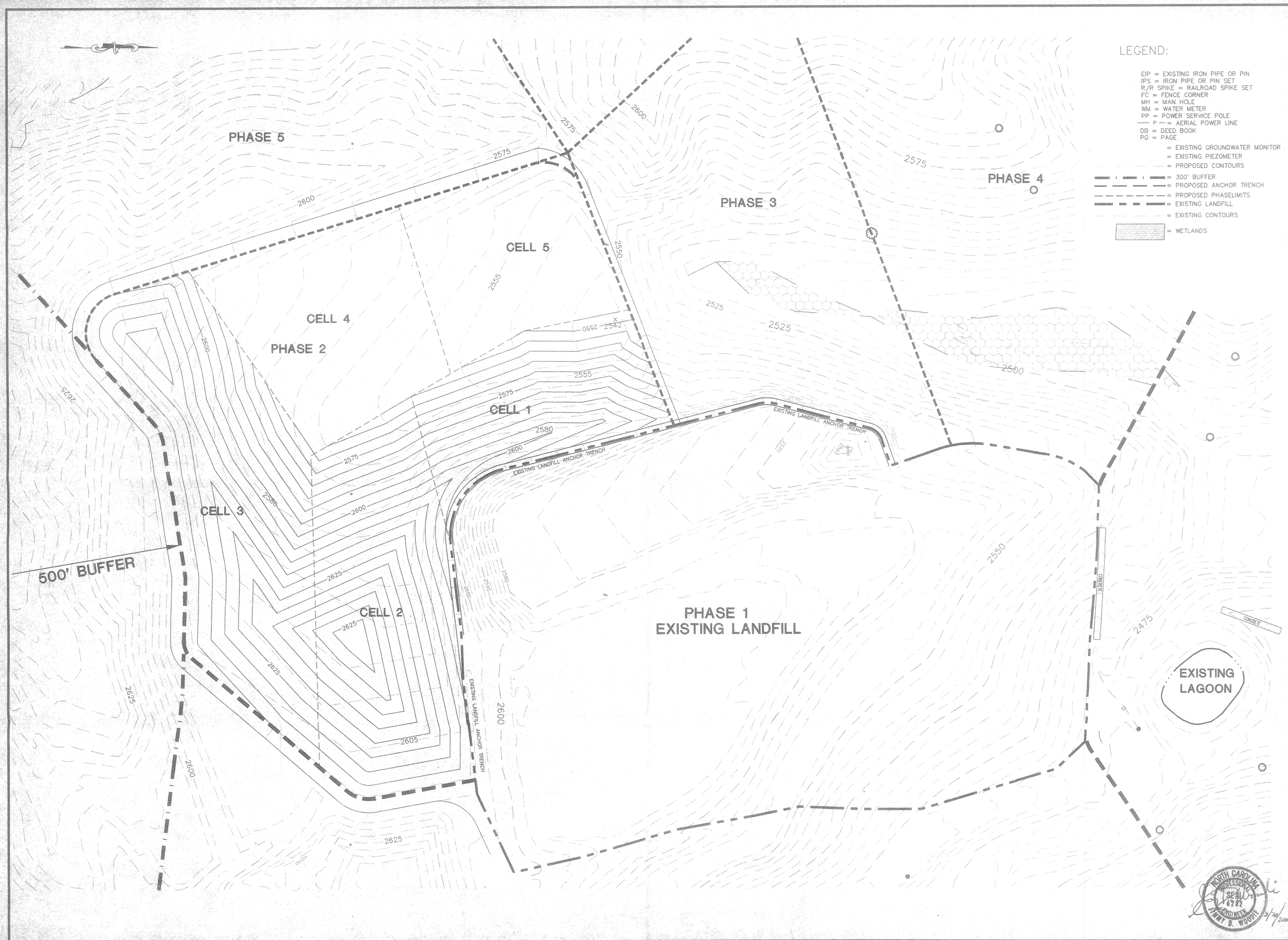
Municipal Engineering Services Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY

OPERATION PLAN

DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 60'
DATE: 3/13/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVA
PROJECT NUMBER
G98010.6
DRAWING NO. P3
SHEE 5 O

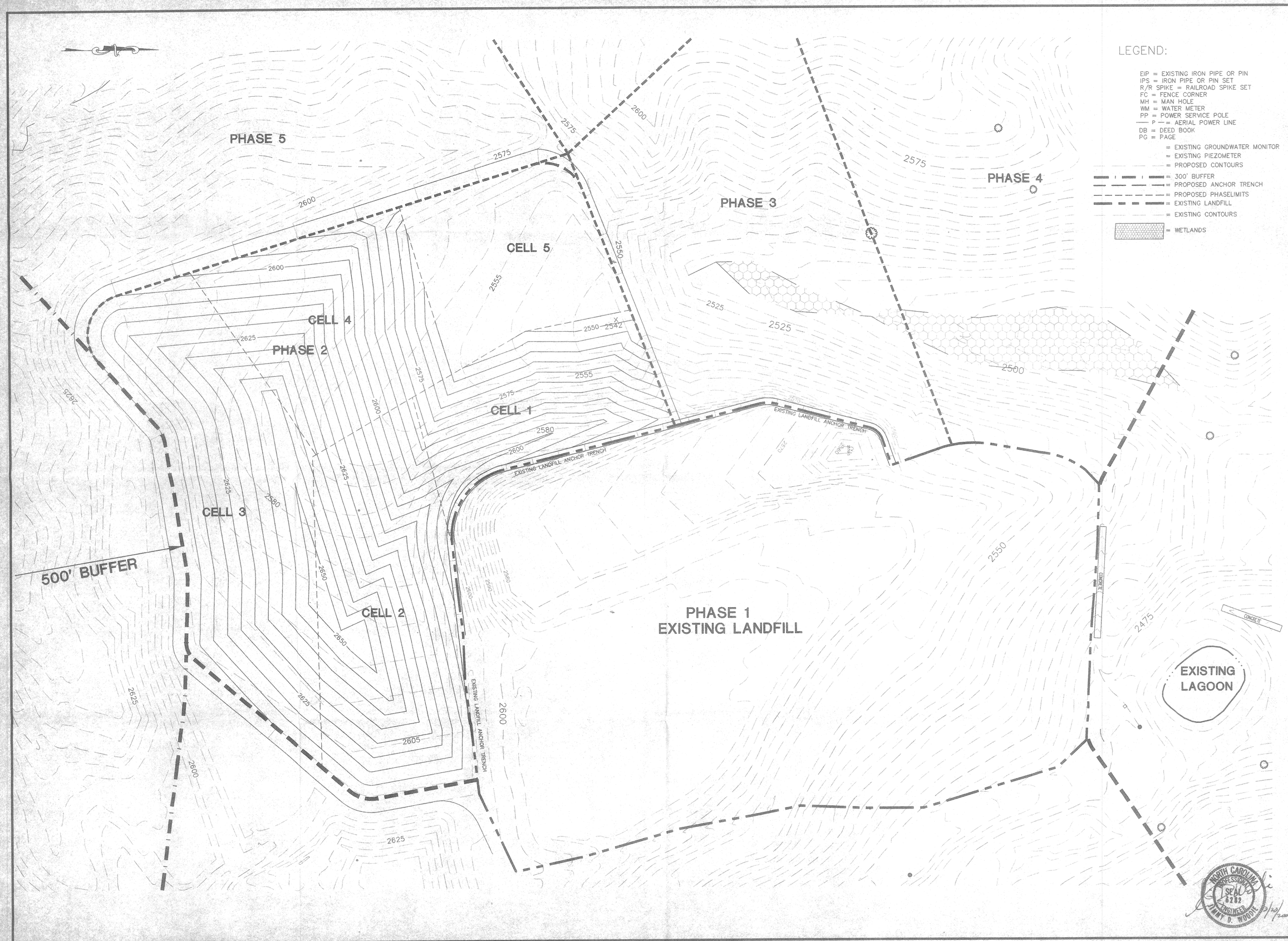


Municipal Engineering

MUNICIPAL SOLID WASTE LANDFILL

DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 6
DATE: 3/13/
DRWN. BY: B. BA
CHKD. BY: W. SU
PROJECT NU
G9801
DRAWING NO.
P4



Municipal Engineering Services Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

OPERATION PLAN

DATE	BY	REV.	DESCRIPTION

SCALE: 1" = 60'
DATE: 3/13/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. P5
SHEET 7 OF

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE
3/20/2000

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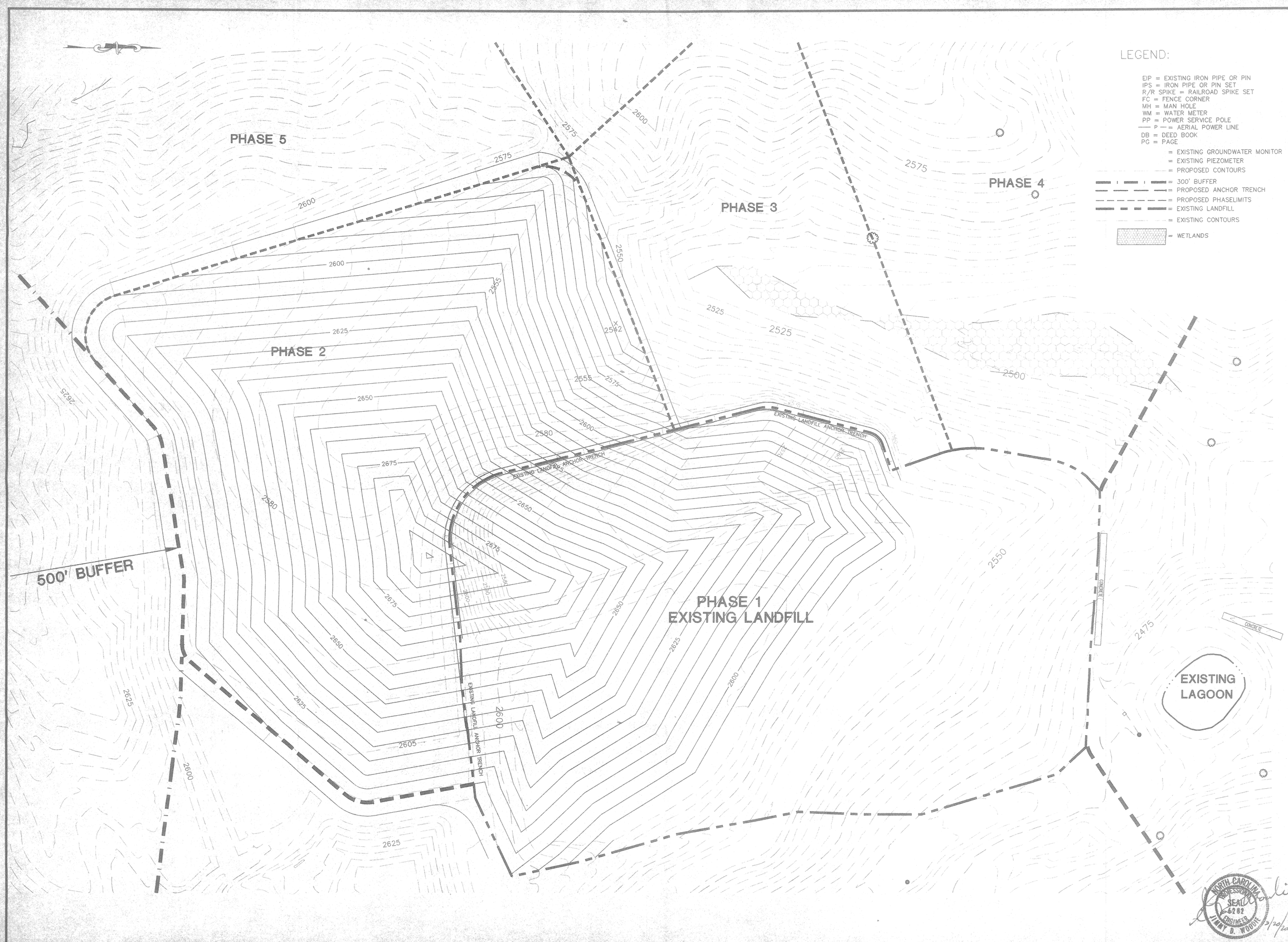

Municipal Engineering Services Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

OPERATION PLAN
PHASE 2 FINAL FILL

DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 80'
DATE: 3/15/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. P6
SHEET NO. 8 OF

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE
3/20/2000

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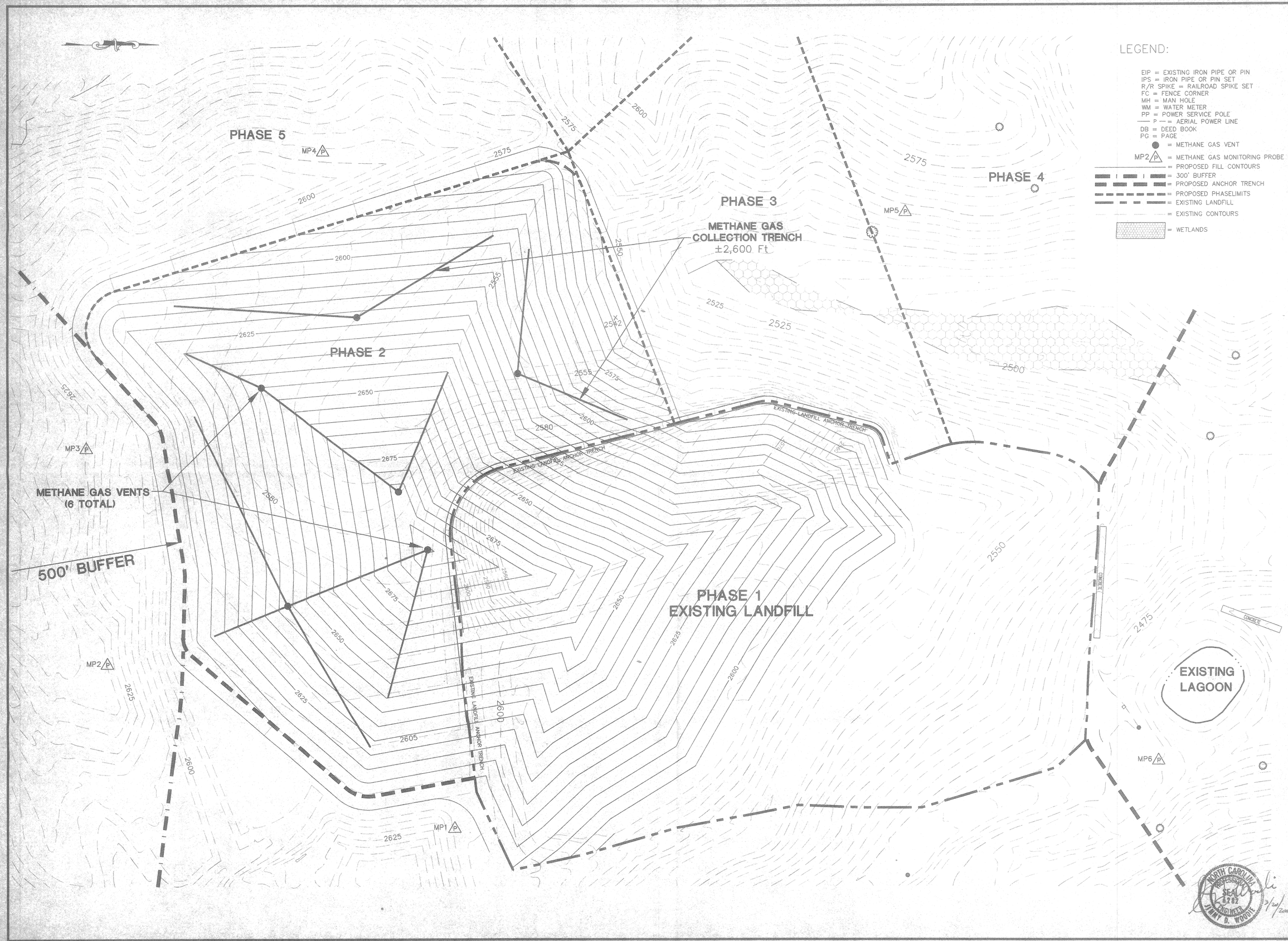


Municipal Services Engineering Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

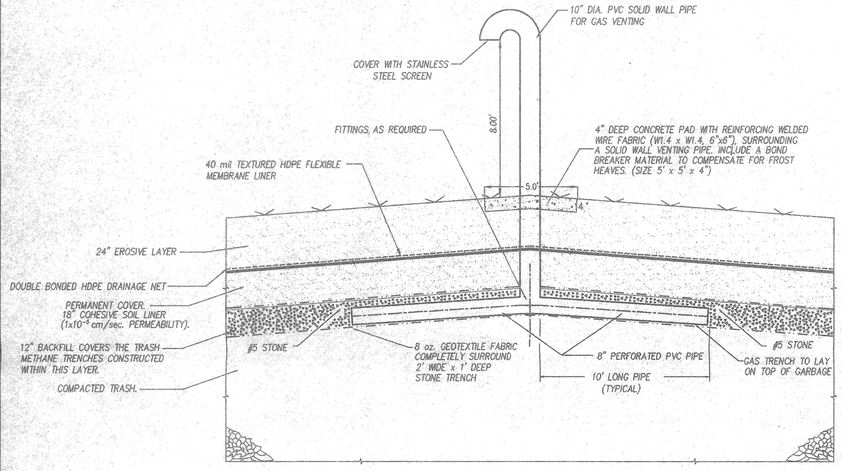
OPERATION PLAN
METHANE GAS COLLECTION

DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 60'
DATE: 3/15/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. P7
SHEET NO. 9 OF 12

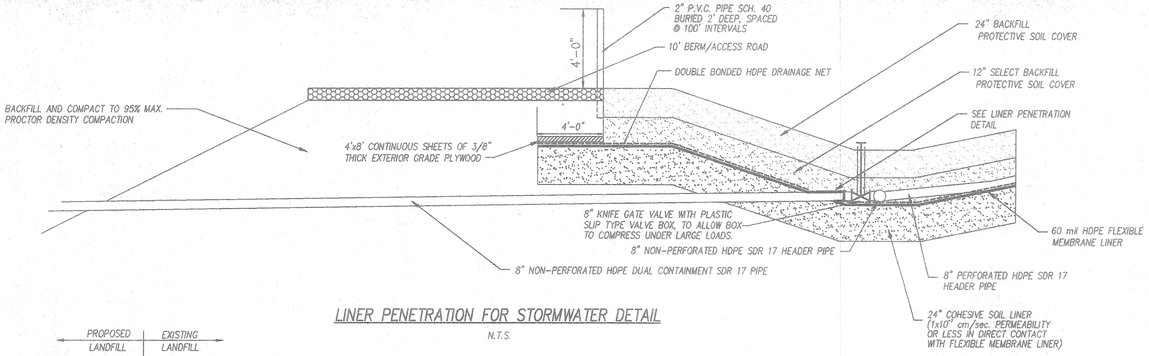
NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE
3/20/2000

G:\haywood\pitcphase i\operations\98010p09.dwg Thu Mar 16 14:38:01 2000 BMB



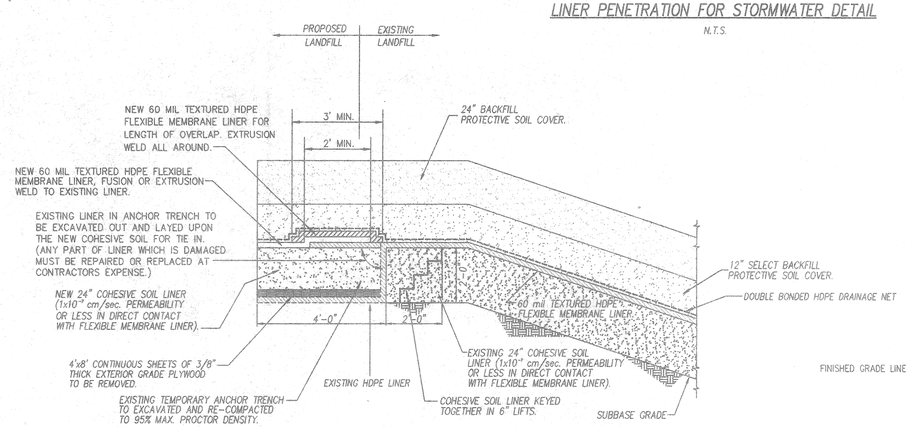
TYPICAL METHANE GAS COLLECTION TRENCH CLOSURE DETAIL AND CAP COVER DETAIL

N.T.S.



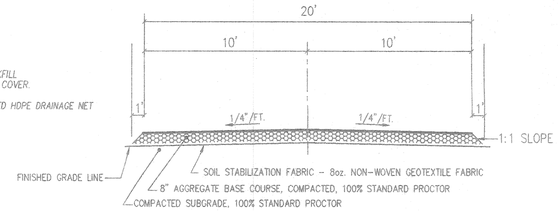
LINER PENETRATION FOR STORMWATER DETAIL

N.T.S.



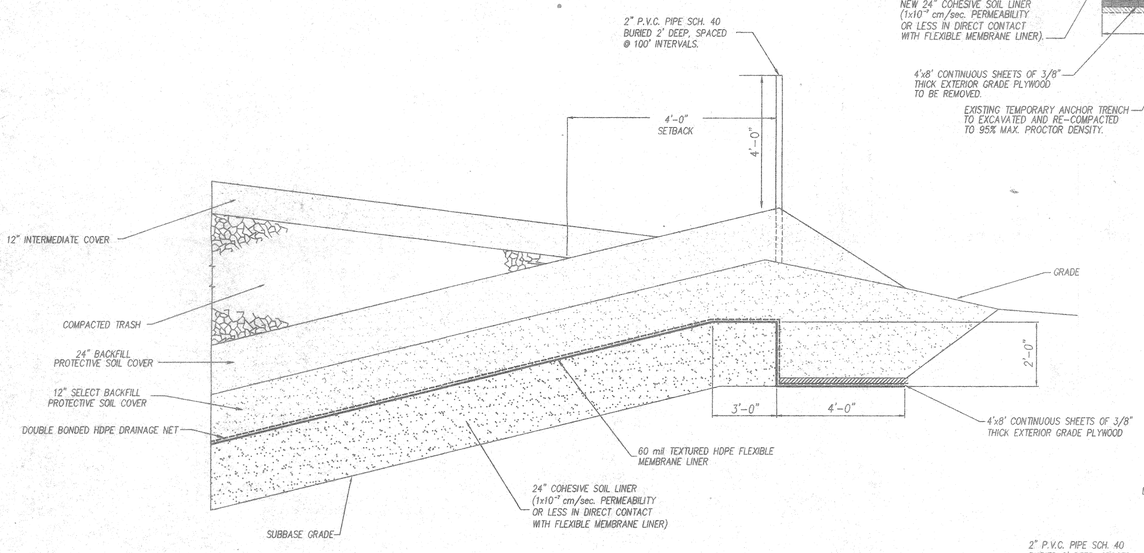
TIE-IN TO EXISTING LINER

N.T.S.



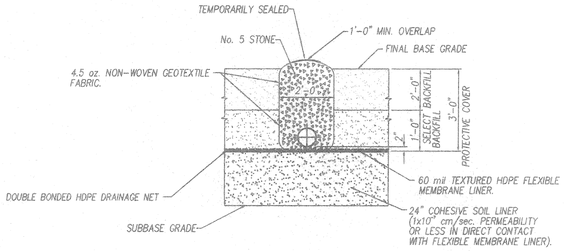
GRAVEL DRIVE DETAIL

N.T.S.



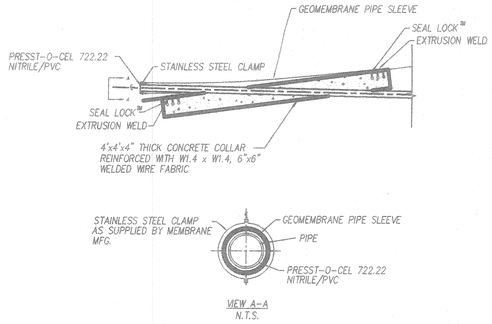
TEMPORARY ANCHOR TRENCH DETAIL

N.T.S.



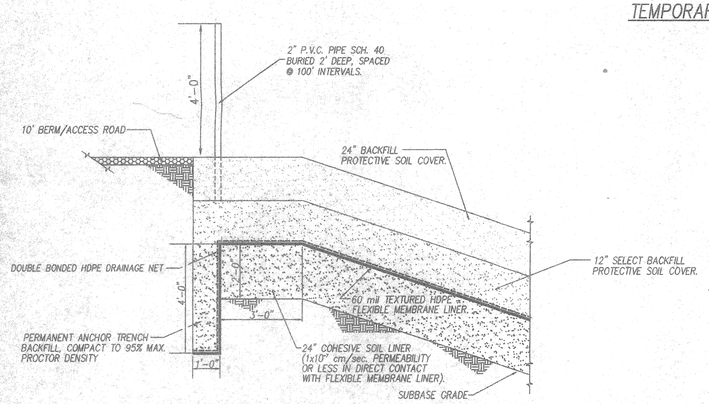
LEACHATE COLLECTION TRENCH DETAIL

N.T.S.



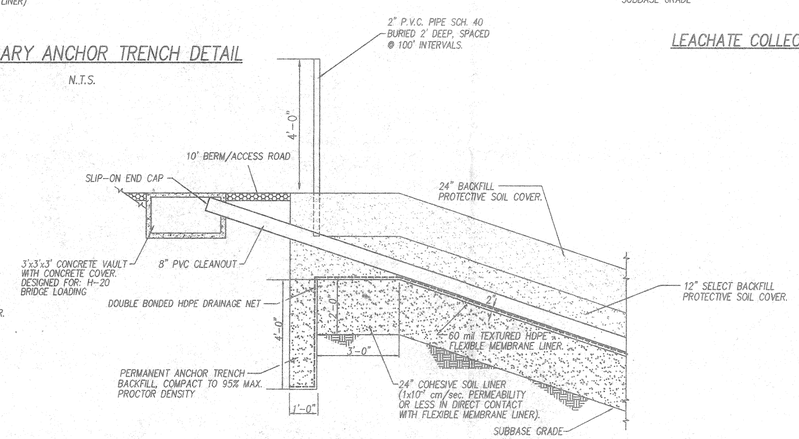
LINER PENETRATION DETAIL

N.T.S.



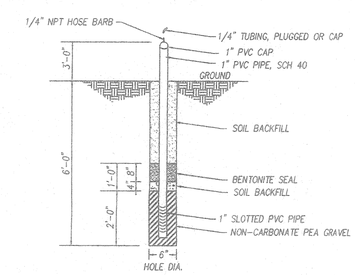
PERMANENT ANCHOR TRENCH DETAIL

N.T.S.



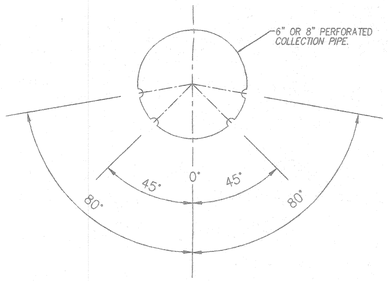
TYPICAL SECTION @ CLEANOUT

N.T.S.



METHANE GAS MONITORING PROBE

N.T.S.



1. 0° CORRESPONDS TO PIPE INVERT.
2. PROVIDE FOUR 1/2" DIAMETER PERFORATIONS AS SHOWN, 6" O.C.

LEACHATE COLLECTION SYSTEM PERFORATION PATTERN DETAIL

N.T.S.

Municipal Services Engineering Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL FACILITY
HAYWOOD COUNTY NORTH CAROLINA

OPERATION PLAN

DATE	BY	REV.	DESCRIPTION

SCALE:	NTS
DATE:	3/13/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	P8
SHEET	10 OF

NORTH CAROLINA PROFESSIONAL SEAL 6262 ENGINEER JIMMY D. WOODIE

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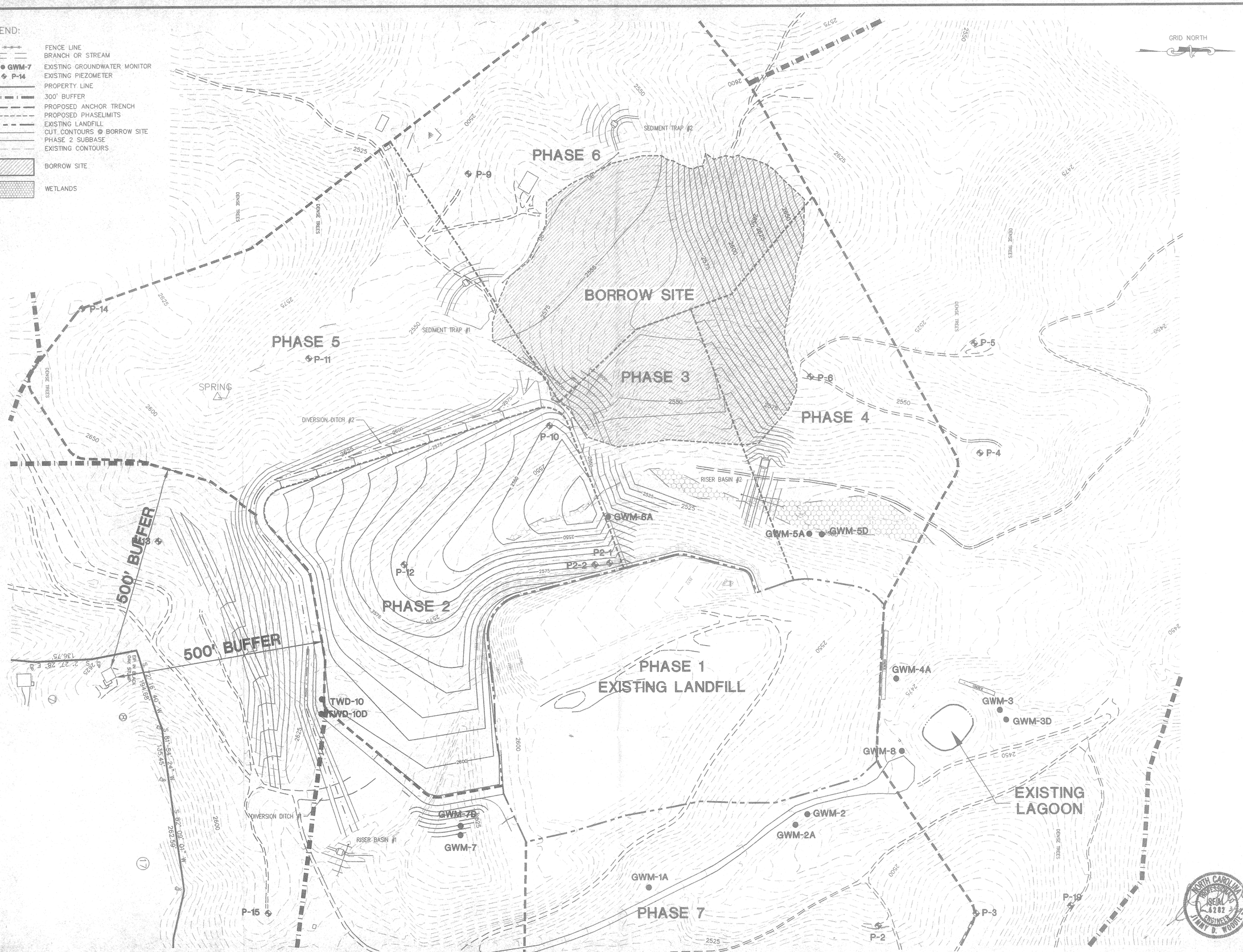


Municipal Engineering Services Company, P.A.

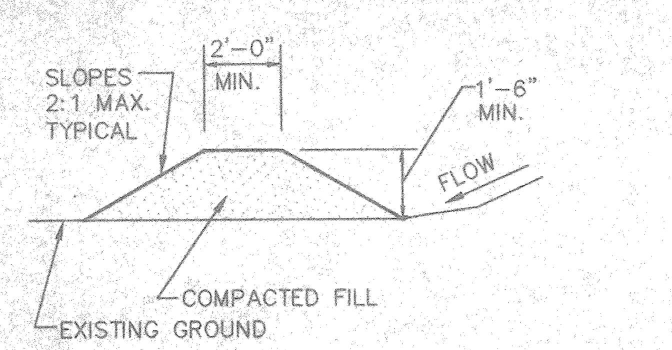
P.O. BOX 97 GARNER, N.C. 27529 P.O. BOX 349 BOONE, N.C. 28607

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

OPERATION PLAN
EROSION CONTROL PLAN

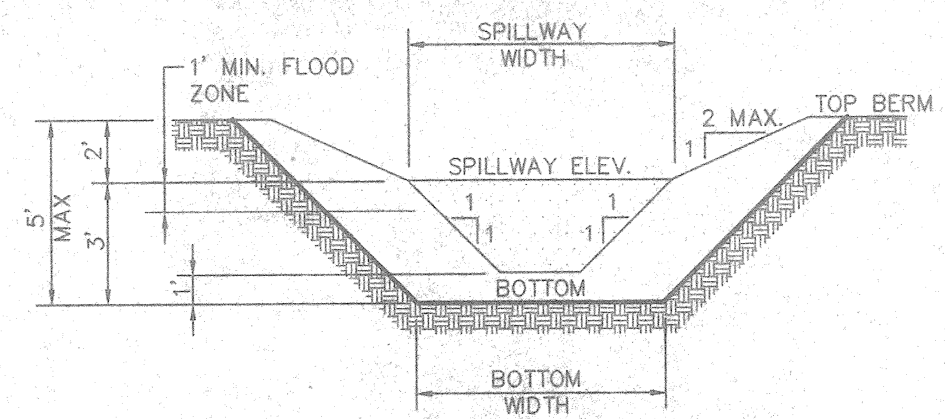
DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 100'
DATE: 3/15/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. P9
SHEET NO. 11 OF

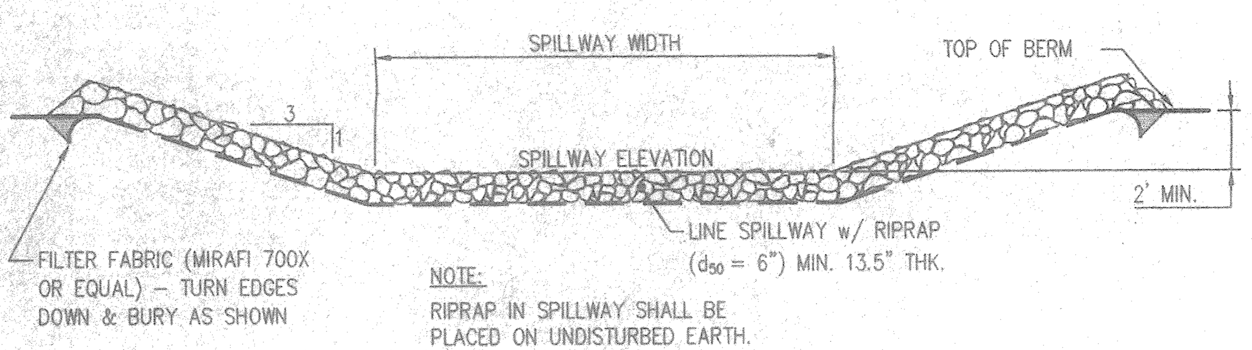


DIVERSION BERM DETAIL

NOT TO SCALE



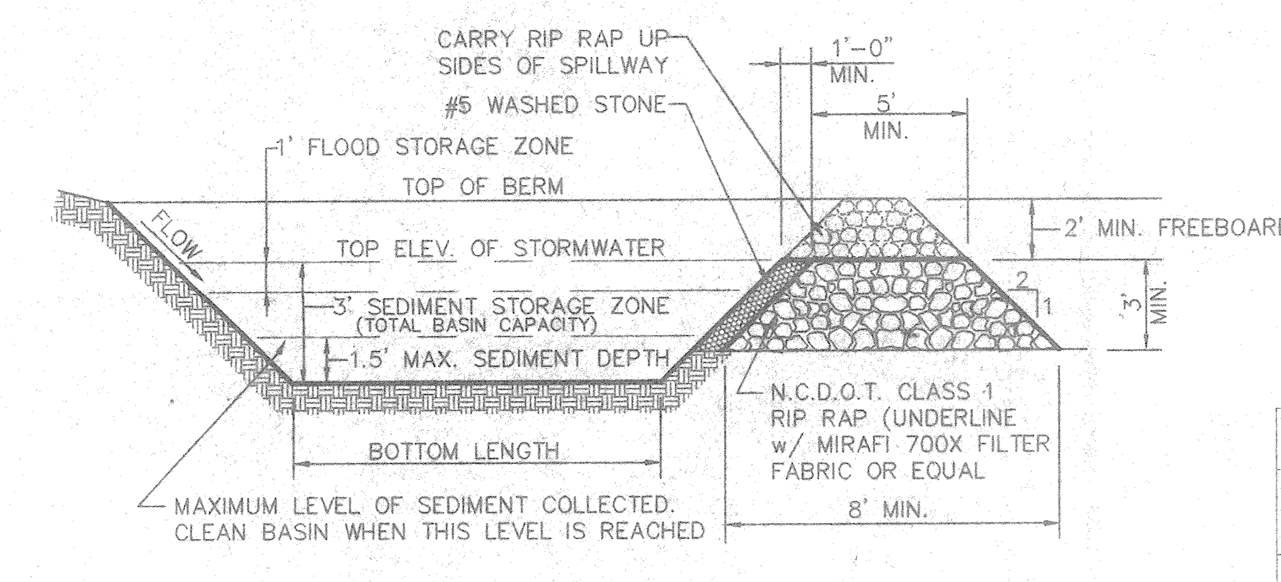
TRANSVERSE SECTION



NOTE:
RIPRAP IN SPILLWAY SHALL BE PLACED ON UNDISTURBED EARTH.

RIPRAP SPILLWAY SECTION

NOT TO SCALE



LONGITUDINAL SECTION

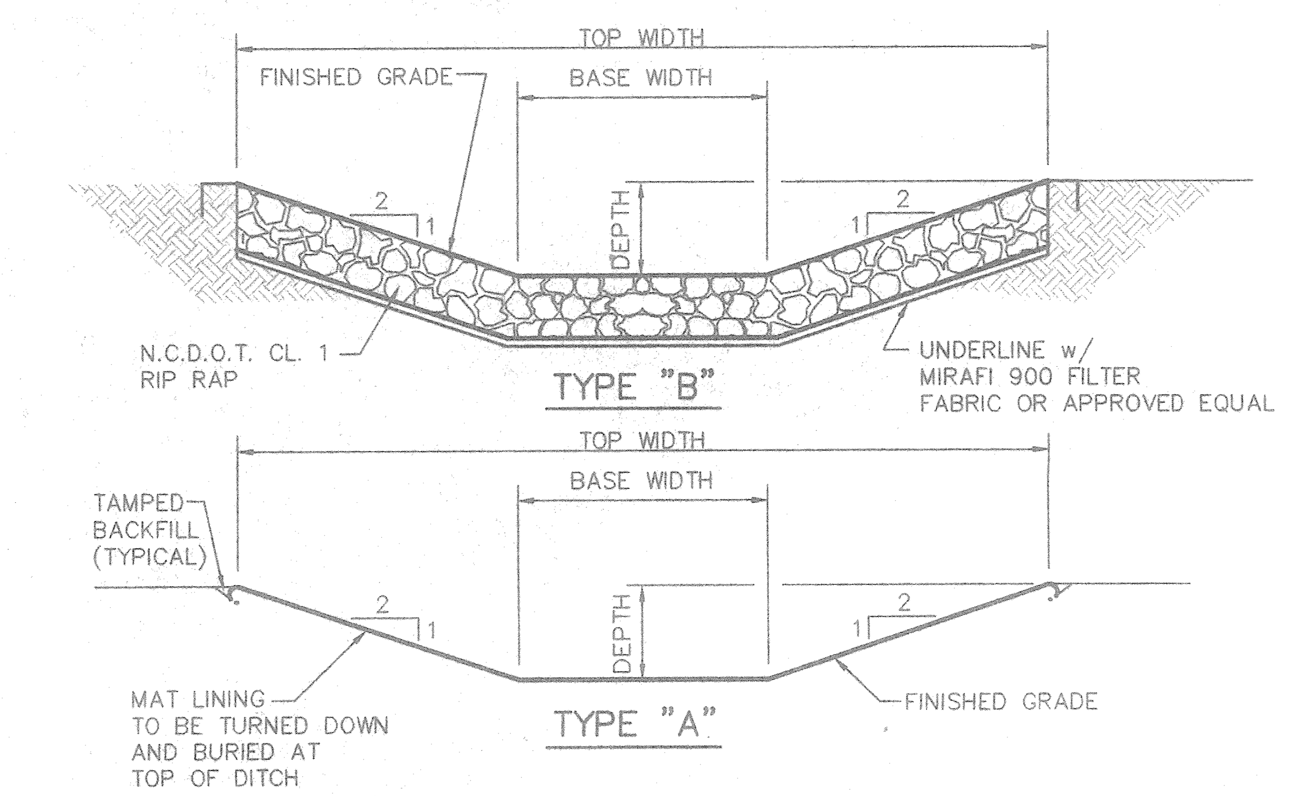
SEDIMENT TRAP SCHEDULE

NOTES:
1. BASIN SHALL BE CLEANED OUT AT 12 MONTH INTERVALS OR WHEN MAX. SEDIMENT LEVEL IS REACHED. REPLACE FILTER AS REQUIRED.
2. SOIL SHALL BE COMPACTED TO 95% STD. PROCTOR MAX. DENSITY.
3. ESTABLISH VEGETATION ON BERMS.

TRAP NO.	BOTTOM			SPILLWAY		BERM ELEV.
	LEN.	WIDTH	ELEV.	WIDTH	ELEV.	
1	SEE PLAN		2545.0'	12.0'	2548.0'	2550.0'
2	SEE PLAN		2540.0'	10.0'	2543.0'	2545.0'

SEDIMENT TRAP DETAIL

NOT TO SCALE



DIVERSION DITCH SCHEDULE

DITCH NO.	TYPE	TOP WIDTH	DEPTH	BASE WIDTH	VELOCITY (F.P.S.)	RIP RAP d50	RIP RAP THICKNESS	TEMPORARY LINER
1	A	9' MIN	SEE PLAN	5'	3.25	–	–	JUTE NET
2	B	5' MIN.	1'	1'	5.75	6"	9" MIN.	–

DIVERSION DITCH DETAIL

NOT TO SCALE

SEEDBED PREPARATION (SP)

SP-1 FILL SLOPES 3:1 OR STEEPER TO BE SEEDE BY A HYDRAULIC SEEDER (PERMANENT SEEDING)
1) Leave the last 4-6 inches of fill loose and uncompacted, allowing rocks, roots, large clods and other debris to remain on the slope.
2) Roughen slope faces by making grooves 2-3 inches deep, perpendicular to the slope.
3) Spread lime evenly over slopes at rates recommended by soil tests.

SP-2 Fill slopes 3:1 or steeper (temporary seedings)
1) Leave a loose, uncompacted surface. Remove large clods, rocks, and debris which might hold netting above the surface.
2) Spread lime and fertilizer evenly at rates recommended by soil tests.
3) Break up large clods and rake into a loose, uniform seedbed.
4) Rake to loosen surface just prior to applying seed.

SP-4 Gentle or flat slopes where topsoil is not used.
1) Remove rocks and debris.
2) Apply lime and fertilizer at rates recommended by soil tests; spread evenly and incorporate into the top 6" with a disk, chisel plow, or rotary tiller.
3) Break up large clods and rake into a loose, uniform seedbed.
4) Rake to loosen surface just prior to applying seed.

SEEDING METHODS (SM)

SM-1 Fill slopes steeper than 3:1 (permanent seeding)
Use hydraulic seeding equipment to apply seed and fertilizer, a wood fiber mulch at 45 lb./1,000 s.f., and mulch tackifer.

SM-2 Gentle to flat slopes or temporary seedings
1) Broadcast seed at the recommended rate with a cyclone seeder, drop spreader, or cultipacker seeder.
2) Rake seed into the soil and lightly pack to establish good contact.

MULCH (MU)

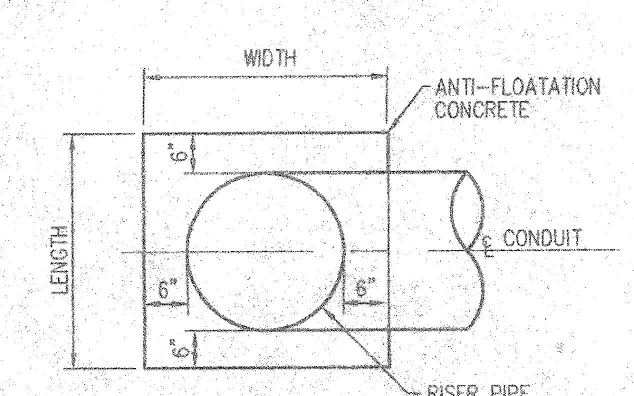
MU-1 Steep slopes (3:1 or greater)
In mid-summer, late fall or winter, apply 100 lb./1,000 s.f. grain straw, cover with netting and staple to the slope. In spring or early fall use 45lb. / 1,000 s.f. wood fiber in a hydroseeder slurry.

MU-2 High-maintenance vegetation and temporary seedings
Apply 90 lb./1,000 s.f. (4000 lb./acre) grain straw and tack with 0.1 gal./s.y. asphalt (11 gal./1,000 s.f.).

MU-3 Grass-lined channels
Install excelsior mat in the channel, extend up the channel banks to the highest calculated depth of flow, and secure according to manufactur's specifications.
On channel shoulders, apply 100 lb./1,000 s.f. grain straw and anchor with 0.1 gal./s.y. (11 gal./1,000 s.f.) asphalt.

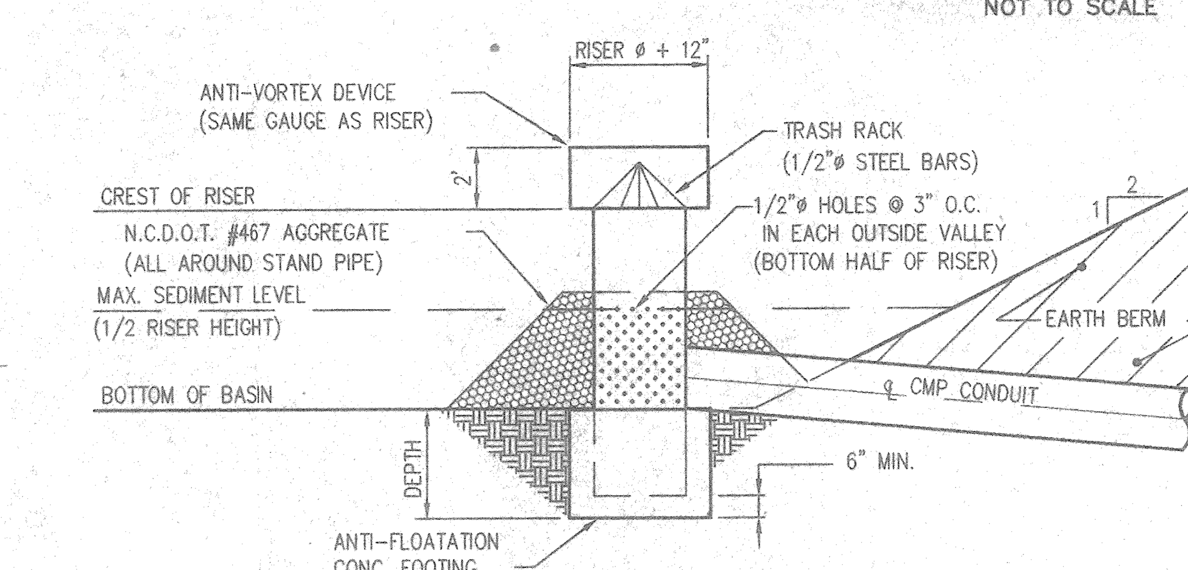
MAINTENANCE (MA)

MA-1 Refertilize in late winter or early spring the following year. Mow as desired.
MA-3 Inspect and repair mulch and lining. Refertilize in late winter of the following year with 150 lb./acre 10-10-10 (3.5 lb./1,000 s.f.). Mow regularly to a height of 3-4 inches.
MA-4 Topdress with 10-10-10 fertilizer if growth is not fully adequate.
MA-5 Topdress with 50 lb./acre (1 lb./1,000 s.f.) nitrogen in March. If cover is needed through the following summer, overseed with 50 lb./acre Kobe lespedeza.



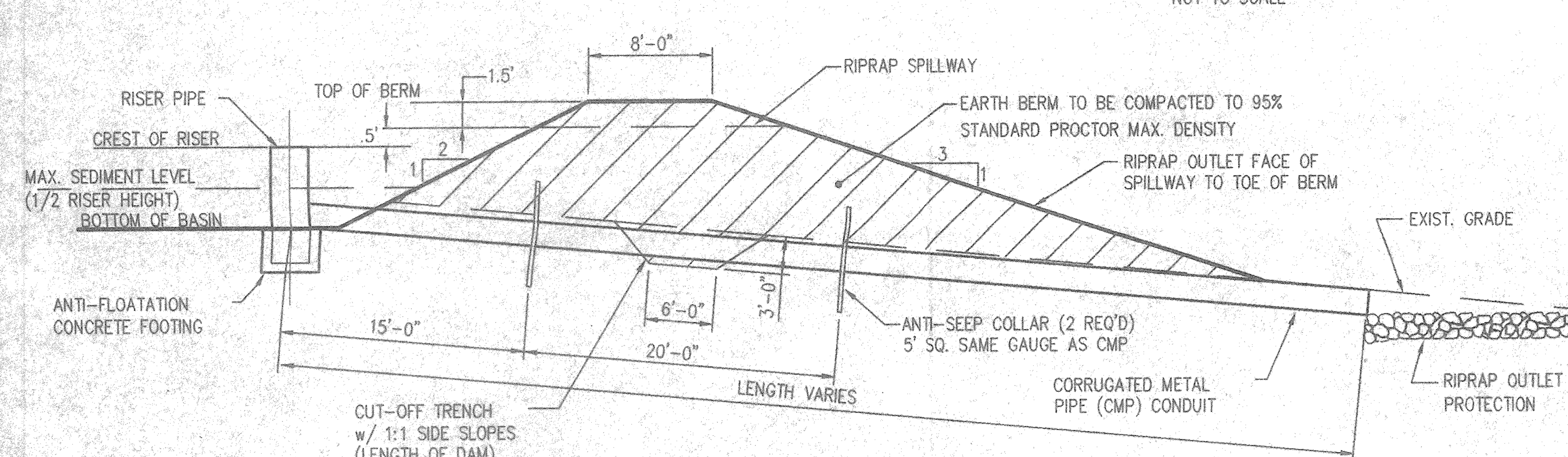
RISER FOOTING PLAN

NOT TO SCALE



STAND PIPE SECTION

NOT TO SCALE



RISER BASIN DAM SECTION

NOT TO SCALE

BASIN NO.	BOTTOM		SPILLWAY		BERM ELEV.	RISER		CONDUIT			FOOTING FOR RISER PIPE				CONDUIT OUTLET PROTECTION				
	SIZE	ELEV	WIDTH	ELEV		DIA.	CREST	DIA.	LENGTH	INV.IN	TOP EL.	LENGTH	WIDTH	DEPTH	LENGTH	WIDTH	d_{50}	THICK.	ELEV.
1	SEE PLAN	2600.0'	10'	2606.5'	2608.0'	18"	2606.0'	12"	80'	2600.0'	2600.0'	2.5'	2.5'	1.0'	14'	15'	9"	13.5" MIN	2585.0'
2	SEE PLAN	2510.0'	20'	2520.5'	2522.0'	33"	2520.0'	21"	100'	2510.0'	2510.0'	4.0'	4.0'	2.0'	21'	22.75'	9"	13.5" MIN	2505.0'

TEMPORARY RISER BASIN DETAIL

SCALE AS NOTED

TEMPORARY SEEDING RECOMMENDATIONS FOR LATE WINTER AND EARLY SPRING

Seeding Mixture

species	Rate(lb./acre)
Rye (grain)	120
Annual lespedeza (Kobe in Piedmont and Coastal Plain,Korean in Mountains)	50

Omit annual lespedeza when duration of temporary cover is not to extend beyond June.

SEEDING DATES
Mountains-Above 2500ft.:Feb. 15 - May 15
Below 2500ft.:Feb. 1 - May 1
Piedmont-Jan. 1 - May 1
Coastal Plain-Dec. 1 - Apr. 15

SOIL AMENDMENTS
Follow recommendations of soil tests or apply 2,000 lb./acre ground agricultural limestone and 750 lb./acre 10-10-10 fertilizer.

MULCH
Apply 4,000 lb./acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulching tool.

MAINTENANCE
Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage.

TEMPORARY SEEDING RECOMMENDATIONS FOR SUMMER

Seeding Mixture

species	Rate(lb./acre)
German millet	40

In the Piedmont and Mountains, a small-stemmed Sudangrass may be substituted at a rate of 50 lb./acre.

SEEDING DATES
Mountains-May 15 - Aug.15
Piedmont-May 1 - Aug. 15
Coastal Plain-Apr. 15 - Aug. 15

SOIL AMENDMENTS
Follow recommendations of soil tests or apply 2,000 lb./acre ground agricultural limestone and 750 lb./acre 10-10-10 fertilizer.

MULCH
Apply 4,000 lb./acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulching tool.

MAINTENANCE
Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage.

TEMPORARY SEEDING RECOMMENDATIONS FOR FALL

Seeding Mixture

species	Rate(lb./acre)
Rye (grain)	120

SEEDING DATES
Mountains-Aug.15 - Dec. 15
Coastal Plain and Piedmont-Aug. 15 - Dec. 30

SOIL AMENDMENTS
Follow recommendations of soil tests or apply 2,000 lb./acre ground agricultural limestone and 1,000 lb./acre 10-10-10 fertilizer.

MULCH
Apply 4,000 lb./acre straw. Anchor straw by tacking with asphalt, straight can be used as a mulching tool.

MAINTENANCE
Repair and refertilize damaged areas immediately. Topdress with netting, or a mulch anchoring tool. A disk with blades set nearly 50 lb./acre of nitrogen in March. If it is necessary to extend temporary cover beyond June 15, overseed with 50 lb./acre Kobe (Piedmont and Coastal Plain) or Korean (Mountains)lespedeza in late February or early March.

SEEDING SPECIFICATION 1M

Seeding Mixture

Species	Rate (lb/acre)
Tall fescue	100
Sericea lespedeza	20
Korean lespedeza	10
Redtop	5
Kentucky bluegrass	5

Seeding Notes

1. After Aug. 15 use unscarified sericea seed.

Nurse Plants

Between May 1 and Aug. 15, add 10 lb/acre German Millet 15 lb/acre Sudangrass. Prior to May 1 or after Aug. 15 add 40 lb/acre rye (grain). It may be benificial to plant the grasses in the late summer and overseed the lespedezas in March.

Seeding Dates

	Best	Possible
Below 2500':	Aug. 15 - Sept. 1 Mar. 1 - Apr. 1	Aug. 20 - Oct. 15 Mar. 1 - May 10
Above 2500':	July 25 - Aug. 15 Mar. 20 - Apr. 20	July 15 - Aug. 30 Mar. 5 - May 15

Complete sedding earlier in fall, and start later in spring on north and east facing slopes.

Soil Amendments

Apply lime and fertilizer according to soil tests, or apply 4,000 lb/acre ground agricultural limestone and 1,000 lb/acre 5-10-10 fertilizer.

Mulch

Apply 4,000-5,000 lb/acre grain straw or equivalent cover of another suitable mulch. Anchor straw by tacking with asphalt,netting, or roving. Netting is the prefered anchoring method on steep slopes.

Maintenance

Refertilize in the second year unless growth is fully adequate. May be mowed once. Reseed, fertilize,and mulch damaged ares immediately.

SEEDING SPECIFICATIONS 3M

SEEDING MIXTURE

Species	Rate (lb./acre)
Tall fescue	60
Kentucky bluegrass	10
Sericea lespedeza	15
Korean lespedeza	10

SEEDING NOTES

1. After Aug. 15, use unscarified sericea seed.
*2. Where appearance is a consideration, omit sericea lespedeza and increase Korean lespedeza to 40 lb./acre.

NURSE PLANTS

Between May 1 and Aug. 15, add 10 lb./acre German millet or 15 lb./acre Sudangrass, Prior to May 1 or after Aug. 15, add 40 lb./acre rye (grain)

SEEDING DATES	Best	Possible
Below 2500 ft.:	Aug. 15-Sept. 1 Mar. 1-Apri 1	July 25-Sept. 15 Mar. 1-May 10
Above 2500 ft.:	July 25-Aug. 15 Mar. 20-Apr. 20	July 15-Aug. 30 Mar. 5-May 15

SOIL AMENDMENTS

Apply lime and fertilizer according to soil tests, or apply 4000 lb/acre ground agricultural limestone and 1000 lb/acre 10-10-10 fertilizer.

MULCH

Apply 4,000 lb./acre grain straw. Anchor straw by tacking with asphalt, neting, or roving or by crimping with a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring tool.

MAINTENANCE

Refertilize in the second year unless growth is fully adequate. May be mowed once or twice per year, but mowing is not necessary. Reseed, fertilize, and mulch damaged areas immediately.

SEEDING SPECIFICATION 8M

Seeding Mixture

Species	Rate (lb/acre)
Tall fescue	175-200(3 lb/1,000 sq.ft.)
Kentucky bluegrass	20 (1 lb/1,000 sq.ft.)

Nurse Plants

Between May 1 and Aug. 15, add 10 lb/acre German Millet or 15 lb/acre Sudangrass. Prior to May 1 or after Aug. 15 add 40 lb/acre rye (grain).

Seeding dates

	Best	Possible
Below 2500 ft.:	Aug. 15 - Sept. 1 Mar. 1 - Apr. 1	July 25 - Sept. 15 Mar. 1 - May 10
Above 2500 ft.:	July 25 - Aug. 15 Mar. 20 - Apr. 20	July 15 - Aug. 30 Mar. 5 - May 15

Avoid seeding from Nov. to Jan. If seeding must be done at this time, add 40 lb/acre rye grain and use a channel linning that offers maximum protection.

Soil Amendments

Apply lime and fertilizer according to soil tests, or apply 4,000 lb/acre ground agricultural limestone and 1,000 lb/acre 10-10-10 fertilizer.
Operate tillage equipment across the waterway.

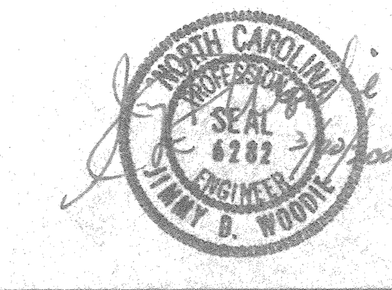
Mulch

Use jute, excelsior matting or other effective channel linning material to cover the bottom of channels and ditches, and staple securely. The linning should extend above the highest calculated depth flow. On channel side slopes above this height, and in drainages not requiring temporary linnings, apply 4,000 lb/acre grain straw and anchor straw by stapling netting over the top.

Mulch and anchoring materials must not be allowed to wash down slopes where they can clog drainage devices.

Maintenance

Inspect and repair mulch frequently. Refertilize in late winter of the following year; use soil tests or apply 150 lb/acre 10-10-10 fertilizer (3 lb/1,000 sq.ft.). Mow regularly to a height of 2-4 inches.



Municipal Engineering Services Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

OPERATION PLAN
EROSION CONTROL DETAILS

SCALE:	NOT TO SCALE
DATE:	3/15/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	SHEET NO.
P10	12 OF 12

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HAYWOOD COUNTY MUNICIPAL SOLID WASTE LANDFILL ENGINEERING PLAN PERMIT RENEWAL PHASE 2

BOARD OF COMMISSIONERS

CHAIRMAN - Jim Stevens
VICE-CHAIRMAN - Robert Forga
COMMISSIONNERS:
Mary Ann Enloe
Carlyle Ferguson
Wade Francis

COUNTY MANAGER

JACK HORTON

SOLID WASTE MANAGER

JOE WALKER

Engineer
Municipal Engineering Services Company, P.A.
Garner, N.C. Boone, N.C.

NORTH CAROLINA PROFESSIONAL SEAL 8282 ENGINEER JIMMY D. WOODIE
3/20/2000

by _____
Professional Engineer

Municipal Engineering Services Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (704) 262-1767

SCALE:	NTS
DATE:	3/10/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	T1
SHEET NO.	1 of 12

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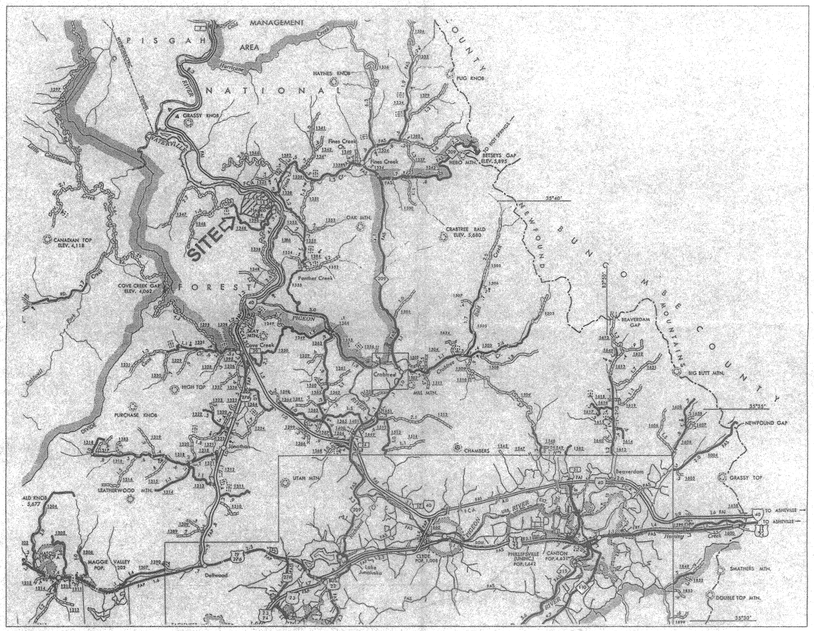
INDEX

SHEET NO.	DRAWING NO.	DESCRIPTION
01	T1	TITLE SHEET
02	T2	INDEX
03	E1	EXISTING CONDITIONS
04	E2	SUBBASE
05	E3	TOP OF COMPOSITE LINER
06	E4	TOP OF PROTECTIVE COVER
07	E5	LEACHATE COLLECTION SYSTEM
08	E6	ENGINEERING DETAILS
09	E7	SUMP AREA AND PIPE PROFILE
10	E8	CROSS SECTIONS
11	E9	EROSION CONTROL PLAN
12	E10	EROSION CONTROL DETAILS



Municipal Services Engineering Company, P.A.

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE

3/20/2000

SCALE:	NTS
DATE:	3/10/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
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SHEET	2 of

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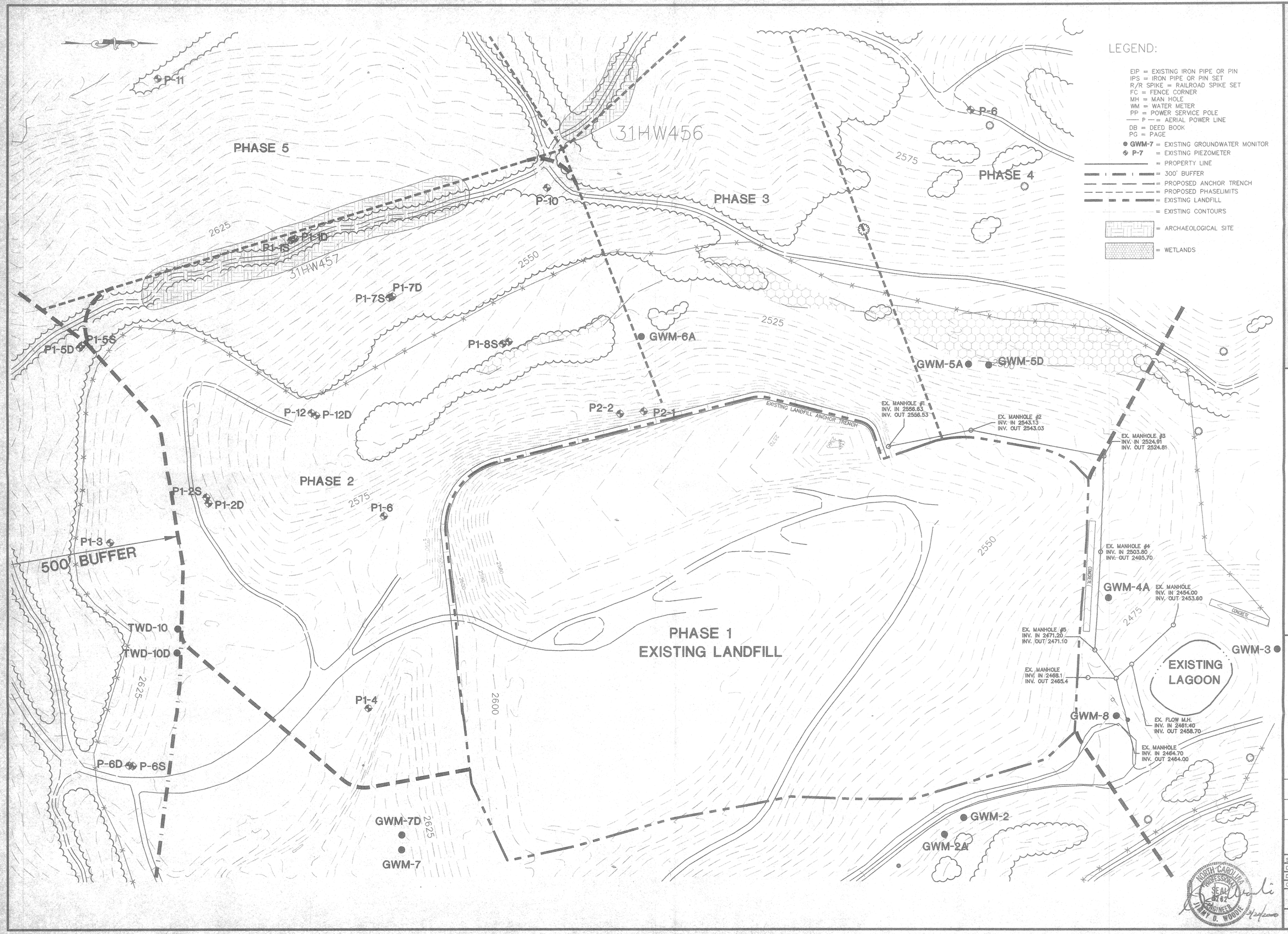

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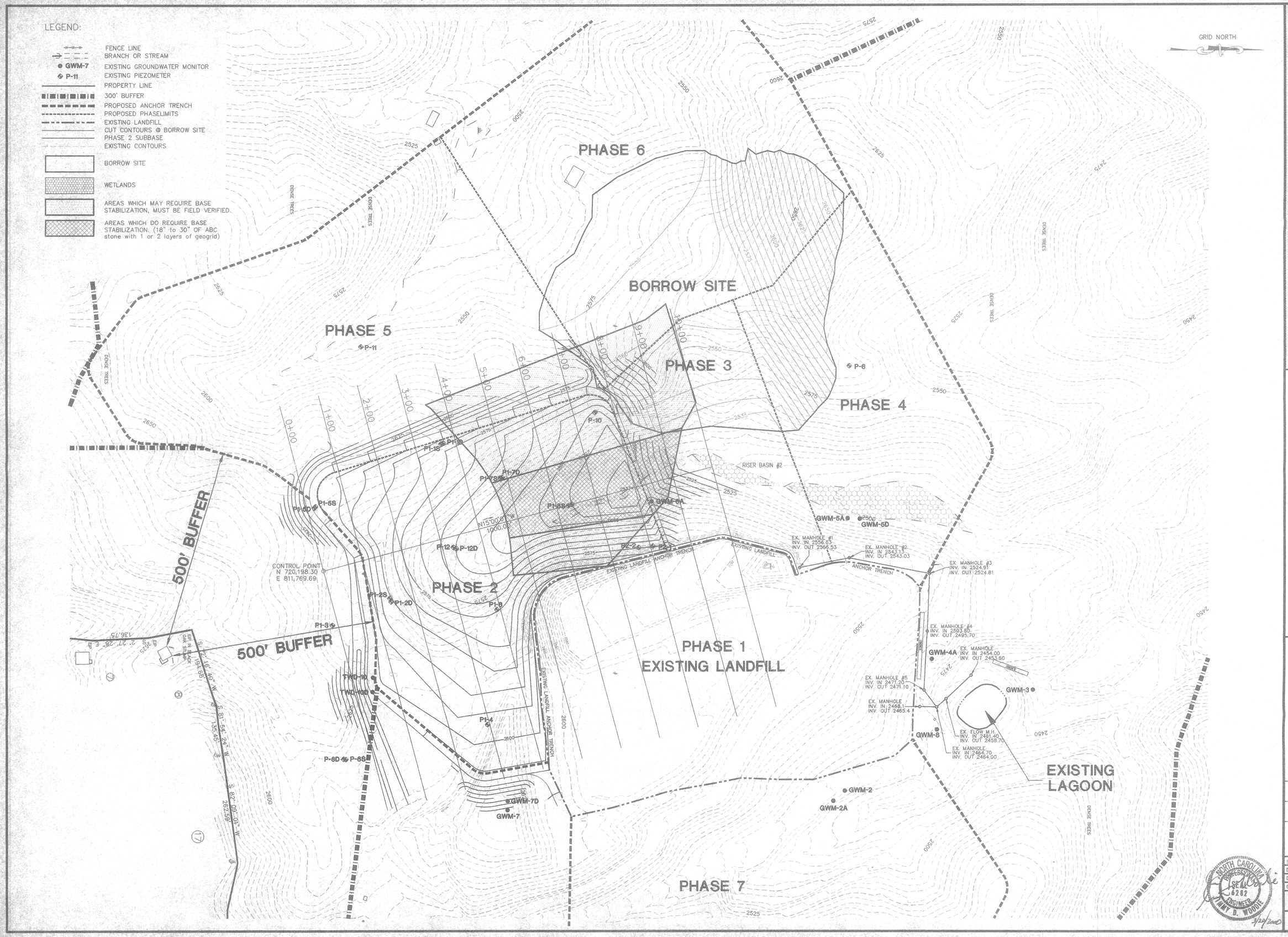
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN
EXISTING CONDITIONS

SCALE:	1"= 60'
DATE:	3/10/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	E1
SHEET NO.	3 OF 12



Municipal Engineering Services Company, P.A.

P.O. BOX 97 GARNER, N.C. 27529

P.O. BOX 349 BOONE, N.C. 28607

MUNICIPAL SOLID WASTE LANDFILL FACILITY
HAYWOOD COUNTY
NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN
SUBBASE

SCALE:	1"= 100'
DATE:	3/14/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	E2
SHEET NO.	4 OF 1

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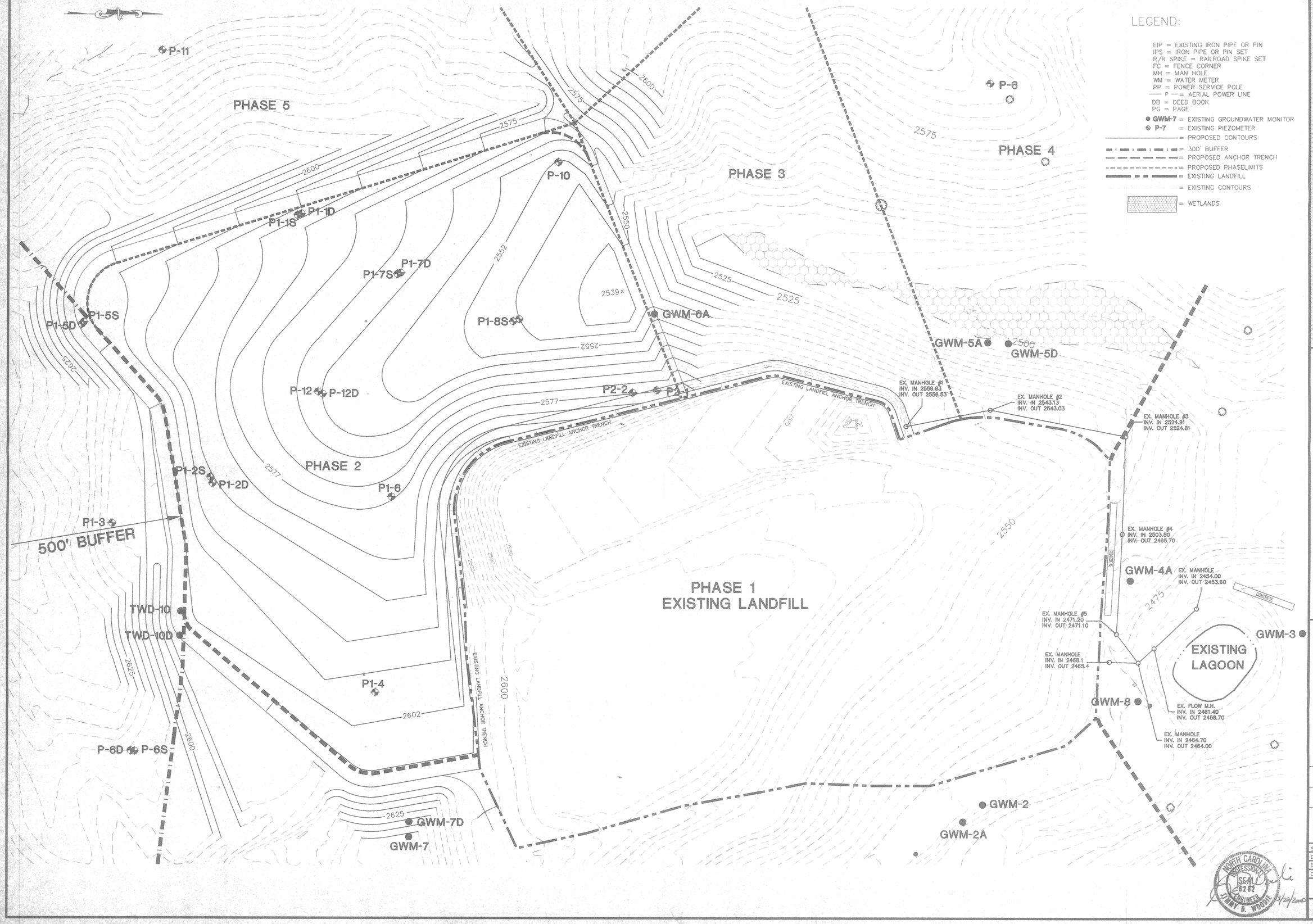

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P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

ENGINEERING PLAN
TOP OF COMPOSITE LINER

DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 60'
DATE: 3/1/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. E3
SHEET NO. 5 OF 12

NORTH CAROLINA PROFESSIONAL SEAL 6262 ENGINEER JIMMY D. WOODIE
3/20/2000

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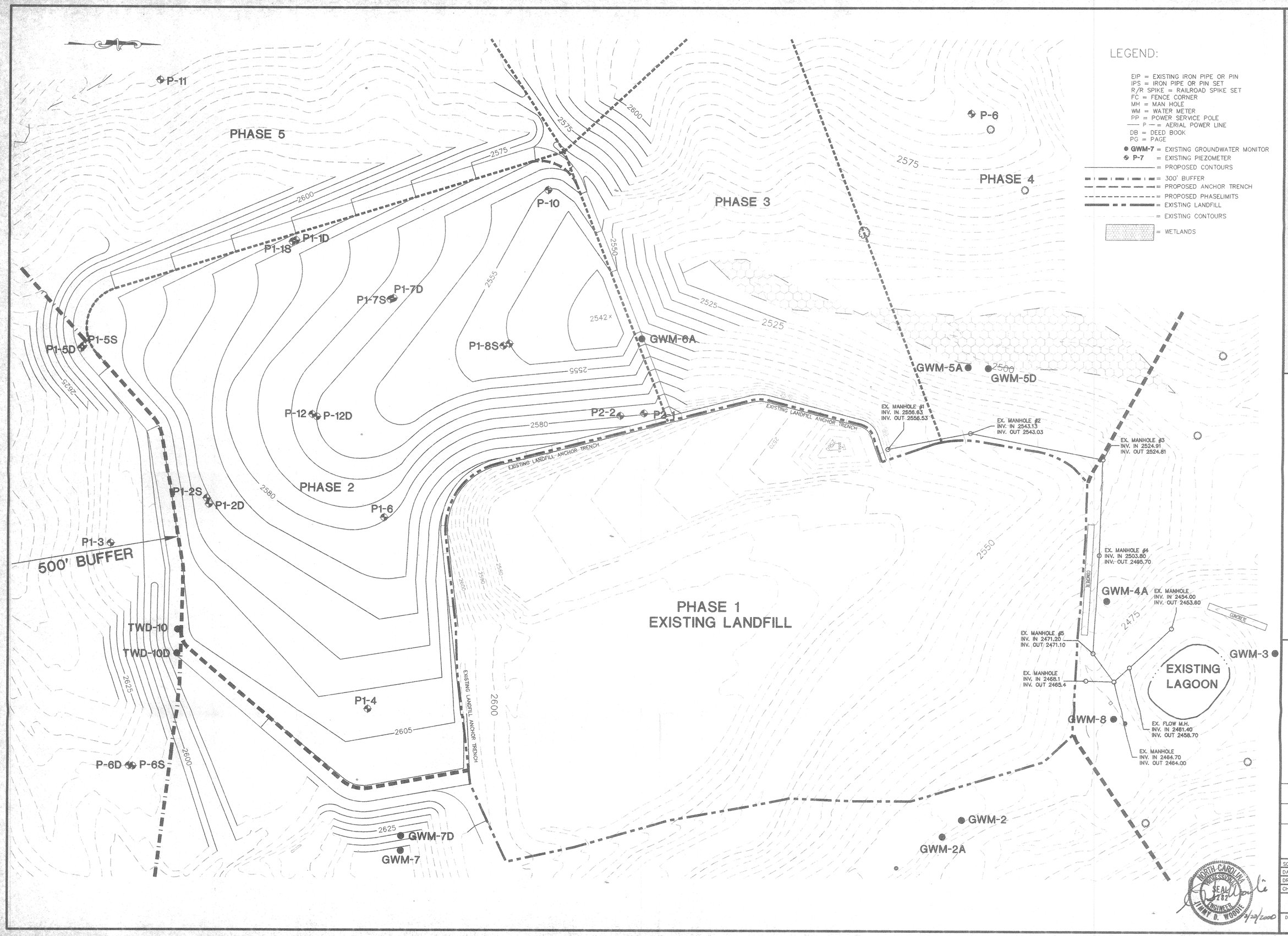

Municipal Engineering Services Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

ENGINEERING PLAN
TOP OF PROTECTIVE COVER

DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 60'
DATE: 3/1/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. E4
SHEET NO. 6 OF 1

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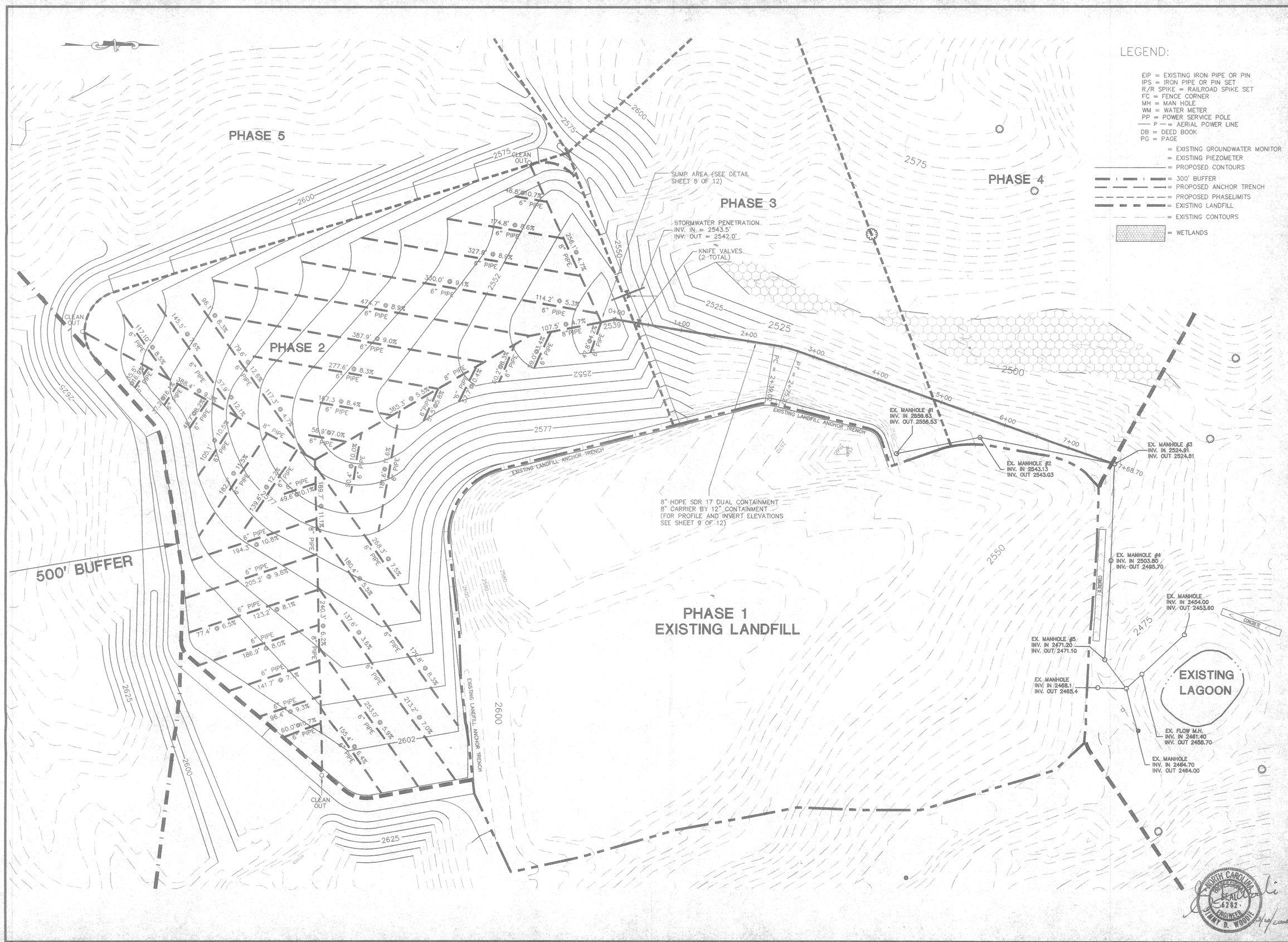

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P.O. BOX 349 BOONE, N.C. 28607

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

ENGINEERING PLAN
LEACHATE COLLECTION SYSTEM

DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 60'
DATE: 3/2/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. E5
SHEET NO. 7 OF 12

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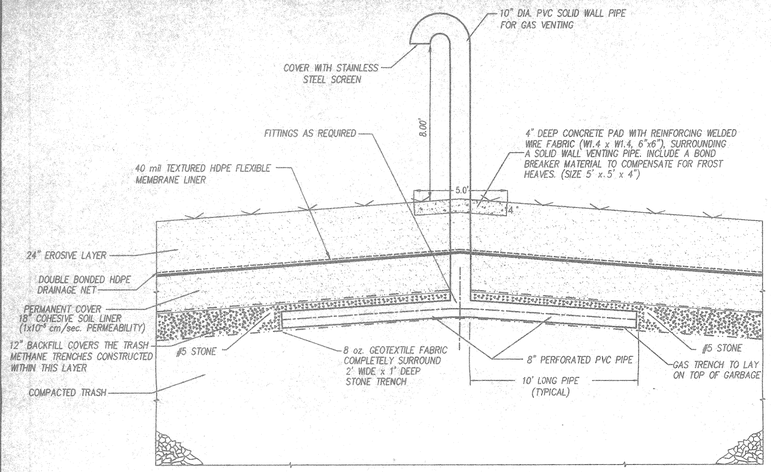
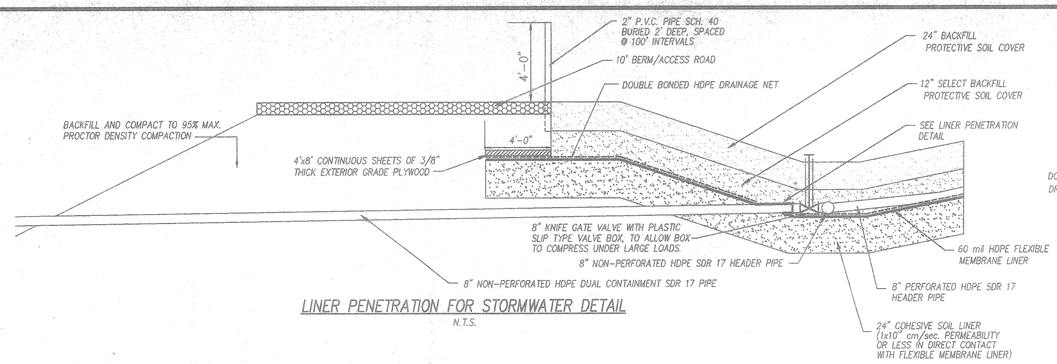


TYPICAL METHANE GAS COLLECTION TRENCH CLOSURE DETAIL AND CAP COVER DETAIL

N.T.S.



LINER PENETRATION FOR STORMWATER DETAIL

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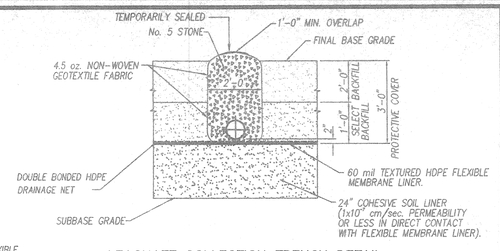

LEACHATE COLLECTION TRENCH DETAIL

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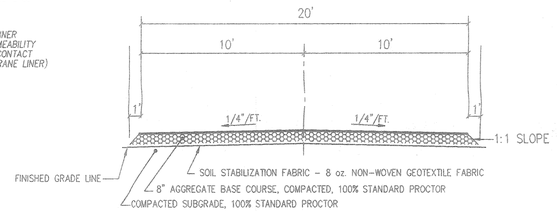
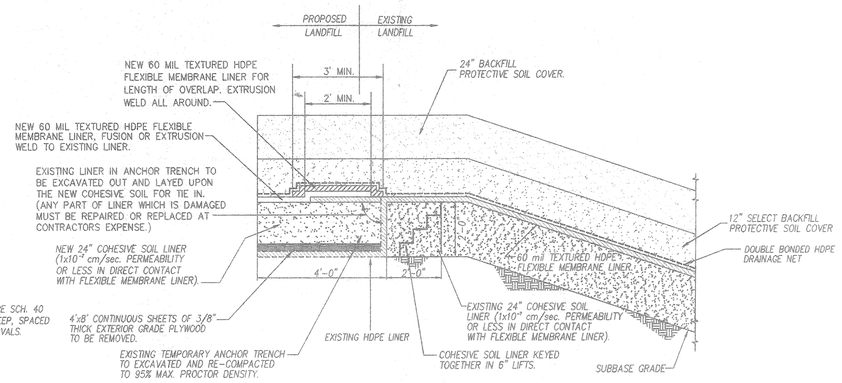


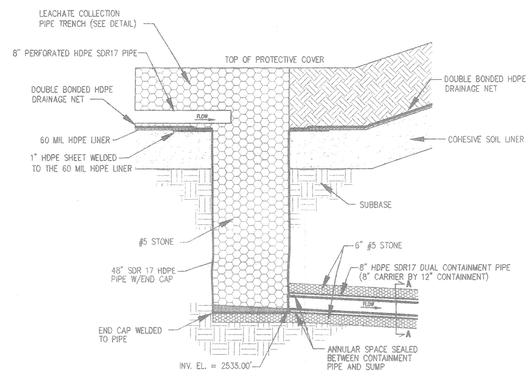
GRAVEL DRIVE DETAIL

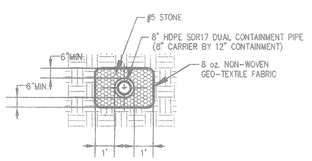
N.T.S.



TIE-IN TO EXISTING LINER

N.T.S.

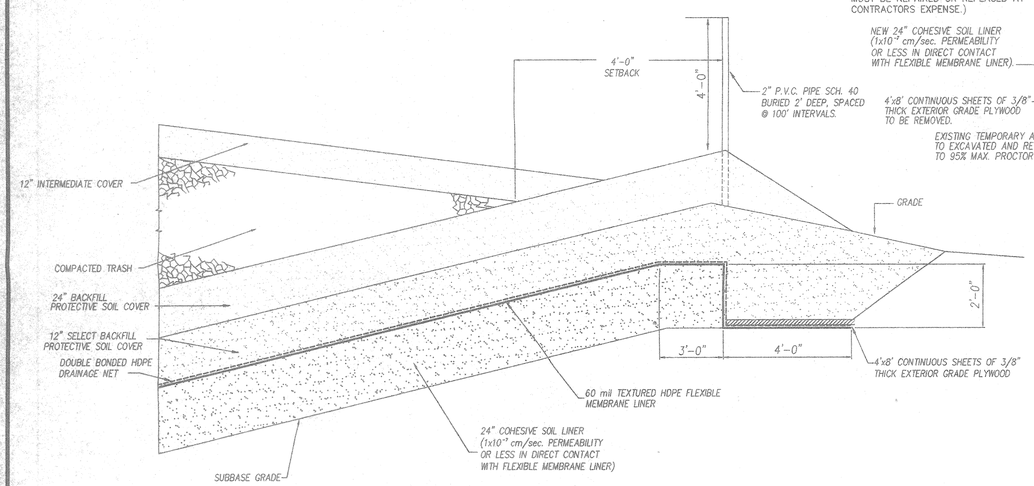




SECTION A-A

SUMP DETAIL

N.T.S.



TEMPORARY ANCHOR TRENCH DETAIL

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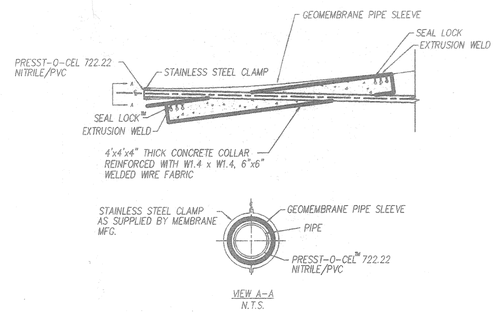

LINER PENETRATION DETAIL

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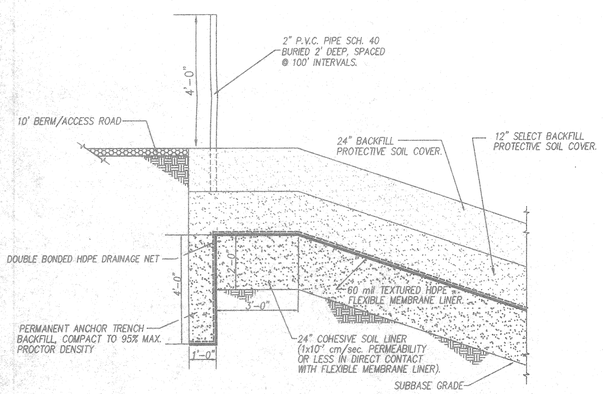

PERMANENT ANCHOR TRENCH DETAIL

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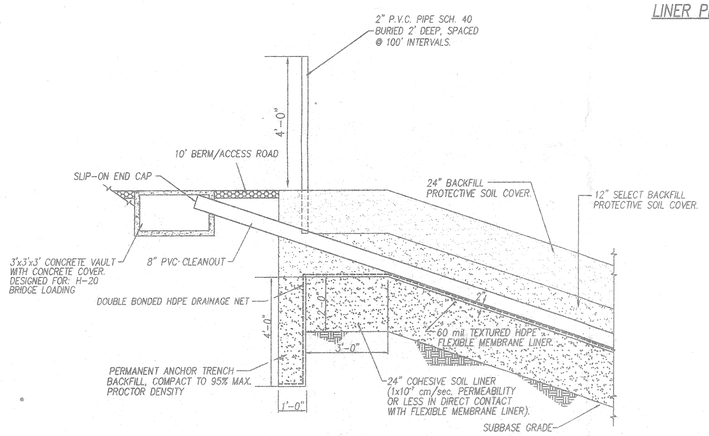
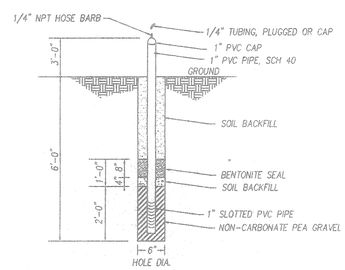


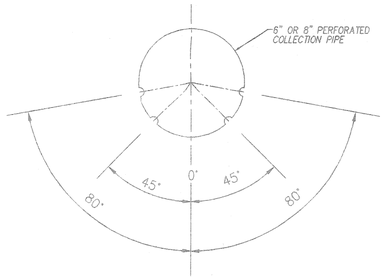
TYPICAL SECTION @ CLEANOUT

N.T.S.



METHANE GAS MONITORING PROBE

N.T.S.



1. 0° CORRESPONDS TO PIPE INVERT.
2. PROVIDE FOUR 1/2" DIAMETER PERFORATIONS AS SHOWN, 6" O.C.

LEACHATE COLLECTION SYSTEM PERFORATION PATTERN DETAIL

N.T.S.

NORTH CAROLINA PROFESSIONAL SEAL 4282 ENGINEER JIMMY D. WOODIE 3/20/2000

Municipal Engineering Services Company, P.A.
P.O. BOX 67 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (704) 262-0767

MUNICIPAL SOLID WASTE LANDFILL FACILITY
HAYWOOD COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN
ENGINEERING DETAILS

SCALE:	NTS
DATE:	3/2/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	E6
SHEET NO.	8 OF 12

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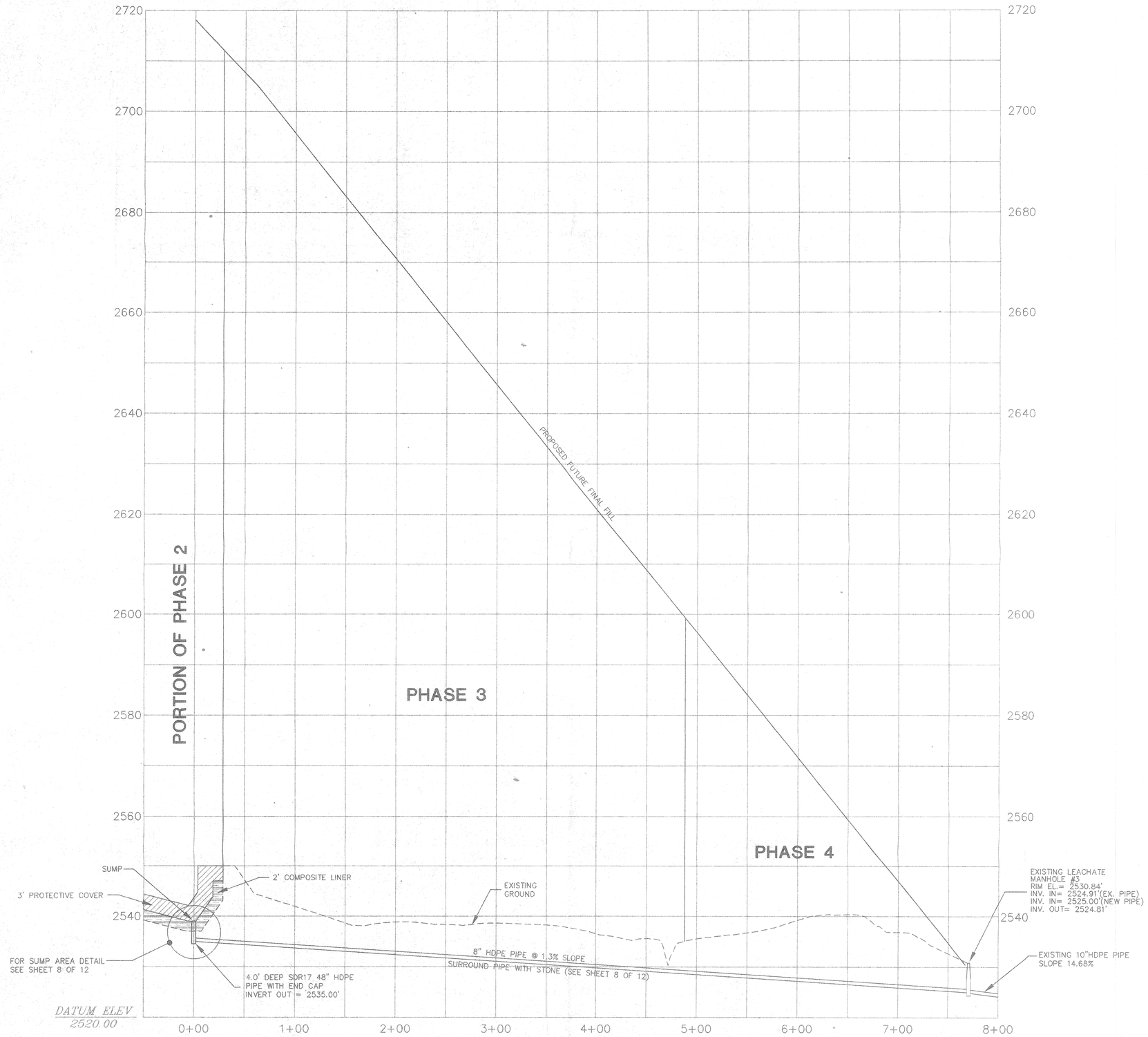


PROFILE OF SUMP & PIPING AREA

HORIZONTAL SCALE 1"= 50'
VERTICAL SCALE 1"= 10'

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE 3/20/2000

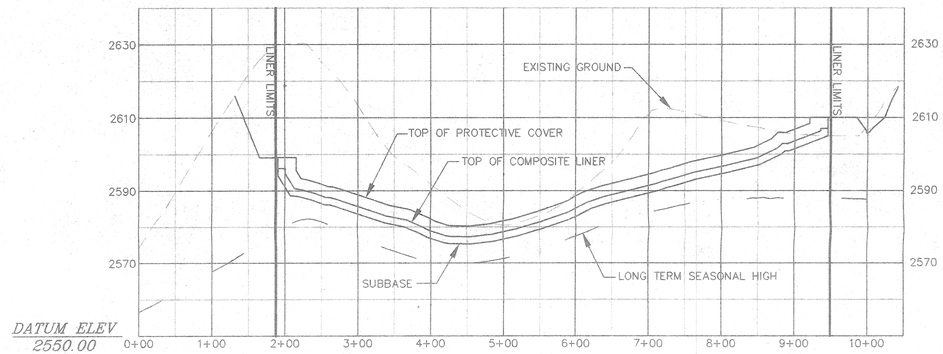
Municipal Services Engineering Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

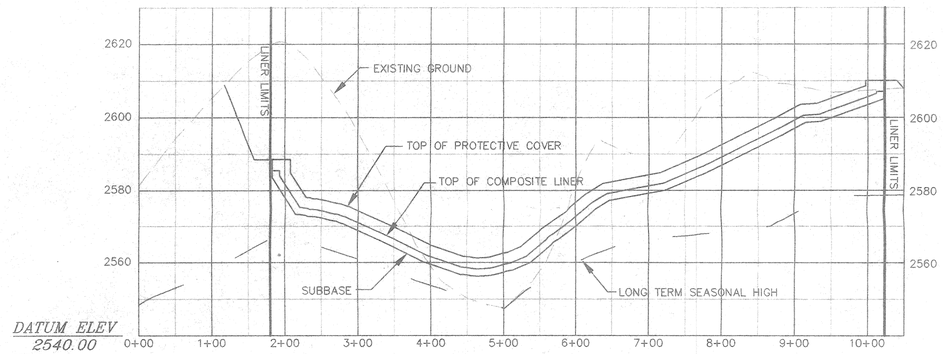
ENGINEERING PLAN
SUMP AREA & PIPE PROFILE

SCALE: 1"= 50'
DATE: 3/9/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. E7
SHEET NO. 9 OF 1



STA. 2+00

HORIZONTAL SCALE 1"= 100'
VERTICAL SCALE 1"= 20'



STA. 4+00

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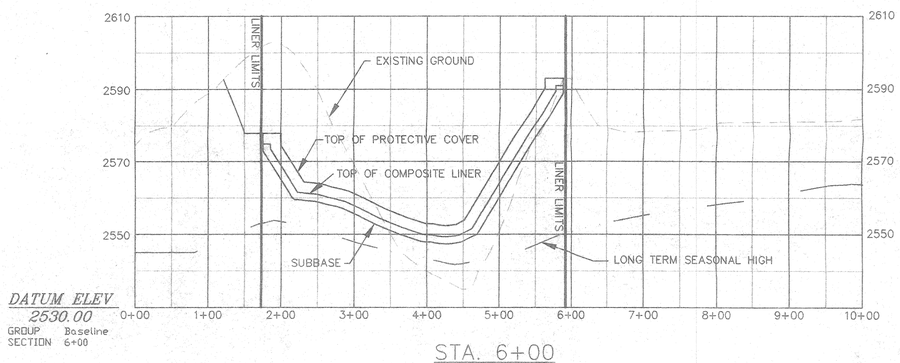
VERTICAL SCALE 1"= 20'



STA. 6+00

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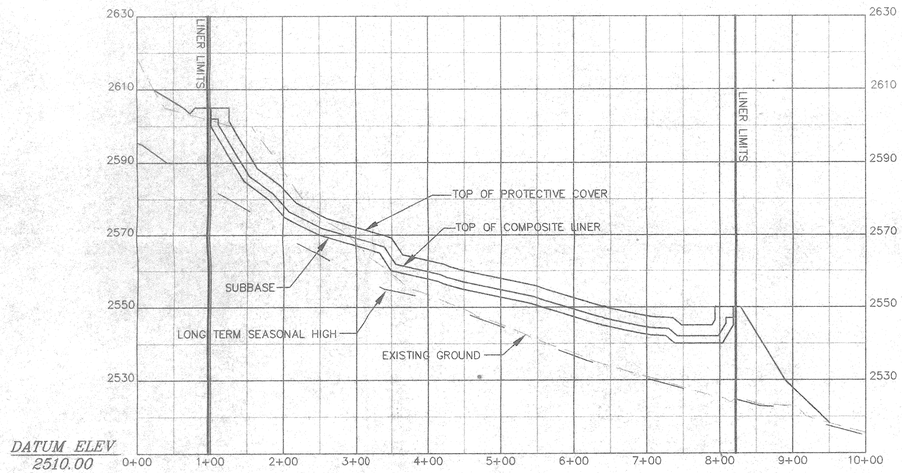

BASELINE

HORIZONTAL SCALE 1"= 100'
VERTICAL SCALE 1"= 20'

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P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

ENGINEERING PLAN
CROSS SECTIONS

NORTH CAROLINA PROFESSIONAL SEAL 4282 ENGINEER JIMMY D. WOODY
3/20/2000

SCALE:	1"= 100'
DATE:	3-10-00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	E8
SHEET NO.	10 OF 12

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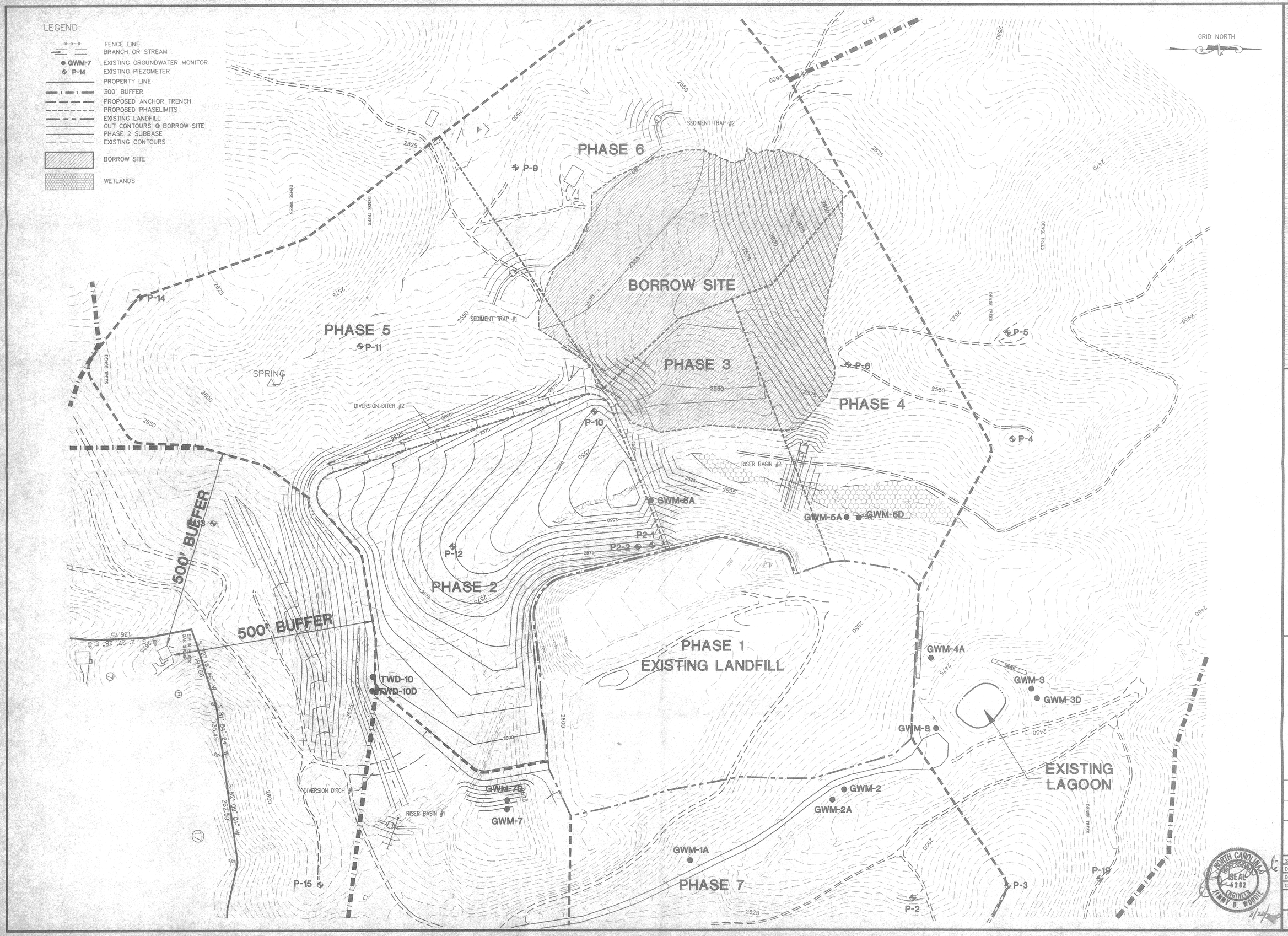


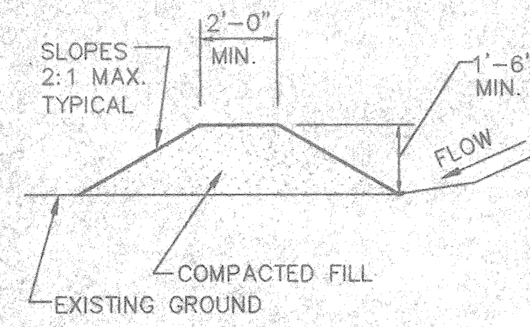
Municipal Engineering Services Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

ENGINEERING PLAN

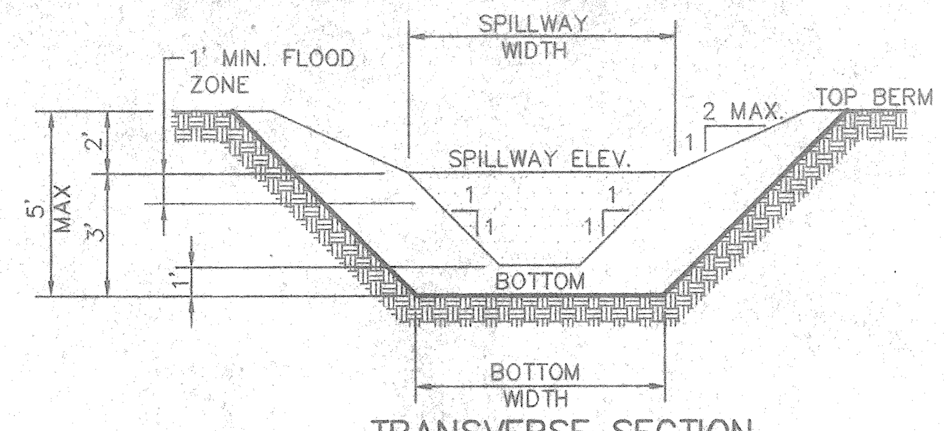
DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 100'
DATE: 3/14/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. E9
SHEET NO. 11 OF

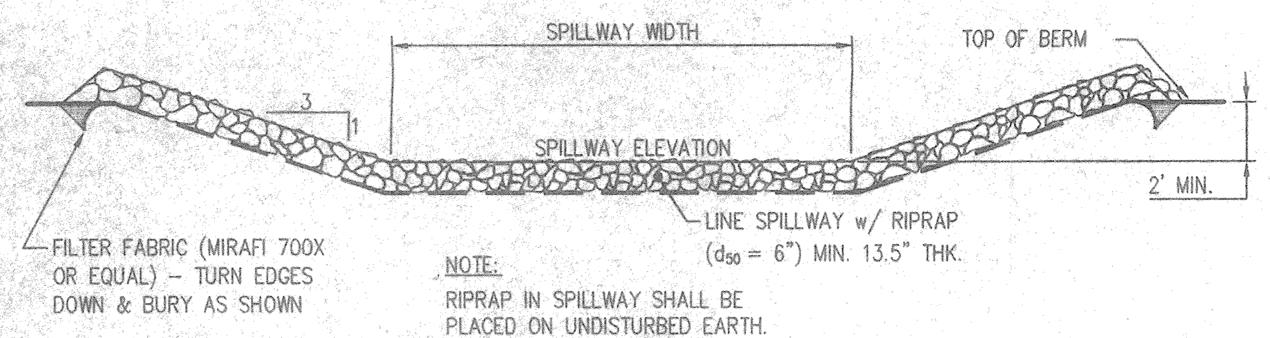


DIVERSION BERM DETAIL

NOT TO SCALE



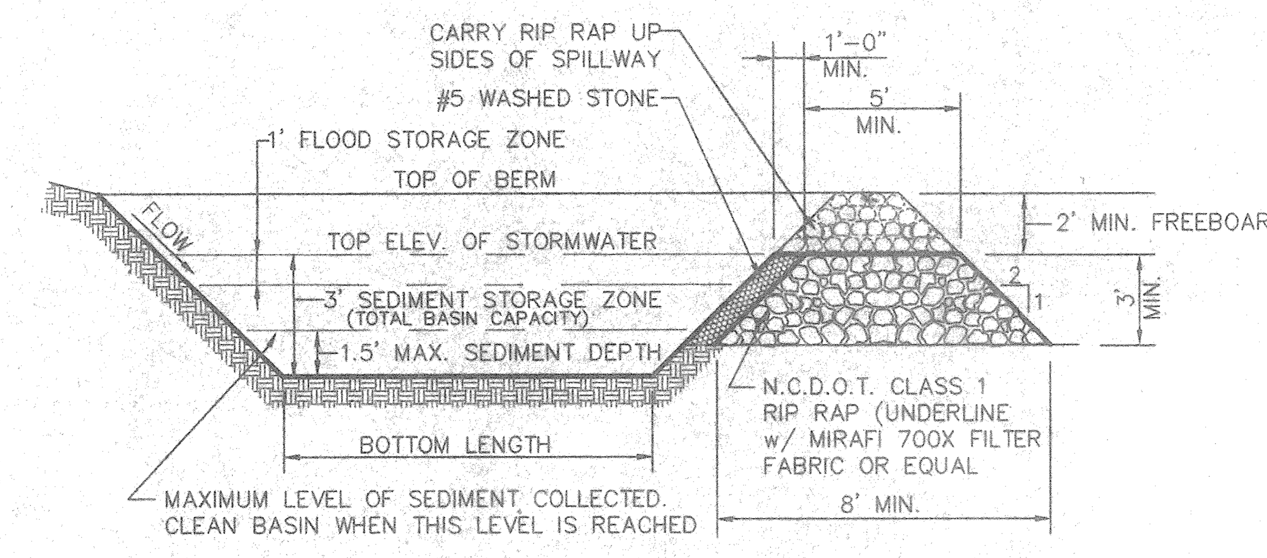
TRANSVERSE SECTION



NOTE:
RIPRAP IN SPILLWAY SHALL BE PLACED ON UNDISTURBED EARTH.

RIPRAP SPILLWAY SECTION

NOT TO SCALE



LONGITUDINAL SECTION

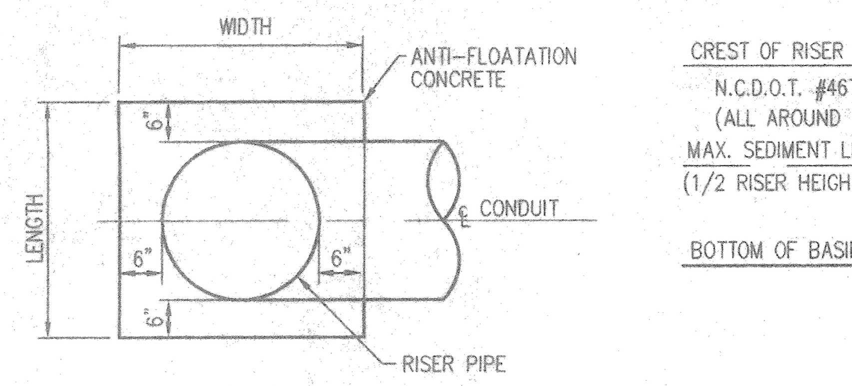
SEDIMENT TRAP SCHEDULE

NOTES:
1. BASIN SHALL BE CLEANED OUT AT 12 MONTH INTERVALS OR WHEN MAX. SEDIMENT LEVEL IS REACHED. REPLACE FILTER AS REQUIRED.
2. SOIL SHALL BE COMPACTED TO 95% STD. PROCTOR MAX. DENSITY.
3. ESTABLISH VEGETATION ON BERMS.

TRAP NO.	BOTTOM			SPILLWAY		BERM ELEV.
	LEN.	WIDTH	ELEV.	WIDTH	ELEV.	
1	SEE PLAN		2545.0'	12.0'	2548.0'	2550.0'
2	SEE PLAN		2540.0'	10.0'	2543.0'	2545.0'

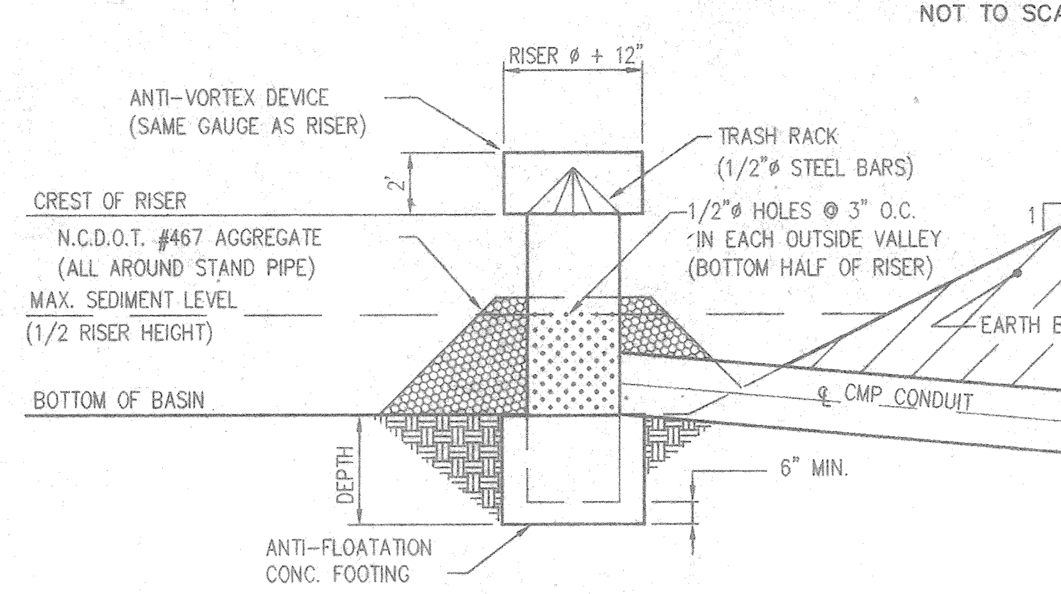
SEDIMENT TRAP DETAIL

NOT TO SCALE



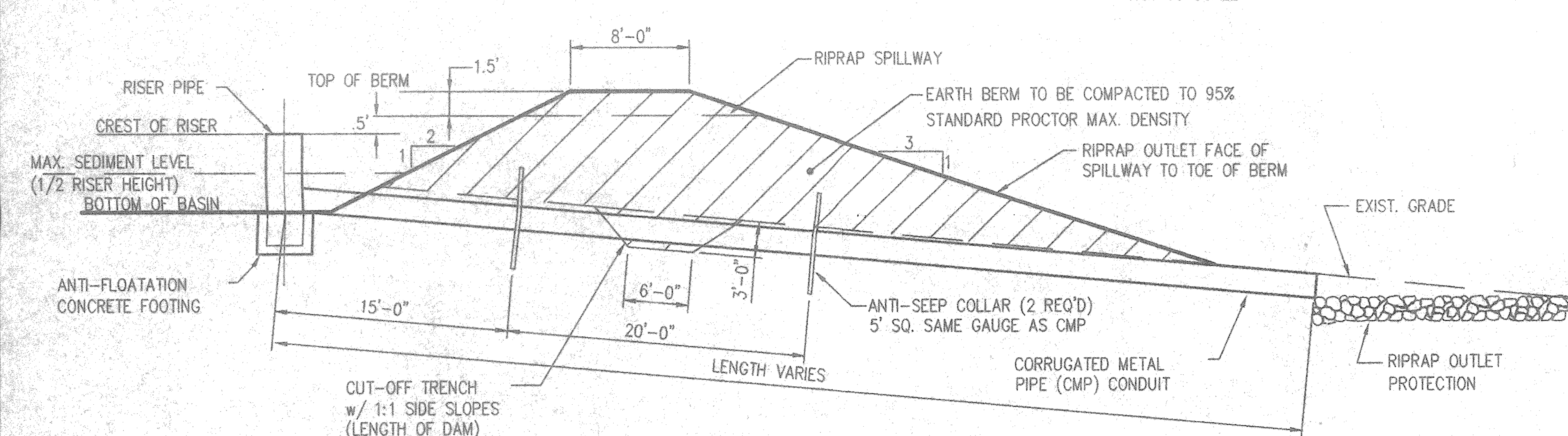
RISER FOOTING PLAN

NOT TO SCALE



STAND PIPE SECTION

NOT TO SCALE



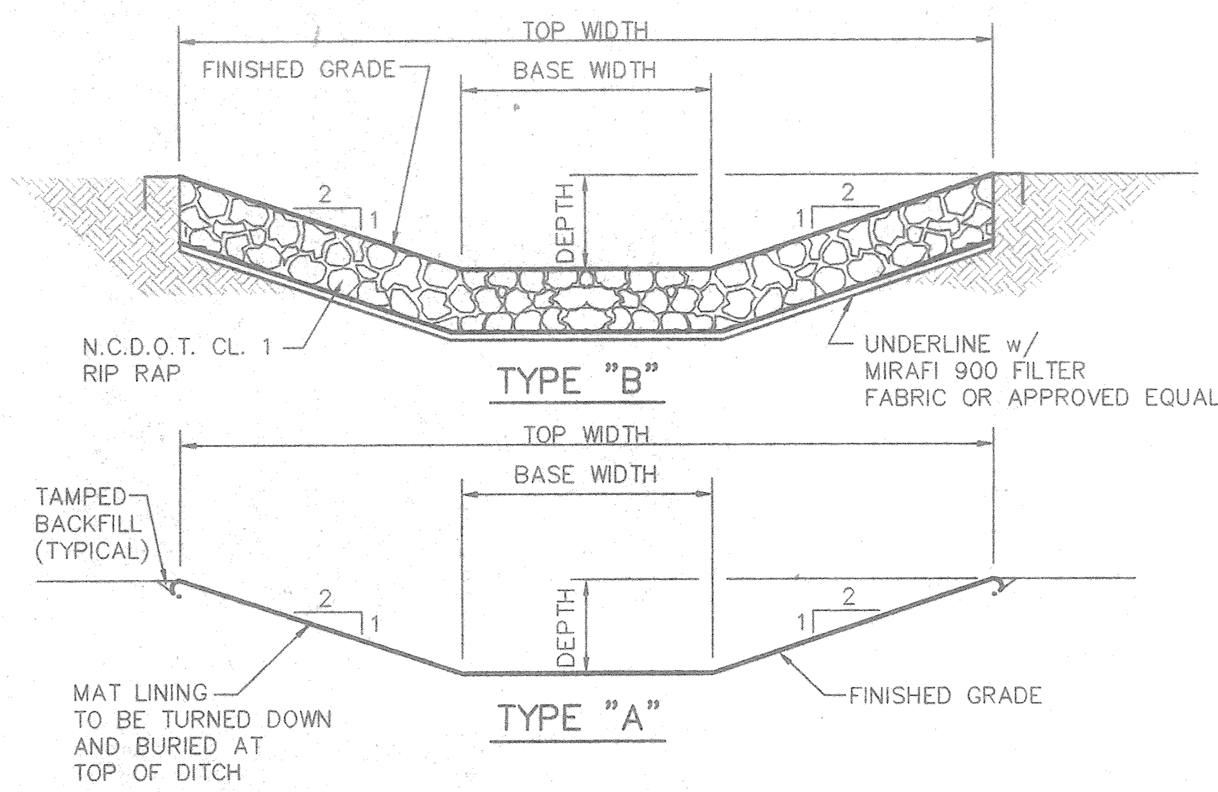
RISER BASIN DAM SECTION

NOT TO SCALE

BASIN NO.	BOTTOM		SPILLWAY		BERM ELEV.	RISER		CONDUIT			FOOTING FOR RISER PIPE				CONDUIT OUTLET PROTECTION				
	SIZE	ELEV	WIDTH	ELEV		DIA.	CREST	DIA.	LENGTH	INV.IN	TOP EL.	LENGTH	WIDTH	DEPTH	LENGTH	WIDTH	d_{50}	THICK.	ELEV.
1	SEE PLAN	2600.0'	10'	2606.5'	2608.0'	18"	2606.0'	12"	80'	2600.0'	2600.0'	2.5'	2.5'	1.0'	14'	15'	9"	13.5" MIN	2585.0'
2	SEE PLAN	2510.0'	20'	2520.5'	2522.0'	33"	2520.0'	21"	100'	2510.0'	2510.0'	4.0'	4.0'	2.0'	21'	22.75'	9"	13.5" MIN	2505.0'

TEMPORARY RISER BASIN DETAIL

SCALE AS NOTED



DIVERSION DITCH SCHEDULE

DITCH NO.	TYPE	TOP WIDTH	DEPTH	BASE WIDTH	VELOCITY (F.P.S.)	RIP RAP d50	RIP RAP THICKNESS	TEMPORARY LINER
1	A	9' MIN	SEE PLAN	5'	3.25	–	–	JUTE NET
2	B	5' MIN.	1'	1'	5.75	6"	9" MIN.	–

DIVERSION DITCH DETAIL

NOT TO SCALE

TEMPORARY SEEDING RECOMMENDATIONS
FOR LATE WINTER AND EARLY SPRING

Seeding Mixture

species	Rate(lb./acre)
Rye (grain)	120
Annual lespedza (Kobe in Piedmont and Coastal Plain,Korean in Mountains)	50

Omit annual lespedeza when duration of temporary cover is not to extend beyond June.

SEEDING DATES
Mountains-Above 2500ft.:Feb. 15 – May 15
Below 2500ft.:Feb. 1 – May 1
Piedmont-Jan. 1 – May 1
Coastal Plain-Dec. 1 – Apr. 15

SOIL AMENDMENTS
Follow recommendations of soil tests or apply 2,000 lb./acre ground agricultural limestone and 750 lb./acre 10-10-10 fertilizer.

MULCH
Apply 4,000 lb./acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulching tool.

MAINTENANCE
Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage.

TEMPORARY SEEDING RECOMMENDATIONS
FOR SUMMER

Seeding Mixture

species	Rate(lb./acre)
German millet	40

In the Piedmont and Mountains, a small-stemmed Sudangrass may be substituted at a rate of 50 lb./acre.

SEEDING DATES
Mountains-May 15 – Aug.15
Piedmont-May 1 – Aug. 15
Coastal Plain-Apr. 15 – Aug. 15

SOIL AMENDMENTS
Follow recommendations of soil tests or apply 2,000 lb./acre ground agricultural limestone and 750 lb./acre 10-10-10 fertilizer.

MULCH
Apply 4,000 lb./acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulching tool.

MAINTENANCE
Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage.

TEMPORARY SEEDING RECOMMENDATIONS
FOR FALL

Seeding Mixture

species	Rate(lb./acre)
Rye (grain)	120

SEEDING DATES
Mountains-Aug.15 – Dec. 15
Coastal Plain and Piedmont-Aug. 15 – Dec. 30

SOIL AMENDMENTS
Follow recommendations of soil tests or apply 2,000 lb./acre ground agricultural limestone and 1,000 lb./acre 10-10-10 fertilizer.

MULCH
Apply 4,000 lb./acre straw. Anchor straw by tacking with asphalt, straight can be used as a mulching tool.

MAINTENANCE
Repair and refertilize damaged areas immediately. Topdress with netting, or a mulch anchoring tool. A disk with blades set nearly 50 lb./acre of nitrogen in March. If it is necessary to extend temporary cover beyond June 15, overseed with 50 lb./acre Kobe (Piedmont and Coastal Plain) or Korean (Mountains)lespedeza in late February or early March.

SEEDING SPECIFICATION 1M

Seeding Mixture

Species	Rate (lb/acre)
Tall fescue	100
Sericea lespedeza	20
Korean lespedeza	10
Redtop	5
Kentucky bluegrass	5

Seeding Notes

1. After Aug. 15 use unscarified sericea seed.

Nurse Plants

Between May 1 and Aug. 15, add 10 lb/acre German Millet 15 lb/acre Sudangrass. Prior to May 1 or after Aug. 15 add 40 lb/acre rye (grain). It may be benificial to plant the grasses in the late summer and overseed the lespedezas in March.

Seeding Dates

	Best	Possible
Below 2500':	Aug. 15 – Sept. 1 Mar. 1 – Apr. 1	Aug. 20 – Oct. 15 Mar. 1 – May 10
Above 2500':	July 25 – Aug. 15 Mar. 20 – Apr. 20	July 15 – Aug. 30 Mar. 5 – May 15

Complete sedding earlier in fall, and start later in spring on north and east facing slopes.

Soil Amendments

Apply lime and fertilizer according to soil tests, or apply 4,000 lb/acre ground agricultural limestone and 1,000 lb/acre 5-10-10 fertilizer.

Mulch

Apply 4,000-5,000 lb/acre grain straw or equivalent cover of another suitable mulch. Anchor straw by tacking with asphalt,netting, or roving. Netting is the prefered anchoring method on steep slopes.

Maintenance

Refertilize in the second year unless growth is fully adequate. May be mowed once. Reseed, fertilize,and mulch damaged ares immediately.

SEEDING SPECIFICATIONS 3M

SEEDING MIXTURE

Species	Rate (lb./acre)
Tall fescue	60
Kentucky bluegrass	10
Sericea lespedeza	15
Korean lespedeza	10

SEEDING NOTES
1. After Aug. 15, use unscarified sericea seed.
2. Where appearance is a consideration, omit sericea lespedeza and increase Korean lespedeza to 40 lb./acre.

NURSE PLANTS
Between May 1 and Aug. 15, add 10 lb./acre German millet or 15 lb./acre Sudangrass, Prior to May 1 or after Aug. 15, add 40 lb./acre rye (grain)

SEEDING DATES

	Best	Possible
Below 2500 ft.:	Aug. 15-Sept. 1 Mar. 1-April 1	July 25-Sept. 15 Mar. 1-May 10
Above 2500 ft.:	July 25-Aug. 15 Mar. 20-Apr. 20	July 15-Aug. 30 Mar. 5-May 15

SOIL AMENDMENTS
Apply lime and fertilizer according to soil tests, or apply 4000 lb/acre ground agricultural limestone and 1000 lb/acre 10-10-10 fertilizer.

MULCH
Apply 4,000 lb./acre grain straw. Anchor straw by tacking with asphalt, netting, or roving or by crimping with a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring tool.

MAINTENANCE
Refertilize in the second year unless growth is fully adequate. May be mowed once or twice per year, but mowing is not necessary. Reseed, fertilize, and mulch damaged areas immediately.

SEEDBED PREPARATION (SP)

SP-1 FILL SLOPES 3:1 OR STEEPER TO BE SEEDE BY A HYDRAULIC SEEDER (PERMANENT SEEDING)
1) Leave the last 4-6 inches of fill loose and uncompacted, allowing rocks, roots, large clods and other debris to remain on the slope.
2) Roughen slope faces by making grooves 2-3 inches deep, perpendicular to the slope.
3) Spread lime evenly over slopes at rates recommended by soil tests.

SP-2 Fill slopes 3:1 or steeper (temporary seedings)
1) Leave a loose, uncompacted surface. Remove large clods, rocks, and debris which might hold netting above the surface.
2) Spread lime and fertilizer evenly at rates recommended by soil tests.
3) Break up large clods and rake into a loose, uniform seedbed.
4) Rake to loosen surface just prior to applying seed.

SP-4 Gentle or flat slopes where topsoil is not used.
1) Remove rocks and debris.
2) Apply lime and fertilizer at rates recommended by soil tests; spread evenly and incorporate into the top 6" with a disk, chisel plow, or rotary tiller.
3) Break up large clods and rake into a loose, uniform seedbed.
4) Rake to loosen surface just prior to applying seed.

SEEDING METHODS (SM)

SM-1 Fill slopes steeper than 3:1 (permanent seeding)
Use hydraulic seeding equipment to apply seed and fertilizer, a wood fiber mulch at 45 lb./1,000 s.f., and mulch tackifer.
SM-2 Gentle to flat slopes or temporary seedings
1) Broadcast seed at the recommended rate with a cyclone seeder, drop spreader, or cultipacker seeder.
2) Rake seed into the soil and lightly pack to establish good contact.

MULCH (MU)

MU-1 Steep slopes (3:1 or greater)
In mid-summer, late fall or winter, apply 100 lb./1,000 s.f. grain straw, cover with netting and staple to the slope. In spring or early fall use 45lb. / 1,000 s.f. wood fiber in a hydroseeder slurry.

MU-2 High-maintenance vegetation and temporary seedings
Apply 90 lb./1,000 s.f. (4000 lb./acre) grain straw and tack with 0.1 gal./s.y. asphalt (11 gal./1,000 s.f.).

MU-3 Grass-lined channels
Install excelsior mat in the channel, extend up the channel banks to the highest calculated depth of flow, and secure according to manufactur's specifications.
On channel shoulders, apply 100 lb./1,000 s.f. grain straw and anchor with 0.1 gal./s.y. (11 gal./1,000 s.f.) asphalt.

MAINTENANCE (MA)

MA-1 Refertilize in late winter or early spring the following year. Mow as desired.
MA-3 Inspect and repair mulch and lining. Refertilize in late winter of the following year with 150 lb./acre 10-10-10 (3.5 lb./1,000 s.f.). Mow regularly to a height of 3-4 inches.
MA-4 Topdress with 10-10-10 fertilizer if growth is not fully adequate.
MA-5 Topdress with 50 lb./acre (1 lb./1,000 s.f.) nitrogen in March. If cover is needed through the following summer, overseed with 50 lb./acre Kobe lespedeza.

SEEDING SPECIFICATION 8M

Seeding Mixture

Species	Rate (lb/acre)
Tall fescue	175-200(3 lb/1,000 sq.ft.)
Kentucky bluegrass	20 (1 lb/1,000 sq.ft.)

Nurse Plants

Between May 1 and Aug. 15, add 10 lb/acre German Millet or 15 lb/acre Sudangrass. Prior to May 1 or after Aug. 15 add 40 lb/acre rye (grain).

Seeding dates

	Best	Possible
Below 2500 ft.:	Aug. 15 – Sept. 1 Mar. 1 – Apr. 1	July 25 – Sept. 15 Mar. 1 – May 10
Above 2500 ft.:	July 25 – Aug. 15 Mar. 20 – Apr. 20	July 15 – Aug. 30 Mar. 5 – May 15

Avoid seeding from Nov. to Jan. If seeding must be done at this time, add 40 lb/acre rye grain and use a channel linning that offers maximum protection.

Soil Amendments

Apply lime and fertilizer according to soil tests, or apply 4,000 lb/acre ground agricultural limestone and 1,000 lb/acre 10-10-10 fertilizer.
Operate tilliage equipment across the waterway.

Mulch

Use jute, excelsior matting or other effective channel linning material to cover the bottom of channels and ditches, and staple securely. The linning should extend above the highest calculated depth flow. On channel side slopes above this height, and in drainages not requiring temporary linnings, apply 4,000 lb/acre grain straw and anchor straw by stapling netting over the top.

Mulch and anchoring materials must not be allowed to wash down slopes where they can clog drainage devices.

Maintenance

Inspect and repair mulch frequently. Refertilize in late winter of the following year; use soil tests or apply 150 lb/acre 10-10-10 fertilizer (3 lb/1,000 sq.ft.). Mow regularly to a height of 2-4 inches.

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE 3/20/2000

Municipal Services Engineering Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY
NORTH CAROLINA

ENGINEERING PLAN

DATE	BY	REV.	DESCRIPTION

SCALE:	NOT TO SCALE
DATE:	3/14/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	E10
SHEET	12 OF

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HAYWOOD COUNTY MUNICIPAL SOLID WASTE LANDFILL FACILITY PLAN PERMIT RENEWAL PHASE 2

BOARD OF COMMISSIONERS

CHAIRMAN - JIM STEVENS
VICE-CHAIRMAN - ROBERT FORGA
COMMISSIONNERS:
Mary Ann Enloe
Carlyle Ferguson
Wade Francis

COUNTY MANAGER

JACK HORTON

SOLID WASTE MANAGER

JOE WALKER

Engineer
Municipal Engineering Services Company, P.A.
Garner, N.C. Boone, N.C.

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. MOODY 12/20/2000

by _____
Professional Engineer

Municipal Engineering Services Company, P.A.

SCALE:	NTS
DATE:	3/1/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	T1
SHEET	1 of

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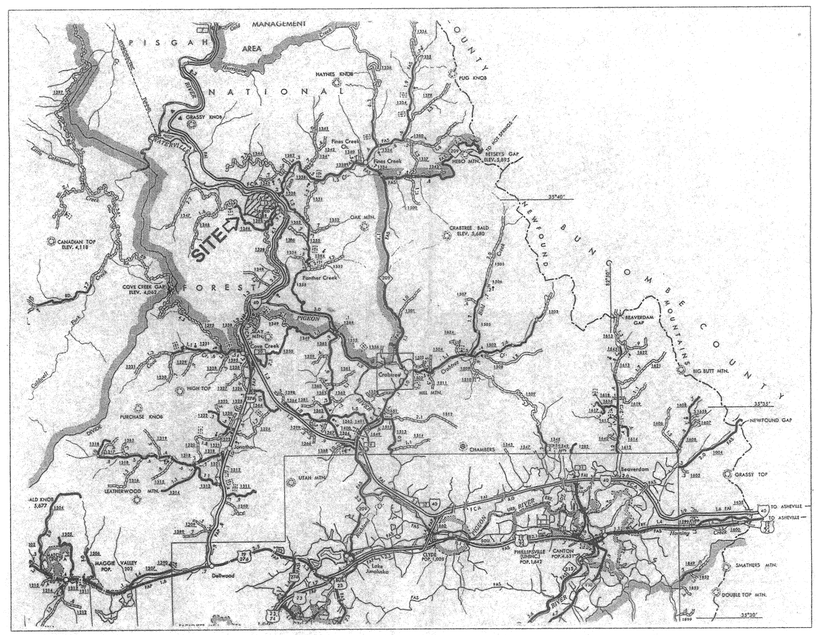
INDEX

SHEET NO.	DRAWING NO.	DESCRIPTION
01	T1	TITLE SHEET
02	T2	INDEX
03	F1	EXISTING CONDITIONS
04	F2	SUBGRADE
05	F3	LEACHATE COLLECTION SYSTEM
06	F4	FINAL FILL PLAN



Municipal Engineering Services Company, P.A.

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODIE

SCALE:	NTS
DATE:	3/1/00
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CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010.6
DRAWING NO.	T2
SHEET	2 of

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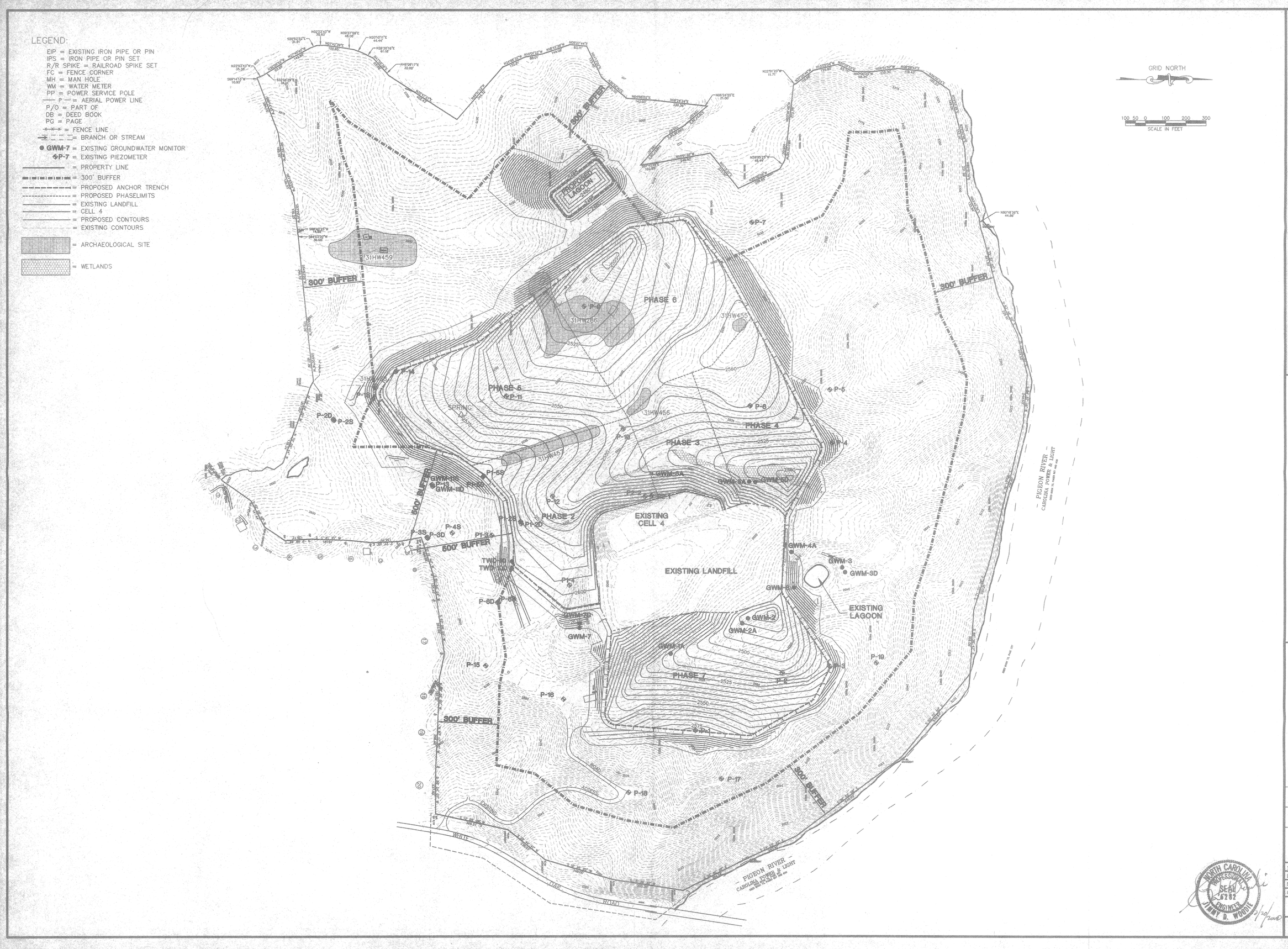

Municipal Engineering Services Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY

FACILITY PLAN

DATE	BY	REV.	DESCRIPTION

SCALE: 1"= 200'
DATE: 3/1/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010.6
DRAWING NO. F2
SHEET 4 OF

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 6282 JIMMY D. WOODIE
3/20/2000

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LEGEND:

- EIP = EXISTING IRON PIPE OR PIN
- IPS = IRON PIPE OR PIN SET
- R/R SPIKE = RAILROAD SPIKE SET
- FC = FENCE CORNER
- MH = MAN HOLE
- WM = WATER METER
- PP = POWER SERVICE POLE
- —— P —— = AERIAL POWER LINE
- P/O = PART OF
- DB = DEED BOOK
- PG = PAGE
- = FENCE LINE
- = BRANCH OR STREAM
- = EXISTING GROUNDWATER MONITOR
- = EXISTING PIEZOMETER
- = PROPERTY LINE
- = 300' BUFFER
- = PROPOSED ANCHOR TRENCH
- = PROPOSED PHASE LIMITS
- = EXISTING LANDFILL
- = CELL 4
- = PROPOSED CONTOURS
- = EXISTING CONTOURS
- = PROPOSED LEACHATE COLLECTION SYSTEM

Municipal Engineering Services Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY

DATE	BY	REV.	DESCRIPTION

FACILITY PLAN

SCALE:	1"= 200'
DATE:	3/1/00
DRWN. BY:	B. BADEY
CHKD. BY:	W. SULLIVAN
PROJECT NUMBER	G98010
DRAWING NO.	F3
SHEET	5 O

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER JIMMY D. WOODY

3/10/2000

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LEGEND:

EIP = EXISTING IRON PIPE OR PIN
IPS = IRON PIPE OR PIN SET
R/R SPIKE = RAILROAD SPIKE SET
FC = FENCE CORNER
MH = MAN HOLE
WM = WATER METER
PP = POWER SERVICE POLE
—— P —— = AERIAL POWER LINE
P/O = PART OF
DB = DEED BOOK
PG = PAGE
= FENCE LINE
= BRANCH OR STREAM
= PROPERTY LINE
= 300' BUFFER
= PROPOSED ANCHOR TRENCH
= PROPOSED PHASELIMITS
= EXISTING LANDFILL
= CELL 4
= EXISTING CONTOURS
= PROPOSED FINAL FILL
= PROPOSED SUBGRADE

Municipal Services Engineering Company, P.A.

MUNICIPAL SOLID WASTE LANDFILL
HAYWOOD COUNTY

DATE	BY	REV.	DESCRIPTION

FACILITY PLAN

SCALE: 1"= 200'
DATE: 3/1/00
DRWN. BY: B. BADEY
CHKD. BY: W. SULLIVAN
PROJECT NUMBER G98010
DRAWING NO. F4
SHEET 6 OF

NORTH CAROLINA PROFESSIONAL SEAL 6282 ENGINEER TIMMY D. WOODIE

3/10/2000

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