STATE OF ALASKA
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
555 Cordova Street
Anchorage, AK 99501

SOLID WASTE DISPOSAL PERMIT

Permit No. **SW1A007-15**

Date Issued: February 21, 2014
Date Expires: November 19, 2015

The Alaska Department of Environmental Conservation (ADEC), under authority of AS 46.03 and 18 AAC 60, issues a solid waste disposal permit to:

Matanuska-Susitna Borough
Palmer Central Landfill
350 E. Dahlia Avenue
Palmer, AK 99645-6488

and designated representatives for the management and operation of a Class I municipal solid waste landfill. It authorizes operation of municipal waste cells 2A, 2B, cell 3, and separate cells for construction and demolition (C&D) waste and asbestos containing material.

The landfill is located at Milepost 3 of the Palmer-Wasilla Highway at the southern end of North 49th State Street. The active landfill is currently limited to an approximately 160-acre section of the 620-acre site, legally described as S ½ Section 1, E ½ SE ¼ Section 2, NE ¼ NE ¼, E ½ NW ¼ NE ¼ Section 11, N ½ NW ¼, N ½ SW ¼ NW ¼, N ½ SE ¼ NW ¼, NW ¼ NE ¼ of Section 12, Township 17 North, Range 1 East, Seward Meridian.

The permit holder shall manage and operate the facility in accordance with:

- 18 AAC 60
- permit application materials submitted November 3, 2010, and additional application materials submitted November 19, 2010

In addition, the following permit conditions are required:

Specific Conditions

Explosive Gas Monitoring Plan

1. MSB must submit a facility wide gas monitoring plan, including installation of a gas monitoring well system that meets the requirements of 18 AAC 60.350. The plan must be submitted to ADEC for approval, no later than June 1, 2010 and the gas monitoring wells must be installed and operational no later than June 1, 2012.

Landfill Closure

1. MSB must submit a facility wide conceptual closure plan that meets the requirements of 18 AAC 60.395, no later than June 1, 2011. The closure plan should include intended closure sequence for all landfill cells you expect to operate over the life of the landfill. The plan must also include updated calculations of the cost estimate for closure and post-closure care of the landfill.

Facility Design

1. Limit vertical expansion of Cell 2A to 355 feet elevation.

2. Limit vertical expansion of current and future cells to 340 feet elevation.

Facility Operations

1. For noise control:

   a. Not operate any heavy equipment or commercial size trucks at the landfill working face from 9 p.m. to 7 a.m., excluding emergency situations;
   b. Only operate vehicles at the landfill with properly sized and functional mufflers installed;
   c. Not operate construction equipment or commercial size trucks at the landfill from 10 p.m. to 6 a.m. for the construction of new landfill cells.

2. Maintain a minimum separation distance of 50 feet between the active placement of solid waste and the facility boundary, except next to residential areas. All new cells next to residential areas must have a separation distance of 300 feet between the cell boundary and the facility boundary.

3. Ensure that landfill personnel conduct random waste inspections of incoming loads on a weekly basis to check for prohibited wastes. Ensure that landfill personnel receive adequate training in the identification of hazardous waste and prohibited waste. Maintain a record of the random inspections noting the date, inspector name, and any prohibited wastes identified. The inspection records shall be maintained in the facility record.

Municipal Waste Cell Operations

1. Ensure that only one working face/dumping location for municipal waste is exposed at any one time, and that it is located within the footprint of cells 2A, 2B or cell 3. The maximum size of the working face shall not exceed 200 feet wide and 10 feet tall.

2. Maintain a slope no greater than 3 to 1 (horizontal to vertical) on interior slopes of the cells. Interior slopes are those that will have waste placed against them at some time in the future based on the approved facility plans.

3. Maintain a slope no greater than 4 to 1 (horizontal to vertical) on all exterior slopes of the cells. Exterior slopes are those that will not have waste placed against them in the future

based on the approved facility plans.

Construction & Demolition (C&D) Cell Operations

1. Ensure that only one working face/dumping location for C&D waste is exposed at any one time.

2. Compact, consolidate, and cover the C&D waste monthly or more frequently if needed to control litter and vectors.

3. Ensure that no asbestos containing material (ACM) is disposed in the C&D cell.

Asbestos Cell Operations

1. Ensure that all ACM is disposed in the asbestos cell. Friable ACM must be sealed in leak-proof bags or containers with proper labeling prior to acceptance at the facility. Non-friable ACM, if not containerized, must be deposited in the designated asbestos disposal area in a manner that does not result in breakage and the subsequent release of asbestos dust.

2. Ensure that all asbestos-containing waste material is covered with at least six (6) inches of soil material by the end of the day of disposal.

3. Ensure that a designated representative is present at the site to supervise each disposal.

Visual Monitoring

1. Visually monitor the site each month for signs of damage or potential damage from settlement, ponding, erosion, leachate seeps, animal attraction and compliance with other permit conditions. Record the inspection results on the form submitted in the monitoring plan. Maintain the inspection results in the facility's operating record.

Groundwater Monitoring

1. Conduct groundwater monitoring at the facility as described in the monitoring plan, dated October 2010

    a. Groundwater elevations for all wells must be recorded at each sampling event.

    b. For wells designated for detection monitoring, test all water quality samples for the constituents listed in Appendix I of Title 40, part 258 of the Code of Federal Regulations (40 CFR 258) and the following compounds from Table J of 18 AAC 60: specific conductivity, temperature, pH, Chloride, DRO, GRO, Mercury, and Total Dissolved Solids.

    c. For wells subject to assessment monitoring, test all water samples for all constituents listed in Appendix II of 40 CFR 258 in the June sampling. In the December sampling, these wells must be tested for Appendix I constituents, plus any Appendix II constituents detected above the method detection limit (MDL) at the facility in any sampling event.

d. No later than 60 days after receiving the laboratory results for a monitoring event, submit a report to ADEC in an approved format including the appropriate analyses.

General Conditions

1. Access and inspection - The Permittee shall allow the Commissioner or his representative access to the permitted facilities at reasonable times to conduct scheduled or unscheduled inspections or tests to determine compliance with this permit, State laws, and regulations.

2. Information access - Except for information relating to confidential processes or methods of manufacture, all records and reports submitted in accordance with the terms of this permit shall be available for public inspection at the State of Alaska, Department of Environmental Conservation, 555 Cordova Street, Anchorage, AK 99501.

3. Civil and criminal liability - Nothing in this permit shall relieve the Permittee from civil or criminal penalties for noncompliance, whether or not such noncompliance is due to factors beyond his control, including, but not limited to, accidents, equipment breakdowns, or labor disputes.

4. Availability - The Permittee shall post or maintain a copy of this permit available to the public at the disposal facility.

5. Adverse impact - The Permittee shall take all necessary means to minimize any adverse impacts to the receiving waters or lands resulting from noncompliance with any limitation specified in this permit, including any additional monitoring needed to determine the nature and impact of the non-complying activity. The Permittee shall clean up and restore all areas adversely impacted by the noncompliance.

6. Cultural or paleontological resources - Should cultural or paleontological resources be discovered as a result of this activity, work which would disturb such resources is to be stopped, and the State Historic Preservation Office, Division of Parks and Outdoor Recreation, Department of Natural Resources, is to be notified immediately (907-269-8721).

7. Applications for renewal - In accordance with 18 AAC 15.100(d), applications for renewal or amendment of this permit must be made no later than 30 days before the expiration date of the permit or the planned effective date of the amendment.

8. Other legal obligations - The requirements, duties, and obligations set forth in this permit are in addition to any requirements, duties, or obligations contained in any permit that the Alaska Department of Environmental Conservation or the U.S. Environmental Protection Agency has issued or may issue to the Permittee. This permit does not relieve the Permittee from the duty to obtain any and all necessary permits and to comply with the requirements contained in any such permit or with applicable state and federal laws and

regulations. All activities conducted by the Permittee pursuant to the terms of this permit and all plans implemented by the Permittee pursuant to the terms of this permit shall comply with all applicable state and federal laws and regulations.

9. Pollution prevention - In order to prevent and minimize present and future pollution, when making management decisions that affect waste generation, the Permittee shall consider the following order of priority options: waste source reduction; recycling of waste; waste treatment; and waste disposal.

This permit expires on November 19, 2015 and may be revoked or amended in accordance with 18 AAC 60.260. The permit can be renewed if the facility will operate beyond this date. **To avoid expiration of this permit, a renewal application must be submitted to ADEC at least 30 days before the expiration date, as set forth in 18 AAC 15.110.**

Lori Aldrich
Solid Waste Program Coordinator

MATANUSKA-SUSITNA BOROUGH
SOLID WASTE DIVISION
350 E. DAHLIA AVE
PALMER, ALASKA 99645
PHONE - 746-2856 FAX - 746-2847

LETTER OF TRANSMITTAL

DATE: 11-3-10	JOB NO.
ATTENTION: Ms. Lori Aldrich	
RE: Mat-Su 2010 Permit Renewal Application	
Proposal No.	

Solid Waste Program Coordinator
Alaska Department of Environmental Conservation
555 Cordova Street
Anchorage, AK 99501

WE ARE SENDING YOU ☒ Attached ☐ Under separate cover via the following items:

☐ Shop drawings ☐ Prints ☐ Plans ☐ Reports ☐ Specifications ☐ Copy of letter ☐ Change order

COPIES	DATE	NO.	DESCRIPTION
1	11-3-10		Permit Application
1			Attachment's A-F and H –R, Attachment G to follow next week

THESE ARE TRANSMITTED as checked below:

☐ For approval ☐ for your use ☐ As requested ☐ For review/comment

COPY TO: ____________________

SIGNED:

Kent Crafton, Project Manager

If enclosures are not as noted, kindly notify us at once.

Instructions

- This packet contains instructions and forms to complete a permit application for a Class I Municipal Solid Waste (MSW) Landfill. This application is valid for new permits or for renewing existing permits.
- Each item must be completed and included in your application in order for the Alaska Department of Environmental Conservation (DEC) to process your permit application. Please address each item. The requested information in this form represents the minimum that is required; additional information can and should be provided as necessary or applicable.
- If the required information is not applicable, please explain why.
- If the required information is included in a previous application, AND the information has not changed since it was submitted, you must provide a specific reference or citation explaining where the information can be found.
- Check off each item as you complete it, and submit the entire packet, the required information, and the required application fee.
- For new facilities and lateral expansions, please prepare a draft application, develop a list of questions, and then schedule a pre-application meeting with the DEC office that will be reviewing your application materials.
- Please submit the completed application and any questions to your nearest DEC Solid Waste Program office, listed below.

DEC Contact Information
The Alaska Department of Environmental Conservation
Division of Environmental Health
Solid Waste Program
http://www.dec.state.ak.us/eh/sw

Anchorage
555 Cordova Street
Anchorage, AK 99501
(907) 269-7802
FAX (907) 269-7600

Fairbanks
610 University Avenue
Fairbanks, AK 99709
(907) 451-2108
FAX (907) 451-2188

Juneau
410 Willoughby Avenue
Juneau, AK 99801-1795
(907) 465-5350
FAX (907) 465-5362

Soldotna
43335 Kalifornsky Beach Road, Suite 11
Soldotna, AK 99669-9792
(907) 262-5210
FAX (907) 262-2294

Part One: Fees

A check or money order for the appropriate fees must be submitted with the permit application. If the required fees are not included, the permit application will be returned to the applicant.

✓	#	Requirement:	Regulatory Citation
	1	Submit a check or money order to cover the permit application review fee, as listed in 18 AAC 60.700 Table I-2.	18 AAC 60.210(b)(8) 18 AAC 60.700
	2	Submit a check or money order to cover waiver request fees, if applicable, as listed in 18 AAC 60.700 Table I-2.	

Class I MSWLF
Solid Waste Permit Application

Alaska Department of
Environmental Conservation
Division of Environmental Health
Solid Waste Program

Part Two: Cover Letter and Certifications

A cover letter must be prepared, as outlined below, and submitted with the permit application.

✓	#	Requirement - letter must include:	Regulatory Citation
X	1	A statement indicating you wish to obtain a permit for a Class I Municipal Solid Waste (MSW) landfill. **Attachment A**	18 AAC 60.210(b)(1)
X	2	Evidence showing that the proposed facility meets the requirements for a Class I MSW landfill.	
X	3	A brief general description of the site topography, geology, climate, surface hydrology and groundwater hydrology.	
X	4	A statement that you are aware of all applicable local ordinances, zoning requirements, and the Alaska Coastal Zone Management Program requirements of 11 AAC 110.	
X	5	The applicant must submit a **signed original** of the application cover letter.	18 AAC 15.030 18 AAC 60.210(a) 18 AAC 60.210(b)(2)
X	6	The applicant must submit a **signed original** of the following statement, which may be added, exactly as shown in the box below, to the cover letter. As an alternative, the applicant may sign this sheet and submit it as an attachment to the cover letter.	

I, Shaune O'Neil, certify under penalty of perjury, that all of the information and exhibits in this cover letter and application are true, accurate, and complete.

Shaune O'Neil
Applicant's Signature

11 / 2 / 10
Month / Day / Year

Public Works Director
Applicant's Title

Information about signatures

All permits or applications must be signed as follows, per 18 AAC 15.030:

- **Corporations**: A principal executive officer, an officer that is no lower than the level of vice president, or a duly authorized representative who is responsible for the overall management of the project or operation
- **Partnerships**: A general partner
- **Sole proprietorship**: The proprietor
- **Municipal, state, federal, or other public entity**: A principal executive officer, ranking elected official, or duly authorized employee

Part Three: Contact Information

✓	#	Requirement:	Regulatory Citation
	1	Fill out the form completely and submit as part of the application.	18 AAC 60.210(b)(2)

APPLICANT

Name: Matanuska Susitna Borough
Contact name: Greg Goodale
Mailing address: 350 East Dahlia Ave.
City/State/Zip: Palmer AK 99645
Telephone Number: 907-746-2841
FAX Number: 907-746-2847
Email Address: ggoodale@matsugov.us

Type of entity: Individual ☐ Partnership ☐ Corporation ☐ Other: Municipal

State of incorporation or registration:
Alaska business license number:
IRS tax identification number:

FACILITY OWNER

Name: Matanuska Susitna Borough
Mailing address: 350 East Dahlia Ave.
City/State/Zip: Palmer AK 99645
Telephone Number: 907-746-2841
FAX Number: 907-746-2847
Email Address: ggoodale@matsugov.us

Part Three: Contact Information (continued)

LANDOWNER

Name	Matanuska Susitna Borough
Mailing address	350 East Dahlia Ave.
City/State/Zip	Palmer AK 99645
Telephone Number	907-746-2841
FAX Number	907-746-2847
Email Address	ggoodale@matsugov.us

OPERATOR

Name	Matanuska Susitna Borough
Mailing address	350 East Dahlia Ave.
City/State/Zip	Palmer AK 99645
Telephone Number	907-746-2841
FAX Number	907-746-2847
Email Address	ggoodale@matsugov.us

AGENT

Name	
Mailing address	
City/State/Zip	
Telephone Number	
FAX Number	
Email Address	

Part Four: Waste Handling and Processing Information

✓	#	Requirement:	Regulatory Citation
X	1	Fill out the form completely and submit as part of the application.	18 AAC 60.210(b)(2) 18 AAC 60.210(b)(3)(B) 18 AAC 60.210(b)(4)

1 List the amounts of the various wastes you expect to receive at the site each year:

(Tons/Year) Quantity	Waste Type
60k	Municipal Solid Waste
10k	Inert or C&D Waste
80	Asbestos (Regulated Asbestos Containing Material)
	Asbestos (Non-Regulated Asbestos Containing Material)
	Sewage Solids or Biosolids
	Animal Waste
	Fish Waste
	Ash
	Contaminated Soils/Polluted Soils
	Woodwaste
	Other
	Other
	Other

2 Check the type(s) of waste processing done at the landfill before waste is disposed of:

- [ ] Baling/Compacting
- [ ] Shredding
- [x] Salvage/Reuse
- [x] Separation/Segregation
- [ ] Composting
- [ ] Dewatering
- [ ] Incinerator: list model
- [ ] Other

Part Five – Location Information

Please fill out the form where required, attach the appropriate documentation, and submit as part of the application. You may submit maps that show more than one of the required items. For example, one map can show property boundaries, nearest airport, wetland and surface water locations, etc. Please ensure that all the requested information is included in the completed application.
NOTE: Maps must have notations about sources of information, including a complete citation.

✓	#	Requirement:	Regulatory Citation
	1	**Property ownership and location** information must include the following:	18 AAC 60.210(b)(3)(A) 18 AAC 60.210(b)(7)
X	(a)	Fill in a legal description of the property, with meridian, range, township and section, as well as latitude and longitude. **The 620-acre site is legally described as:** **S ½ Section 1, E ½ SE ¼ Section 2, NE ¼ NE ¼, E ½ NW ¼ NE ¼ Section 11, N ½ NW ¼,** **N ½ SW ¼ NW ¼, N ½ SE ¼ NW ¼, NW ¼ NE ¼ of Section 12, Township 17 North, Range 1 East, Seward Meridian, Alaska.**	
X	(b)	Fill in an informal location description such as mileposts, landmarks, distance and direction from nearest community. **The Central Landfill is located at the southern terminus of North 49th State Street in Palmer Alaska. The Central Landfill is approximately 3 miles from the City of Palmer and approximately 10 miles from the City of Wasilla.**	
X	(c)	Attach a copy of the deed or another legal document that identifies the landowner. **Attachment B**	
	(d)	If the applicant is not the landowner, attach a written and notarized statement signed by the landowner showing that the landowner consents to the landfill, or a copy of any lease agreement that is relevant to the proposed activity.	
X	(e)	Attach a map or aerial photo that shows the location of the landfill property boundaries. **Attachment C**	

Part Five – Location Information (continued)

✓	#	Requirement:	Regulatory Citation
	2	**Surface water** information must include:	18 AAC 60.210(b)(3)(B) 18 AAC 60.210(b)(3)(D) 18 AAC 60.225
X	(a)	Fill in information about any potential for surface water to enter the site from up gradient areas. **There is no surface water bodies' up gradient from the Central Landfill that would have the potential to enter the site.**	
	(b)	Fill in information about any potential for sediment carried by runoff to impact nearby surface water. N/A	
X	(c)	Attach a map and/or aerial photo that shows the location of surface water bodies and streams within 200 feet of the landfill boundary. **There are no surface water bodies within 200 feet of the landfill boundary.**	
	3	**Wetlands information**	18 AAC 60.210(b)(3)(B) 18 AAC 60.315 40 CFR 230.5
	(a)	For new facilities or lateral expansions, attach a Wetlands Determination from the U.S. Army Corps of Engineers or information from the National Wetlands Inventory documenting that the area is not designated as a wetlands. NOTE – if the new landfill site or the lateral expansion is located in a wetland, you must also complete a DEC Additional Wetlands Information Form, and submit as part of this package.	
X	(b)	Attach a map or aerial photo that shows the location of the boundary of any wetlands within 200 feet of the landfill boundary. **There are no wet lands within 200 feet on the landfill boundary.**	

Part Five – Location Information (continued)

✓	#	Requirement:	Regulatory Citation
	4	**Permafrost** information must include:	18 AAC 60.210(b)(3)(B) 18 AAC 60.227
	(a)	If the landfill is located on permafrost, fill in information to explain why there is no practical alternative to the site chosen.	
	(b)	If the landfill is in an area of discontinuous permafrost, attach a map and/or aerial photo that shows the location of the boundary of any permafrost within 200 feet of the landfill boundary.	
	5	**Airport safety** information must include the following:	18 AAC 60.210(b)(3)(B) 18 AAC 60.305 49 USC 40101 FAA AC 150/5200-33A
X	(a)	Attach documentation that the landfill is located at least 10,000 feet from any airport used by turbojet aircraft, or 5,000 feet from any airport used only by piston-type aircraft; OR If the landfill is located within 5,000 feet from the end of a runway for airports used only by piston-type aircraft, attach a demonstration that the landfill is designed and operated so it does not pose a bird hazard to aircraft; OR If the landfill is located within 10,000 feet from the end of a runway for airports used by turbojet type aircraft, attach both a copy of FAA waiver **AND** a demonstration that the landfill is designed and operated so it does not pose a bird hazard to aircraft. Note 4 - Palmer Airport is 3 miles away from Central Landfill. Turbojet aircraft occasionally use the airport, but it is farther than 10,000 feet from the landfill and no bird problems have been reported in association with the landfill. There are five airstrips within a 3 mile radius of the landfill, but they do not meet the federal definition of an airport and the bird hazard restrictions do not apply to private airstrips. An FAA waiver was included within our 2000 permit.	
X	(b)	Attach a map and/or aerial photo of the landfill that shows the distance and direction to the closest portion of the airport runway. **Attachment D**	

Part Five – Location Information (continued)

✓	#	Requirement:	Regulatory Citation
	6	**Other** required information:	18 AAC 60.040 18 AAC 60.210(a) 18 AAC 60.217 18 AAC 60.310 18 AAC 60.320 18 AAC 60.820(a)(8) 11 AAC 110.205
X	(a)	Attach information showing the highest measured level of groundwater under the landfill area; new cells or cell expansions may not be located closer than 10 feet above groundwater. **Attachment E**	
X	(b)	Annual precipitation ___**15.3 inches**______. What source was used to determine annual precipitation? **CH2M Hill Leachate Calculation, Future Cell Sequencing Plan 2006**	
	(c)	For new facilities or lateral expansions, attach a completed Coastal Project Questionnaire if the proposed operation is in, or might affect, the Coastal Zone of Alaska.	
X	(d)	Attach a map and/or aerial photo that shows the location of all nearby drinking water wells; there should be no wells within 500 feet of the waste area. **There are no drinking water wells within 500'**	
X	(e)	Attach a map and/or aerial photo that shows the location of the boundary of any 100-year floodplain in the area. NOTE: If the landfill is located in a 100-year floodplain, attach documentation to demonstrate that the landfill will not restrict the flow of the 100-year flood, reduce the temporary storage capacity of the floodplain, or result in washout of solid waste. **There are no 100 year flood plain areas near to the Central Landfill**	
X	(f)	Attach a map and/or aerial photo that shows the location of any documented earthquake faults or unstable areas within 200 feet of the landfill boundary. **There are no documented earthquake faults or unstable areas within 200 feet of the landfill boundary.**	

Part Six – Facility Design

A complete set of design drawings must be submitted showing all the information in the following table, with drawings included for both the design and closure of the landfill, as appropriate. Landfill drawings should be organized as shown below, with design drawings placed in the first part of the drawing set and closure drawings included at the end of the drawing set. It is understood that landfill closure design drawings will be conceptual only.

✓	#	Requirement – engineering drawings must include:	Regulatory Citation
LANDFILL DESIGN DRAWINGS:			18 AAC 60.210(b)(3)(B) 18 AAC 60.210(b)(3)(C) 18 AAC 60.220 18 AAC 60.233 18 AAC 60.330 18 AAC 60.450(b)
	1	**Site map(s)** which show site conditions including:	
X	(a)	All previous, existing, and planned disposal areas; the drawing should demonstrate that waste will be at least 50' from property boundary. **Attachment F**	
X	(b)	Fences, gates, berms, and other access control devices around the facility. **Attachment F**	
X	(c)	Access roads to and within the facility. **Attachment F**	
X	(d)	Equipment storage area, covers material storage area, and salvage storage area. **Attachment F**	
X	(e)	If the facility will have an **asbestos disposal area**, attach a site plan showing the asbestos disposal area. **Attachment F**	
	2	**Plan view drawings** with contour lines <u>and</u> cross sections that show:	18 AAC 60.210(b)(3) 18 AAC 60.210(b)(4)
X	(a)	Any planned excavations before waste cell construction. **Attachment G – To Follow Awaiting for Engineer's report**	
X	(b)	All roads, ditches, trenches, and berms associated with the landfill. **Attachment G – To Follow Awaiting engineer's report**	
	(c)	Any planned leachate collection piping system, including manholes and pump stations. **N/A**	
	(d)	Any planned gas venting or gas collection piping system. **N/A**	
	3	**Construction detail drawings <u>and</u> cross sections** that show:	18 AAC 60.210(b)(3) 18 AAC 60.225 18 AAC 60.330
X	(a)	Liner construction details, including cover and liner anchors, liner penetrations, etc. **Attachment H**	
	(b)	Storm water drainage structures, culverts, and other surface water control devices. **N/A**	
LANDFILL CLOSURE DRAWINGS:			18 AAC 60.210(b)(3)(E) 18 AAC 60.395
X	4	**Conceptual drawings** of the facility after closure is completed. **Attachment I**	

Part Six – Facility Design (continued)

NOTE: Supporting calculations and data for both the design and closure of the landfill must be attached to the permit application and include the information shown in the following table.

✓	#	Requirement – supporting calculations and data must include:	Regulatory Citation
	5	**Design calculations, data, and documentation** must include:	18 AAC 60.210(b)(3) 18 AAC 60.210(b)(4) 18 AAC 60.210(c) 18 AAC 60.227(b) 18 AAC 60.320(a) 18 AAC 60.320(b) 18 AAC 60.330(b) 18 AAC 60.330(c)
X	(a)	Printouts of inputs, assumptions, and outputs from any computer model used to support the facility design. **Attachment J**	
X	(b)	An estimate (including calculations) of the maximum inventory of wastes that will be onsite over the life of the facility. **Attachment K**	
X	(c)	An explanation (including calculations) of the expected usable life of the facility. **Attachment K**	
	(d)	If located on permafrost, documentation showing that the permafrost will remain frozen to the greatest extent practical. **N/A**	
	(e)	If located in an unstable area, attach information and calculations for engineering measures to ensure the integrity of the structural components will be protected. **N/A**	
	(f)	If located in a seismic impact zone, attach documentation showing how the requirements of 18 AAC 60.320(a)(1) and (2) will be met. **N/A**	
	(g)	For a new landfill or lateral expansion of an existing landfill, provide data and calculations showing how the requirements of 18 AAC 60.330(b)(1) and (2) will be met. **N/A**	
X	(h)	Information and calculations used to estimate the permeability and maximum anticipated depth of leachate over any proposed liner. **Attachment L**	
X	(i)	A Quality Assurance Plan for the liner installation. **Attachment M**	
X	6	All design documents must be stamped and sealed by a registered engineer.	18 AAC 60.210(c)

Part Seven – Operations Plan

The operations plan should provide sufficient detail and information that a landfill operator could use to perform all required tasks for day-to-day operation of the landfill. The operations plan is a flexible document that should be reviewed annually and updated/modified, as necessary. The following table represents the minimum requirements to be included in an operations plan. Additional information should be added, as needed, to ensure the facility operates in compliance with the State Solid Waste Regulations. A copy of the operations plan should be kept at the landfill facility.

✓	#	Requirement - operations plan must include:	Regulatory Citation
	1	**Access control -** must include a description of how:	18 AAC 60.210(b)(3)(C) 18 AAC 60.220
X	(a)	access to the facility will be controlled, including gates, fences, berms, or other means of preventing access, hours of operation, signage, and other control measures. **Attachment N**	
X	(b)	prohibited activities such as target practice or off road vehicle use will be prevented. **Attachment N**	
X	(c)	salvaging practices, if allowed, will not interfere with facility operations, create a safety hazard, or cause pollution. **Attachment N**	
X	(d)	access and onsite roads will be kept passable and safe for vehicles year round. **Attachment N**	
	2	**Waste acceptance and handling policy** must include a description of:	18 AAC 60.210(b)(3)(C) 18 AAC 60.240(a) 18 AAC 60.240(b) 18 AAC 60.360 18 AAC 60.365
X	(a)	waste screening procedures to ensure no prohibited or unacceptable wastes are disposed in the facility. **Attachment N**	
X	(b)	any signage placed at the facility entrance. **Attachment N**	
	(c)	any waste processing procedures prior to disposal. **Not Applicable**	
	3	**Waste placement plan** must include a description of:	18 AAC 60.210(b)(3)(B) 18 AAC 60.210(b)(3)(C) 18 AAC 60.225(a)
X	(a)	waste placement methods. **Attachment N**	
X	(b)	planned progression of the working face, including landfill development over the life of the facility (diagrams are acceptable). **Attachment N**	
X	(c)	how unstable slopes will be avoided. **Attachment N**	
	4	**Daily Cover plan** must include information about:	18 AAC 60.210(b)(3)(B) 18 AAC 60.210(b)(3)(C) 18 AAC 60.340
X	(a)	The type of cover material(s) that will be used, and for each type of cover, describe: • where the cover material will be obtained and stored; • the frequency with which the cover will be applied; and • the depth of cover that will be applied. **Attachment N**	

Part Seven: Operations Plan (continued)

✓	#	Requirement - operations plan must include:	Regulatory Citation
	5	**Litter, vector, and nuisance control plan** must include:	18 AAC 60.210(b)(3)(C) 18 AAC 60.210(b)(3)(D) 18 AAC 60.230(a) 18 AAC 60.233(2) AS 46.06.080
X	(a)	procedures to ensure wildlife and domestic animals do not endanger the public or landfill staff, are not harmed by contact with the waste, and do not become a nuisance. **Attachment N**	
X	(b)	procedures to control dust, odor, noise, traffic, litter, disease vectors, and other effects from facility operations so they do not become a nuisance or hazard outside of the facility boundary. **Attachment N**	
	6	**RACM Cell Operations (if applicable)** must include a description or explanation of the following:	18 AAC 60.210(b)(3)(C) 18 AAC 60.240(a) 18 AAC 60.240(b) 18 AAC 60.420(b) 18 AAC 60.450(c) 18 AAC 60.450(d)
X	(a)	Waste acceptance and handling - must include a description of:	
X	(b)	waste screening procedures to ensure no prohibited or unacceptable wastes are disposed in the facility. **Attachment N**	
X	(c)	any signage placed at the facility entrance. **Attachment N**	
X	(d)	waste inspection procedures to ensure: o proper containment in leak-proof bags; o bags are properly labeled; and o all bags are accompanied by complete and accurate shipping records. **Attachment N**	
X	(e)	waste handling procedures to prevent breaking of bags or release of asbestos fibers. **Attachment N**	
X	(f)	Daily cover - include information about: The type of cover material(s) that will be used, describe: o where the cover material will be obtained and stored; o the frequency with which the cover will be applied (must be within 24 hours of waste placement); and o the depth of cover that will be applied (minimum of 6 inches) **Attachment N**	
	7	**Corrective action plan** must include procedures for immediately:	18 AAC 60.210(b)(3)(C) 18 AAC 60.210(b)(3)(D) 18 AAC 60.815(a)
X	(a)	• cleaning up any improper or unauthorized waste disposal; • repairing any damage to the facility or structures; and • addressing any violations of regulations or permit conditions. **Attachment N**	
X	8	**Operator training** – a description of how the landfill manager will ensure the requirements of 18 AAC 60.335 will be met (at least one qualified landfill operator or manager is on the facility staff at all times). **Attachment N**	18 AAC 60.235(a)(2) 18 AAC 60.335

Part Seven: Operations Plan (continued)

✓	#	Requirement - operations plan must include:	Regulatory Citation
X	9	**Operating record** – Please state where the operating record for the facility will be kept. NOTE: The operating record must contain all documentation listed in 18 AAC 60.235, and be retained in a location readily accessible to DEC and facility employee Kept in landfill manager's office_________________	18 AAC 60.235 18 AAC 60.450

Part Eight – Monitoring Plan

The monitoring plan must include sufficient detail to adequately perform all tasks required for field monitoring and sampling, submit samples to a laboratory with a complete list of parameters to be analyzed, and prepare a monitoring report with all of the information required by DEC.

✓	#	Requirement - monitoring plan must include:	Regulatory Citation
	1	**Visual monitoring plan**. Must include:	18 AAC 60.210(b)(3)(D) 18 AAC 60.800(a)
X	(a)	A description of the procedures for visual monitoring of the landfill. **Attachment O**	
X	(b)	A checklist or visual monitoring form including all items in 18 AAC 60.800(a). **Attachment O**	
	2	**Surface water monitoring plan** (if required by DEC) must include:	18 AAC 60.210(b)(3)(D) 18 AAC 60.810 18 AAC 60.840
X	(a)	Brief information about topography and surface water flow at the landfill. **Attachment O**	
X	(b)	A detailed map showing permanent sampling site locations. **Attachment O**	
X	(c)	Identification and information about background and compliance sampling sites, including documentation showing why the site was chosen. **Attachment O**	
X	(d)	Specific information about sampling frequency and schedules. **Attachment O**	
X	(e)	A proposed list of constituents for which samples will be analyzed. **Attachment O**	
X	(f)	Detailed monitoring procedures outlined in 18 AAC 60.810(e). **Attachment O**	
X	(g)	A statement that monitoring reports will be submitted to DEC within 60 days of receiving laboratory data or by the date(s) stipulated in the permit. **Attachment O**	
	3	**Groundwater monitoring plan** (if applicable) must include:	18 AAC 60.210(b)(3)(D) 18 AAC 60.217 18 AAC 60.820 18 AAC 60.825 18 AAC 60.830 18 AAC 60.840
X	(a)	Information about hydrology at the landfill including depth to groundwater, direction and velocity of flow, with supporting documentation. **Attachment O**	
X	(b)	A detailed map showing well locations and groundwater flow direction and rate. **Attachment O**	
X	(c)	Identification and information about background and compliance wells. **Attachment O**	
X	(d)	An explanation of how each groundwater monitoring well location was selected, including documentation such as geophysical reports, survey data, or maps, well drilling logs, soil boring logs, or any other data used to evaluate subsurface conditions at the site and to determine monitoring well placement. **Attachment O**	
X	(e)	Specific information about sampling frequency and schedules.	

X	(f)	A list of constituents for which samples must be analyzed. **Attachment O**	
X	(g)	Information about statistical methods that will be used in statistical analysis of the analytical data. **Attachment O**	

Part Eight – Monitoring Plan (continued)

✓	#	Requirement - monitoring plan must include:	Regulatory Citation
X	(h)	A Quality Assurance and Quality Control Plan providing specific details about sampling and testing methodology. **Attachment O**	
X	(i)	A statement that monitoring reports will be submitted to DEC within 60 days of receiving laboratory data or by the date(s) stipulated in the permit. **Attachment O**	
X	(j)	A statement that monitoring reports will be submitted to DEC in the approved format, as shown on the "Groundwater Monitoring Report Format" fact sheet, available at DEC offices, or on the Solid Waste Program website. **Attachment O**	
	4	**Explosive gas monitoring plan** (if applicable) must include:	18 AAC 60.210(b)(3)(D) 18 AAC 60.350
X	(a)	Identification and information about the construction and placement of gas monitoring wells and other monitoring sites. **Attachment O**	
X	(b)	A detailed map showing gas well and other monitoring locations, and all structures on and within one-quarter mile of the landfill. **Attachment O**	
X	(c)	Specific information about sampling frequency and schedules. **Attachment O**	
X	(d)	Information about equipment and procedures used for methane concentration measurements. **Attachment O**	
X	(e)	Information about how methane levels will be reported to DEC. **Attachment O**	
X	(f)	A statement that DEC will be notified immediately if levels exceed limits listed in 18 AAC 60.350. **Attachment O**	
	5	**Thermal monitoring plan** (if applicable) must include:	18 AAC 60.210(b)(3)(D) 18 AAC 60.227 18 AAC 60.228(b)
	(a)	Identification and information about the construction and placement of thermal monitoring wells, and sampling frequency or schedules.	
	(b)	A detailed map showing thermal monitoring well locations.	
	(c)	Information about equipment and procedures used for thermal monitoring.	
	(d)	Information about how thermal monitoring results will be reported to DEC.	
	6	**Slope stability monitoring plan** (if required by DEC) must include:	18 AAC 60.210(b)(3)(D) 18 AAC 60.320
X	(a)	Identification and information about the type and location of all monitoring points, and sampling frequency or schedules. **Attachment R**	
	(b)	A detailed map showing monitoring monument locations.	
X	(c)	Information about equipment and procedures used for monitoring. **Attachment R**	

X	(d)	Information about how slope stability monitoring results will be evaluated. Attachment R	
X	(e)	Information about how slope stability monitoring results and analysis will be reported to DEC. **Attachment R**	

Part Nine - Closure Plan and Cost Estimate

It is understood that the closure plan submitted with the permit application will be conceptual, and may change throughout the active life of the facility. If the landfill is within 5 years of closure, a detailed closure plan must be submitted and approved by DEC.

✓	#	Requirement - closure plan must include:	Regulatory Citation
	1	**A description of the closure process** for the facility must include:	18 AAC 60.210(b)(3)(E) 18 AAC 60.210(b)(6) 18 AAC 60.245 18 AAC 60.270 18 AAC 60.395 18 AAC 60.397(c)(3)
X	(a)	A description of the final cover and appearance of the facility meeting the standards of 18 AAC 60.395. **Attachment P**	
X	(b)	A description of the methods and procedures for final cover installation. **Attachment P**	
X	(c)	A timeline or schedule for all activities needed to complete closure. **Attachment P**	
X	(d)	A description of the anticipated post closure (future) use of the property. **Attachment P**	
X	(e)	A description and map of proposed survey monuments or permanent markers. **Attachment P**	
X	(f)	A statement of how DEC will be notified that the requirements of 18 AAC 60.270 and 18 AAC 60.395 have been met. **Attachment P**	
	2	**Financial information** must include:	18 AAC 60.210(b)(5) 18 AAC 60.210(b)(3)(F) 18 AAC 60.265
X	(a)	The total present-day equivalent cost estimates for closing the facility. **Attachment Q**	
X	(b)	The total present-day equivalent cost estimates for post-closure care of the facility. **Attachment Q**	
X	(c)	Detailed proof of financial responsibility to cover the cost of closing the landfill and post closure care. **Attachment Q**	

Part Ten - Waiver Requests and Justification

NOTE: 18 AAC 60.900 allows DEC to grant an exemption from any regulation not required by federal law.

✓	#	Requirement - waiver requests must include:	Regulatory Citation
	1	A list of each regulation you are requesting a waiver from, and a detailed justification for each, as described in 18 AAC 60.900.	18 AAC 60.210(b)(1)(D) 18 AAC 60.900
	2	Note - Each waiver request increases the permit application fee by the amount listed on Table I-2 of 18 AAC 60.700.	18 AAC 60.700

MATANUSKA-SUSITNA BOROUGH
Public Works Department
Solid Waste Division
350 East Dahlia Avenue • Palmer, AK 99645
Phone (907) 746-2841 • Fax (907) 746-2847
E-Mail Ggoodale@matsugov.us

CENTRAL LANDFILL, SOLID WASTE PERMIT
SWMSB 00119862010MA

October 22, 2010

Lori Aldrich
Solid Waste Program Coordinator
Alaska Department of Environmental Conservation
555 Cordova Street
Anchorage, Alaska 99501

Subject: Matanuska-Susitna Borough Central Landfill
Renewal of Solid Waste Permit # SWMSB00119862010MA

Dear Ms. Aldrich

Attached is the application for renewal of Matanuska-Susitna Borough's Central Landfill permit. The application is for a lined municipal waste cell with a leachate collection system, a construction and demolition (C&D) cell and asbestos disposal cell.

The Central Landfill is a class I municipal solid waste landfill (MSWLF) as defined by 18 ACC 60.300(c). The landfill serves a population of approximately 85,000 and accepts for disposal an average of about 160 tons per day of municipal solid waste (MSW) approximately 30 tons per day of C&D and 90 tons of asbestos per year. We are requesting a single solid waste permit for all waste disposal units within this facility.

A general description of the site topography, geology, climate, surface hydrology, and groundwater hydrology is as follows. The landfill is located on a 620 acre parcel of land designated by the Matanuska-Susitna Borough Resolution 89-182 for sanitary landfill purposes. The topography of the parcel is characterized by hilly terrain. The surface of the property varies in elevation 140 to 300 feet above sea level. The general geology of the property is characterized by gravel moraine soils with a silty loess layer about one to five feet deep over the surface. A clay or silty clay confining layer is located at a depth of about 30 to 195 feet below the surface, depending upon location. The climate is relatively dry, with an average annual precipitation rate below 16 inches. Mean monthly temperatures in summer months are 56 degrees Fahrenheit (F) and 15 degrees F in the winter. The surface hydrology is characterized by well draining soils with no stream or lakes. A small ephemeral pond in located in the southern undeveloped portion of the property. The ground water hydrology is characterized by two primary aquifers. The upper unconfined aquifer consists of sand and gravel underlain by a think clay layer or silty clay aquitard. The surface of the aquitard generally slopes to the south at about a 2 percent grade, but becomes much steeper near the southern limits of the property. Monitoring wells are screened in the upper unconfined aquifer. The confined aquifer is artesian with a hydraulic gradient upward and to the south. The Borough has taken into account all applicable local ordinances, zoning requirements, and the Alaska Coastal Management Program requirements of 6 AAC 50.

The Matanuska-Susitna Borough's Solid Waste Management Plan was approved on November 17^{th} 2003 by Mr. Jason Weigle and remains our active management planning document.

Please feel free to contact me with any questions or comments you might have regarding this renewal application.

Sincerely,

Greg Goodale
Solid Waste Division Manager

2007-015485-0
Recording Dist: 311 - Palmer
6/22/2007 2:47 PM Pages: 1 of 3

A
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cc

WAIVER RESOLUTION SERIAL NO. 2007-081-PWm
MATANUSKA-SUSITNA BOROUGH
Platting Authority

A RESOLUTION OF THE PLATTING AUTHORITY WHICH APPROVES THE WAIVING OF THE PLATTING REQUIREMENTS SET FORTH IN MATANUSKA-SUSITNA BOROUGH, TITLE 16 SUBDIVISION REGULATIONS, TO PERSONS NOTED BELOW, FOR THE DIVISION OF THAT PROPERTY DESCRIBED MORE PARTICULARLY HEREIN.

WHEREAS, the applicant(s) **MATANUSKA-SUSITNA BOROUGH,** did make application to waive the preparation, submission for approval and recording of a plat, following the proper procedures as established by the Platting Authority for processing such requests, and

WHEREAS, satisfactory evidence has been submitted that a conveyance of a part of a larger tract, described as:

PARENT PARCEL: Parcel #2 of MSB Waiver 86-67-PWd as filed of record as 86-18W and refilled 87-6W on February 11, 1987 located in Sections 1 & 2, 11 & 12, Township 17 North, Range 1 East, Seward Meridian, Alaska, located in the Palmer Recording District, containing 640 acres, and more particularly described *on Page 3.*

WHEREAS, the tract(s) parcel(s) lot(s) created from the above described parcel are described as follows:

Parcel 1 See Page 3
Parcel 2 See Page 3

WHEREAS, the applicant has complied with all the requirements set forth in Matanuska-Susitna Borough, Title 16, Chapter 16.15.022 B Waivers, and the Matanuska-Susitna Borough Coastal Management Plan, except as indicated on page 2 of this Resolution, if any:

NOW THEREFORE, BE IT RESOLVED that the Platting Authority for the Matanuska-Susitna Borough does grant a waiver of the platting requirement for the aforedescribed tract:

APPROVED AND ADOPTED BY THE MATANUSKA-SUSITNA BOROUGH PLATTING AUTHORITY THIS ____ DAY OF JUNE 2007.

ATTEST:

MATANUSKA-SUSITNA-BOROUGH SEAL STATE OF ALASKA PLATTING BOARD

Marilyn McGuire
PLATTING CLERK,
MARILYN MCGUIRE

PLANNING & LAND USE DIRECTOR
M. MURPH O'BRIEN

Central Landfill 2010 Permit Application
Attachment B

LEGAL DESCRIPTION

Parent Parcel: Parcel #2 Waiver Resolution Serial No. 86-67-PWd , Re-filed to correct the acreage as Waiver Resolution Serial No. 86-184W and recorded February 11, 1987 as Waiver No. 87-6W.
Parcel #2 (as corrected):
S½ Section 1, E½ SE¼ Section 2, NE¼ NE¼, E½ NW¼ NE¼, N½ SE¼ NE¼ Section 11, N½ NW¼, N½ SW¼ NW¼, N½ SE¼ NW¼, NW¼ NE¼ Section 12, Township 17 North, Range 1 East, Seward Meridian, Alaska and containing approximately 640 acres more or less.

New Parcel #1
NW¼ SW¼ Section 1, N. 1232' of the E½ SE¼ Section 2, Township 17 North, Range 1 East, Seward Meridian, Alaska and containing approximately 77 acres more or less.

New Parcel #2
S½ Section 1, E½ SE¼ Section 2, NE¼ NE¼, E½ NW¼ NE¼, N½ SE¼ NE¼ Section 11, N½ NW¼, N½ SW¼ NW¼, N½ SE¼ NW¼, NW¼ NE¼ Section 12, Township 17 North, Range 1 East, Seward Meridian, Alaska Excepting Parcel #1 and containing approximately 563 acres more or less.

MATANUSKA-SUSITNA BOROUGH

2007085

Application for Waiver of Platting Requirements
(Please type or clearly print)

APPLICANT: MATANUSKA-SUSITNA BOROUGH Phone: KENT CRAFTON 746-2856
(Applicant must be owner of property)

ADDRESS: 350 E. DAHLIA AVENUE PALMER, AK 99645
Zip Code

Mortgagor: N/A
Zip Code

Address:

Description of parent parcel (OR see attached deed): PARCEL #2
MSB WAIVER 86-67-PWd AS FILED OF RECORD AS 86-184W &
REFILED 87-6W ON 2-11-87 * (PALMER) Recording District.

Acreage must be indicated: (Parent Parcel) 640 AC. ± Date: 2-11-87

Book: Page: and/or Serial # 87-003197 of deed attached, showing ownership of property. * LOCATED W/IN SECTIONS 1, 2, 11 & 12 T17N, R 1E, S.M AK

Description of parcels as they will exist after waiver approval (OR attach separate sheet(s)):
SEE ATTACHED

Acreage of each parcel must be indicated: PARCEL # 1 = 77 AC., PARCEL #2 = 583 AC.

Parcels described by metes and bounds must be certified by a registered land surveyor:

Name: Phone #:

Address: Zip Code:

Will all parcels created have legal & physical access to a public road system?

50' road easements must be documented and attached when applicable.

See page 6, #6, for parcels requiring access off of a state maintained ROW.

Name of Road: N. 49TH STATE ST. / N. LOMA PRIETA DR.

Width of Road: 80' / 60'

Type of Road: PAVED / PAVED

Are all proposed parcels within 2,640' of a publicly recorded survey marker and referenced thereto?

YES ☑ NO ☐

Utility easements to all parcels being created approved by:

MEA: (attached)

MTA: (attached)

ENSTAR: (if in service area)

MATANUSKA-SUSITNA BOROUGH

Application for Waiver of Platting Requirements
(Please type or clearly print)

APPLICANT: MATANUSKA-SUSITNA BOROUGH Phone: KENT CRAFTON 746-2856
(Applicant must be owner of property)

ADDRESS: 350 E. DAHLIA AVENUE PALMER, AK 99645
Zip Code

Mortgagor: N/A
Zip Code

Address:

Description of parent parcel (OR see attached deed): SEE ATTACHED

( ) Recording District.

Acreage must be indicated: (Parent Parcel) 640 AC. Date: 2-11-87

Book: Page: and/or Serial # 87-003197 of deed attached, showing ownership of property.

Description of parcels as they will exist after waiver approval (OR attach separate sheet(s)):
SEE ATTACHED

Acreage of each parcel must be indicated: PARCEL # 1 = 77 AC., PARCEL #2 = 583 AC.

Parcels described by metes and bounds must be certified by a registered land surveyor:

Name: Phone #:

Address: Zip Code:

Will all parcels created have legal & physical access to a public road system?

50' road easements must be documented and attached when applicable.

See page 6, #6, for parcels requiring access off of a state maintained ROW.

Name of Road: N. 49TH STATE ST. / N. LOMA PRIETA DR.

Width of Road: 80' / 60'

Type of Road: PAVED / PAVED

Are all proposed parcels within 2,640' of a publicly recorded survey marker and referenced thereto?

YES ☑ NO ☐

Utility easements to all parcels being created approved by:

MEA:

MTA: 3-16-07 MTA-OK B. Bailey

ENSTAR: (if in service area)

This application is accompanied by: (Indicate by X)

NA EXEMPT (A) Certification that all taxes (and special assessments, including LIDs) levied on the property or to be levied <u>through the year of application are paid</u> and/or security deposited by cashiers check, money order or cash. <u>Tax sheet to be completed by Platting Staff after waiver is submitted.</u>

☑ (B) A neat, legible drawing on 8½" x 11" paper or even increment thereof, showing location of markers, recorded easements, improvements, existing utility lines and roads, boundaries of deed attached and proposed parcel boundaries, nearest public road location, north arrow, section, township and range.

☑ (C) Copy of deed whereby applicant gained title to his/her property.

☑ (D) Proof of recorded utility easement, or statement of how utility easements will be provided. Must be signed off by MEA, MTA & Enstar, if in service area, on Page 2.

☑ (E) $500.00 filing fee payable to the MATANUSKA-SUSITNA BOROUGH (Filing fee is not refundable.)

☐ (F) $__________ Recording Fee - check made payable to the DEPT. of NATURAL RESOURCES. (Fee to be determined by platting staff prior to time of recordation.)

NA (G) Soils information (Per MSB 16.20.280(B)(1), all parcels smaller than 400,000 S.F. (9.183 acres) need soils information provided by a Registered Engineer and must contain 20,000 S.F. of useable area.)

☑ (H) Flood Hazard Identification (Per MSB 17.29, all applications will include Flood Hazard Identification by Registered Civil Engineer or Registered Land Surveyor.)

This application is requested by: Matanuska-Susitna Borough

______________________	Marian Romano
Signature of Mortgagor	Signature of Owner Acting Borough Manager
______________________	______________________
Signature of Mortgagor	Signature of Owner
______________________	______________________
Signature of Mortgagor	Signature of Owner
______________________	______________________
Signature of Mortgagor	Signature of Owner

AFFIDAVIT

STATE OF ALASKA)
) ss
THIRD JUDICIAL DISTRICT)

Marien Romano, being duly sworn, deposes and says that the following access road: N. 49TH STATE ST., N. LOMA PRIETA DR. and shown on the attached application is a State maintained road or a borough road that has been constructed to Matanuska-Susitna Borough standards or is an existing road meeting borough standards, which are as follows:

1. Roadway traveled surface is a minimum of 18 feet in width and is comprised of gravel material to a minimum depth of 12 inches.

2. Roadway has no centerline grades in excess of 7% or MSB Dept. of Public Works has approved centerline grades in excess of 7 %.

3. Roadway as constructed, provides for the continuation of natural drainage and does not create ponding or water course concentration problems.

4. The roadway including any slopes, cuts, fills actually used for access is located entirely within the easement or right-of-way dedicated to the public or over other legal access as defined in 16.20.120 of Title 16.

5. Pioneer access right-of-way width shall be a minimum of fifty feet (50').

6. Access off of a State maintained road must be signed off by the State of Alaska, Dept. of Transportation.

The legal documentation for said road has been recorded in the ______________ Recording District, Date ______________, Book ______________ Page __________ and/or Serial # ______________

Should it be demonstrated that the road does not meet the requisite standards, such deviation from this affidavit is reason to withdraw approval of the application for which this affidavit is given.

Owner(s) Marian Romano ______________

Personally appeared Marian Romano, Acting Borough Manager of the Matanuska-Susitna Borough

Sworn to before me this 23rd day of March, 2007.

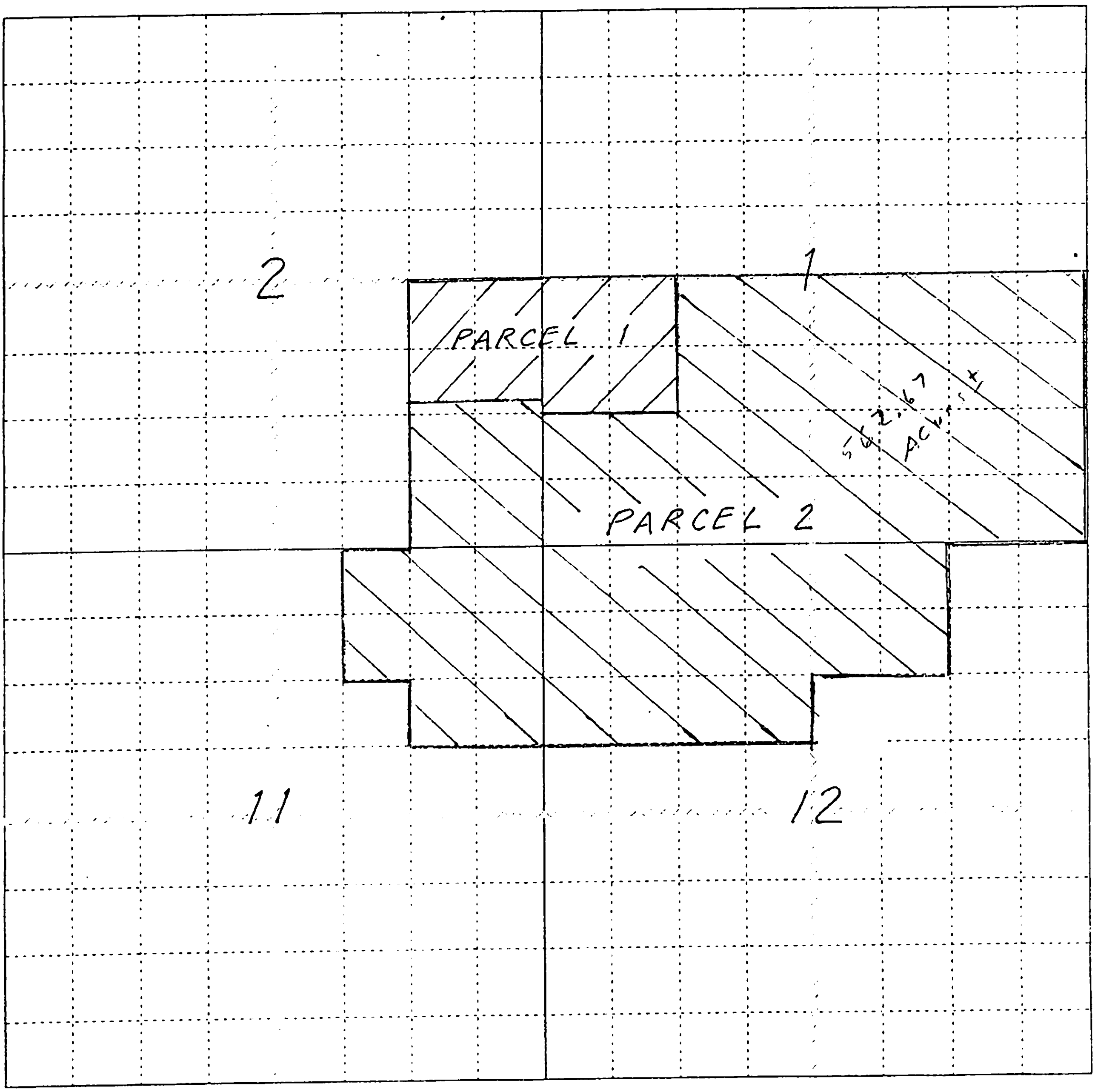
(Seal)

OFFICIAL SEAL
Alisha Deans
NOTARY PUBLIC-STATE OF ALASKA
My Comm. Expires: 1/10/2011

Alisha Deans
Notary Public for Alaska
My Commission Expires: 1/10/2011

MATANUSKA-SUSITNA BOROUGH

SECTION 1, 2, 11 & 12 TOWNSHIP 17 N RANGE 1 W, SEWARD MERIDIAN



2 MILE

NAME: MSB DATE: 03-16-07

Alaska
Rim
Engineering, Inc.

Phone (907) 745-0222
Fax (907) 746-0222
akrim@rogershsa.com

P.O. Box 2749
Palmer, Alaska 99645

March 16, 2007

Mr. Paul Hulbert
Matanuska-Susitna Borough
Platting Department
350 East Dahlia
Palmer, Alaska 99645

RECEIVED
MAR 22 2007
PLATTING DIV.

RE: MSB 17.29.160(A)(4)(f)- Flood Damage Prevention
Central Landfill
Tax Parcels: TP D2 & D3, Section 1; TP D2, Section 2; TP A1, Section 11; TP B3, Section 12; T17N; R01E; SM; AK
Client: Matanuska-Susitna Borough
Alaska Rim Reference No. 06-01083

Dear Mr. Hulbert:

The parent parcel is located on FEMA FIRM 9725 as indicated on the enclosed FIRMette. It is shown as being in Zone C, an area of minimal flooding.

There are no water bodies on or near the parent parcel and no significantly developed drainage areas in this glacial moraine area. The 1% recurrence interval precipitation event (BFE) would produce only very limited, localized, temporary accumulation of water in low area due to the lack of a developed drainage system and due to absorption of water by gravel soils in the moraine area.

Therefore, there is less than a one percent chance that any part of the platted area will be inundated by the BFE in any given year.

Sincerely,

ALASKA RIM ENGINEERING, INC.

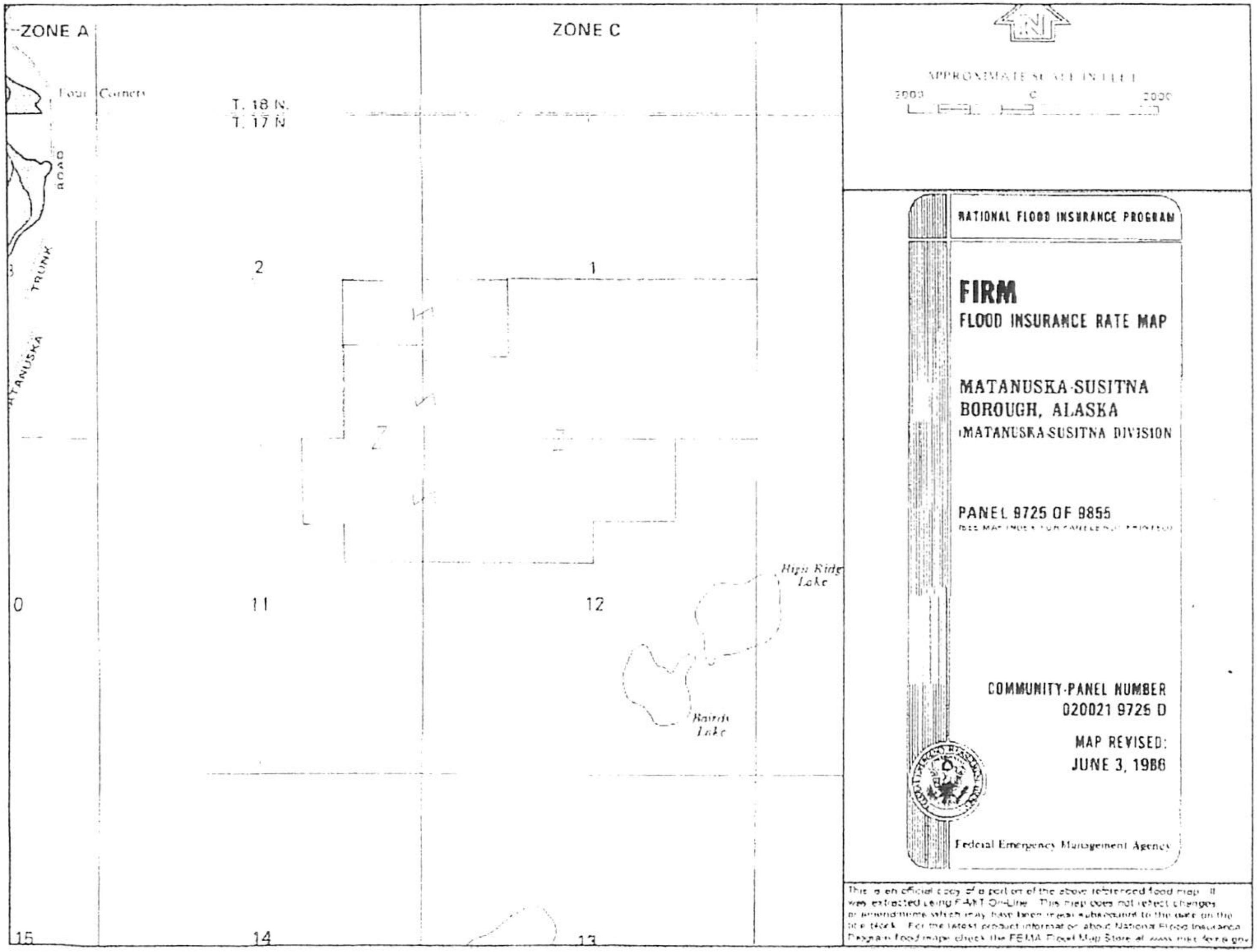
Kyle J. Cherry

Kyle J. Cherry, P.E.
Senior Engineer

STATE OF ALASKA
49TH
Kyle J. Cherry
CE-2116
3/16/07
REGISTERED PROFESSIONAL ENGINEER

ENCL: Waiver Drawing
Topographic Map w/Location of Project.
Aerial Photograph w/Location of Project
FIRMette from FEMA FIRM Panel 9725 w/Location of Project

CC: MSB
AK Rim File No. 06-01083


ZONE A
ZONE C
Four Corners
T. 18 N.
T. 17 N.
ROAD
TRUNK
MATANUSKA
2
1
11
12
15
14
13
High Ridge Lake
Bairds Lake
APPROXIMATE SCALE IN FEET
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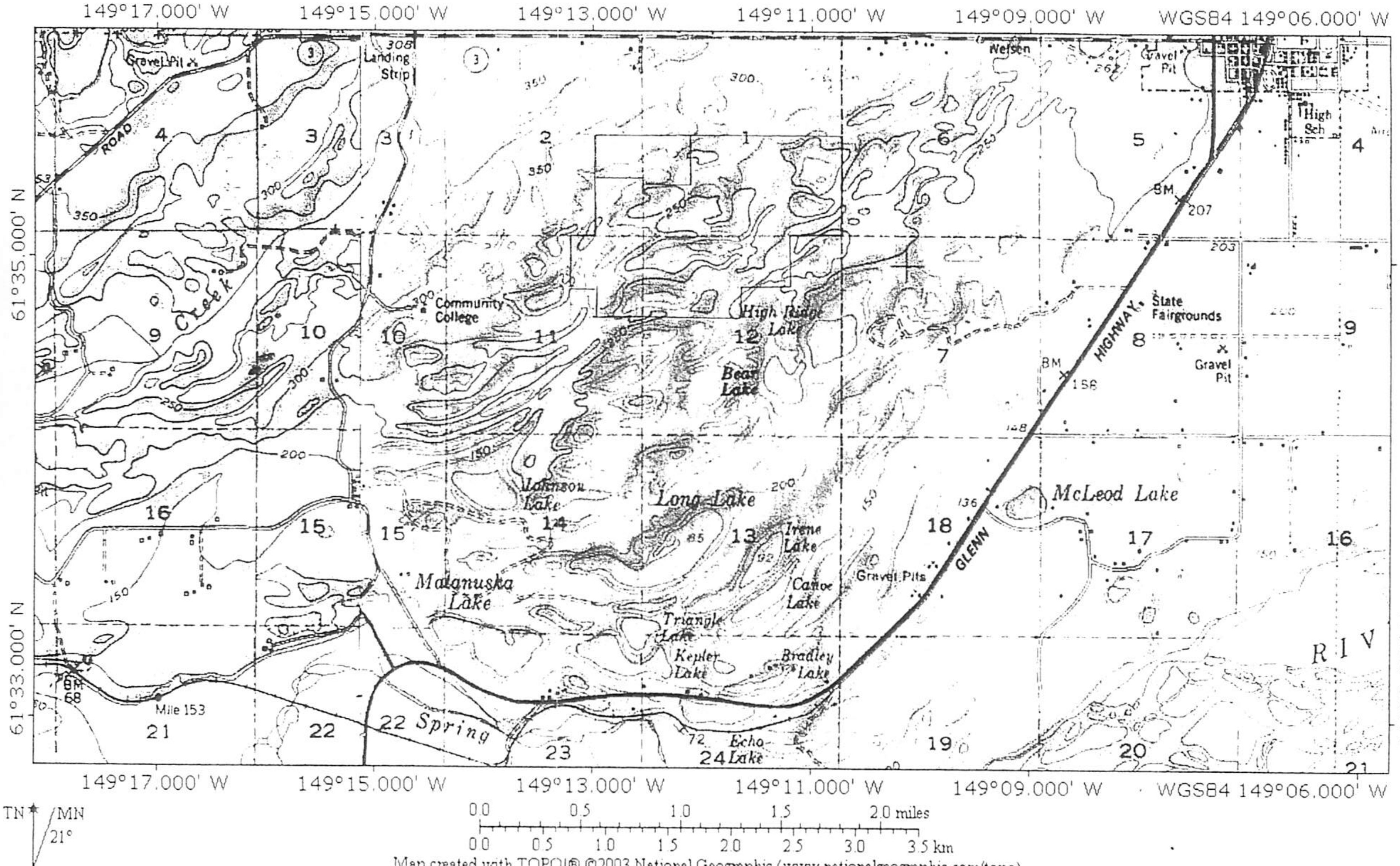
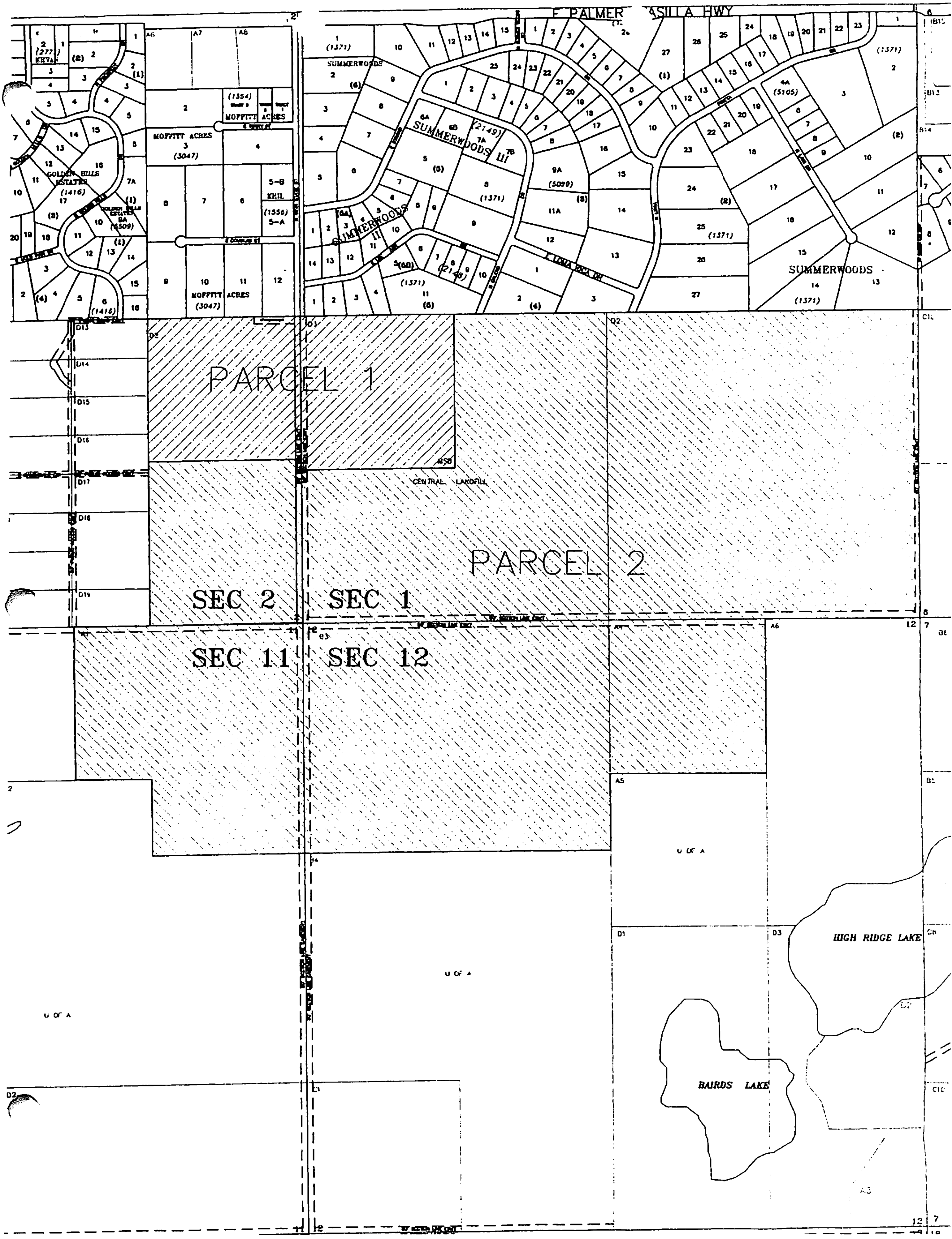
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
MATANUSKA-SUSITNA BOROUGH, ALASKA
(MATANUSKA-SUSITNA DIVISION
PANEL 9725 OF 9855
COMMUNITY-PANEL NUMBER
020021 9725 D
MAP REVISED:
JUNE 3, 1986
Federal Emergency Management Agency

TOPO! map printed on 03/14/07 from "Untitled.tpo"



Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)



E PALMER WASILLA HWY
SUMMERWOODS
SUMMERWOODS III
SUMMERWOODS II
MOFFITT ACRES
GOLDEN HILLS ESTATES
KEIL
PARCEL 1
PARCEL 2
CENTRAL LANDFILL
SEC 2
SEC 1
SEC 11
SEC 12
U OF A
HIGH RIDGE LAKE
BAIRDS LAKE

Central Landfill 2010 Permit Application
Attachment C

U.S. Department of Transportation
Federal Aviation Administration

Alaskan Region

222 W. 7th Avenue #14
Anchorage, Alaska
99513-7587

June 5, 2000

Mr. Henry Friedman
Project Manager
CH2MHILL
301 W Northern Lights Blvd. Suite 601
Anchorage, AK 99503-2648

REF:Mat-Su Central Landfill

Dear Mr. Friedman:

Thank you for submitting Federal Aviation Administration (FAA) Form 7460-1 notifying us of your proposed expansion of the Mat-Su Central Landfill. The FAA understands this landfill is located over 3.4 miles from the Palmer Municipal Airport.

We note in your letter of May 17, 2000, that a variety of birds are attracted to the landfill but stay close to the working face and have not been observed to flock into the airport airspace. Based upon the information you have provided and contingent upon the following actions, the FAA does not object to the expansion plans for the Mat-Su Central Landfill expansion.

1) Adequate cover is maintained daily over all organic material at the Mat-Su Central Landfill.

2) Report any bird strikes or other aircraft and wildlife incidents to the FAA.

If you have any further questions, please contact me at 271-5446.

Sincerely,

John Lovett, Project Manager
Programming and Planning Branch
Airports Division

Please Type or Print on This Form

Form Approved OMB No. 2120-0001

U.S. Department of Transportation
Federal Aviation Administration

Failure To Provide All Requested Information May Delay Processing of Your Notice

Notice of Proposed Construction or Alteration

FOR FAA USE ONLY
Aeronautical Study Number
- - -

1. Sponsor *(person, company, etc. proposing this action)* :
Attn. of: James Swing, Public Works Director
Name: Matanuska-Susitna Borough
Address: Public Works Department
350 East Dahlia Avenue
City: Palmer State: AK Zip: 99645
Telephone: (907) 745-9828 Fax: (907) 745-9825

2. Sponsor's Representative *(if other than #1)* :
Attn. of: Henry Friedman
Name: CH2M HILL
Address: 301 W. Northern Lights Boulevard
Suite 601
City: Anchorage State: AK Zip: 99503
Telephone: (907) 278-2551 Fax: (907) 257-2000

3. Notice of: ☐ New Construction ☒ Alteration ☐ Existing

4. Duration: ☒ Permanent ☐ Temporary (months, days)

5. Work Schedule: Beginning July 2000 End September 2001

6. Type: ☐ Antenna Tower ☐ Crane ☐ Building ☐ Power Line ☒ Landfill ☐ Water Tank ☐ Other

7. Marking/Painting and/or Lighting Preferred:
☐ Red Lights and Paint ☐ Dual - Red and Medium Intensity White
☐ White - Medium Intensity ☐ Dual - Red and High Intensity White
☐ White - High Intensity ☒ Other No Preference

8. FCC Antenna Structure Registration Number *(if applicable)*:
N/A

9. Latitude: 61° 35' 30. 00"

10. Longitude: 149° 12' 00. 00"

11. Datum: ☐ NAD 83 ☒ NAD 27 ☐ Other

12. Nearest: City: Palmer State: Alaska

13. Nearest Public-use (not private-use) or Military Airport or Heliport:
Palmer Municipal Landfill

14. Distance from #13. to Structure: 3.4 miles

15. Direction from #13. to Structure: Due West 260 degrees

16. Site Elevation *(AMSL)*: 290 ft.

17. Total Structure Height *(AGL)*: 40 ft.

18. Overall height (#16. + #17.) *(AMSL)*: 330 ft.

19. Previous FAA Aeronautical Study Number (if applicable):
N/A - OE

20. Description of Location: (Attach a USGS 7.5 minute Quadrangle Map with the precise site marked and any certified survey.)

The Mat-Su Central Landfill is located at the southern end of North 49th State Street (formerly Moffit Drive).

21. Complete Description of Proposal:

The proposed construction activity is a scheduled expansion of the existing Central Landfill. Regulation 14 CFR 77.13 requires a sponsor to notify the FAA of the proposed construction or expansion of a municipal landfill located near an airport. In addtion, state regulation 18 AAC 60.305(b) requires a landfill owner to notify the FAA of a proposed landfill lateral expansion located within a five mile radius of an airport runway end used by turbojet or piston type aircraft.

A new waste cell for construction and demolition waste will be constructed in the summer of 2000. A lateral expansion of the existing municipal waste cell will be constructed in the summer of 2001. The municipal landfill cell (2B) is estimated to reach its final design height of 330 feet above mean sea level in the year 2006 or 2007. A new expansion cell will be constructed before the active cell is full.

Although the landfill attracts seagulls in summer months, the birds at the landfill are not known to interfer with the approach or departure airspace of the Palmer Municipal Airport.

Frequency/Power (kW)	

Notice is required by 14 Code of Federal Regulations, part 77 pursuant to 49 U.S.C., Section 44718. Persons who knowingly and willingly violate the notice requirements of part 77 are subject to a civil penalty of $1,000 per day until the notice is received, pursuant to 49 U.S.C., section 46301 (a).

I hereby certify that all of the above statements made by me are true, complete, and correct to the best of my knowledge. In addition, I agree to mark and/or light the structure in accordance with established marking and lighting standards as necessary.

Date	Typed or Printed name and Title of Person Filing Notice	Signature
5/11/00	JAMES P. SWING	James P Swing

FAA Form 7460-1 (2-99) Supercedes Previous Edition

NSN: 0052-00-012-0008

INSTRUCTIONS FOR COMPLETING FAA FORM 7460-1

PLEASE TYPE or PRINT

ITEM #1. Please include the name, address, and phone number of a personal contact point as well as the company name.

ITEM #2. Please include the name, address, and phone number of a personal contact point as well as the company name.

ITEM #3. New Construction would be a structure that has not yet been built.

Alteration is a change to an existing structure such as the addition of a side mounted antenna, a change to the marking and lighting, a change to power and/or frequency, or a change to the height. The nature of the alternation shall be included in **ITEM #21** "Complete Description of Proposal".

Existing would be a correction to the latitude and/or longitude, a correction to the height, or if filing on an existing structure which has never been studied by the FAA. The reason for the notice shall be included in **ITEM #21** "Complete Description of Proposal".

ITEM #4. If Permanent, so indicate. If Temporary, such as a crane or drilling derrick, enter the estimated length of time the temporary structure will be up.

ITEM #5. Enter the date that construction is expected to start and the date that construction should be completed.

ITEM #6. Please indicate the type of structure. **DO NOT LEAVE BLANK.**

ITEM #7. In the event that obstruction marking and lighting is required, please indicate type desired. If no preference, check "other' and indicate "no preference'. **DO NOT LEAVE BLANK.** *NOTE: High intensity lighting shall be used only for structures over 500'AGL.* In the absence of high intensity lighting for structures over 500' AGL, marking is also required.

ITEM #8. If this is an existing tower that has been registered with the FCC, enter the FCC Antenna Structure Registration number here.

ITEM #9. and **#10.** Latitude and longitude must be geographic coordinates, accurate to within the nearest second or to the nearest hundredth of a second if known. Latitude and longitude derived solely from **a hand-held GPS instrument is NOT acceptable.** A hand-held GPS is only accurate to within 100 meters *(328 feet)* 95 per cent of the time. This data, when plotted, should match the site depiction submitted under **ITEM #20.**

ITEM #11. NAD 83 is preferred; however, latitude/longitude may be submitted in NAD 27. Also, in some geographic areas where NAD 27 and NAD 83 are not available other datums may be used. It is important to know which datum is used. **DO NOT LEAVE BLANK.**

ITEM #12. Enter the name of the nearest city/state to the site. If the structure is or will be in a city, enter the name of that city/state.

ITEM#13. Enter the full name of the nearest public-use (not private-use) airport (or heliport) or military airport (or heliport) to the site.

ITEM #14. Enter the distance **from** the airport or heliport listed in **#13 to the structure.**

ITEM #15. Enter the direction **from** the airport or heliport listed in **#13 to the structure.**

ITEM #16. Enter the site elevation above mean sea level and expressed in **whole feet** rounded to the nearest foot (e.g. 17' 3" rounds to 17', 17'6" rounds to 18'). This data should match the ground contour elevations for site depiction submitted under **ITEM #20.**

ITEM #17. Enter the total structure height **above ground level in whole feet** rounded to the **next highest foot** (e.g. 17'3" rounds to 18'). **The total structure height shall include anything mounted on top of the structure, such as antennas, obstruction lights, lightning rods, etc.**

ITEM #18. Enter the overall height above mean sea level and expressed in **whole feet.** This will be the total of **ITEM #16 + ITEM #17.**

ITEM #19. If an FAA aeronautical study was previously conducted, enter the previous study number.

ITEM #20. Enter the relationship of the structure to roads, airports, prominent terrain, existing structures, etc. Attach an 8-1/2" X 11" non-reduced copy of the appropriate 7.5 minute U.S. Geological Survey (USGS) Quadrangle Map MARKED WITH A PRECISE INDICATION OF THE SITE LOCATION. To obtain maps, Contact USGC at 1-800-435-7627 or via Internet at "http://mapping.usgs.gov". If available, attach a copy of a documented site survey with the surveyor's certification stating the amount of vertical and horizontal accuracy in feet.

ITEM #21.

- For transmitting stations, include maximum effective radiated power (ERP) and all frequencies.
- For antennas, include the type of antenna and center of radiation *(Attach the antenna pattern, if available).*
- For microwave, include azimuth relative to true north.
- For overhead wires or transmission lines, include size and configuration of wires and their supporting structures *(Attach depiction).*
- For **each** pole/support, include coordinates, site elevation, and structure height above ground level or water.
- For buildings, include site orientation, coordinates of **each** corner, dimensions, and construction materials,
- For alterations, explain the alteration thoroughly,
- For existing structures, thoroughly explain the reason for notifying the FAA *(e.g. corrections, no record of previous study, etc.).*

Filing this information with the FAA does not relieve the sponsor of this construction or alteration from complying with any other federal state or local rules or regulations. If you are not sure what other rules or regulations apply to your proposal, contact local/state aviation and zoning authorities.

Paperwork Reduction Work Act Statement: This information is collected to evaluate the effect of proposed construction or alteration on air navigation and is not confidential. Providing this information is mandatory for anyone proposing construction or alteration that meets or exceeds the criteria contained in 14 CFR , part 77. We estimate that the burden of this collection is an average 19 minutes per response. An agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless R displays a currently valid OMB control number. The OMB control number for this collection is 2120-0001.

TRUM# (D-14-12866)

THE STATE of ALASKA

GOVERNOR SEAN PARNELL

Department of Environmental Conservation

DIVISION OF ENVIRONMENTAL HEALTH
Solid Waste Program

555 Cordova Street
Anchorage, Alaska 99501
Phone: 907.269.7622
Fax: 907.269.7600

Certified Mail #7008 1830 0003 5207 8017
Return Receipt Requested

February 21, 2014

Terry Berger
Acting Solid Waste Manager
Matanuska-Susitna Borough
350 East Dahlia Avenue
Palmer, Alaska 99654

Subject: Waiver Request for Elevation of Palmer Central Landfill Cell 2A

Dear Mr. Berger:

The Alaska Department of Environmental Conservation (DEC) Solid Waste Program reviewed the Matanuska-Susitna Borough's (MSB's) waiver request, dated January 24, 2014, to raise the final elevation allowed in Palmer Central Landfill Cell 2A.

The change request was created to address Municipal Solid Waste Landfill (MSWLF) Permit SW1A007-15, Specific Condition in Facility Design; limiting vertical expansion of the landfill cells to 340 feet elevation. Cell 2A was originally surveyed using locally established datum, which DEC considered when developing the 340 feet height restriction for Cell 2A. This condition was included first in the MSWLF Permit No. 9922-BA003, issued in November 20, 2000, and then in each successive permit. The MSB has recently updated their datum to NAVD 88. When performing the survey for the Cell 2A Closure project a difference of approximately 8.5 feet between the previous datum and the NAVD 88 datum was discovered. The result is a corrected elevation of 348.5 feet, although it represents no actual physical change in elevation. To properly close Cell 2A, in compliance with the current closure plan, the height of the cell will need to be raised to 355 feet (NAVD 88).

DEC approves the waiver of the vertical expansion limit for Cell 2A to 355 feet (NAVD 88) under 18 AAC 60.900. MSB has shown that the proposed alternative action will provide equal environmental protection with the identified provision. ADEC finds that this is not a significant change to the landfill permit and does not require public notice. The change is reflected in the attached revised permit # SW1A007-15. MSB will need to submit a revised closure plan for each additional cell to show how closure of other cells will meet the 340 foot elevation or require modification for purposes of overall closure contours.

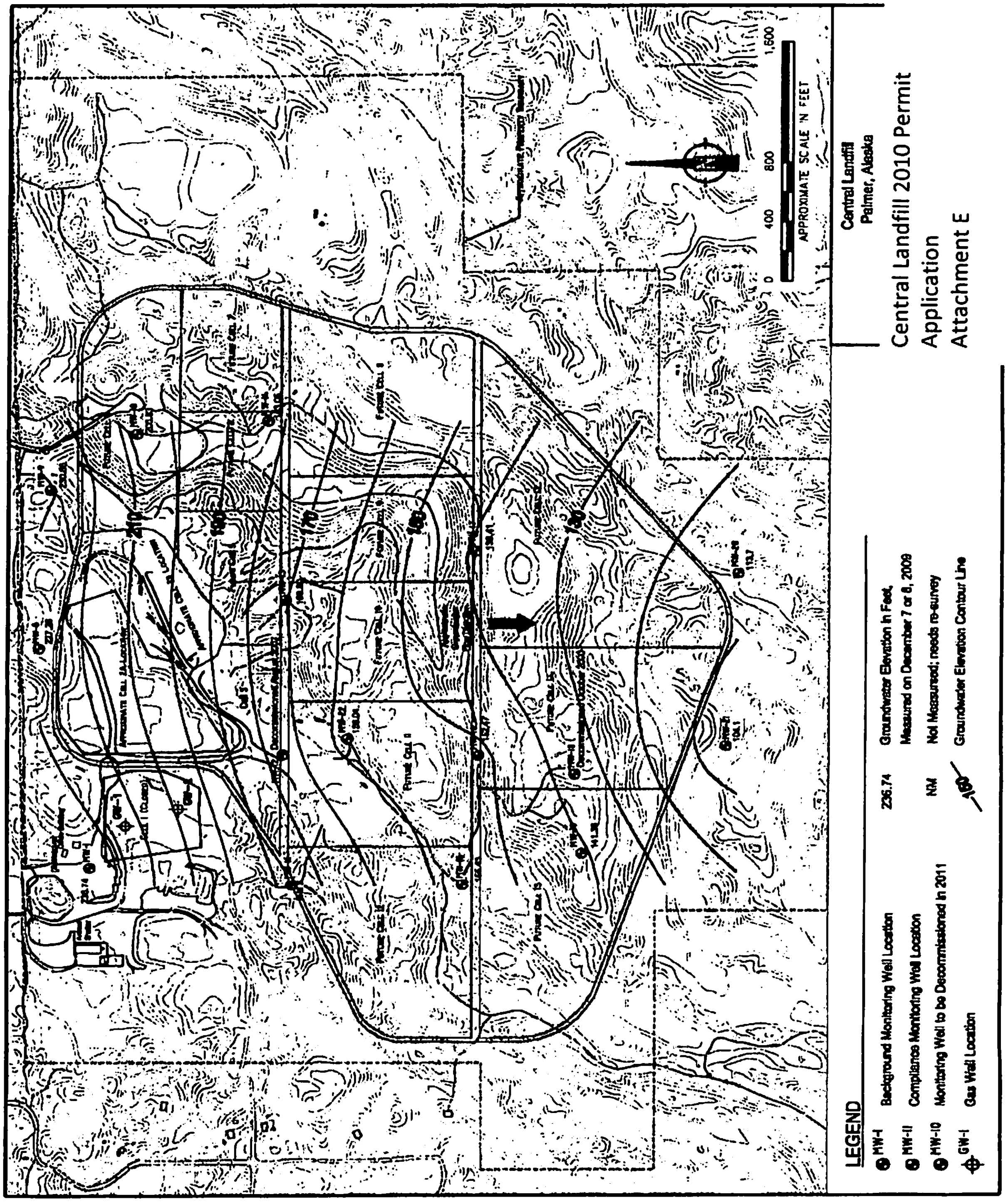
Any person who disagrees with this decision may request an adjudicatory hearing in accordance with 18 AAC 15.195 - 18 AAC 15.340 or an informal review by the Division Director in accordance with 18 AAC 15.185. **Informal review requests** must be delivered to the Division Director, Alaska Department of Environmental Conservation, 555 Cordova Street, Anchorage, AK 99501 within 15 days of the permit decision. **Adjudicatory hearing requests** must be delivered to the Commissioner of the Department of Environmental Conservation, 410 Willoughby Avenue, Suite 303, Juneau, Alaska 99801, within 30 days of the permit decision. If a hearing is not requested within 30 days, the right to appeal is waived. More information regarding submitting a request for an informal review or adjudicatory hearing may be found at www.dec.state.ak.us/commish/ReviewGuidance.htm. Even if an adjudicatory hearing has been requested and granted, all conditions remain in effect unless a stay has been granted.

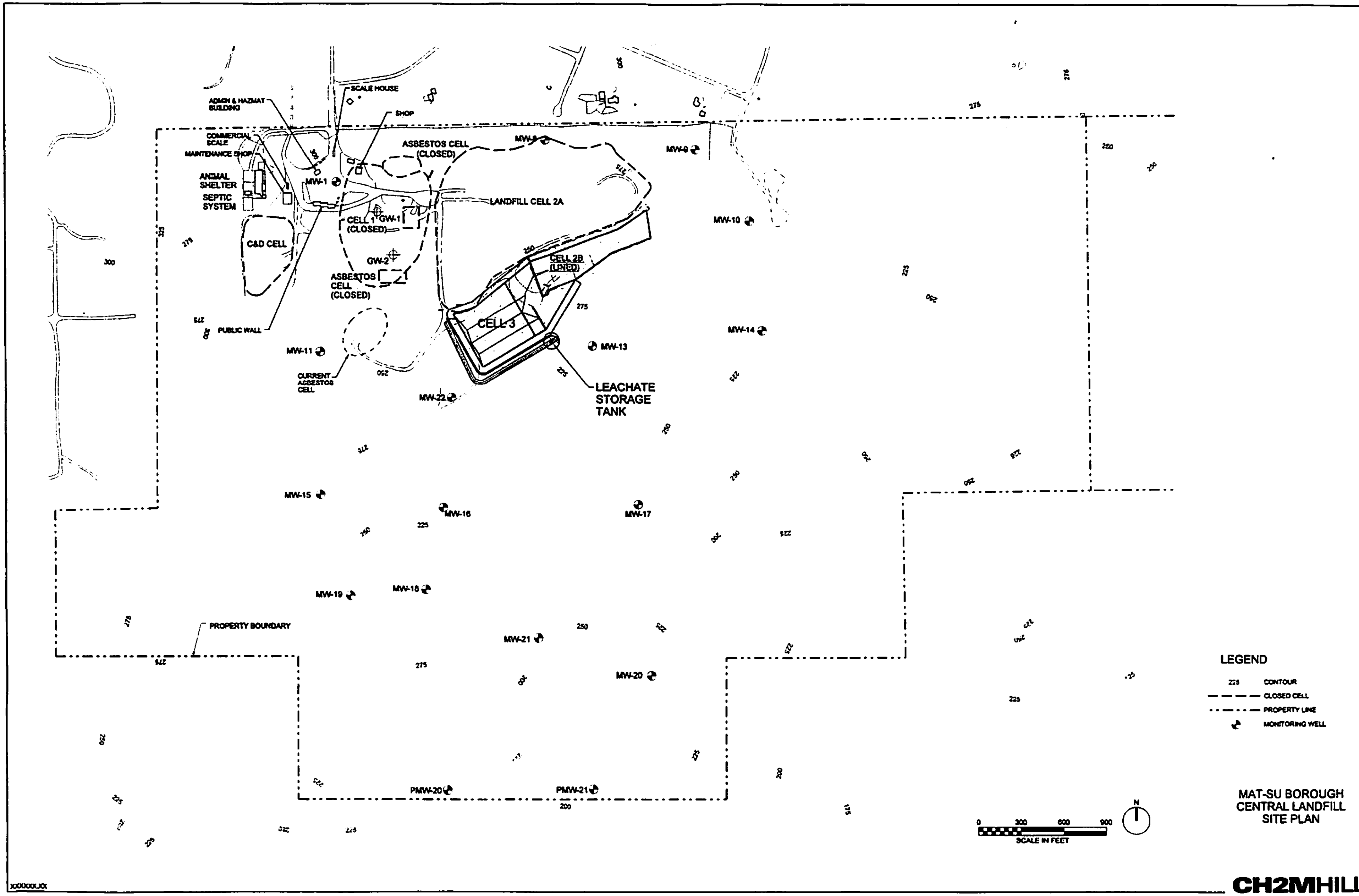
Sincerely,

Lori Aldrich
Solid Waste Program Regional Manager

Enclosure: Municipal Solid Waste Permit No. SW1A007-15

Figure 1


LEGEND
MW-I Background Monitoring Well Location
MW-II Compliance Monitoring Well Location
MW-10 Monitoring Well to be Decommissioned in 2011
GW-I Gas Well Location
236.74 Groundwater Elevation in Feet, Measured on December 7 or 8, 2009
N/M Not Measured; needs re-survey
Groundwater Elevation Contour Line
0 400 800 1,600
APPROXIMATE SCALE IN FEET
Central Landfill
Palmer, Alaska
Central Landfill 2010 Permit
Application
Attachment E



CH2MHILL.

Central Landfill 2010 Permit
Application
Attachment F

MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION
PALMER, ALASKA

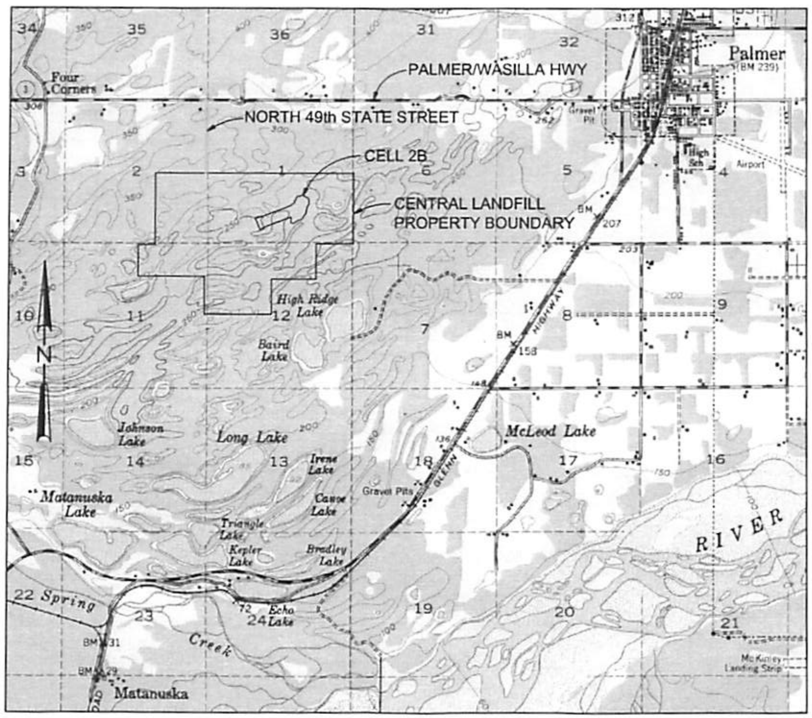
RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

THESE RECORD DRAWINGS HAVE BEEN PREPARED, IN PART, ON THE BASIS OF INFORMATION COMPILED BY OTHERS. THEY ARE NOT INTENDED TO REPRESENT IN DETAIL THE EXACT LOCATION, TYPE OF COMPONENT NOR MANNER OF CONSTRUCTION. BASED ON THE INFORMATION AVAILABLE TO ME THE PROVIDED DATA APPEARS TO REPRESENT THE PROJECT AS CONSTRUCTED. THE TRANSFER OF INFORMATION COMPILED BY OTHERS TO THESE RECORD DRAWINGS WERE CHECKED BY:

Revisions Checked by Cory Hinds Date June 8, 2005

JUNE 2004



LOCATION MAP
NTS

DRAWING INDEX

SHEET NO.	DRAWING NO.	DRAWING TITLE
1		COVER SHEET, LOCATION MAP, AND DRAWING INDEX
2	G1	LEGEND, ABBREVIATIONS, AND GENERAL NOTES
3	G2	SURVEY BASELINES
4	C1	CELL 2B EXCAVATION PLAN
5	L1	CELL 2B GCL/GEOMEMBRANE & LEACHATE COLLECTION PLAN
6	L2	CELL 2B FINAL GRADING PLAN
7	L3	CELL 2B LINER SECTIONS AND DETAILS
8	L4	CELL 2B LINER SECTIONS AND DETAILS
9	L5	CELL 2B BERM CONNECTION PLAN AND SECTION
10	LC1	CELL 2B LEACHATE COLLECTION SYSTEM, SECTIONS AND DETAIILS
11	LC2	CELL 2B LEACHATE CONTAINMENT BERM, PENETRATION DETAILS
12	LL1	CELL 2B LEACHATE STORAGE TANK, SITE PLAN AND DETAILS
13	LL2	CELL 2B LEACHATE STORAGE TANK, SECTIONS AND DETAILS
14	LL3	CELL 2B LEACHATE PUMPING STATION, SECTIONS AND DETAILS
15	LL4	CELL 2B LEACHATE STORAGE TANK SECTION PUMP ENCLOSURE DETAIL
16	LL5	CELL 2B LEACHATE PUMP AND CONTROL PLAN
17	LL6	CELL 2B DETAILS
18	GCL	PANEL LAYOUTS
19	TNK	UNDERGROUND STORAGE TANK
20	HTR	HEAT TRACE DETAIL
21	E1	CELL 2B ELECTRICAL SITE PLAN, ONE-LINE DIAGRAM AND PANELBOARD SCHEDULE
22	E2	CELL 2B LEACHATE STORAGE TANK, ELECTRICAL SITE PLAN AND DETAILS

CH2MHILL

ABBREVIATIONS

@	AT
A	AIR
AB	ANCHOR BOLT
AC	ASPHALT CONCRETE
ALT	ALTERNATE
ALUM	ALUMINIUM
APPROX	APPROXIMATE
BF	BUTTERFLY
BLDG	BUILDING
BM	BENCHMARK
BOT	BOTTOM
BTWN	BETWEEN
C	CHEMICAL
℄	CENTERLINE
CB	CATCH BASIN
CC	CENTER OF CURVE
CDF	CONTROLLED DENSITY FILL
CF	CUBIC FOOT(FEET)
CI	CAST IRON
CLR	CLEAR
CMP	CORRUGATED METAL PIPE
CO	CLEANOUT
COC	CENTER OF CONCRETE
COL	COLUMN
CONC	CONCRETE
CONN	CONNECTION
CONT	CONTINUED, CONTINUOUS
CP	SURVEY CONTROL POINT
CPEP	CORRUGATED POLYETHYLENE PIPE
CPLG	COUPLING
CPVC	CHLORINATED POLYVINYL CHLORIDE
CTR	CENTER
CU	COPPER
CY	CUBIC YARDS
△	DEFLECTION ANGLE, DELTA
D	DEGREE OF CURVE
D	DRAIN
DET	DETAIL
DI	DUCTILE IRON
DIA	DIAMETER
DIM	DIMENSION
DWG	DRAWING
DWV	DRAIN WASTE VENT
E	EAST
E	EFFLUENT
EA	EACH
ECC	ECCENTRIC
ECM	EROSION CONTROL MATTING
EL	ELEVATION
ELL	ELBOW
EQ	EQUAL
ESC	EROSION AND SEDIMENTATION CONTROL
ETC	ET CETERA
EW	EACH WAY
E/W	EAST AND WEST
EXST	EXISTING
FCA	FLANG COUPLING ADAPTER
FD	FLOOR DRAIN
FL	FLANGE
FLA	FLANGE COUPLING ADAPTER
℄	FLOWLINE
FLEX	FLEXIBLE
FLR	FLOOR
FND	FOUND
FRP	FIBERGLASS REINFORCED PLASTIC
FT	FOOT (FEET)
FTG	FITTING, FOOTING
GA	GAUGE
GALV	GALVANIZED
GB	GRADE BREAK
GDM	GRANULAR DRAINAGE MATERIAL
GCL	GEOSYNTHETIC CLAY LINING
GP	GAS PROBE
GWB	GYPSUM WALLBOARD
HDPE	HIGH DENSITY POLYETHYLENE
HM	HOLLOW METAL
HORIZ	HORIZONTAL
HP	HORSEPOWER
HT	HEIGHT
HTR	HEATER
I	INFLUENT
ID	INSIDE DIAMETER
IE	INVERT ELEVATION
INSUL	INSULATION
L	LENGTH OF CURVE
LB	POUND
LCP	LEACHATE COLLECTION PIPE PERFORATED
LC	LEACHATE COLLECTION PIPE NON-PERFORATED
LF	LINEAR FEET, LANDFILL
LG	LENGTH, LONG
LOR	LIMITS OF REFUSE
L.S.	LAND SURVEYOR
MAX	MAXIMUM
MB	MACHINE BOLTS
MCY	MILLION CUBIC YARDS
MDFT	MINIMUM DRY FILM THICKNESS
MDO	MEDIUM DENSITY OVERLAY
MEA	MATANUSKA ELECTRIC ASSOCIATION
MFR	MANUFACTURER, MANUFACTURED
MH	MANHOLE
MIN	MINIMUM
MM	MILLIMETER
MON	MONUMENT
MRKR	MARKER
MW	MONITORING WELL
N	NORTH
N/A	NOT APPLICABLE
NIC	NOT IN CONTRACT
NO.	NUMBER
NPT	NATIONAL PIPE THREADS
NTS	NOT TO SCALE
N/S	NORTH AND SOUTH
OC	ON CENTER
OD	OUTSIDE DIAMETER
OPP	OPPOSITE
OV	EMERGENCY OVERFLOW PIPING
%	PERCENT
PC	POINT OF CURVATURE
PE	PLAIN END
PE	POLYETHYLENE
PERF	PERFORATED
PI	POINT OF INTERSECTION
℘	PROPERTY LINE
PL	PLATE
PLYWD	PLYWOOD
POB	POINT OF BEGINNING
POE	POINT OF ENDING
PP	POWER POLE
PR	PAIR
PT	POINT OF TANGENCY
R	RADIUS
RAP	RECYCLED ASPHALT PAVEMENT
RD	ROAD
RDCR	REDUCER
RECIRC	RECIRCULATION
REQD	REQUIRED
RM	ROOM
RT	RIGHT

GENERAL LEGEND & TOPOGRAPHIC SYMBOLS

S	SEWER
S	SOUTH
SC	SURVEY CONTROL MONUMENT
SCHD	SCHEDULE
SD	STORM DRAIN
SDR	STANDARD DIMENSION RATIO
SH	SHEET
SIM	SIMILAR
SPEC	SPECIFICATION
SQ	SQUARE
SST	STAINLESS STEEL
ST	STREET
STA	STATION
STD	STANDARD
STL	STEEL
SW	SURFACE WATER
T	LENGTH OF TANGENT
TBM	TEMPORARY BENCH MARKER
T & B	TOP AND BOTTOM
TEMP	TEMPORARY
THK	THICK
TOPO	TOPOGRAPHY
TS	TUBULAR STEEL
TYP	TYPICAL
UPG	UNDERGROUND POWER
USGS	UNITED STATES GEOLOGICAL SURVEY
UTL	UTILITY
VERT	VERTICAL
VC	VERTICAL CURVE
VPC	VERTICAL POINT OF CURVATURE
VPI	VERTICAL POINT OF INTERSECTION
VPT	VERTICAL POINT OF TANGENCY
W	WATER
W	WEST
W/	WITH
W/OUT	WITHOUT
WL	WATER LEVEL
WP	WEATHER PROOF

PLAN

EXISTING GRADE SPOT ELEVATIONS	× 106.4
FINISHED GRADE SPOT ELEVATIONS	⊗ 106.4
EXISTING CONTOURS	350
DESIGN CONTOURS (MAJOR)	350
DESIGN CONTOURS (MINOR)	
SLOPE EMBANKMENT	2:1
SURFACE DRAINAGE (NEW)	
COORDINATE POINT	

PLAN

DIRECTION OF SURFACE DRAINAGE AND SLOPE	2% or 2:1
EXISTING TREE OR BRUSH LINE	
2 HORIZONTAL TO 1 VERTICAL	2:1
SLOPE DESIGNATION	2 / 1
EXCAVATION LIMIT	
EMBANKMENT LIMIT	
℄ OF DITCH OR BERM	
CONTROL LINE	
POLYGRID FENCE	
EDGE OF GCL/GEOMEMBRANE	

SECTION

UNDISTURBED EARTH OR PREPARED SUBGRADE
SELECT EARTHFILL
EARTHFILL
LEACHATE COLLECTION GRAVEL
GRANULAR DRAINAGE MATERIAL
SAND LEVELING COURSE

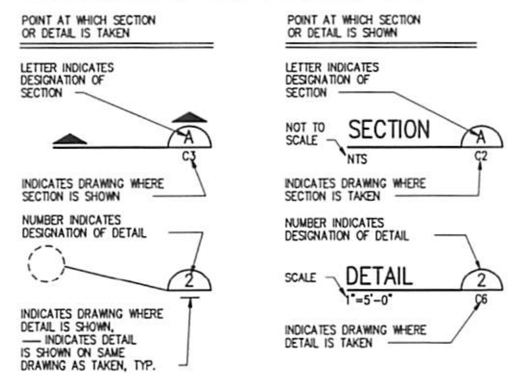
PIPING SYMBOLS

LEACHATE COLLECTION PIPE NON-PERFORATED	LC
LEACHATE COLLECTION PIPE PERFORATED	LCP

GENERAL NOTES

1. SOME EXCAVATION, SETTLEMENT, SITE GRADING, AND ROAD CONSTRUCTION HAVE OCCURRED IN LOCALIZED AREAS AND MAY NOT BE REFLECTED ON THE DRAWINGS. CONTRACTOR IS RESPONSIBLE FOR VERIFICATION OF EXISTING SITE TOPOGRAPHY AND PLANIMETRIC FEATURES PRIOR TO CONSTRUCTION. NOTIFY ENGINEER OF DEVIATIONS FROM THESE PLANS.
2. THE LOCATIONS OF EXISTING FACILITIES AND UTILITIES SHOWN ARE APPROXIMATE. OTHER FACILITIES OR UTILITIES MAY EXIST WHICH ARE NOT SHOWN ON THE DRAWINGS. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY THE PRESENCE AND CORRECT LOCATION OF ALL FACILITIES AND UTILITIES PRIOR TO CONSTRUCTION SO AS TO AVOID DAMAGE OR DISTURBANCE.
3. IN GENERAL, EXISTING FACILITIES ARE NOTED AS "EXISTING" AND SHOWN IN LIGHT LINE WEIGHTS, OR AS SCREENED BACKGROUND. NEW FEATURES ARE SHOWN IN HEAVY LINE WEIGHT.
4. MANY OF THE SYMBOLS ON THIS LEGEND ARE USED ONLY WHERE THEY PROVIDE CLARITY AND ARE NOT NECESSARILY USED AT ALL APPLICATIONS. SOME DRAWINGS IN THE CONTRACT DOCUMENTS HAVE ADDITIONAL LEGENDS APPLICABLE TO THOSE SPECIFIC DRAWINGS.

SECTION AND DETAIL DESIGNATION



RECORD DRAWINGS

Revisions Drawn by Jorge Morroy Date June 8, 2005

THESE RECORD DRAWINGS HAVE BEEN PREPARED, IN PART, ON THE BASIS OF INFORMATION COMPILED BY OTHERS. THEY ARE NOT INTENDED TO REPRESENT IN DETAIL THE EXACT LOCATION, TYPE OF COMPONENT NOR MANNER OF CONSTRUCTION. BASED ON THE INFORMATION AVAILABLE TO ME THE PROVIDED DATA APPEARS TO REPRESENT THE PROJECT AS CONSTRUCTED. THE TRANSFER OF INFORMATION COMPILED BY OTHERS TO THESE RECORD DRAWINGS WERE CHECKED BY:

Revisions Checked by Cory Hinds Date June 8, 2005

DSGN C. GIBBS						
DR R. BENFIELD						
CHK K. MERRILL	△	6-8-05	AS BUILT DRAWING	J.M.	C.H.	
APVD K. MERRILL	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

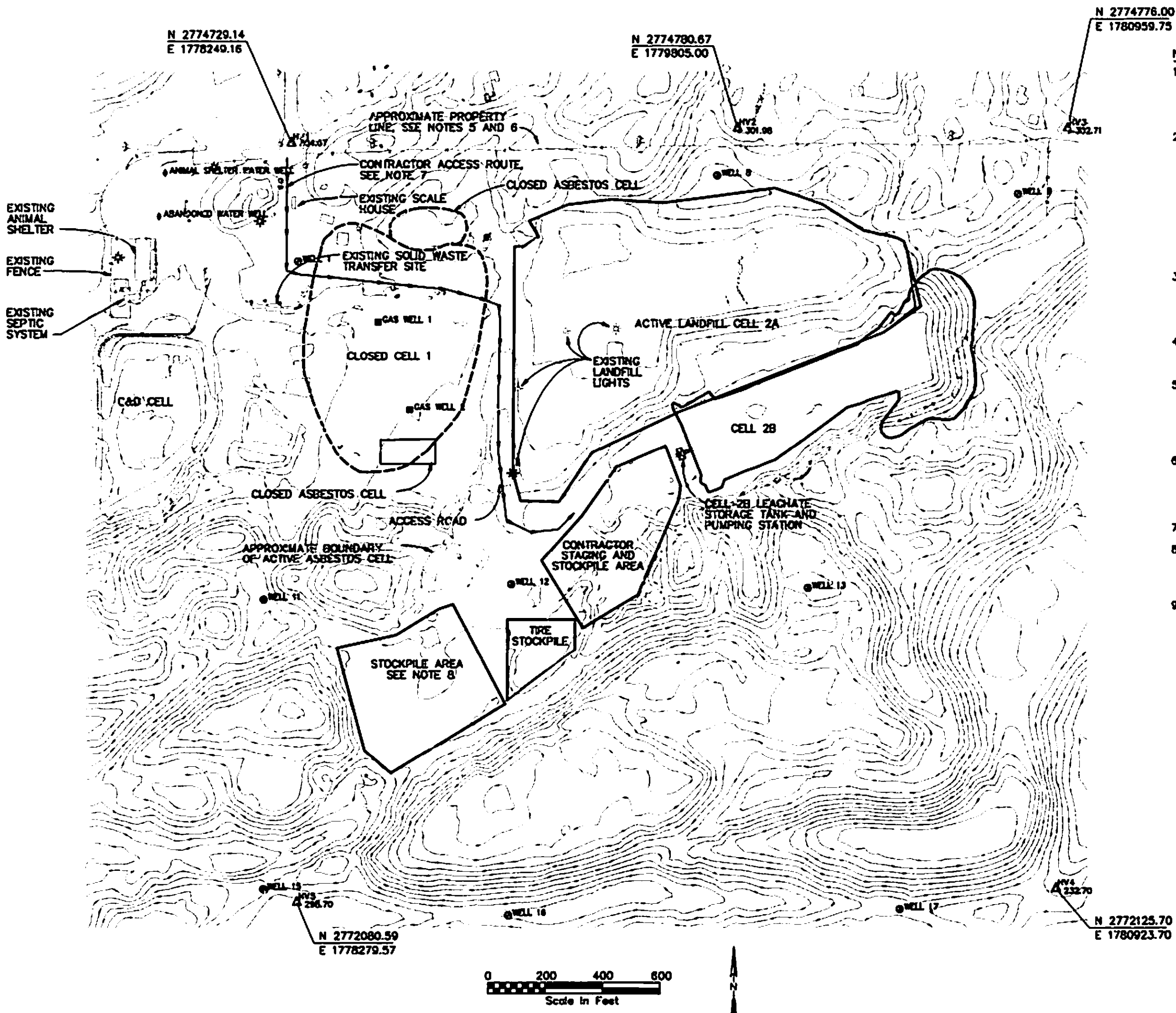
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

LEGEND, ABBREVIATIONS, AND GENERAL NOTES

SHEET	2
DWG NO.	G1
DATE	NOV 2002
PROJ NO.	157050.CL.CC

cell2b157050g1_div.dwg 31-OCT-2002 10:57:32



NOTES:

1. EXISTING TOPOGRAPHY AND PLANIMETRIC FEATURES ARE BASED ON AEROMAP US, INC. PHOTOGRAPHY ACQUIRED 5-26-2001 AT A NOMINAL SCALE OF 1:12000 AND ALASKA STATE PLANE COORDINATES SYSTEM OF 1983, ZONE 4 AS EXPRESSED IN US SURVEY FEET. VERTICAL DATA IS REFERENCED TO A LOCAL MEAN LOWER LOW WATER OBSERVATION.

2. HORIZONTAL AND VERTICAL CONTROL DATA FOR THE SITE ARE LISTED IN THE FOLLOWING TABLE:

PANEL POINT	NORTHING	EASTING	ELEVATION	MONUMENTS
HV 1	2,774,729.14	1,778,249.16	304.67	1/4 COR MON IN ASPHALT
HV 2	2,774,780.67	1,779,805.00	301.98	
HV 3	2,774,776.00	1,780,959.75	302.71	
HV 4	2,772,125.70	1,780,923.70	232.70	
HV 5	2,772,080.59	1,778,279.57	296.70	

3. THE CONDITION OF THE CONTOURS WILL VARY AT THE TIME OF CONSTRUCTION, SINCE WASTE PLACEMENT IN THE ACTIVE CELL 2A, C&D CELL EXCAVATION AND FILLING, AND EXCAVATION IN THE CELL 2B AROUND OTHERS AREAS ADJACENT TO CELL 2A IS OCCURRING ON A CONTINUOUS BASIS. EXISTING GROUND CONTOURS IN EAST END OF CELL 2B ARE BASED ON DESIGN CONTOURS FOR EXCAVATION CARRIED OUT IN SUMMER 2002 BY OTHERS. SEE NOTE 4 ON DWG C1.

4. CONTRACTOR SHALL PROTECT MONITORING WELLS AND OTHER EXISTING FACILITIES THROUGHOUT CONSTRUCTION. ANY DAMAGE SHALL BE REPAIRED AT THE CONTRACTOR'S SOLE EXPENSE.

5. THE ENTIRE PROPERTY BOUNDARY IS NOT SHOWN ON THIS DRAWING. THE WORK LIMITS FOR THE CONTRACTOR SHALL BE WITHIN THE CLEARING LIMITS, STOCKPILE AREAS AND STAGING AREA AS INDICATED ON THE DRAWINGS OR AS SPECIFIED. WORK LIMITS SHALL ALSO INCLUDE APPROVED ACCESS ROUTES TO AND FROM THESE AREAS. THE CONTRACTOR SHALL REQUEST APPROVAL FROM THE ENGINEER IN ORDER TO HAVE ACCESS TO AREAS OUTSIDE THE WORK LIMITS.

6. PROPERTY LINE LEGAL DESCRIPTION:
S 1/2 OF SECTION 01; E 1/2, SE 1/4 OF SECTION 02; NE 1/4, NE 1/4 OF SECTION 11; E 1/2, NW 1/4, NE 1/4 OF SECTION 11; N 1/2, NW 1/4 OF SECTION 12; N 1/2, SW 1/4, NW 1/4 OF SECTION 12; NW 1/4, NE 1/4 OF SECTION 12; N 1/2, SE 1/4, NW 1/4 OF SECTION 12; TOWNSHIP 17 NORTH, RANGE 01 EAST, SEWARD MERIDIAN.

7. CONTRACTOR SHALL OBTAIN OWNER APPROVAL BEFORE DEVIATING FROM ACCESS ROUTE SHOWN.

8. CONTRACTOR MAY PLACE EXCESS EXCAVATED MATERIAL IN STOCKPILE AREAS SHOWN. STOCKPILE SIDE SLOPES SHALL NOT EXCEED 2H:1V. THE OWNER SHALL HAVE CONTINUOUS ACCESS THROUGH CONTRACTOR STAGING AND STOCKPILE AREAS AND TO SURROUNDING AREAS AS REQUIRED TO MAINTAIN LANDFILL OPERATIONS.

9. WATER, GAS, AND MONITORING WELLS SHOWN ARE EXISTING.

LEGEND

- HORIZONTAL AND VERTICAL CONTROL
- EXISTING MONITORING WELLS
- EXISTING WATER WELLS
- EXISTING GAS WELLS

RECORD DRAWINGS

Revisions Drawn by: Jonna Mooney Date: June 8, 2005

THESE RECORD DRAWINGS HAVE BEEN PREPARED, IN PART, ON THE BASIS OF INFORMATION COMPILED BY OTHERS. THEY ARE NOT INTENDED TO REPRESENT IN DETAIL THE EXACT LOCATION, TYPE OF COMPONENT NOR MANNER OF CONSTRUCTION. BASED ON THE INFORMATION AVAILABLE TO ME THE PROVIDED DATA APPEARS TO REPRESENT THE PROJECT AS CONSTRUCTED. THE TRANSFER OF INFORMATION COMPILED BY OTHERS TO THESE RECORD DRAWINGS WERE CHECKED BY:

Revisions Checked by: Cory Hinds Date: June 8, 2005

DSGN	C. GIBBS				
DR	R. BENFIELD				
CHK	K. MERRILL	1	6-8-05	AS BUILT DRAWING	J.M. / C.H.
APVD	K. MERRILL	NO.	DATE	REVISION	BY / APVD

BAR IS ONE INCH ON ORIGINAL DRAWING. IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

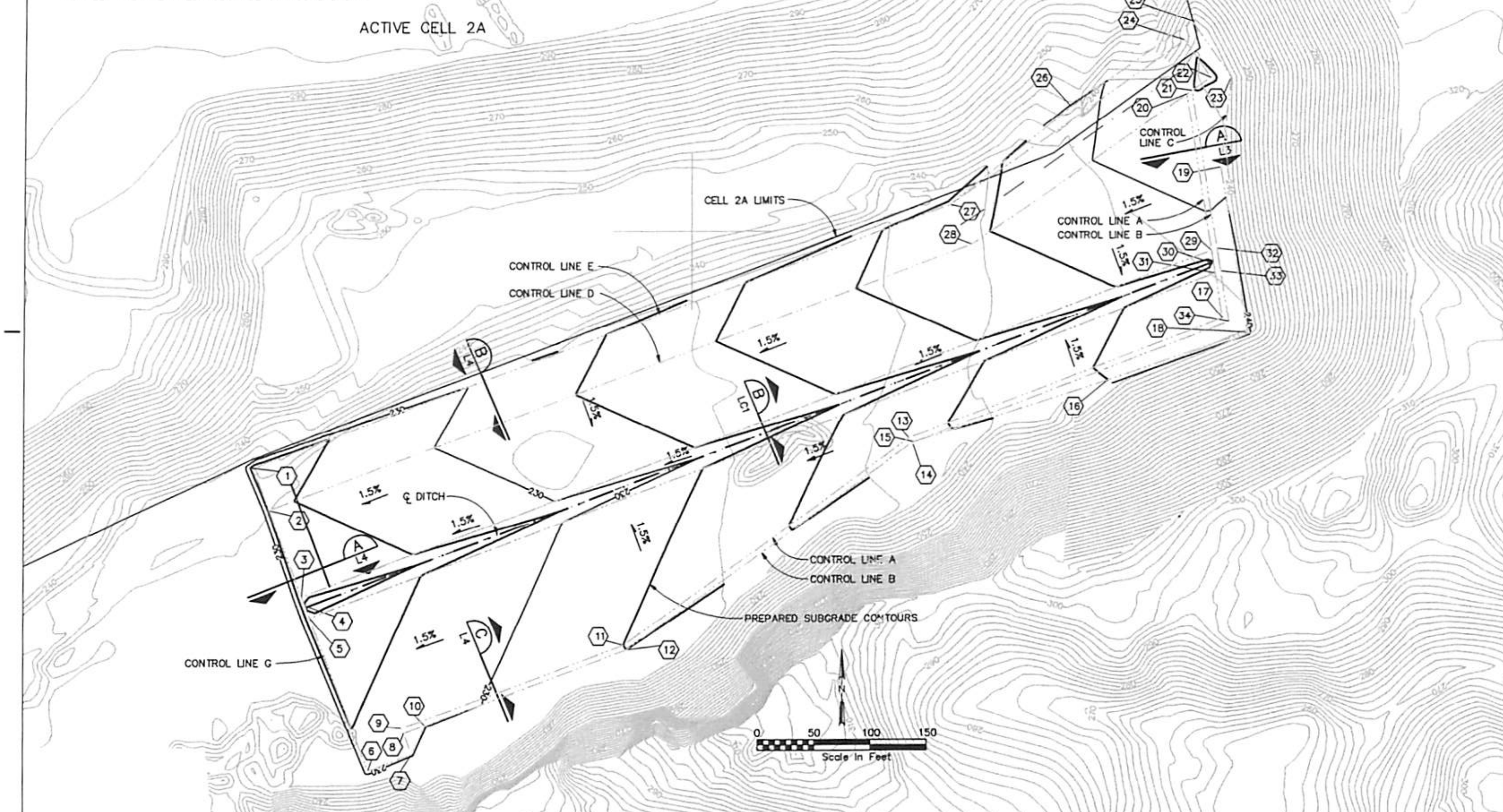
SURVEY BASELINES

SHEET 3
DWG NO. 02
DATE NOV 2002
PROJ NO. 157050.CL.CC

cell2b157050g2_dv.dwg 09-FEB-2002 10:51:12

NOTES:

1. EXCAVATE AND CONSTRUCT CELL IN ACCORDANCE WITH COORDINATE INFORMATION ON C1, L1, L2, AND TYPICAL SECTIONS AND DETAILS.
2. SLOPE CALLOUTS AND CONTOURS SHOWN ARE APPROXIMATE. CONTROL LINE COORDINATES AND TYPICAL SECTIONS SHALL TAKE PRECEDENCE.
3. TYPICAL CLEARING LIMITS ARE 10 FEET OUTSIDE CUT AND FILL LIMITS, UNLESS OTHERWISE NOTED. CONTRACTOR SHALL ACQUIRE APPROVAL FROM THE ENGINEER BEFORE CLEARING BEYOND THESE LIMITS.
4. EXISTING CONTOURS IN THE 2:1 EXCAVATION AREA, LOCATED AT THE EAST END OF CELL 2B, WERE GENERATED FROM AN AS BUILT CONSTRUCTION SURVEY (JANUARY 2003). CONTRACTOR TO FIELD VERIFY ALL EXISTING CONTOURS IN CELL 2B AREA PRIOR TO BEGINNING EXCAVATION OR FILL PLACEMENT, SEE SPECIFICATIONS.
5. CONTRACTOR SHALL PLACE EARTHFILL IN LOW AREAS AND EXCAVATE HIGH AREAS AS REQUIRED TO MEET THE PREPARED SUBGRADE CONTOURS SHOWN.



COORDINATE DATA			
NO.	NORTHING	EASTING	ELEVATION
1	2773788.3	1779610.9	226.9
2	2773750.8	1779625.2	227.6
3	2773674.3	1779654.3	226.4
4	2773665.6	1779659.7	224.4
5	2773655.6	1779661.4	226.4
6	2773519.1	1779713.3	228.6
7	2773534.0	1779752.4	229.2
8	2773552.7	1779745.3	228.9
9	2773557.3	1779743.5	228.9
10	2773559.8	1779764.0	229.2
11	2773631.9	1779939.5	232.0
12	2773627.5	1779941.9	232.0
13	2773815.0	1780193.1	235.5
14	2773809.0	1780196.7	234.8
15	2773810.7	1780195.4	235.5
16	2773865.9	1780368.8	238.0
17	2773920.7	1780470.7	239.8
18	2773907.9	1780493.0	238.8
19	2774055.5	1780469.5	240.5
20	2774120.2	1780439.6	241.9
21	2774123.3	1780444.1	242.0
22	2774134.7	1780460.5	242.3
23	2774135.0	1780478.6	241.2
24	2774167.7	1780437.7	241.7
25	2774184.5	1780444.4	241.6
26	2774109.5	1780335.9	239.4
27	2774023.5	1780229.1	237.0
28	2773987.8	1780247.9	237.6
29	2773981.4	1780461.2	239.4
30	2773970.5	1780460.9	237.3
31	2773961.2	1780464.4	239.3
32	2773983.2	1780465.9	239.4
33	2773963.0	1780465.1	239.3
34	2773907.9	1780493.0	238.8

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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Revisions Checked by Cory Hinds Date June 8, 2005

DSGN C. GIBBS						
DR R. BENFIELD						
CHK K. MERRILL	1	6-8-05	AS BUILT DRAWING	J.M.	C.H.	
APVD K.MERRILL	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
EXCAVATION PLAN

SHEET	4
DWG NO.	C1
DATE	FEB 2003
PROJ NO.	157050.CL.CC

cell2b157050c4_div.dwg 09-FEB-2002 15:51:12

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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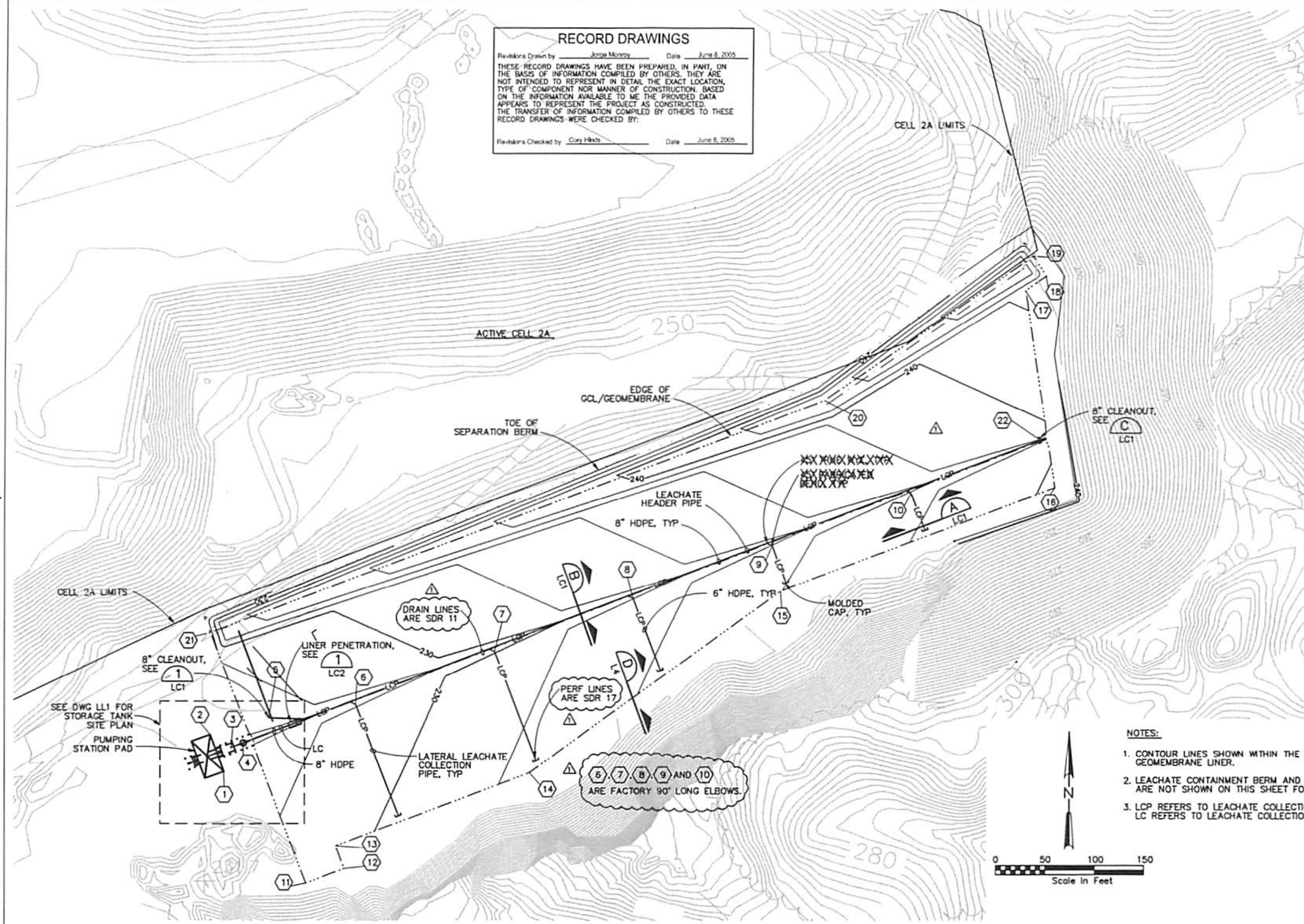
Revisions Checked by Cory Hinds Date June 8, 2005



COORDINATE DATA		
NO.	NORTHING	EASTING
1	2773632.7	1779630.1
2	2773670.3	1779616.4
3	2773657.1	1779637.5
4	2773661.8	1779649.6
5	2773687.0	1779675.3
6	2773700.5	1779763.9
7	2773754.0	1779904.0
8	2773807.5	1780044.1
9	2773861.1	1780184.3
10	2773914.6	1780324.4
11	2773519.1	1779713.3
12	2773534.0	1779752.4
13	2773557.3	1779743.5
14	2773631.9	1779939.5
15	2773815.0	1780193.1
16	2773920.7	1780470.7
17	2774120.2	1780439.6
18	2774134.7	1780460.5
19	2774154.4	1780446.9
20	2774009.1	1780236.6
21	2773773.2	1779616.6
22	2773969.1	1780455.3

NOTES:

1. CONTOUR LINES SHOWN WITHIN THE CELL REPRESENT TOP OF PRIMARY GEOMEMBRANE LINER.
2. LEACHATE CONTAINMENT BERM AND STORMWATER DIVERSION BERM CONTOURS ARE NOT SHOWN ON THIS SHEET FOR CLARITY.
3. LCP REFERS TO LEACHATE COLLECTION PIPE, PERFORATED. LC REFERS TO LEACHATE COLLECTION PIPE, NON-PERFORATED.

DSGN J. POTTS					
DR R. BENFIELD					
CHK K. MERRILL	1	6-8-05	AS BUILT DRAWING	J.M.	C.H.
APVD K. MERRILL	NO.	DATE	REVISION	BY	APVD

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CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
GCL/GEOMEMBRANE AND
LEACHATE COLLECTION PLAN

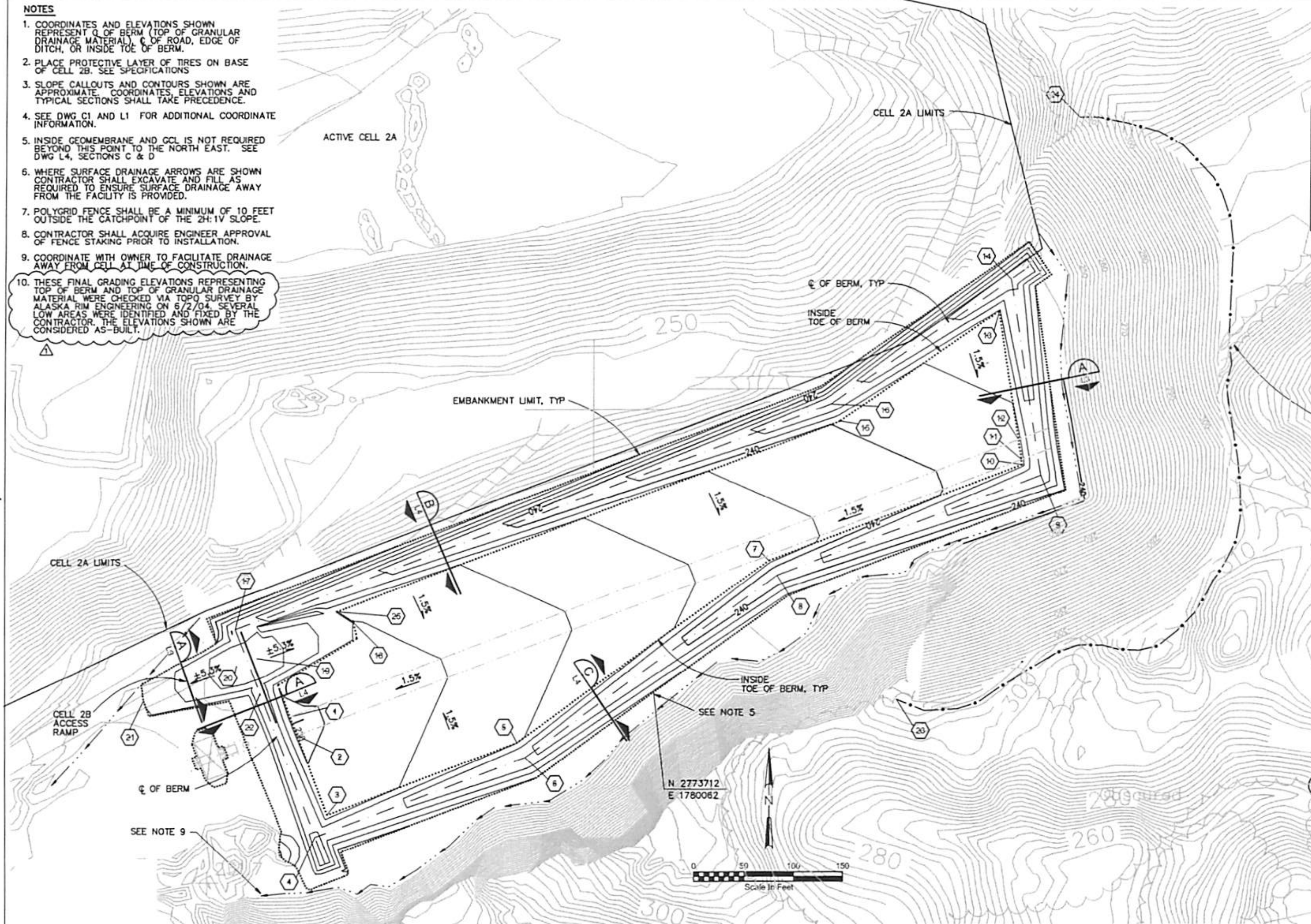
SHEET 5
DWG NO. L1
DATE NOV 2002
PROJ NO. 157050.CL.CC

cell2b157050l1_dlv.dwg 31-OCT-2002 10:59:22

NOTES

1. COORDINATES AND ELEVATIONS SHOWN REPRESENT ℄ OF BERM (TOP OF GRANULAR DRAINAGE MATERIAL), ℄ OF ROAD, EDGE OF DITCH, OR INSIDE TOE OF BERM.
2. PLACE PROTECTIVE LAYER OF TIRES ON BASE OF CELL 2B. SEE SPECIFICATIONS
3. SLOPE CALLOUTS AND CONTOURS SHOWN ARE APPROXIMATE. COORDINATES, ELEVATIONS AND TYPICAL SECTIONS SHALL TAKE PRECEDENCE.
4. SEE DWG C1 AND L1 FOR ADDITIONAL COORDINATE INFORMATION.
5. INSIDE GEOMEMBRANE AND GCL IS NOT REQUIRED BEYOND THIS POINT TO THE NORTH EAST. SEE DWG L4, SECTIONS C & D
6. WHERE SURFACE DRAINAGE ARROWS ARE SHOWN CONTRACTOR SHALL EXCAVATE AND FILL AS REQUIRED TO ENSURE SURFACE DRAINAGE AWAY FROM THE FACILITY IS PROVIDED.
7. POLYGRID FENCE SHALL BE A MINIMUM OF 10 FEET OUTSIDE THE CATCHPOINT OF THE 2H:1V SLOPE.
8. CONTRACTOR SHALL ACQUIRE ENGINEER APPROVAL OF FENCE STAKING PRIOR TO INSTALLATION.
9. COORDINATE WITH OWNER TO FACILITATE DRAINAGE AWAY FROM CELL AT TIME OF CONSTRUCTION.
10. THESE FINAL GRADING ELEVATIONS REPRESENTING TOP OF BERM AND TOP OF GRANULAR DRAINAGE MATERIAL WERE CHECKED VIA TOPO SURVEY BY ALASKA RIM ENGINEERING ON 6/2/04. SEVERAL LOW AREAS WERE IDENTIFIED AND FIXED BY THE CONTRACTOR. THE ELEVATIONS SHOWN ARE CONSIDERED AS-BUILT.

1



RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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Revisions Checked by Cory Hinds Date June 8, 2005

COORDINATE DATA

NO.	NORTHING	EASTING	ELEVATION
1	2773689.1	1779693.4	229.5
2	2773670.5	1779700.6	229.5
3	2773590.1	1779731.0	230.8
4	2773567.3	1779718.9	236.1
5	2773663.0	1779922.7	233.9
6	2773647.9	1779930.8	237.9
7	2773846.2	1780176.2	237.2
8	2773831.1	1780184.4	241.3
9	2773932.4	1780450.7	245.5
10	2773943.4	1780431.6	241.3
11	2773948.4	1780431.0	241.3
12	2773968.6	1780427.8	241.3
13	2774098.1	1780407.6	243.7
14	2774130.3	1780419.8	249.3
15	2773987.8	1780247.9	240.1
16	2774005.1	1780238.8	245.2
17	2773776.9	1779639.1	235.8
18	2773784.1	1779758.1	232.0
19	2773747.7	1779660.5	237.5
20	2773740.3	1779640.4	237.5
21	2773705.3	1779546.5	232.2
22	2773712.6	1779663.5	235.0
23	2773706.3	1780305.6	N/A
24	2774292.9	1780488.8	N/A
25	2773794.9	1779741.4	232.0

DSGN	C. GIBBS				
DR	K. MERRILL				
CHK	C. GIBBS	1	6-8-05	AS BUILT DRAWING	J.M.	C.H.
APVD	K. MERRILL	NO.	DATE	REVISION	BY	APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

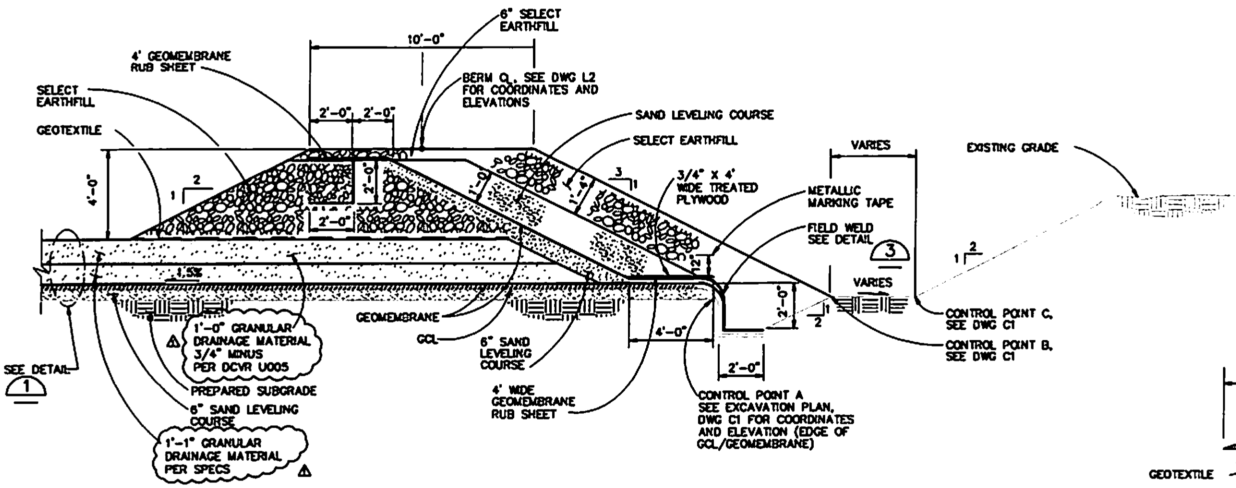
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

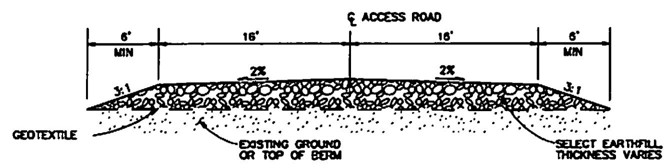
CELL 2B FINAL GRADING PLAN

SHEET 6
DWG NO. L2
DATE NOV 2002
PROJ NO. 157050.CL.CC

cell2b157050l2_dlv.dwg 09-JUN-2004 09:04:14



STORMWATER DIVERSION
BERM – EAST EDGE SECTION (A) C1, L2
NTS



ACCESS RAMP TYPICAL SECTION (A) L2
NTS

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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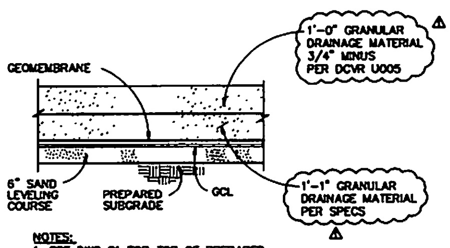
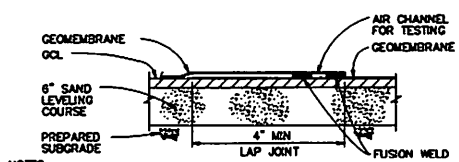
Revisions Checked by Cory Hinds Date June 8, 2005



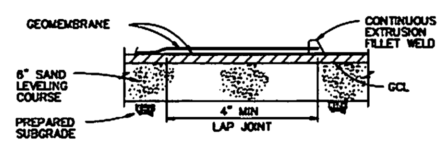
NOTES:
1. SEE DWG C1 FOR TOP OF PREPARED SUBGRADE ELEVATIONS.
2. SEE DETAILS (2) AND (3) FOR WELD DETAILS.

TYPICAL BOTTOM LINING DETAIL (1)
NTS



NOTES:
1. DOUBLE WEDGE WELDS SHALL BE USED WHENEVER FEASIBLE AS DETERMINED BY THE ENGINEER, OR WHERE SHOWN ON THE DRAWINGS. FOR FILLET WELD, SEE DETAIL (3)
2. ALL WELDS SHALL BE CONTINUOUS AND WATERTIGHT.
3. REMOVE UNBONDED TOP EDGE FLAP IF AIR CHANNEL TEST FAILS AND VACUUM BOX TEST IS USED.
4. GCL AND GEOMEMBRANE SEAMS SHALL BE OFFSET A MINIMUM OF 3 FEET UNLESS OTHERWISE SHOWN.

GEOMEMBRANE DOUBLE WEDGE WELD DETAIL (2)
NTS



NOTES:
1. ALL WELDS SHALL BE CONTINUOUS AND WATERTIGHT.
2. VACUUM TEST ALL EXTRUSION FILLET WELDS.
3. GCL AND GEOMEMBRANE SEAMS SHALL BE OFFSET A MINIMUM OF 3 FEET UNLESS OTHERWISE SHOWN.

GEOMEMBRANE FILLET WELD DETAIL (3) L4, LC1
NTS

DSGN C. GIBBS							
DR T. SAMPSON							
CHK K. MERRILL							
APVD K. MERRILL	△	6-8-05	AS BUILT DRAWING	J.M.	C.H.		
	NO.	DATE	REVISION	BY	APVD		

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

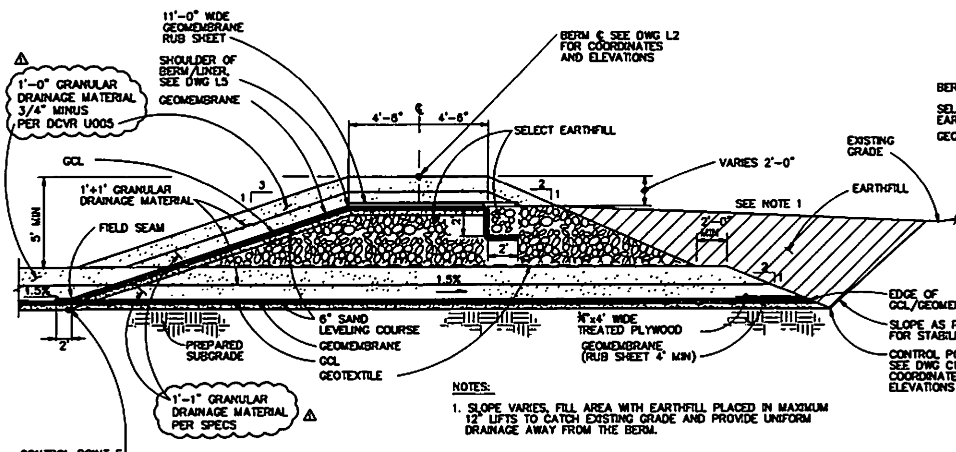
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
LINER SECTIONS AND DETAILS

SHEET 7
DWG NO. L3
DATE NOV 2002
PROJ NO. 157050.CL.CC

cell2b15705013_dtv.dwg 31-OCT-2002 11:16:23



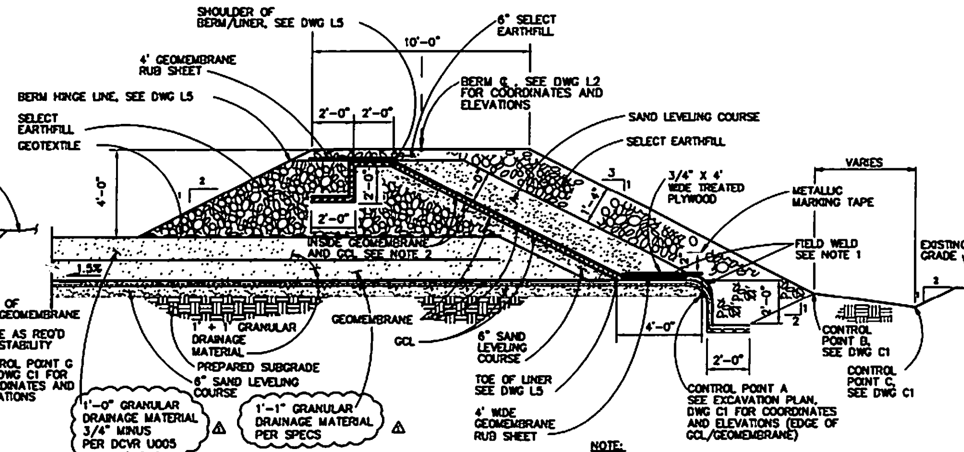
NOTES:

1. SLOPE VARIES, FILL AREA WITH EARTHFILL PLACED IN MAXIMUM 12" LIFTS TO CATCH EXISTING GRADE AND PROVIDE UNIFORM DRAINAGE AWAY FROM THE BERM.

LEACHATE CONTAINMENT BERM WEST EDGE SECTION (A)

NTS

C1, L2, L5



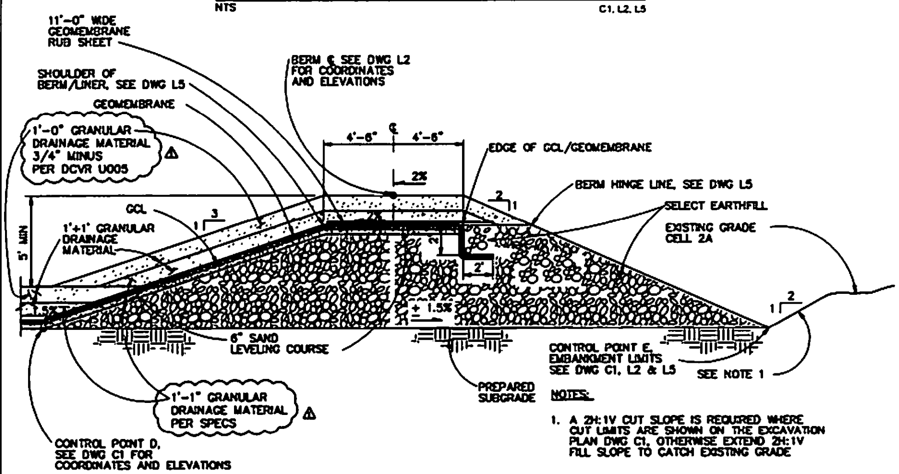
NOTE:

1. FIELD WELD INSIDE AND OUTSIDE GEOMEMBRANE FLAPS, SEE DETAIL (3/L3) WELDS SHALL BE 2'-0" APART MIN.
2. INSIDE GEOMEMBRANE AND GCL IS NOT REQUIRED BEYOND LIMITS SHOWN ON DWG L2 (SEE NOTE 5 ON DWG L2)

STORMWATER DIVERSION BERM SOUTH EDGE SECTION (C)

NTS

C1, L2, L5



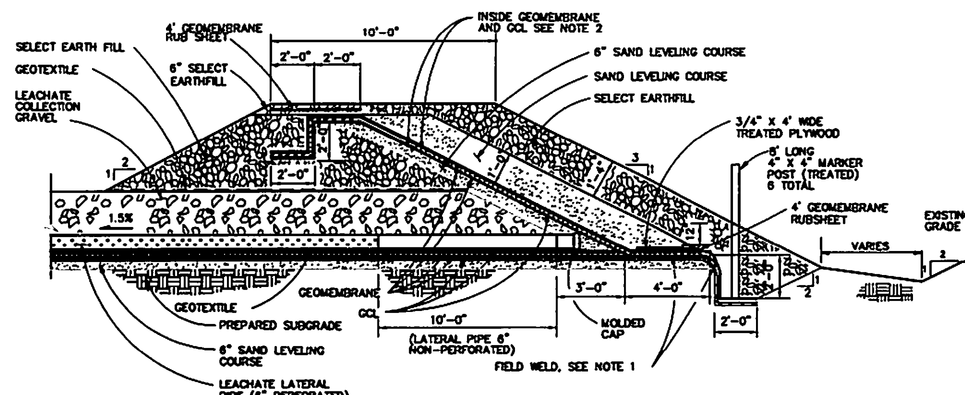
NOTES:

1. A 2H:1V CUT SLOPE IS REQUIRED WHERE CUT LIMITS ARE SHOWN ON THE EXCAVATION PLAN DWG C1, OTHERWISE EXTEND 2H:1V FILL SLOPE TO CATCH EXISTING GRADE

CELL SEPARATION BERM NORTH EDGE SECTION (B)

NTS

C1, L2, L5



NOTE:

1. FIELD WELD INSIDE AND OUTSIDE GEOMEMBRANE FLAPS, SEE DETAIL (3/L3) WELDS SHALL BE 2'-0" APART MIN.
2. INSIDE GEOMEMBRANE AND GCL IS NOT REQUIRED BEYOND LIMITS SHOWN ON DWG L2 (SEE NOTE 5 ON DWG L2)

STORMWATER DIVERSION BERM SOUTH EDGE AT LATERAL SECTION, TYP (D)

NTS

L1

RECORD DRAWINGS

Revisions Drawn by: Jorge Moreno Date: June 8, 2005

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Revisions Checked by: Cory Hinds Date: June 8, 2005

DSGN	C. GIBBS				
DR	T. SAMPSON				
CHK	K. MERRILL	△	6-8-05	AS BUILT DRAWING	J.M. / C.H.
APVD	K. MERRILL	NO.	DATE	REVISION	BY / APVD

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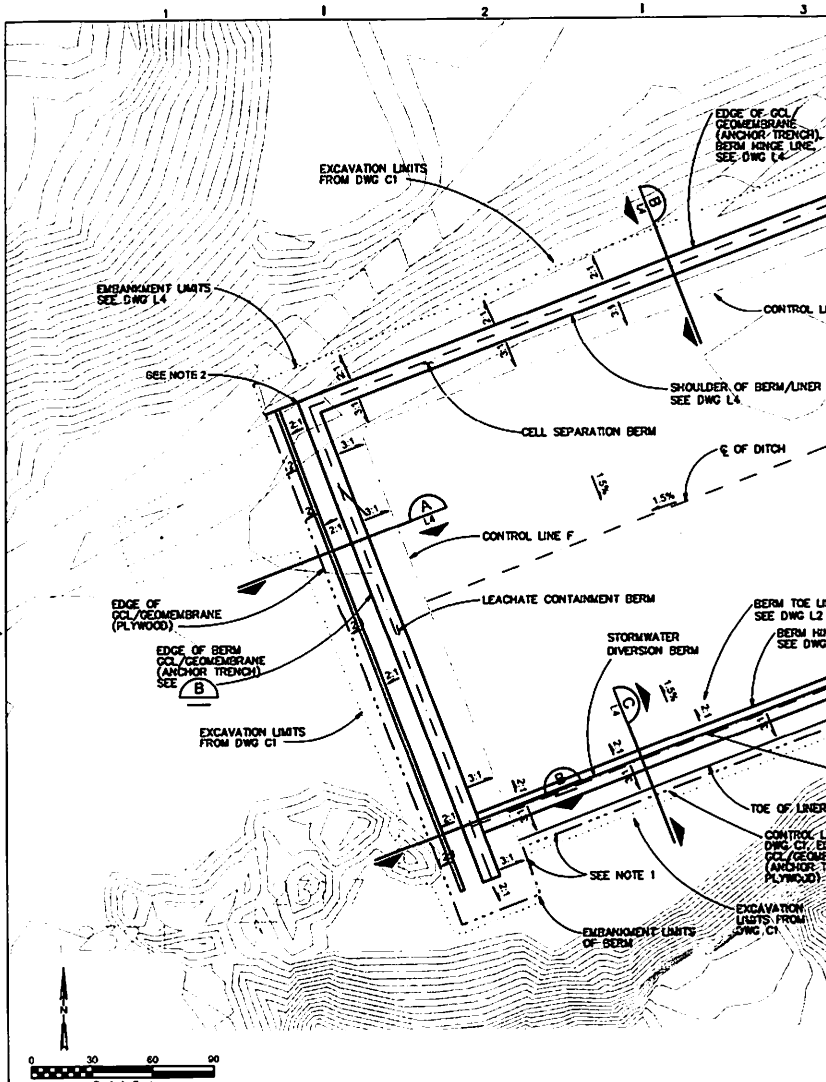
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
LINER SECTIONS AND DETAILS

SHEET	8
DWG NO.	L4
DATE	NOV 2002
PROJ NO.	157050.CL.CC

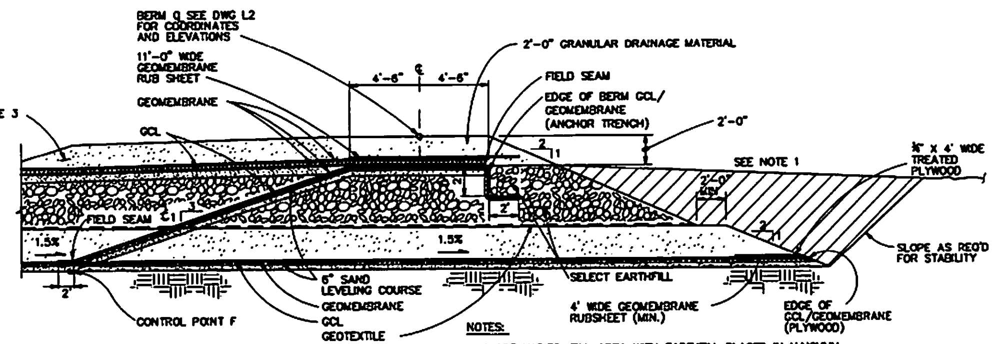
cell2b15705014_dlv.dwg 31-OCT-2002 11:16:50



BERM CONNECTION PLAN

NOTES:

1. FIELD WELD INSIDE AND OUTSIDE GEOMEMBRANE FLAPS OF THE STORMWATER DIVERSION BERM TO THE GEOMEMBRANE FLAP OF THE LEACHATE CONTAINMENT BERM. WELDS SHALL BE 2'-0" APART MIN. SEE 3/L3 CARRY ⅜"x4' WIDE TREATED PLYWOOD TO TOP OF BERM INTERSECTION. ANCHOR TRENCH TRANSITION LIMITS SHALL NOT EXTEND BEYOND 25' FROM CENTERLINE OF LEACHATE CONTAINMENT BERM.
2. FIELD WELD LEACHATE CONTAINMENT BERM GEOMEMBRANE FLAP TO THE CELL SEPARATION BERM FLAP IN ORDER TO PROVIDE UNIFORM LEAK PROOF TRANSITION.
3. CONTRACTOR SHALL PROVIDE BERM TRANSITION LAYOUT PLAN AND OBTAIN ENGINEERS APPROVAL PRIOR TO INSTALLING BERM TRANSITIONS. DOUBLE LINING SYSTEM INTEGRITY SHALL BE MAINTAINED FOR ALL TRANSITIONS.
4. COORDINATE BERM CONNECTION PLAN VIEW WITH LINER SECTIONS AND DETAILS ON DWG L4



NOTES:

1. SLOPE VARIES, FILL AREA WITH EARTHFILL PLACED IN MAXIMUM 12" LIFTS TO CATCH EXISTING GRADE AND PROVIDE UNIFORM DRAINAGE AWAY FROM THE BERM.
2. SEE L4 FOR TYPICAL BERM CONSTRUCTION DETAILS.
3. TRANSITION TO 6" OF SELECT EARTHFILL OVER 10' DISTANCE SEE C/L4

LEACHATE CONTAINMENT BERM/STORMWATER DIVERSION BERM TRANSITION SOUTHWEST CORNER SECTION (B)

NTS

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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Revisions Checked by Cory Hinds Date June 8, 2005

REUSE OF DOCUMENTS:

DSGN	C. GIBBS					
DR	R. BENFIELD					
CHK	K. MERRILL					
APVD	K. MERRILL	1	5-6-05	AS BUILT DRAWING	J.M.	C.H.
		NO.	DATE	REVISION	BY	APVD

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 — 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

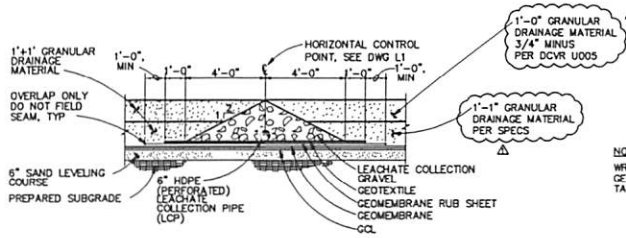
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

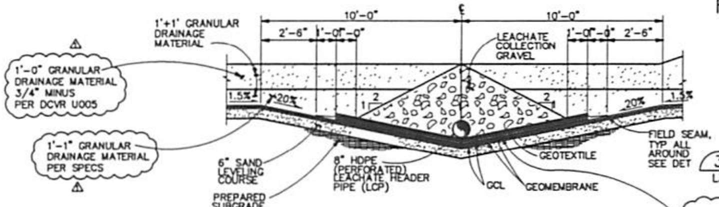
CELL 2B
BERM CONNECTION
PLAN AND SECTION

SHEET	9
DWG NO.	L5
DATE	NOV 2002
PROJ NO.	157050.CL.CC

cell2b15705015_dlv.dwg 31-OCT-2002 11:18:53



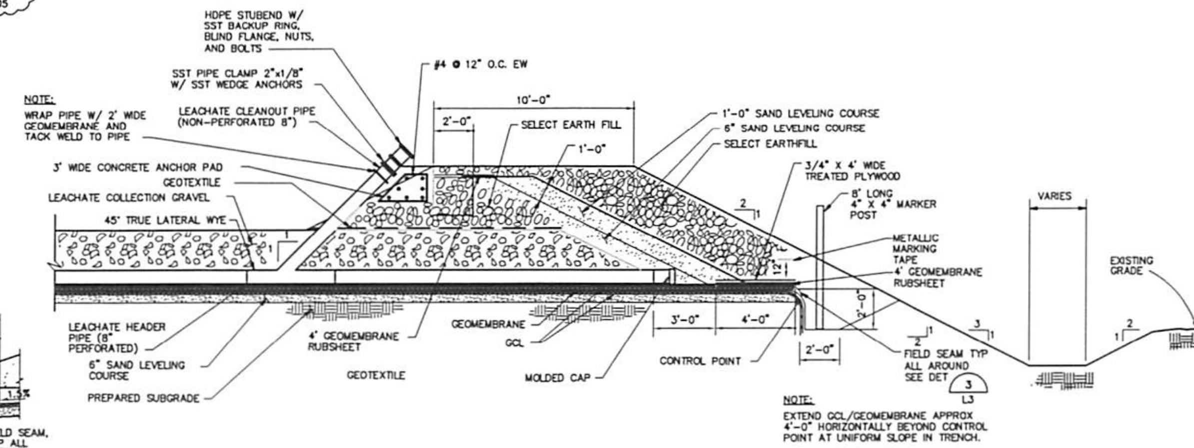
LATERAL LEACHATE COLLECTION PIPE SECTION, TYP (A) L1
NTS



NOTES:
1. ALL GCL SHALL BE KEPT DRY AT ALL TIMES.

NOTE:
SECONDARY GEOMEMBRANE (TOP) WAS CUT ON THE SOUTHERN EDGE JUST ABOVE THE EXTRUSION WELD TO ALLOW TRAPPED WATER TO DRAIN

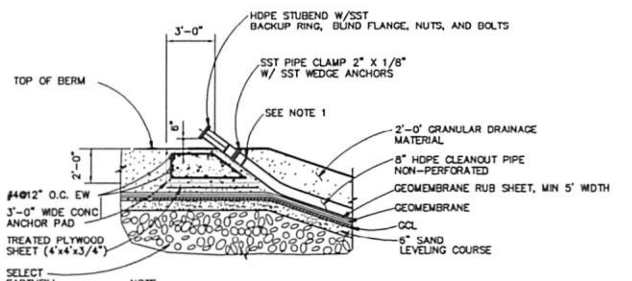
LEACHATE HEADER PIPE SECTION, TYP (B) C1, L1, LC2, LL1
NTS



NOTE:
WRAP PIPE W/ 2' WIDE GEOMEMBRANE AND TACK WELD TO PIPE

NOTE:
EXTEND GCL/GEOMEMBRANE APPROX 4'-0" HORIZONTALLY BEYOND CONTROL POINT AT UNIFORM SLOPE IN TRENCH.

CLEANOUT ON STORMWATER DIVERSION BERM – EAST EDGE SECTION (C) L1
NTS



NOTE:
1. WRAP PIPE 2" WIDE GEOMEMBRANE AND TACK WELD TO PIPE.

CLEANOUT ON LEACHATE CONTAIMENT BERM – WEST EDGE DETAIL (1) L1, L2
NTS

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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Revisions Checked by Cory Hinds Date June 8, 2005

DSGN	C. GIBBS				
DR	T. SAMPSON				
CHK	K. MERRILL	△	6-8-05	AS BUILT DRAWING	J.M. / C.H.
APVD	K. MERRILL	NO.	DATE	REVISION	BY / APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 — 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
LEACHATE COLLECTION SYSTEM
SECTIONS AND DETAILS

SHEET	10
DWG NO.	LC1
DATE	NOV 2002
PROJ NO.	157050.CL.CC

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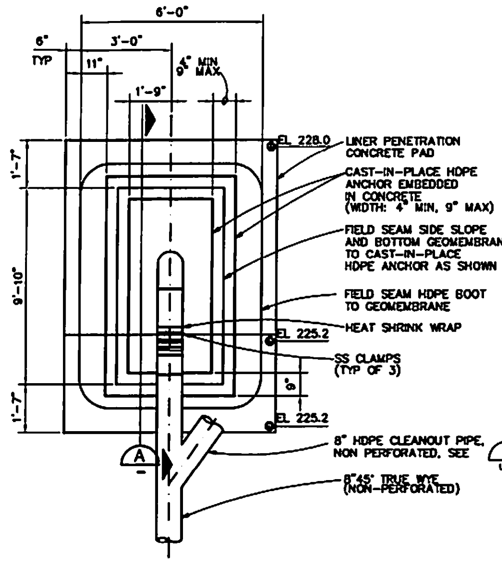

LINER PENETRATION PLAN DETAIL (1) L1, LC1
NTS

NOTES:
1. GRANULAR DRAINAGE MATERIAL AND LEACHATE COLLECTION GRAVEL, ABOVE LINER, NOT SHOWN FOR CLARITY
2. SEE SPECIFICATIONS SECTION 02661 "GEOMEMBRANE-HDPE" FOR INSTALLATION OF CAST-IN-PLACE HDPE ANCHORS

RECORD DRAWINGS

Revisions Drawn by: Jorge Monroy Date: June 8, 2005

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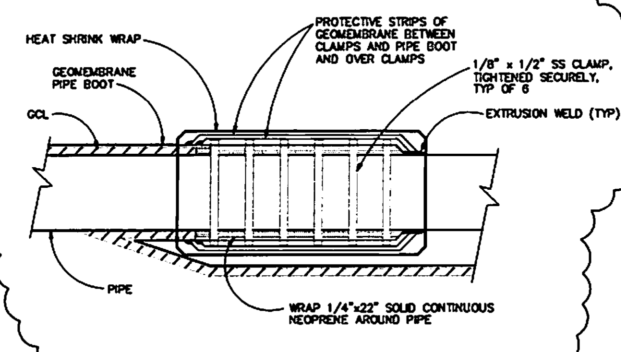
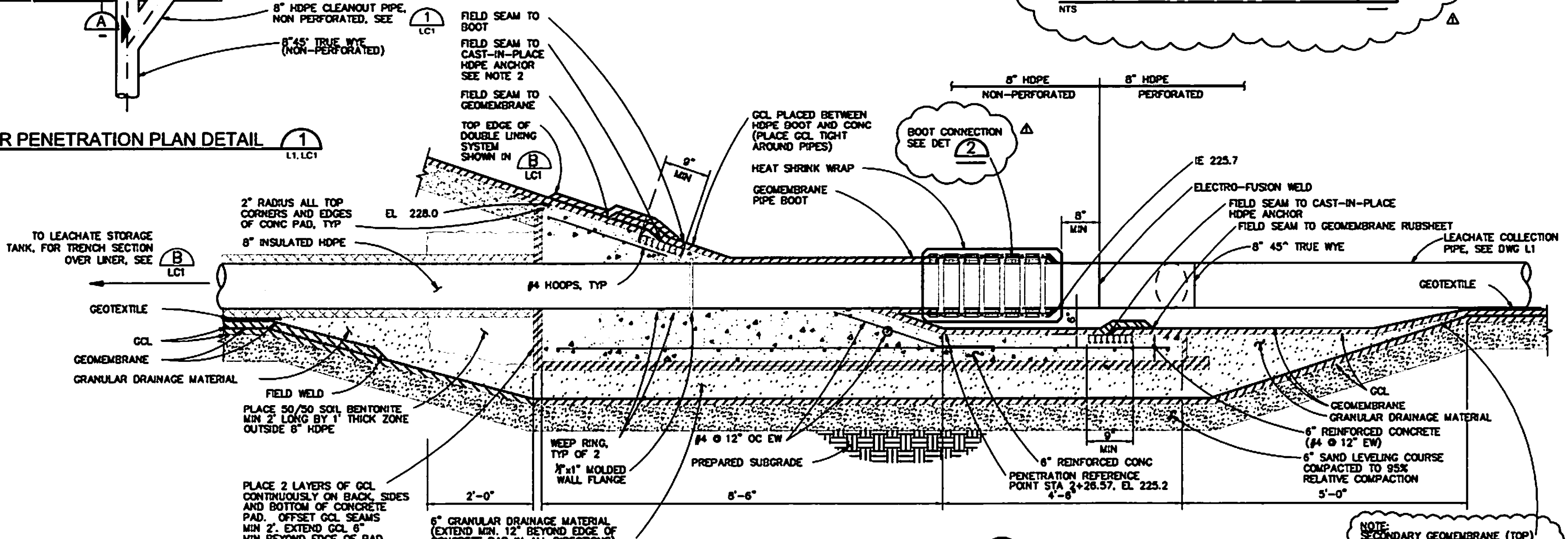


BOOT CONNECTION DETAIL (2)
NTS



LINER PENETRATION SECTION (A)
NTS

NOTE:
SECONDARY GEOMEMBRANE (TOP) WAS CUT ON THE SOUTHERN EDGE JUST ABOVE THE EXTRUSION WELD TO ALLOW TRAPPED WATER TO DRAIN

DSGN	C. GIBBS	NO.	DATE	REVISION
DR	T. SAMPSON	1	6-8-05	AS BUILT DRAWING
CHK	K. MERRILL			
APVD	K. MERRILL			

BY: J.M. APVD: C.H.

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CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
LEACHATE CONTAINMENT BERM
PENETRATION DETAILS

SHEET 11
DWG NO. LC2
DATE NOV 2002
PROJ NO. 157050.CL.CC

cell2b157050lc2_dlv.dwg 31-OCT-2002 11:19:58

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RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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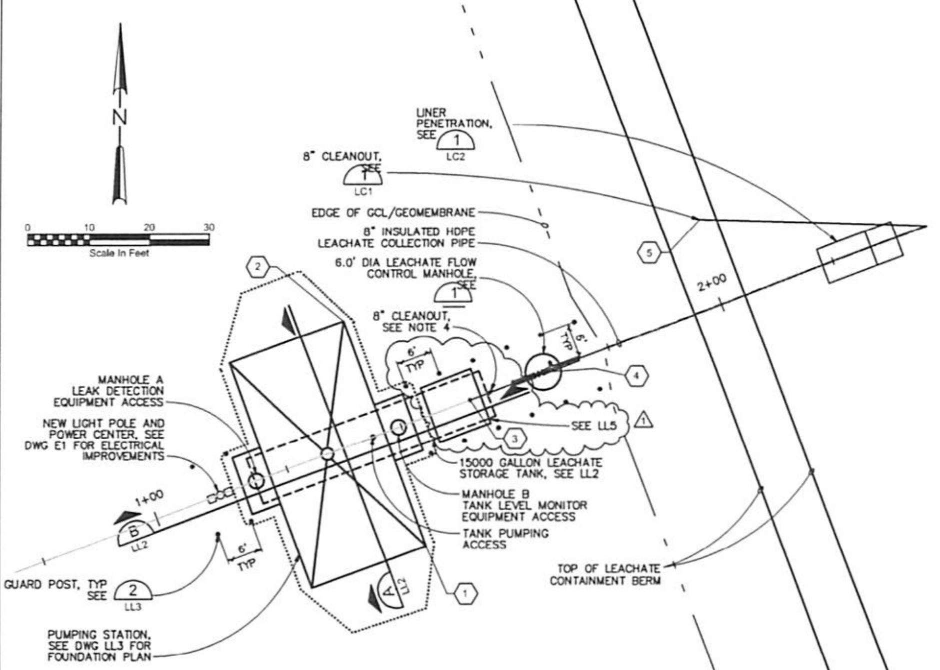
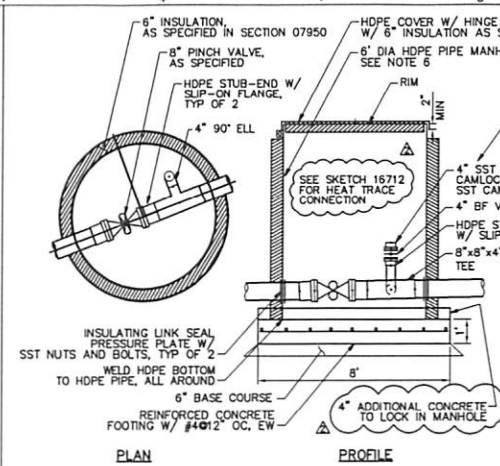


NOTES:

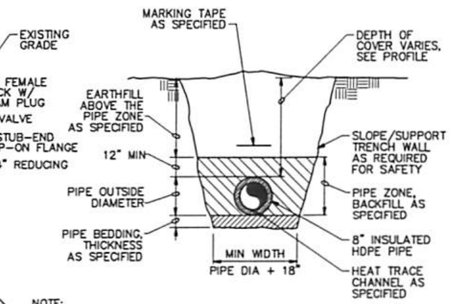
1. CONTOUR LINES SHOWN REPRESENT FINAL GRADING CONTOURS AS SHOWN ON L2.
2. COORDINATE VALUES FOR POINTS (1) THROUGH (5) ARE LISTED IN THE COORDINATE DATA TABLE ON L1. BASIS OF STATIONING IS AS FOLLOWS: 1+00.00 = N 2773637.39, E 1779585.50; 2+00.00 = N 2773672.98, E 1779679.02.
3. SEE TANK, MANHOLE, TRENCH, AND PUMP STATION SECTIONS AND DETAILS FOR ADDITIONAL EXCAVATION LIMITS.
4. CLEANOUT SHALL BE INSULATED W/ HEAT TRACE AS SPECIFIED, CONSTRUCTED W/ 45° TRUE WYE, 45° BEND, AND SPOOL SECTION AS SHOWN, SEE 1 LC1 FOR CLEANOUT CAP (BLIND FLANGE) DETAILS.
5. PIPE INSULATION AND INSULATION OVER TANK NOT SHOWN ON PROFILE. INVERT ELEVATIONS REPRESENT THE INVERT OF THE 8" PIPE. DEPRESS LINER AS NECESSARY TO ACCOMMODATE PIPE INSULATION AND JACKET AT GRADES SHOWN.
6. INSTALL HEAT TRACE POWER CONNECTION KIT INSIDE MANHOLE PER MANUFACTURER'S RECOMMENDATIONS.

LEACHATE STORAGE TANK SITE PLAN



FLOW CONTROL MANHOLE 1

NTS

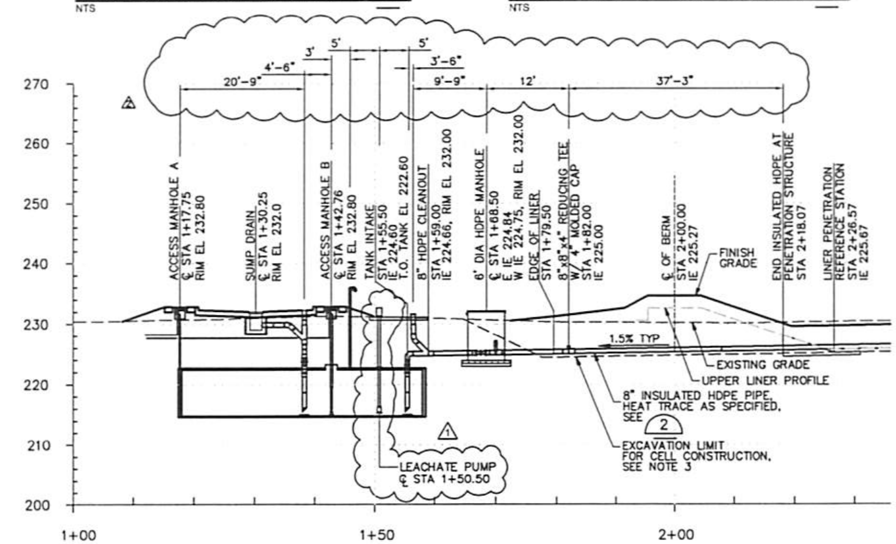


NOTE:

1. SEE B LC1 FOR TYPICAL TRENCH SECTION EAST OF STA 1+79.50.

TYPICAL TRENCH STA 1+55.50 TO STA 1+79.50 2

NTS



LEACHATE STORAGE TANK PROFILE

DSGN	J. POTTS					
DR	R. BENFIELD	2	6-8-05	AS BUILT DRAWING	J.M.	C.H.
CHK	K. MERRILL	1	OCT 9, 2003	ADD LEACHATE PUMP AND PAD	KW	JP
APVD	K. MERRILL	NO.	DATE	REVISION	BY	APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

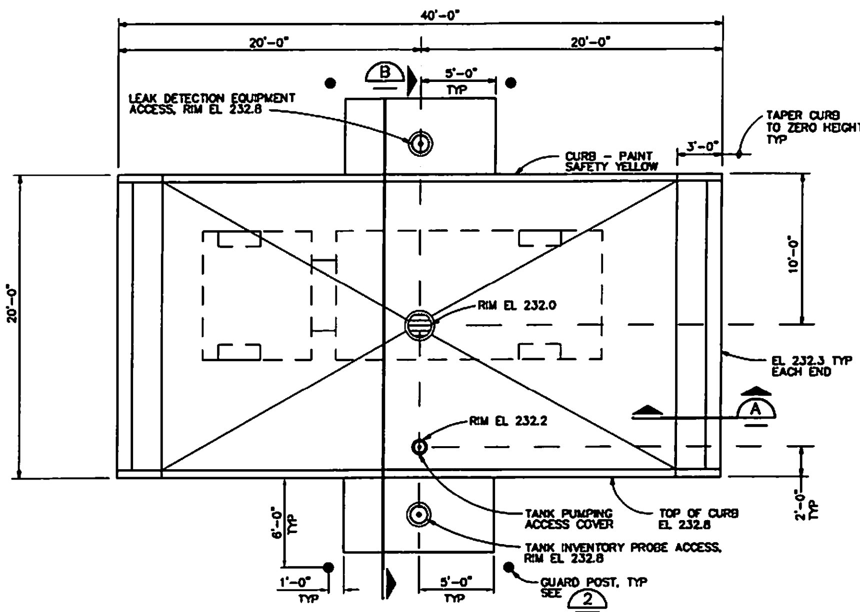
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
LEACHATE STORAGE TANK
SITE PLAN AND DETAILS

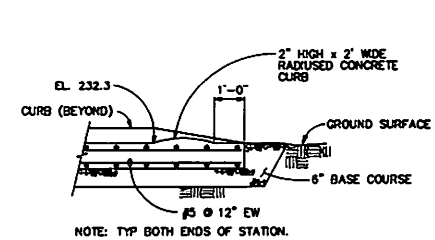
SHEET	12
DWG NO.	LL1
DATE	NOV 2002
PROJ NO.	157050.CL.CC

cell2b157050ll1_dlv.dwg 22-APR-2004 13:36:16



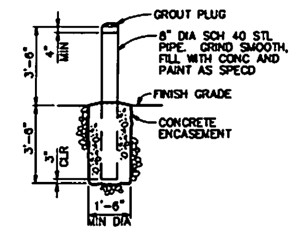
PUMPING STATION FOUNDATION PLAN 1 LL1, LL2

1/4"=1'-0"



SECTION A

3/8"=1'-0"



GUARD POST DETAIL 2 LL1

NTS

REINFORCING STEEL:

1. CLEARANCE FOR REINFORCEMENT BARS, UNLESS SHOWN OTHERWISE, SHALL BE:
   - WHEN PLACED ON GROUND: 3"
   - ALL OTHER CONCRETE SURFACES:
     #5 BAR OR SMALLER 1 1/2"
     #6 BAR OR LARGER 2"
2. ALL BENDS, UNLESS OTHERWISE SHOWN, SHALL BE A 90 DEGREE STANDARD HOOK AS DEFINED IN LATEST EDITION OF ACI 318.
3. UNLESS INDICATED OTHERWISE, CONTRACTOR MAY SPLICE CONTINUOUS SLAB BARS AT LOCATIONS OF HIS CHOOSING. ALL REINFORCEMENT BENDS AND LAPS, UNLESS OTHERWISE NOTED, SHALL SATISFY THE FOLLOWING MINIMUM REQUIREMENT:

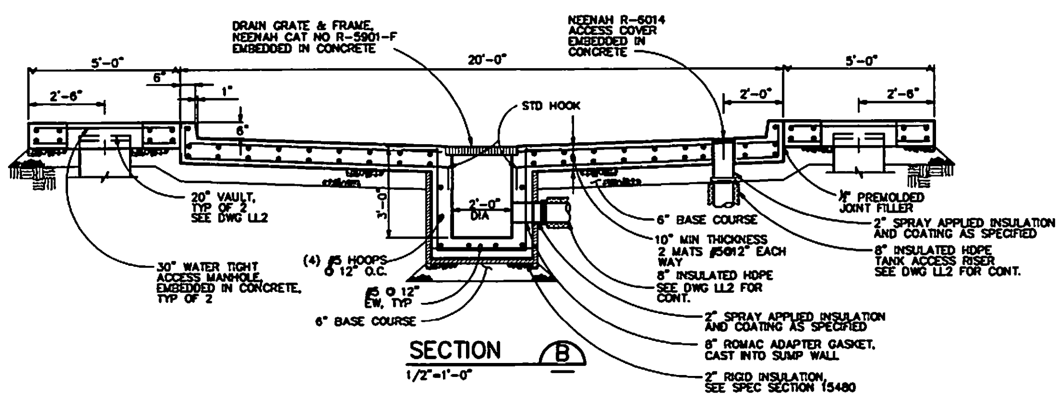
CONCRETE DESIGN STRENGTH = 4,000 PSI		GRADE 60 REINFORCING STEEL								
BAR SIZE		#3	#4	#5	#6	#7	#8	#9	#10	#11
LAP SPLICE LENGTH										
SPACING<6"	TOP BAR*	1'-4"	2'-0"	3'-0"	4'-0"	5'-10"	6'-8"	7'-7"	8'-6"	9'-5"
	OTHER BAR	1'-4"	1'-7"	2'-4"	3'-1"	4'-6"	5'-2"	5'-10"	6'-7"	7'-3"
SPACING≥6"	TOP BAR*	1'-4"	1'-8"	2'-0"	2'-6"	3'-6"	4'-0"	5'-0"	6'-2"	7'-6"
	OTHER BAR	1'-4"	1'-4"	1'-7"	1'-10"	2'-9"	3'-1"	3'-10"	4'-9"	5'-8"
EMBEDMENT LENGTH										
SPACING<6"	TOP BAR*	1'-0"	1'-7"	2'-4"	3'-1"	4'-6"	5'-2"	5'-10"	6'-7"	7'-3"
	OTHER BAR	1'-0"	1'-3"	1'-9"	2'-5"	3'-6"	4'-0"	4'-6"	5'-1"	5'-7"
SPACING≥6"	TOP BAR*	1'-0"	1'-3"	1'-7"	1'-10"	2'-9"	3'-1"	3'-10"	4'-9"	5'-8"
	OTHER BAR	1'-0"	1'-0"	1'-3"	1'-5"	2'-1"	2'-5"	3'-0"	3'-8"	4'-5"

*TOP BARS SHALL BE DEFINED AS ANY HORIZONTAL BARS PLACED SUCH THAT MORE THAN 12" OF FRESH CONCRETE IS CAST IN THE MEMBER BELOW THE BAR IN ANY SINGLE POUR. HORIZONTAL WALL BARS ARE CONSIDERED TOP BARS.

4. PROVIDE AND INSTALL SELECT GRANULAR MATERIAL AS SPECIFIED UNDER ALL SLABS AND FOOTINGS TO UNDISTURBED EARTH WITH MINIMUM THICKNESS EQUAL TO 6". UNLESS OTHERWISE NOTED.

REINFORCING NOTES

NTS



SECTION B

1/2"=1'-0"

RECORD DRAWINGS

Revisions Drawn by Jonna Morrey Date June 8, 2005

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Revisions Checked by Cory Hinds Date June 8, 2005

DSGN	J. POTTS	NO.	DATE	REVISION	BY	APVD
DR	T. SAMPSON	1	6-8-05	AS BUILT DRAWING	J.M.	C.H.
CHK	K. MERRILL					
APVD	K. MERRILL					

VERIFY SCALE: BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1". IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

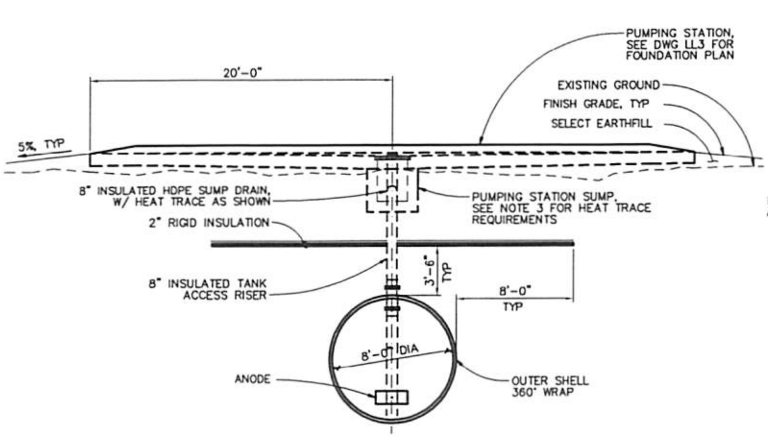
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
LEACHATE PUMPING STATION
SECTIONS AND DETAILS

SHEET 14
DWG NO. LL3
DATE NOV 2002
PROJ NO. 157050.CL.CC

cell2b157050II3_dlv.dwg 31-OCT-2002 11:21:03

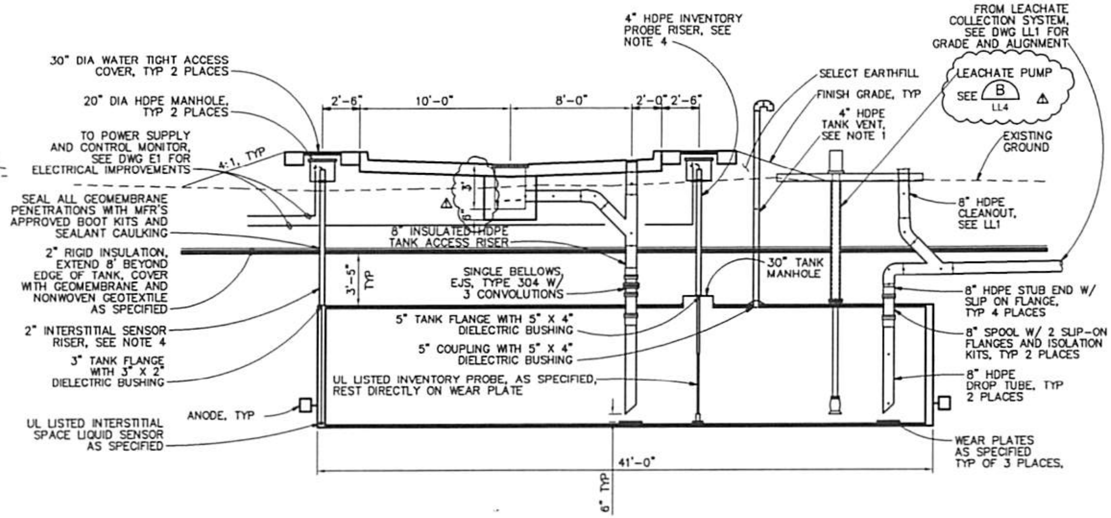


STORAGE TANK NOTES (SECTIONS A & B):

1. INSTALL 4" HDPE TANK VENT TO HEIGHT 5' ABOVE FINISH GRADE.
2. HEAT TRACE SHOWN IS SCHEMATIC. ROUTE HEAT TRACE IN CHANNEL OF PRE-INSULATED PIPING. INSTALL HEAT TRACE IN CONDUIT BETWEEN TANK INTAKE AND THE ACCESS RISER. PROVIDE WATERTIGHT CONNECTION BETWEEN CONDUIT AND PRE-INSULATED PIPING.
3. PROVIDE 6' LOOP OF HEAT TRACE ON SUMP FLOOR. INSTALL INSIDE ¾" CARFLEX CONDUIT FOR PROTECTION. PROVIDE WATERTIGHT CONNECTION BETWEEN CONDUIT AND PRE-INSULATED PIPING.
4. HDPE THREADED TRANSITION FITTINGS SHALL BE USED FOR 2" AND 4" HDPE PIPE CONNECTIONS TO TANK AND MANHOLE FITTINGS.

LEACHATE STORAGE TANK SECTION (A / LL1)

1/4"=1'-0"



LEACHATE STORAGE TANK SECTION (B / LL1)

NTS

RECORD DRAWINGS

Revisions Drawn by: Jorge Monroy Date: June 8, 2005

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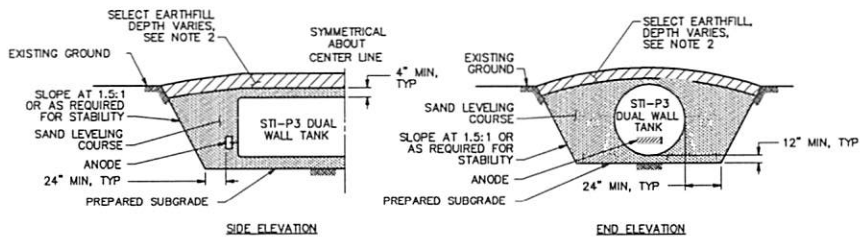
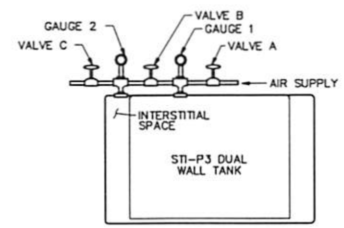


NOTES:

1. TANK DETAILS, MANHOLES, RISERS, AND PUMPING STATION NOT SHOWN FOR CLARITY.
2. SEE MANHOLE, AND PUMPING STATION SECTIONS AND DETAILS FOR ADDITIONAL EXCAVATION AND BACKFILL REQUIREMENTS.
3. COMPACT SAND LEVELING COURSE IN LIFTS PER MANUFACTURER'S RECOMMENDATIONS AND STI-P3 SPECIFICATIONS.

TANK EXCAVATION AND BACKFILL DETAIL (1)

NTS



PRESSURE TEST NOTES:

1. NOTIFY THE ENGINEER PRIOR TO FIELD AIR TESTING.
2. PRESSURE TEST ALL NEW STI-P3 DUAL WALL TANKS IN ACCORDANCE WITH STI-P3 INSTALLATION INSTRUCTIONS, THIS TEST PROCEDURE, AND AS SPECIFIED IN SECTION 15480.
3. DO NOT PRESSURIZE INTERSTICE WITHOUT PRESSURE ON THE INNER TANK. DO NOT PRESSURIZE INTERSTICE GREATER THAN THE PRESSURE WITHIN THE INNER TANK.
4. DO NOT LEAVE PRESSURIZED TANK UNATTENDED.
5. BECAUSE THERE IS SO LITTLE SPACE IN THE INTERSTICE, DO NOT CONNECT A HIGH PRESSURE LINE.
6. USE 4 IN. DIA GAUGE RATED FROM 0 – 15 PSI.

AIR TEST PROCEDURE:

STEP 1 – OPEN VALVE C.
STEP 2 – CLOSE VALVE B.
STEP 3 – OPEN VALVE A AND RAISE PRESSURE ON GAUGE #1 TO 5 PSI. CLOSE VALVE A.
STEP 4 – USE TANK TEST SOLUTION ON ANY PLACE THE INNER TANK IS EXPOSED. (HOLD PRESSURE FOR ON HOUR)
STEP 5 – CLOSE VALVE C.
STEP 6 – OPEN VALVE B.
STEP 7 – PRESSURE GAUGES (#1 AND #2) SHOULD EQUALIZE. HOLD THE NEW PRESSURE FOR ONE HOUR.
STEP 8 – LEAK TEST ALL SEAMS AND FITTINGS.
STEP 9 – TO REMOVE AIR FROM TANK, DISCONNECT AIR SUPPLY AND OPEN VALVE A.

TANK AIR TEST PROCEDURE (2)

NTS

DSGN J. POTTS					
DR T. SAMPSON					
CHK K. MERRILL	△	6-8-05	AS BUILT DRAWING	J.M.	C.H.
APVD K. MERRILL	NO.	DATE	REVISION	BY	APVD

VERIFY SCALE: BAR IS ONE INCH ON ORIGINAL DRAWING. 0 ——— 1". IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

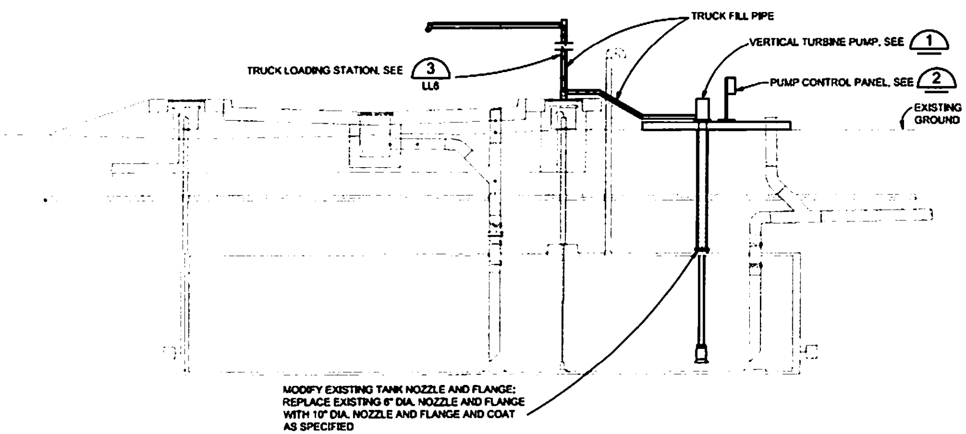
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

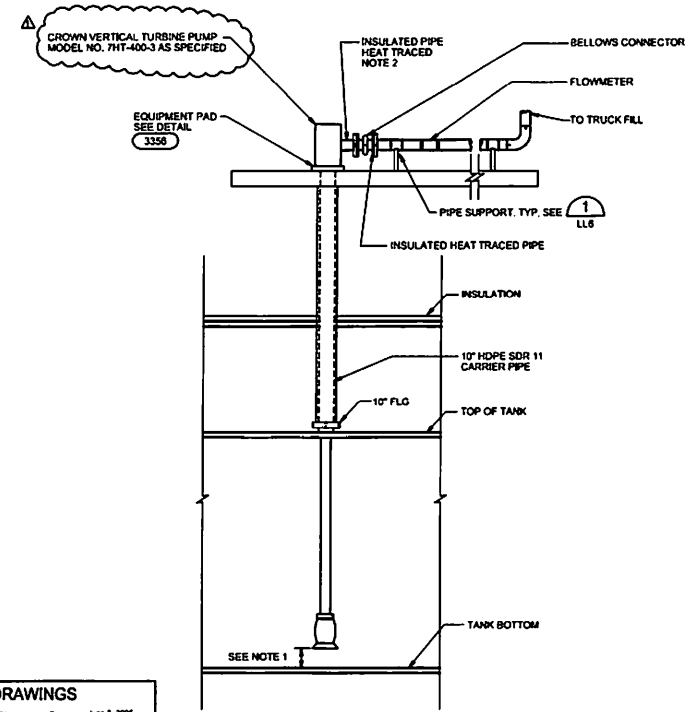
CELL 2B
LEACHATE STORAGE TANK
SECTIONS AND DETAILS

SHEET 13
DWG NO. LL2
DATE NOV 2002
PROJ NO. 157050.CL.CC

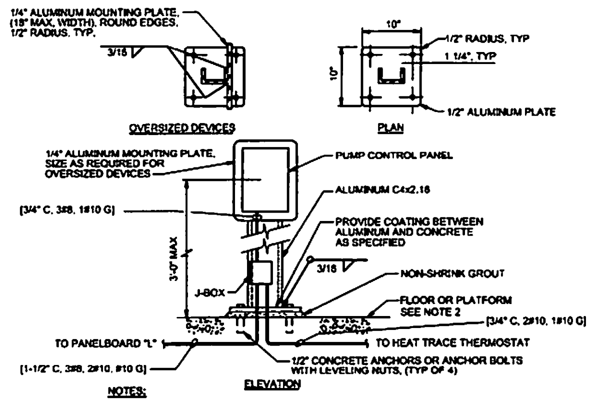
cell2b157050ll2_dlv.dwg 08-AUG-2002 16:48:35



LEACHATE PUMP SECTION AT STORAGE TANK (B) LL5, LL6
1/4" = 1'-0"



LEACHATE PUMP (1)
1/2" = 1'-0"



NOTES:

1. USE STAINLESS STEEL MOUNTING HARDWARE. USE WASHERS AND SPLIT-LOCK WASHERS UNDER ALL NUTS.
2. FOR YARD LOCATIONS, PROVIDE 2'-0" SQUARE x 6" THICK CONCRETE PAD AT GRADE WITH 3#4 REBAR EACH WAY, CENTERED.
3. CONTROL STATIONS DEVICES AND EQUIPMENT HAVING A FRONTAL AREA NOT GREATER THAN 2'-0" SQ. FT. SHALL BE PEDESTAL MOUNTED UNLESS OTHERWISE INDICATED.

PUMP CONTROL PANEL (2)
NTS

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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Revisions Checked by Cory Hinds Date June 8, 2005

NOTES:

1. DIMENSION AS REQUIRED BY PUMP MANUFACTURER, CONTRACTORS SHALL VERIFY ACTUAL PUMP LENGTH TO PROVIDE PUMP MANUFACTURER'S MINIMUM ALLOWABLE DISTANCE FROM THE BOTTOM OF THE TANK.
2. PROVIDE INSULATED, HEAT TRACE ARCTIC PIPE FROM PUMP TO END OF TRUCK FILL PIPE. SEE ALSO DWG HTR AND UN DCVR 009.

REUSE OF DOCUMENTS:

DSGN	K. WINTER				
DR	J. MONROY				
CHK	J. WODRICH				
APVD	J. WODRICH				
NO.	DATE	REVISION	BY	APVD	
△	3-8-05	AS BUILT DRAWING	J.M.	C.H.	

CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
LEACHATE STORAGE TANK SECTION
PUMP ENCLOSURE DETAIL

SHEET	15
DWG NO.	LL4
DATE	OCT 2003
PROJ NO.	157050.A1.01

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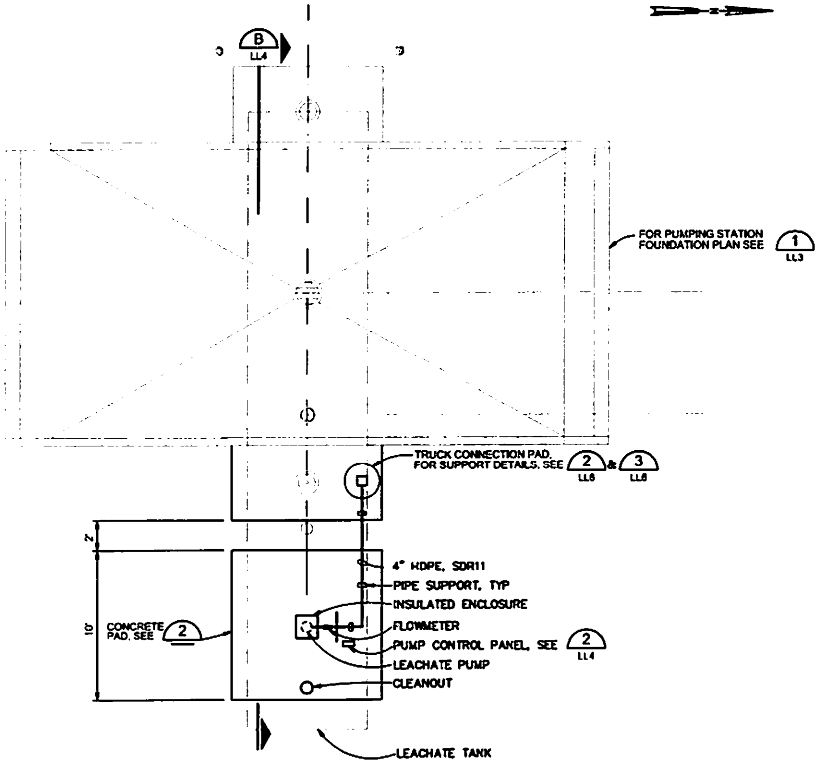
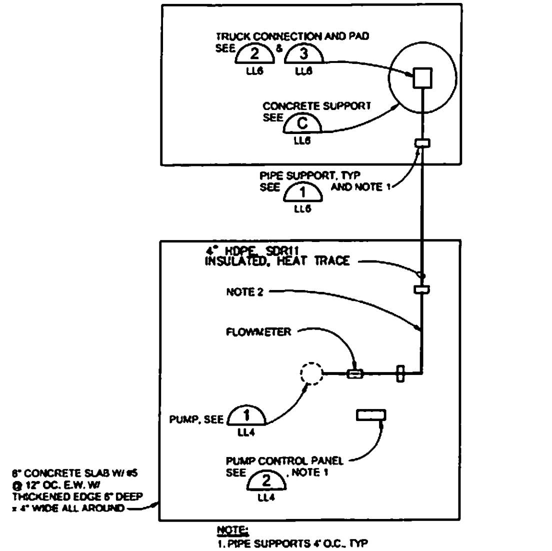


LEACHATE PUMP AND CONTROL PLAN (1)

1/4"=1'-0"



LEACHATE PUMP AND CONTROL (2)

NTS

NOTES:

1. ROUTE FLEX CONDUIT AND FLOWMETER SIGNAL CABLE FROM FLOWMETER TO PUMP CONTROL PANEL.
2. ROUTE TRUCK FILL ARCTIC PIPE UP SLOPE TO TRUCK FILL CONNECTION. CONTRACTOR TO PROVIDE FITTINGS AS NECESSARY, SEE B LL4

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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Revisions Checked by Cory Hinds Date June 8, 2005

DSGN K. WINTER					
DR J. MONROY					
CHK J. WODRICH	△	6-8-05	AS BUILT DRAWING	J.M.	C.H.
APVD J. WODRICH	NO.	DATE	REVISION	BY	APVD

CH2MHILL

CENTRAL LANDFILL EXPANSION CELL 2B CONSTRUCTION

CELL 2B LEACHATE PUMP AND CONTROL PLAN

SHEET	16
DWG NO.	LL5
DATE	OCT 2003
PROJ NO.	157030.A1.01

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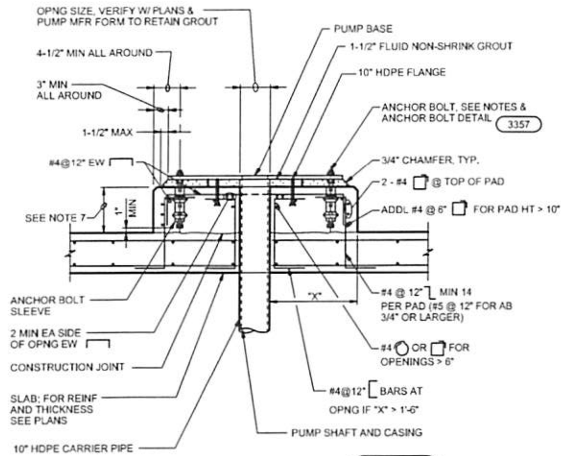


EQUIPMENT PAD DETAIL 3356
NTS

NOTES:

1. PAD SIZE SHALL BE MINIMUM INDICATED OR AS SHOWN ON THE PLANS OR AS INDICATED BY THE MANUFACTURER AND APPROVED BY THE ENGINEER.

2. THE SIZE, NUMBER, TYPE, LOCATION AND THREAD PROTECTION OF THE ANCHOR BOLTS SHALL BE DETERMINED BY THE EQUIPMENT MANUFACTURER AND AS APPROVED BY THE ENGINEER. ANCHOR BOLTS SHALL BE HELD IN POSITION WITH A TEMPLATE OR OTHER ACCEPTABLE MEANS, MATCHING THE BASE PLATE, WHILE PAD IS BEING PLACED.

3. ANCHOR BOLT SLEEEVES SHALL BE USED TO PROVIDE MINIMUM ANCHOR BOLT MOVEMENT OF 1/2" IN ALL HORIZONTAL DIRECTIONS. THE MINIMUM SLEEVE LENGTH SHALL BE 8 TIMES THE BOLT DIAMETER.

4. ANCHOR BOLT SLEEVES SHALL HAVE A MINIMUM INTERNAL DIAMETER 1" GREATER THAN BOLT DIAMETER AND A MAXIMUM INTERNAL DIAMETER 3" GREATER THAN ANCHOR BOLT DIAMETER. SLEEVES SHALL BE FILLED WITH NON-SHRINK GROUT AFTER BOLTS ARE ALIGNED. SEE 3357

5. EQUIPMENT BASES SHALL BE INSTALLED LEVEL UNLESS INDICATED OTHERWISE.

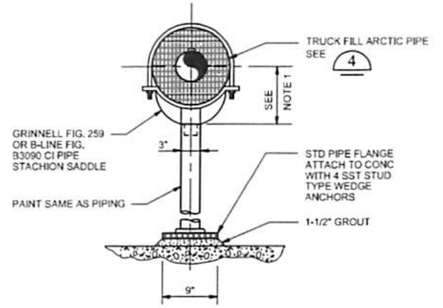
6. WEDGES, SHIMS, OR LEVELING NUTS SHALL BE USED TO SUPPORT THE BASE WHILE THE NON-SHRINK GROUT IS PLACED. WEDGES OR SHIMS THAT ARE LEFT IN PLACE SHALL NOT BE EXPOSED TO VIEW.

7. HEIGHT OF PADS SHALL BE MINIMUM REQUIRED FOR ANCHOR BOLT CLEARANCE TO KEEP ANCHOR BOLT ABOVE SUPPORTING SLAB (SEE TABLE BELOW). WHERE EQUIPMENT OR PIPING ELEVATION REQUIRE A PAD HEIGHT LESS THAN THE MINIMUM SHOWN, USE TYPE "B" EQUIPMENT PAD WITH BLOCKOUT.

8. TYPE "D" PAD SHALL BE USED ONLY WHERE SPECIFICALLY INDICATED. PLACE THE SURROUNDING FLOOR SLAB AFTER THE EQUIPMENT PAD.

9. AT CONTRACTOR'S OPTION, CONCRETE ANCHORS MAY BE USED IN LIEU OF CAST-IN-PLACE ANCHOR BOLTS FOR EQUIPMENT ANCHOR BOLTS LESS THAN 3/4" DIAMETER WHEN APPROVED BY THE EQUIPMENT MANUFACTURER AND APPROVED BY THE ENGINEER. ANCHORS SHALL BE INSTALLED WITH 4" MINIMUM EDGE DISTANCE IN EACH DIRECTION.

AB DIA (IN)	1/2	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
MIN PAD HT (IN)	7	8-1/2	10	11	12-1/2	15	16-1/2	18	21	24

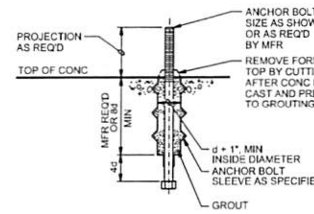


NOTES:

1. PROVIDE HALF ROUND RIGID INSULATION AND INSULATION PROTECTION SHIELD, SIMILAR TO GRINNELL FIGURE 167 OR ELCEN FIGURE 219, WHERE PIPING IS INSULATED.

2. PROVIDE NEOPRENE WAFFLE ISOLATION PAD, SIMILAR TO MASON TYPE "W" OR KORFUND KORPAD 40, UNDER SUPPORT FOOT WHEN PIPING IS ISOLATED OR SUPPORT IS ADJACENT TO MECHANICAL EQUIPMENT.

PIPE SUPPORT DETAIL 1
NTS 1,2

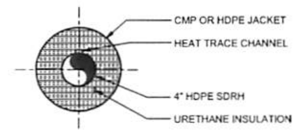


NOTES:

1. FOR CONCRETE EQUIPMENT PAD DETAILS AND NOTES NOT SHOWN SEE 3356

2. MATERIAL TO MATCH BOLT

MACHINERY ANCHOR BOLT DETAIL 3357
NTS



TRUCK FILL ARCTIC PIPE 4
NTS

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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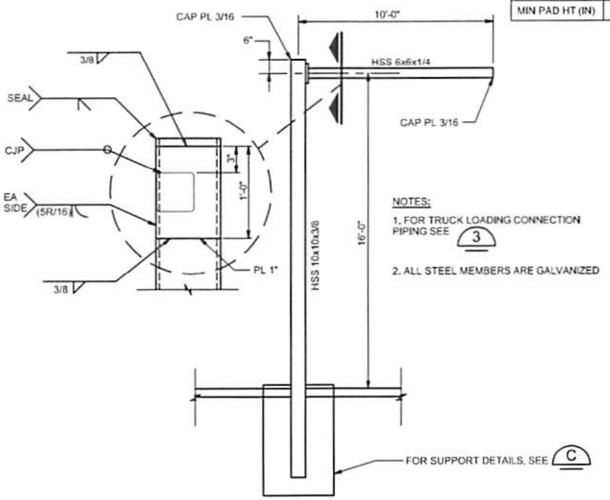
Revisions Checked by Cory Hinds Date June 8, 2005

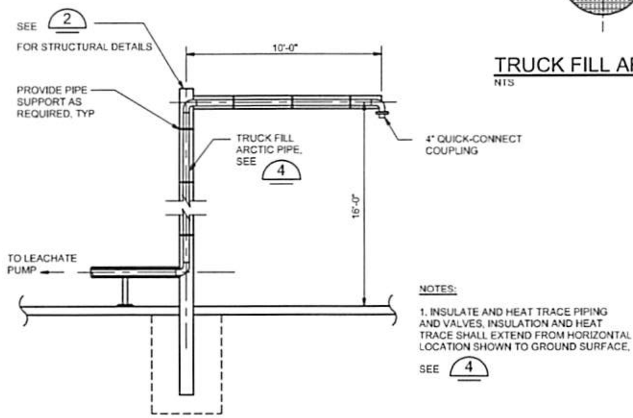


NOTES:

1. FOR TRUCK LOADING CONNECTION PIPING SEE 3

2. ALL STEEL MEMBERS ARE GALVANIZED

TRUCK LOADING SUPPORT 2
NTS LL5

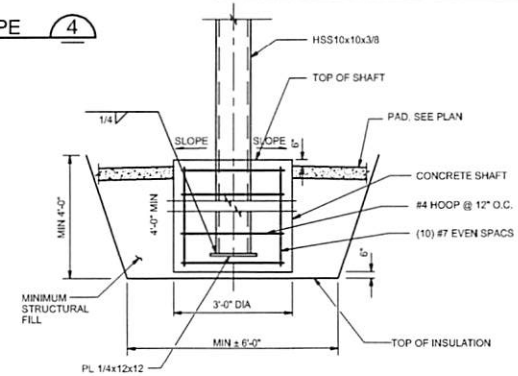


NOTES:

1. INSULATE AND HEAT TRACE PIPING AND VALVES, INSULATION AND HEAT TRACE SHALL EXTEND FROM HORIZONTAL LOCATION SHOWN TO GROUND SURFACE.

SEE 4

TRUCK LOADING STATION DETAIL 3
NTS LL5



SECTION C
NTS LL5

DSGN	K. WINTER					
DR	J. MONROY					
CHK	L. YANG	△	6-8-05	AS BUILT DRAWING	J.M.	C.H.
APVD	L. YANG	NO.	DATE	REVISION	BY	APVD

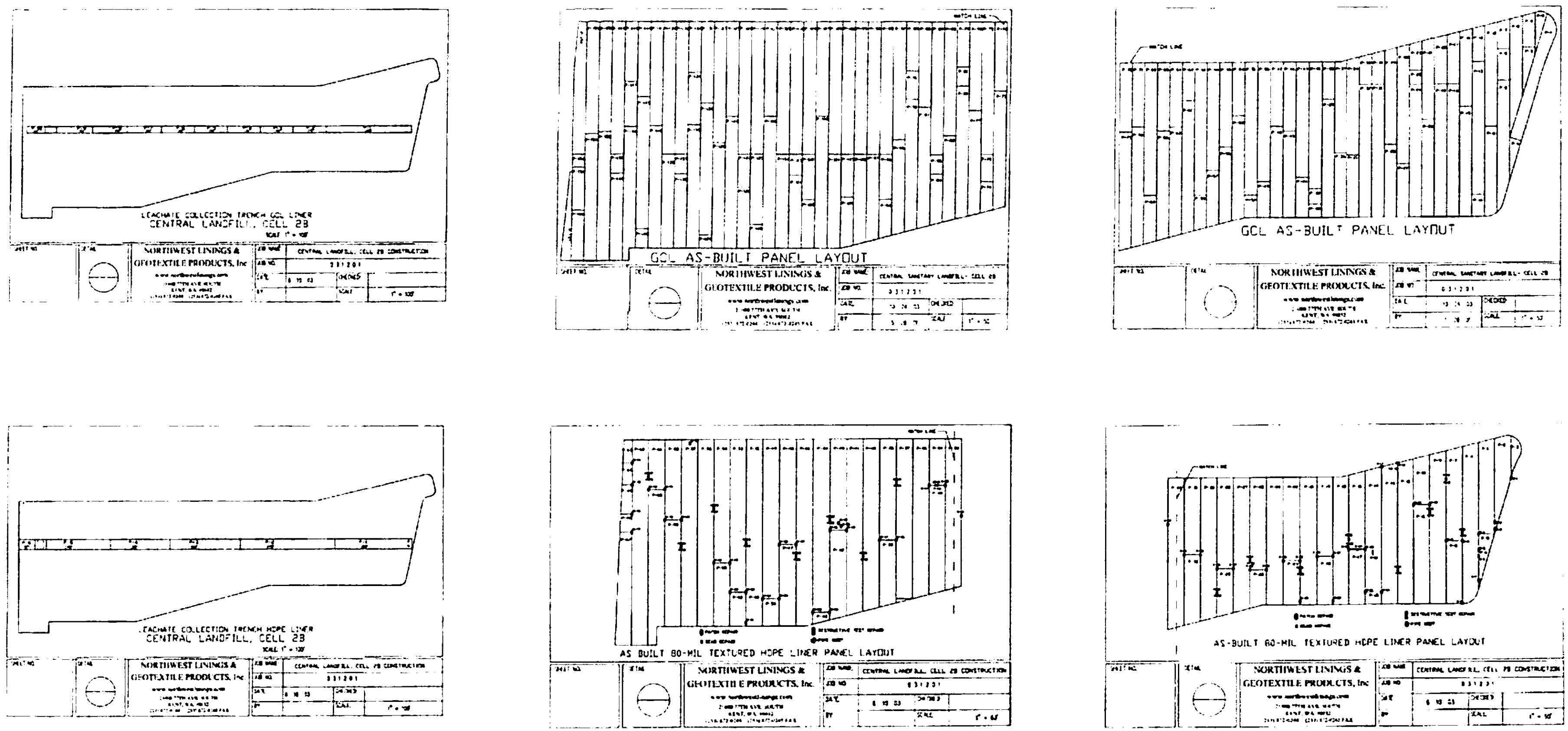
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
DETAILS

SHEET	17
DWG NO.	LL6
DATE	OCT 2003
PROJ NO.	157050.A1.01

CELL2B-SHT4_AB.dwg 09-Jun-2005 13:32:17



RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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Revisions Checked by Cory Hinds Date June 8, 2005

DSGN C. HINDS					
DR J. MONROY					
CHK C. HINDS	⚠	6-8-05	AS BUILT DRAWING	J.M.	C.H.
APVD C. HINDS	NO.	DATE	REVISION	BY	APVD

CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

PANEL LAYOUTS

SHEET	18
DWG NO.	GCL
DATE	JUN 2005
PROJ NO.	157050.A1.01

CELL2B-GCL-PANELS.dwg 09-Jun-2005 10:27:60

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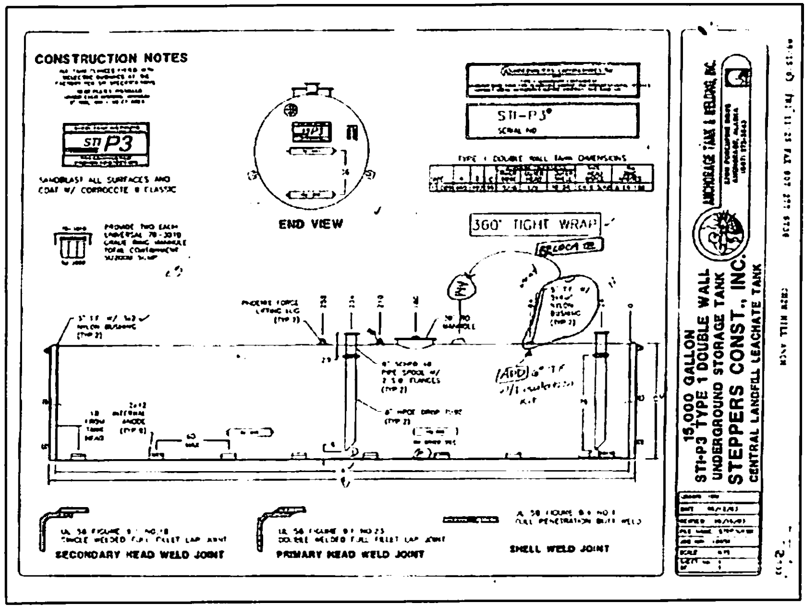

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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Revisions Checked by Cory Hinds Date June 8, 2005

DSGN C. HINDS					
DR J. MONROY					
CHK C. HINDS	△	6-8-05	AS BUILT DRAWING	J.M.	C.H.
APVD C. HINDS	NO.	DATE	REVISION	BY	APVD

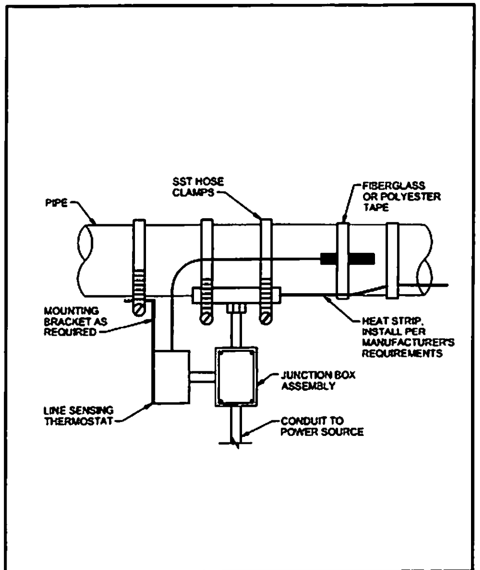
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

UNDERGROUND STORAGE TANK

SHEET	19
DWG NO.	TNK
DATE	JUN 2005
PROJ NO.	157050.A1.01

TANK-DTL.dwg 09-Jun-2005 15:01:12



16712

HEAT TRACE CONNECTION

NTS

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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Revisions Checked by Cory Hinds Date June 8, 2005

NO.	DATE	REVISION	BY	APVD
1	6-8-05	AS BUILT DRAWING	J.M.	C.H.

DSGN C. HINDS
DR J. MONROY
CHK C. HINDS
APVD C. HINDS

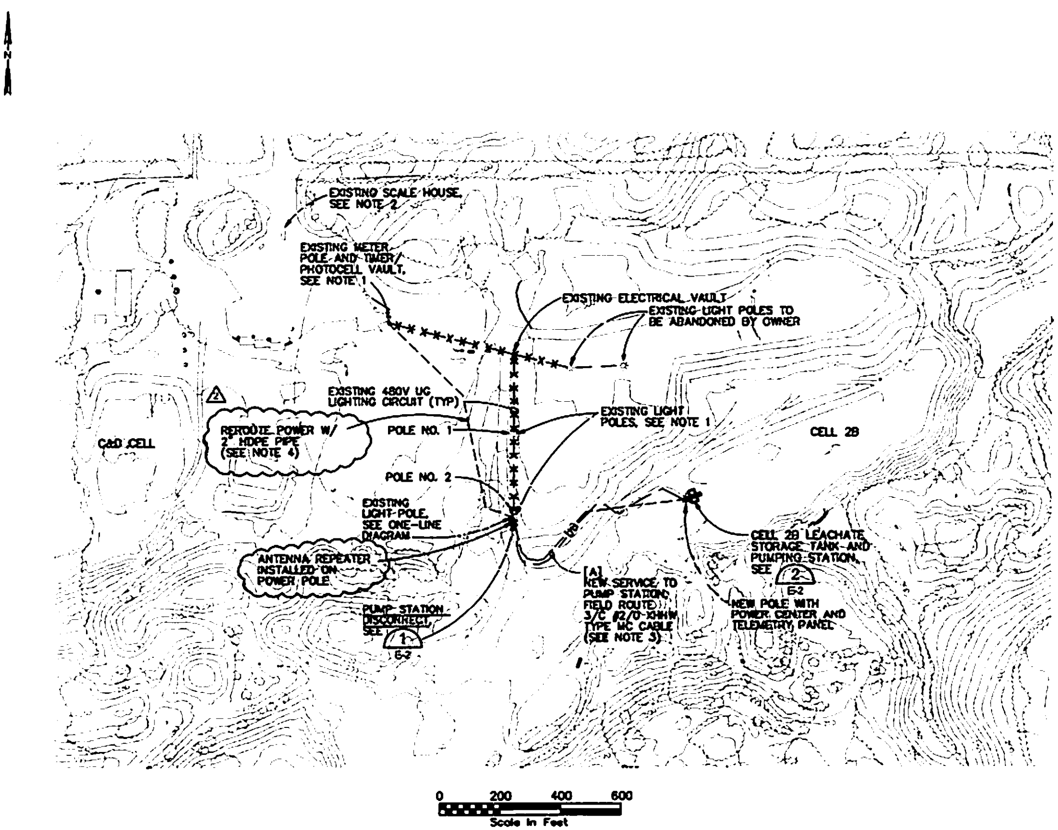
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

HEAT TRACE DETAIL

SHEET 20
DWG NO. HTR
DATE JUN 2005
PROJ NO. 157050.A1.01

HTRACE-DTL.dwg 09-Jun-2005 15:52:55



NOTES:

1. COORDINATE WITH OWNER THE REMOVAL OF EXISTING PC/TIMER/CONTACTOR, AND RELOCATING AND CONNECTING PC/TIMER/CONTACTOR AT EXISTING POLE NO. 1. PROVIDE NEW PC/TIMER/CONTACTOR MATCHING EXISTING AND INSTALL AND CONNECT ON POLE NO. 2. VERIFY REQUIREMENTS PRIOR TO BID.
2. ALL CIRCUITS ARE 3-1/C # 12 XHHW IN 3/4" CONDUIT UNLESS OTHERWISE SPECIFIED.
3. DIRECT BURY MC CABLE 24" BELOW GRADE OR ROADWAY SURFACE WITH WARNING TAPE AT LEAST 12" ABOVE CABLE.
4. AN EMPTY 2" HDPE PIPE WAS BURIED WITH THE MC CABLE TO SUPPORT FUTURE SITE DEVELOPMENT NEEDS.

RECORD DRAWINGS

Revisions Drawn by [illegible] Date [illegible]

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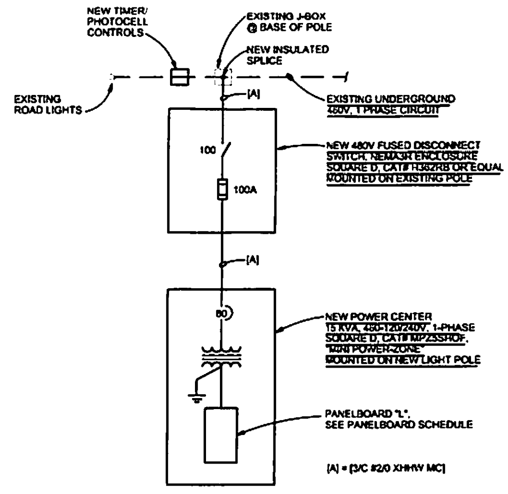
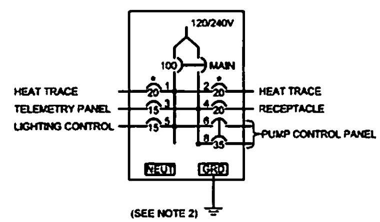
Revisions Checked by [illegible] Date [illegible]



ONE-LINE DIAGRAM
NTS



* GFCI TYPE CIRCUIT BREAKERS, 30mA TRIP

SCHEDULE PANELBOARD "L"
NTS

DSGN J. MAURAIS	2	8-8-05	AS BUILT DRAWING	J.M.	C.H.
DR R. BENFIELD	1	OCT 8, 2003	ADD MODIFICATIONS FOR LEACHATE PUMP STATION	BA	CH
CHK K. MERRELL					
APVD K. MERRELL	NO.	DATE	REVISION	BY	APVD

BAR IS ONE INCH ON ORIGINAL DRAWING. 0 — 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

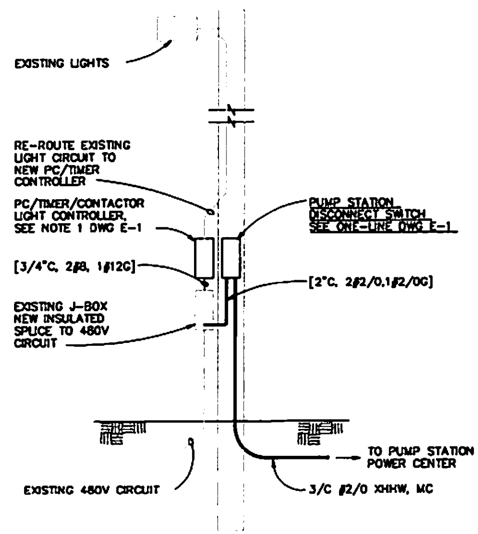
CH2MHILL

CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

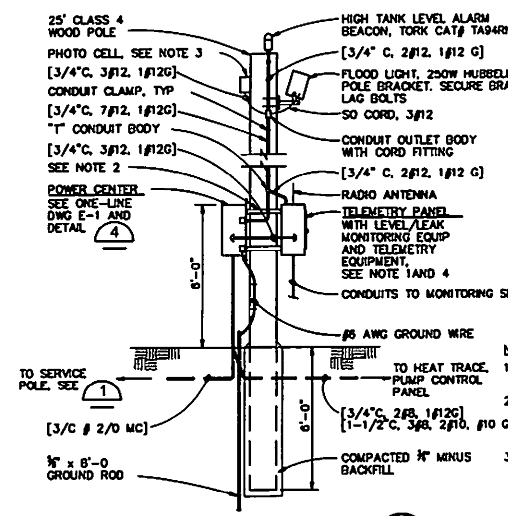
CELL 2B ELECTRICAL SITE PLAN, ONE-LINE DIAGRAM AND PANELBOARD SCHEDULE

SHEET	21
DWG NO.	E1
DATE	OCT 2003
PROJ NO.	157050.CL.CC

cell2b157050e1_dlv.dwg 13-OCT-2003 10:08:22



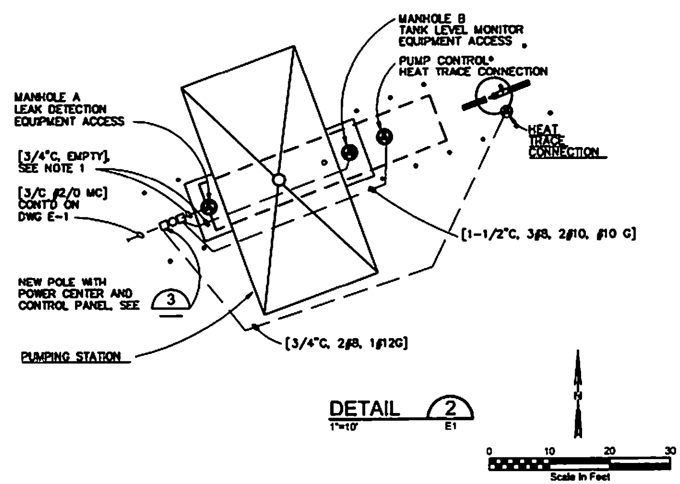
PUMP STATION SERVICE DETAIL (1/E1)
NTS



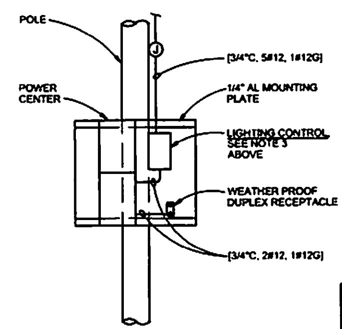
NEW POLE DETAIL (3)
NTS

NOTES:

1. SEE SPECIFICATION SECTION 15480 FOR REQUIREMENTS.
2. PROVIDE POLE MOUNTING HARDWARE CONSTRUCTED FROM UNISTRUT P-1000SS CHANNEL.
3. PROVIDE PHOTO-TIME CONTROL OF FLOODLIGHT. ON-PHOTOCELL, TIME CLOCK-OFF. TIMER SHALL BE TORK MODEL T920L WITH MANUAL-OFF-AUTO SWITCH IN A NEMA 4X ENCLOSURE. PHOTOCELL SHALL BE TORK MODEL 2101.
4. OWNER TO PROVIDE TELEPHONE LINE FOR CONTRACTOR CONNECTION TO TELEMETRY PANEL.



DETAIL (2/E1)
1"=10'



DETAIL (4)
1"=10'

RECORD DRAWINGS

Revisions Drawn by Jorge Monroy Date June 8, 2005

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DSGN J. MAURAIS	2	6-8-05	AS BUILT DRAWING	J.M.	C.H.
DR R. BENFIELD	1	OCT 9, 2003	ADD MODIFICATIONS FOR LEACHATE PUMP STATION	BA	CH
CHK K. MERRILL					
APVD K. MERRILL	NO.	DATE	REVISION	BY	APVD

VERIFY SCALE: BAR IS ONE INCH ON ORIGINAL DRAWING. 0 — 1". IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

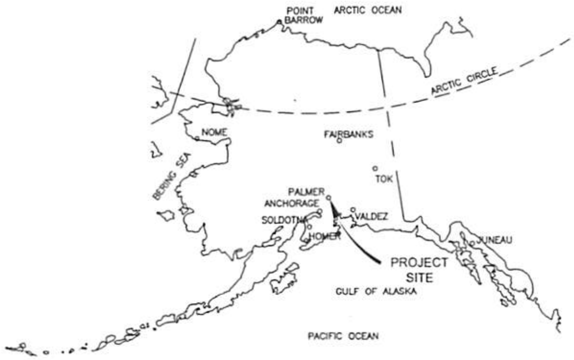
CENTRAL LANDFILL EXPANSION
CELL 2B CONSTRUCTION

CELL 2B
LEACHATE STORAGE TANK
ELECTRICAL SITE PLAN
AND DETAILS

SHEET 22
DWG NO. E2
DATE OCT 2003
PROJ NO. 157050.CL.CC

2a157050e2_dlv.dwg 09-OCT-2003 09:03:11

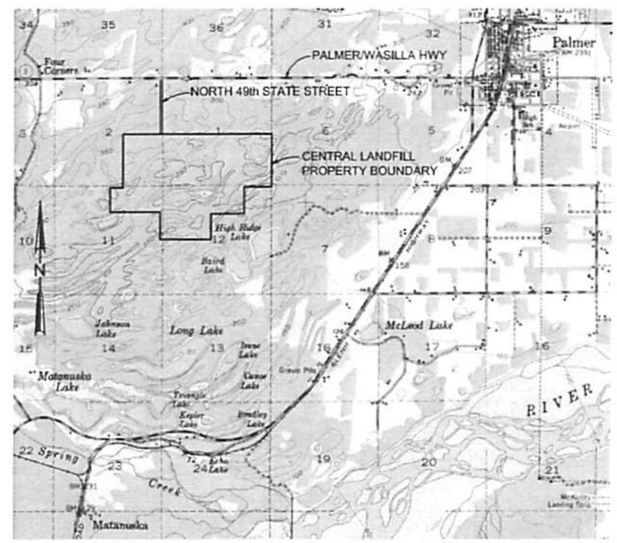
MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION
PALMER, ALASKA



LOCATION MAP

SCALE = NTS

PLAN SHEET INDEX



VICINITY MAP

SCALE = NTS

ISSUED FOR BIDDING
DATE: 6/4/2007

NO.	DATE	REVISIONS	BY	CHK	SCALE: 1=1	DRAWN: CDB			DRAWING: T-1
					THIS BAR IS 1" AT FULL SIZE	DESIGNED: WME	MACTEC	COVER SHEET	SHEET: 1 OF 16
					PROJECT NO.: 4036070010	CHECKED: WTH	601 East 57th Place Anchorage, AK 99518 Phone: (907) 563-8102 Fax: (907) 561-4754 www.mactec.com	MATANUSKA-SUSITNA BOROUGH CENTRAL LANDFILL EXPANSION CELL 3 CONSTRUCTION	DATE: 06-04-2007

Central Landfill 2010 Permit Application
Attachment H
2 of 2

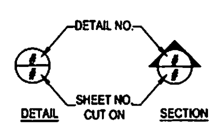
ABBREVIATIONS

APPROX	APPROXIMATE
BLDG	BUILDING
BM	BENCHMARK
BOT	BOTTOM
BTWN	BETWEEN
℄	CENTERLINE
CF	CUBIC FOOT(FEET)
CMP	CORRUGATED METAL PIPE
CO	CLEANOUT
CONC	CONCRETE
CP	SURVEY CONTROL POINT
CPEP	CORRUGATED POLYETHYLENE PIPE
CY	CUBIC YARDS
DIA	DIAMETER
DWV	DRAIN WASTE VENT
EA	EACH
ELEV	ELEVATION
ELL	ELBOW
EW	EACH WAY
EXIST	EXISTING
FT	FOOT (FEET)
GDM	GRANULAR DRAINAGE MATERIAL
GCL	GEOSYNTHETIC CLAY LINING
HDPE	HIGH DENSITY POLYETHYLENE
LCP	LEACHATE COLLECTION PIPE PERFORATED
LC	LEACHATE COLLECTION PIPE NON-PERFORATED
LF	LINEAR FEET, LANDFILL
MAX	MAXIMUM
MH	MANHOLE
MIN	MINIMUM
MON	MONUMENT
MRKR	MARKER
MW	MONITORING WELL
N/A	NOT APPLICABLE
NIC	NOT IN CONTRACT
NTS	NOT TO SCALE
OC	ON CENTER
PC	POINT OF CURVATURE
PE	POLYETHYLENE
PERF	PERFORATED
PI	POINT OF INTERSECTION
PP	POWER POLE
PT	POINT OF TANGENCY
SDR	STANDARD DIMENSION RATIO
S.S.	STAINLESS STEEL
STA	STATION
TBM	TEMPORARY BENCH MARKER
TEMP	TEMPORARY
TOPO	TOPOGRAPHY
TYP	TYPICAL

GENERAL LEGEND & TOPOGRAPHIC SYMBOLS

PLAN

- EXISTING GRADE SPOT ELEVATIONS
- FINISHED GRADE SPOT ELEVATIONS — 106.4
- EXISTING CONTOURS
- DESIGN CONTOURS — 350
- SLOPE EMBANKMENT — 2:1
- SURFACE DRAINAGE (NEW)
- COORDINATE POINT
- POWER POLE
- LIGHT POLE
- SIGN
- WELL — WELL 13
- CUT LIMITS
- FILL LIMITS
- ℄ OF DITCH OR BERM
- GRADE LINE
- EDGE OF GCL/GEOMEMBRANE



PIPING SYMBOLS

- LEACHATE TRANSMISSION PIPE NON-PERFORATED — LTP
- LEACHATE COLLECTION PIPE PERFORATED — LCP

SECTION

- DIRECTION OF SURFACE DRAINAGE AND SLOPE — 2% or 2:1
- 2 HORIZONTAL TO 1 VERTICAL — 2:1
- SLOPE DESIGNATION — 2 / 1

GENERAL NOTES

1. SOME EXCAVATION, SETTLEMENT AND SITE GRADING MAY HAVE OCCURRED IN LOCALIZED AREAS AND MAY NOT BE REFLECTED ON THE DRAWINGS. CONTRACTOR IS RESPONSIBLE FOR VERIFICATION OF EXISTING SITE TOPOGRAPHY AND PLANIMETRIC FEATURES PRIOR TO CONSTRUCTION. NOTIFY ENGINEER OF DEVIATIONS FROM THESE PLANS.
2. IN GENERAL, EXISTING FEATURES ARE NOTED AS "EXISTING" AND SHOWN IN LIGHT LINE WEIGHTS, OR AS SCREENED BACKGROUND.
3. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS BEFORE STARTING WORK AND SHALL IMMEDIATELY NOTIFY THE BOROUGH PROJECT MANAGER OF ANY DISCREPANCIES.
4. DISTANCES SHOWN SHALL BE INTERPRETED TO REFER TO THE HORIZONTAL AND VERTICAL PROJECTED PLANES, UNLESS INDICATED OTHERWISE.
5. THE CONTRACTOR SHALL REPAIR ALL DAMAGE TO EXISTING ACCESS ROADS AND FACILITIES AT NO COST TO THE BOROUGH.
6. CONTRACTOR SHALL COORDINATE WORK WITH LANDFILL OPERATOR TO ENSURE THAT OPERATIONS ARE NOT INTERRUPTED.
7. OPERATOR WILL NEED DAILY ACCESS IN THE AREAS TO THE SOUTH AND EAST OF CELL 3 FOR LEACHATE TRUCKING AND DAILY COVER MATERIAL EXCAVATION.
8. ALL SITE WORK SHALL CONFORM TO APPLICABLE FEDERAL STATE AND LOCAL SAFETY REGULATIONS.

SUMMARY OF ESTIMATED QUANTITIES

ITEM	UNIT
EXCAVATION	188,000 CY
GENERAL FILL	5,400 CY
SELECT FILL	14,500 CY
SAND CUSHION MATERIAL	7,100 CY
GRANULAR DRAINAGE MATERIAL	27,100 CY

QUANTITY NOTES:

1. EXCAVATION IS BANK VOLUME. FILLS AND MANUFACTURED MATERIALS ARE VOLUMES IN PLACED CONDITION. CONTRACTOR TO MAKE OWN DETERMINATION OF SHRINK AND SWELLS.
2. CONTRACTOR SHALL MAKE OWN ESTIMATES AND TAKE OFFS OF ALL QUANTITIES.

STATE OF ALASKA 49TH ... WILLIAM T. HANEY ... CE - 7246 ...

ISSUED FOR BIDDING
DATE: 6/4/2007

NO.	DATE	REVISIONS	BY	CHK

SCALE: 1=1 | THIS BAR IS 1" AT FULL SIZE | PROJECT NO.: 4036070010 | DRAWN: CDB | DESIGNED: WME | CHECKED: WTH

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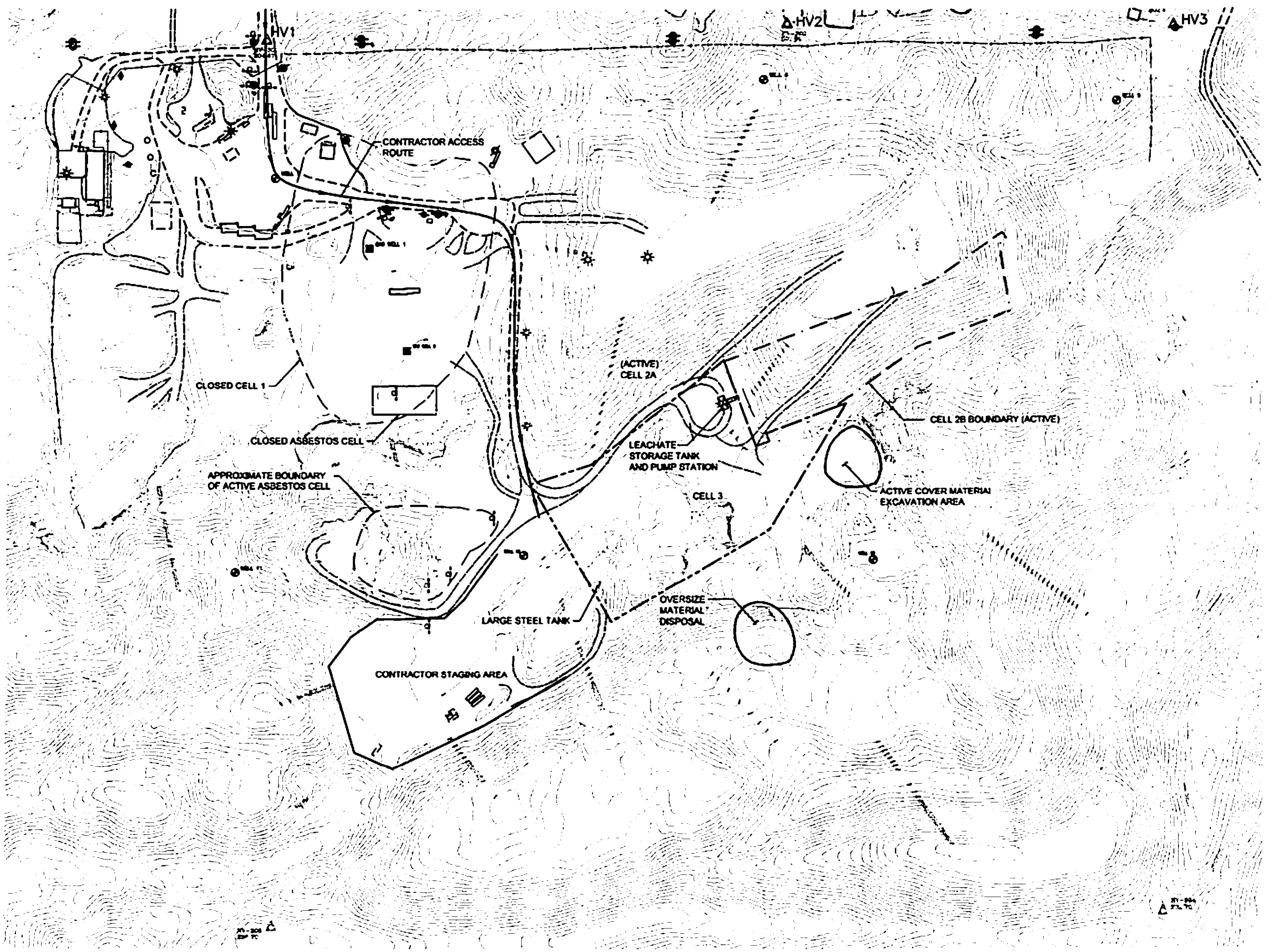
GENERAL NOTES & INFORMATION
MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

DRAWING: G-1
SHEET: 2 OF 16
DATE: 06-04-2007



HORIZONTAL AND VERTICAL CONTROL				
POINT	NORTHING	EASTING	ELEVATION	DESCRIPTION
HV1	2774729.14	1778249.16	304.67	1/4 COR MON. IN ASPH.
HV3	2774776.00	1780959.75	302.71	REBAR

NOTES:

1. EXISTING TOPOGRAPHY AND FEATURES ARE BASED ON A COMBINATION OF AERO-METRIC PHOTOGRAPHY DATED APRIL 25, 2006 AND LOUNSBURY AND ASSOCIATES SURVEY DURING APRIL 2007.
2. SURVEY CONTROL COORDINATES ARE BASED ON ALASKA STATE PLANE COORDINATES SYSTEM OF 1983.
3. EXISTING SURFACE WILL VARY AT TIME OF CONSTRUCTION AS BOROUGH OPERATIONS ARE ACTIVELY EXCAVATING IN THE WORK AREA.
4. STOCKPILE SLOPES ARE TO BE NO STEEPER THAN 1H:1V.
5. "ACTIVE" REFERS TO AREAS WHERE BOROUGH OPERATIONS IS CURRENTLY PLACING WASTE OR EXCAVATING COVER MATERIAL.
6. STOCKPILE EXCESS EXCAVATED MATERIAL IN CONTRACTOR STAGING AREA.
7. DISPOSE OF DEBRIS ENCOUNTERED DURING CONSTRUCTION IN ACTIVE LANDFILL AREAS (AT NO CHARGE).

ISSUED FOR BIDDING
DATE: 6/4/2007

STATE OF ALASKA
WILLIAM T. HARVEY
CE - 7246
6-4-07

NO.	DATE	REVISIONS	BY	CHK

SCALE: 1"=160'
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DESIGNED: WME
CHECKED: WTH

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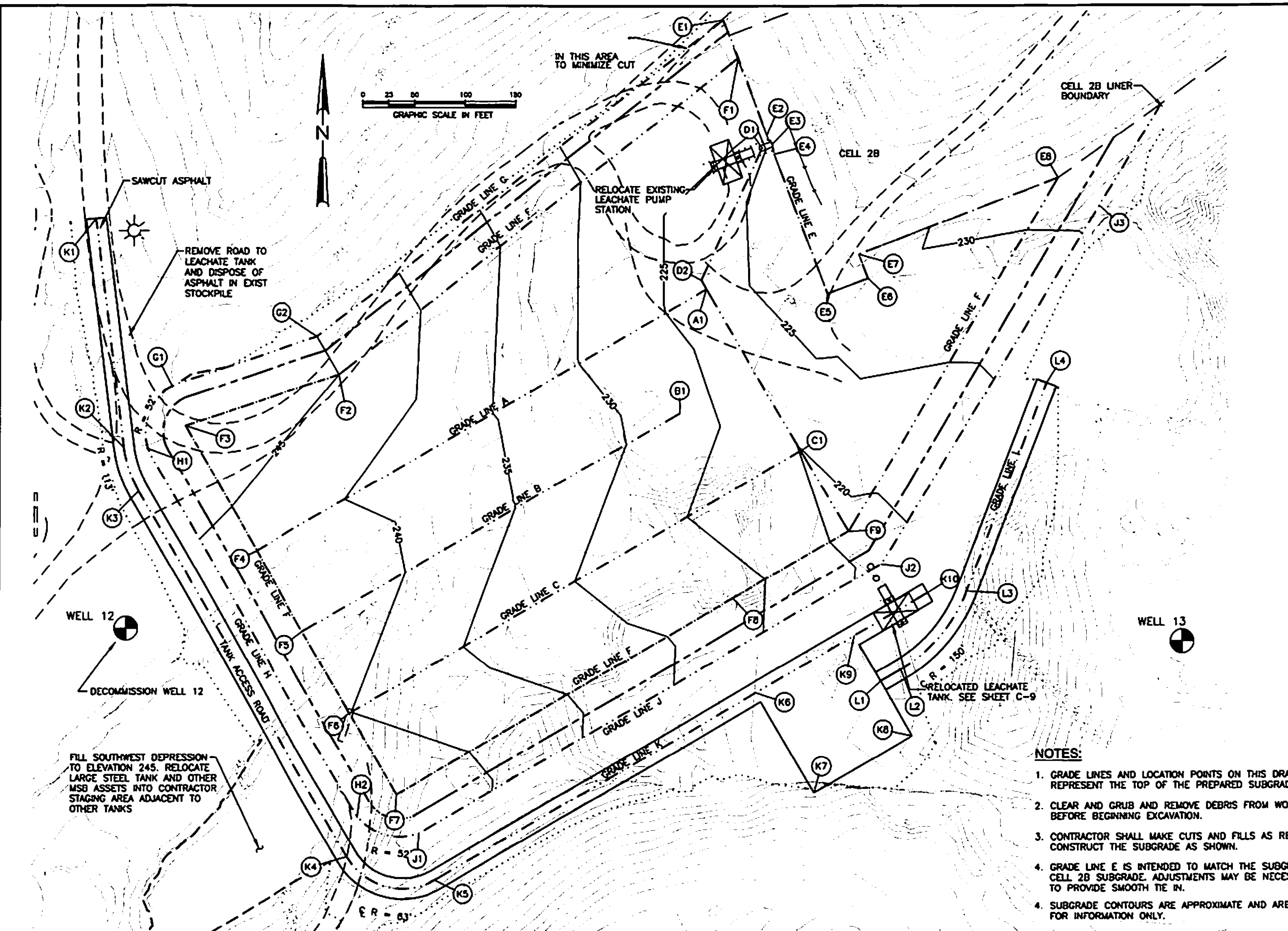
SITE PLAN

MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

DRAWING: G-2
SHEET: 3 OF 16
DATE: 06-04-2007



LAYOUT SCHEDULE			
LOCATION POINT	NORTHING	EASTING	ELEVATION
A1	2773523.6	1779594.6	222.6
B1	2773401.8	1779568.5	227.6
C1	2773364.7	1779687.4	219.9
D1	2773661.8	1779649.6	224.4
D2	2773532.2	1779589.6	222.75
E1	2773788.3	1779610.9	227.25
E2	2773674.3	1779654.3	226.4
E3	2773665.6	1779659.7	224.6
E4	2773655.6	1779661.4	226.4
E5	2773519.1	1779713.3	228.6
E6	2773534.0	1779752.4	229.2
E7	2773557.3	1779743.5	228.9
E8	2773631.9	1779939.5	232.0
F1	2773750.8	1779625.9	227.25
F2	2773440.0	1779235.2	240.0
F3	2773389.5	779082.1	249.0
F4	2773266.2	1779154.2	242.8
F5	2773186.8	1779200.6	244.6
F6	2773107.3	1779247.0	240.1
F7	2773027.9	1779293.4	243.7
F8	2773219.7	1779621.6	224.9
F9	2773285.3	1779733.9	218.55
G1	2773429.4	1779068.9	249.0
G2	2773477.1	1779213.8	240.0
H1	2773367.3	1779044.1	249.0
H2	2773005.7	1779255.4	243.7
J1	2772989.9	1779315.6	243.7
J2	2773252.9	1779765.7	218.55
J3	2773604.6	1779979.5	231.0
K1	2773591.8	1778993.8	MATCH
K2	2773368.1	1779021.8	250.7
K3	2773325.1	1779036.4	249.0
K4	2772967.0	1779245.6	245.0
K5	2772944.4	1779331.8	245.0
K6	2773127.3	1779644.8	227.0
K7	2773029.7	1779701.8	225.0
K8	2773085.2	1779796.8	225.0
K9	2773182.8	1779739.8	225.7
K10	2773224.5	1779811.2	225.7
L1	2773138.5	1779765.7	225.5
L2	2773150.0	1779785.4	225.5
L3	2773226.1	1779849.9	227.0
L4	2773431.3	1779927.9	MATCH

NOTES:

1. GRADE LINES AND LOCATION POINTS ON THIS DRAWING REPRESENT THE TOP OF THE PREPARED SUBGRADE SURFACE.
2. CLEAR AND GRUB AND REMOVE DEBRIS FROM WORK AREA, BEFORE BEGINNING EXCAVATION.
3. CONTRACTOR SHALL MAKE CUTS AND FILLS AS REQUIRED TO CONSTRUCT THE SUBGRADE AS SHOWN.
4. GRADE LINE E IS INTENDED TO MATCH THE SUBGRADE OF CELL 2B SUBGRADE. ADJUSTMENTS MAY BE NECESSARY TO PROVIDE SMOOTH TIE IN.
4. SUBGRADE CONTOURS ARE APPROXIMATE AND ARE SHOWN FOR INFORMATION ONLY.

ISSUED FOR BIDDING
DATE: 6/4/2007

STATE OF ALASKA
WILLIAM T. HARTLEY
CE - 7346
6.4.07

NO.	DATE	REVISIONS	BY	CHK

SCALE: 1"=100'
THIS BAR IS 1" AT FULL SIZE:
PROJECT NO.: 4036070010
DRAWN: CDB
DESIGNED: WME
CHECKED: WTH

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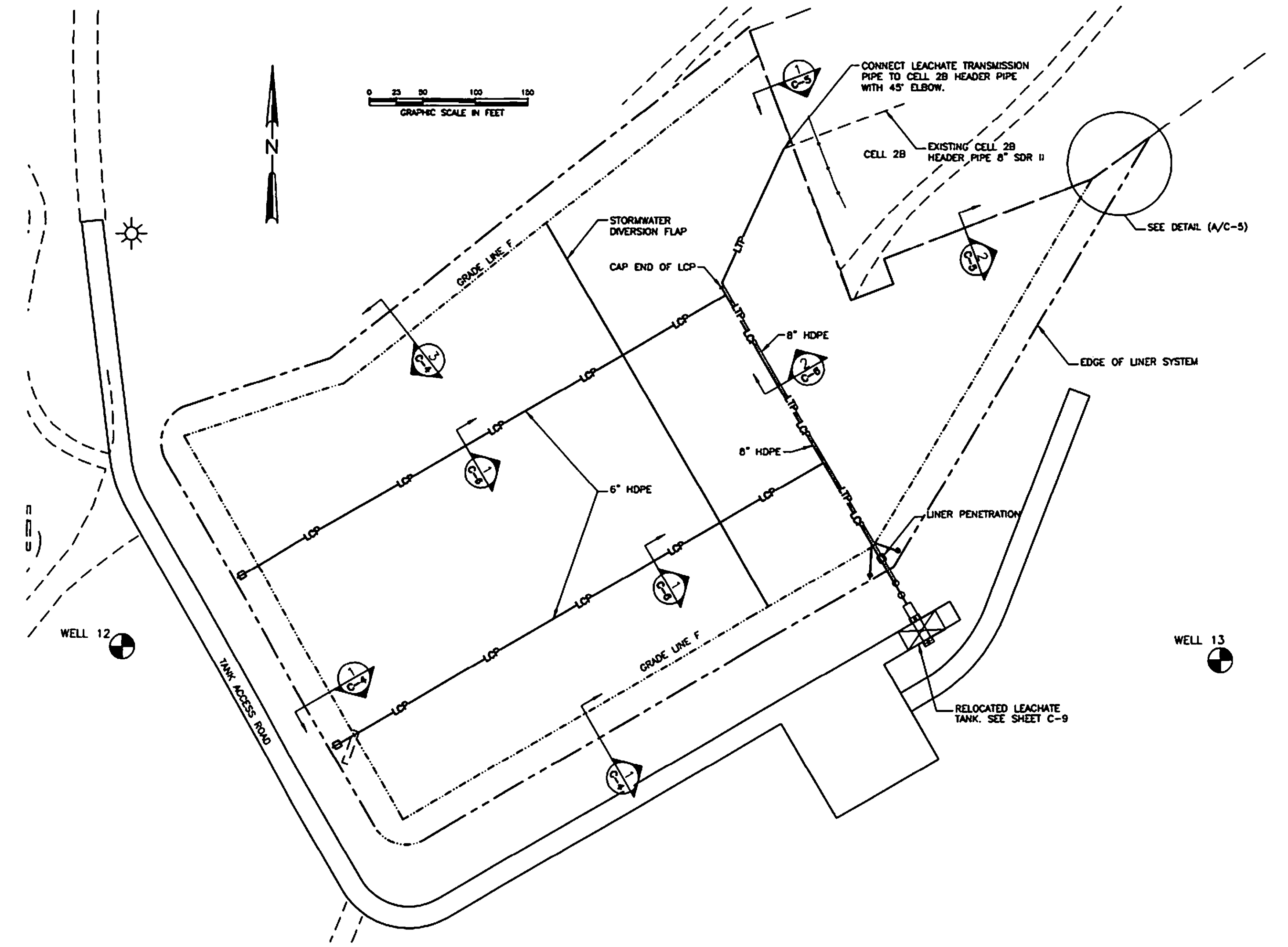
EXCAVATION AND GRADING PLAN

MATANUSKA-SUSITNA BOROUGH

CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

DRAWING: C-1
SHEET: 4 of 16
DATE: 06-04-2007

P:\Group\Mat-Su Borough\Cell 3 Design\CAD\acad\CELL3-C-01, 1=50, 06/04/07 at 14:21 by cdb
LAYOUT: C-1 XREF: CELL3-DESIGN, CELL3-EXISTING



NOTE:

1. EDGE OF LINER SYSTEM IS DEFINED BY BERM CROSS SECTIONS ON DRAWINGS C-4 AND C-5.
2. STORMWATER DIVERSION FLAP TO BE FIELD LOCATED BY OWNER

ISSUED FOR BIDDING
DATE: 6/4/2007

NO.	DATE	REVISIONS	BY	CHK

SCALE: 1"=100'
THIS BAR IS 1" AT FULL SIZE:
PROJECT NO.: 4036070010
DRAWN: CDB
DESIGNED: WME
CHECKED: WTH

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LINER AND LEACHATE COLLECTION PLAN

MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

DRAWING: C-2
SHEET: 5 OF 16
DATE: 06-04-2007

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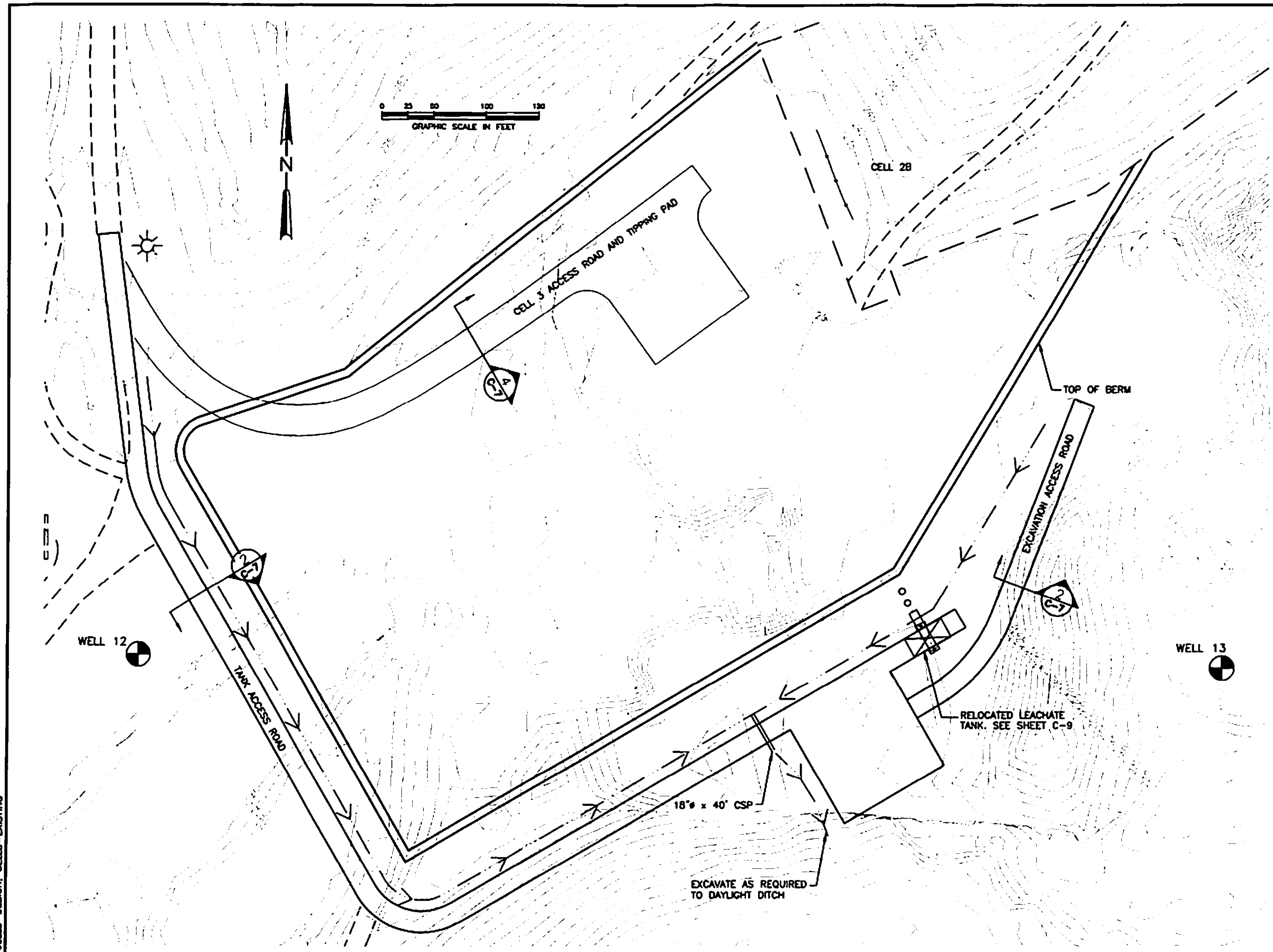

NOTES:

1. CONSTRUCT BERMS AND ACCESS ROADS FROM TYPICAL SECTIONS AND SUBGRADE LINE AND GRADES DETAILED ON SHEET C-2.
2. CULVERT TO BE 18" CORRUGATED STEEL PIPE (CSP) IN ACCORDANCE WITH ALASKA DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES STANDARDS. STAKE TO DRAIN.
2. CONSTRUCT CELL 3 ACCESS ROAD AND TIPPING PAD AS SHOWN. MAXIMUM GRADE ALLOWED ON ROAD IS 5 PERCENT.

ISSUED FOR BIDDING
DATE: 6/4/2007

NO.	DATE	REVISIONS	BY	CHK

SCALE: 1"=100'
THIS BAR IS 1" AT FULL SIZE:
PROJECT NO.: 4036070010
DRAWN: CDB
DESIGNED: WME
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FINISH GRADING PLAN

MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

DRAWING: C-3
SHEET: 6 OF 16
DATE: 06-04-2007

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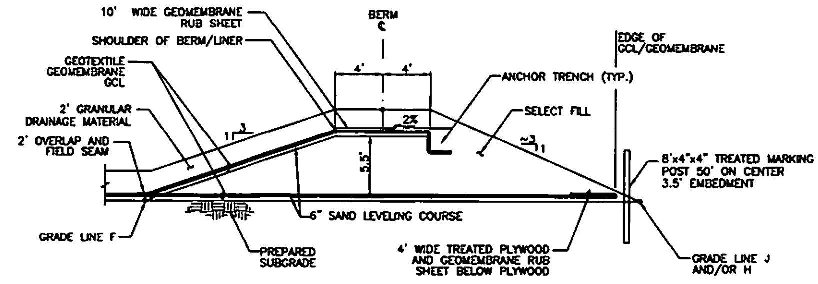
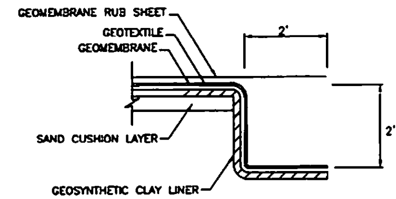
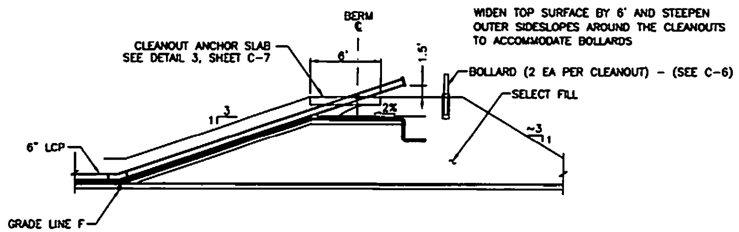
LAYOUT: C-3 XREF: CELL3-DESIGN, CELL3-EXISTING



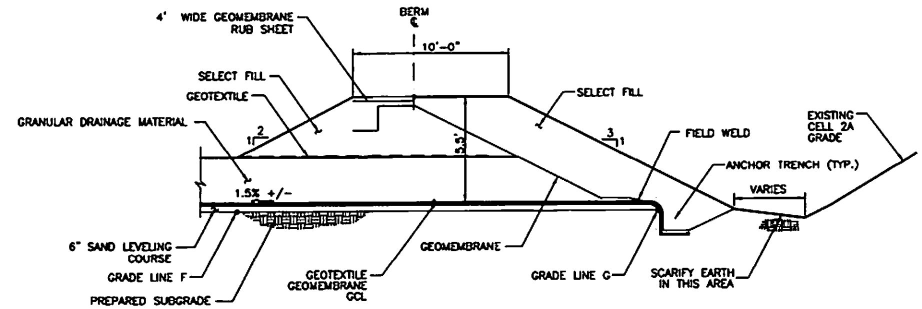
WEST AND SOUTH EDGE BERM SECTION (1/C-4)
NTS



ANCHOR TRENCH TYPICAL
NTS



CLEANOUT ON BERM TYPICAL (2/C-4)
NTS

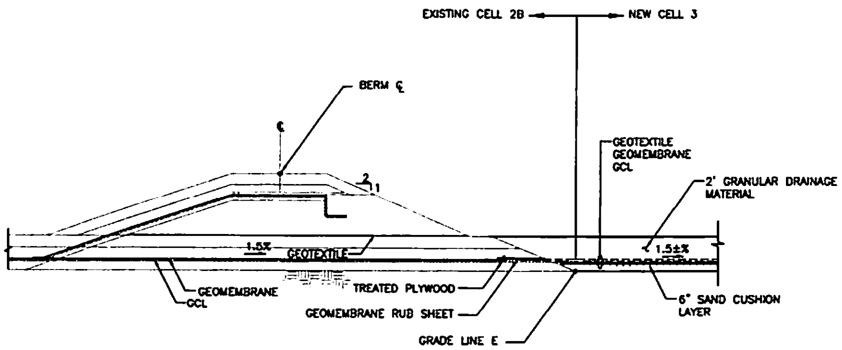


NORTH EDGE BERM SECTION (3/C-4)
NTS

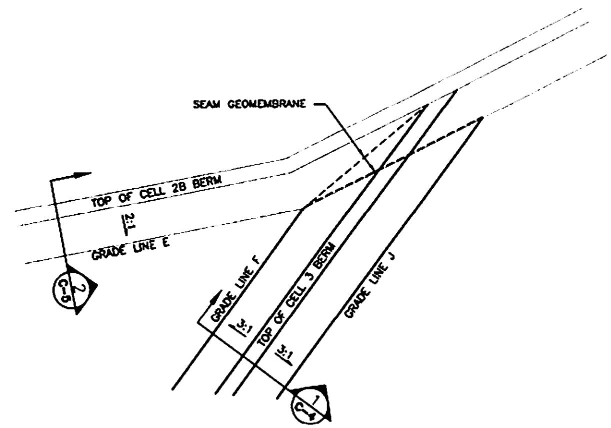
GENERAL EXCAVATION NOTE:
CUT AND FILL SLOPES OUTSIDE OF GRADE LINES G, H AND J ARE TO BE 2:1. CATCH POINTS ARE SHOWN ON C-1.

ISSUED FOR BIDDING
DATE: 6/4/2007

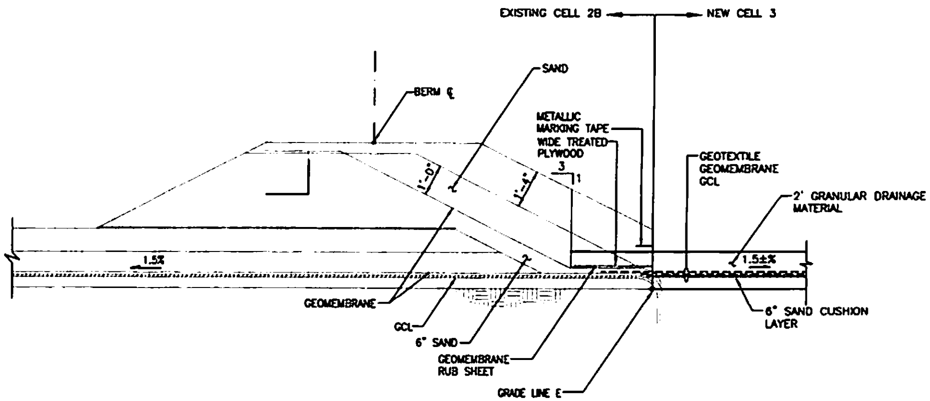
NO	DATE	REVISIONS	BY	CHK	SCALE: 1=1	DRAWN: CDB	MACTEC	BERM SECTIONS	DRAWING: C-4
					THIS BAR IS 1" AT FULL SIZE	DESIGNED: WME	601 East 57th Place, Anchorage, AK 99518, Phone: (907) 563-8102, Fax: (907) 561-4754, www.mactec.com	MATANUSKA-SUSITNA BOROUGH CENTRAL LANDFILL EXPANSION CELL 3 CONSTRUCTION	SHEET: 7 OF 16
					PROJECT NO.: 4036070010	CHECKED: WTH			DATE: 06-04-2007



EDGE CONNECTION TO CELL 2B
GRADE LINE POINT E1 TO E5 (1/C-5)



BERM CONNECTION DETAIL (A/C-5)
NTS



EDGE CONNECTION TO CELL 2B
GRADE LINE POINT E5 TO E8 (2/C-5)

NOTES:

1. EXCAVATE AND PREPARE THE SUBGRADE WITH CARE ALONG THE CONNECTION LINE. ADJUST SUBGRADE AS REQUIRED TO BUILD SMOOTH TRANSITION FROM CELL 2B TO CELL 3.
2. EXCAVATE TO EXPOSE PLYWOOD. HAND DIG AS NECESSARY TO PREVENT DAMAGE TO THE CELL 2B LINER COMPONENTS.
3. REMOVE PLYWOOD AND RUB SHEET.
4. CLEAN AND DRY CELL 2B GEOMEMBRANE BENEATH THE REMOVED RUB SHEET.
5. PLACE SAND CUSHION MATERIAL TO PROVIDE SMOOTH TRANSITION BETWEEN CELL 2B AND CELL 3.
6. FOLD BACK CELL 2B GEOMEMBRANE TO EXPOSE GCL. OVERLAP WITH NEW GCL AS SPECIFIED.
7. WELD AND TEST CELL 2B AND CELL 3 GEOMEMBRANE AS SPECIFIED.
8. COVER WELDS AND 4 FOOT WIDE STRIP OF EXPOSED CELL 2B WITH GEOTEXTILE BEFORE PLACING GRANULAR DRAINAGE MATERIAL.

ISSUED FOR BIDDING
DATE: 6/4/2007

STATE OF ALASKA 49TH WILLIAM T. HANEY CE-7244 6.4.07

NO	DATE	REVISIONS	BY	CHK

SCALE: 1=1 | DRAWN: CDB
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PROJECT NO.: 4036070010 | CHECKED: WTH

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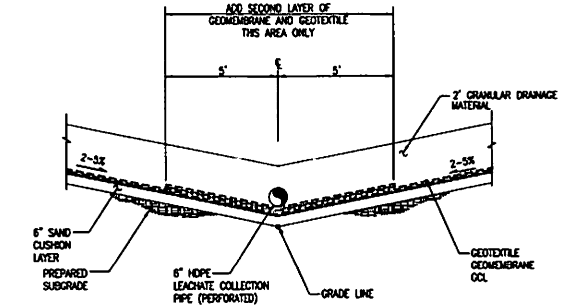
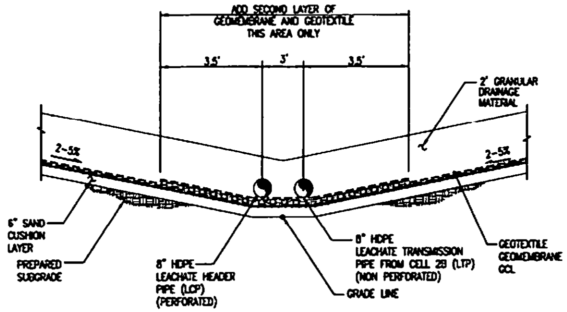
CONNECTION TO CELL 2B
MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

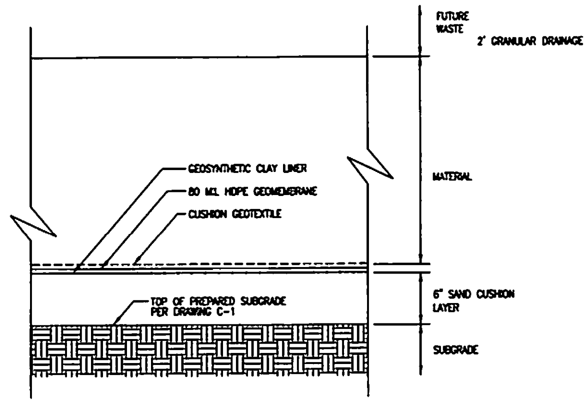
DRAWING: C-5
SHEET: 8 OF 16
DATE: 06-04-2007



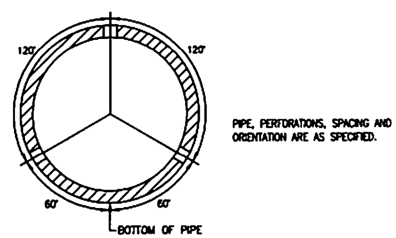
LCP SECTION, TYP 1/C-6
NTS



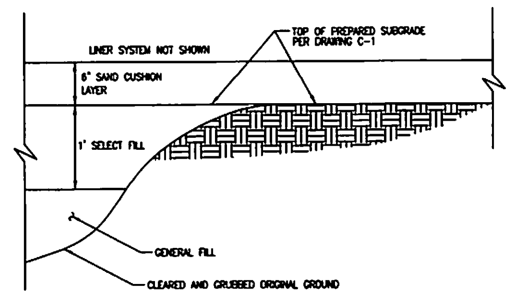
LCP/LTP SECTION, TYP 2/C-6
NTS



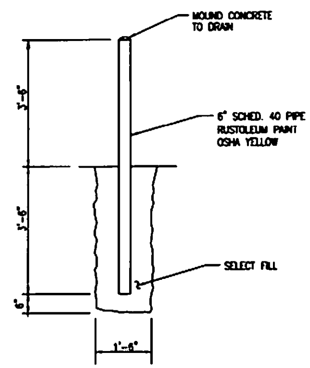
TYPICAL LINER SECTION 3/C-6
NTS



PIPE PERFORATION DETAIL
NTS



SUBGRADE CUT/FILL TRANSITION DETAIL
NTS



TYPICAL BOLLARD DETAIL 4/C-6
NTS

ISSUED FOR BIDDING
DATE: 6/4/2007

NO	DATE	REVISIONS	BY	CHK

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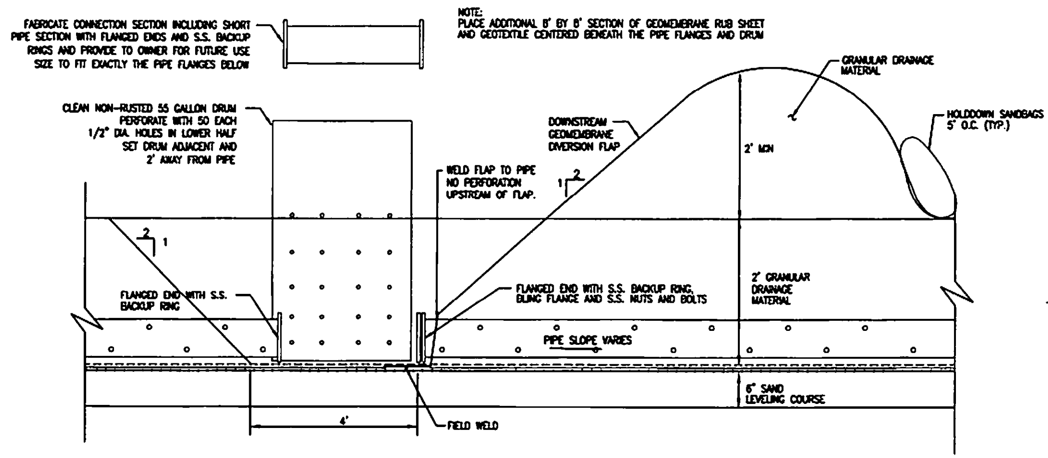
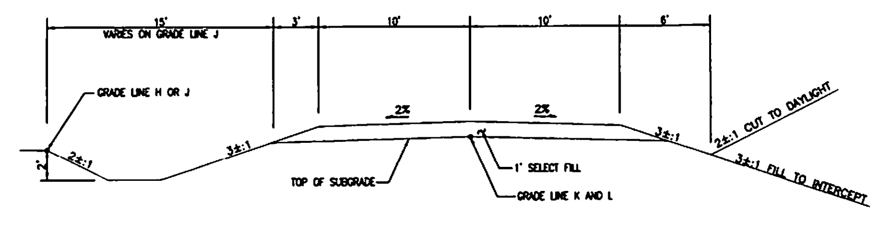
SECTIONS AND DETAILS
MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

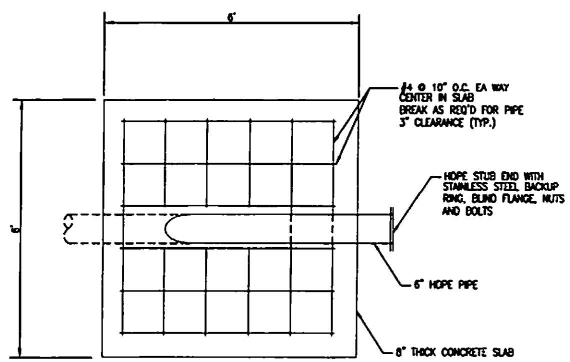
DRAWING: C-6
SHEET: 9 OF 16
DATE: 06-04-2007



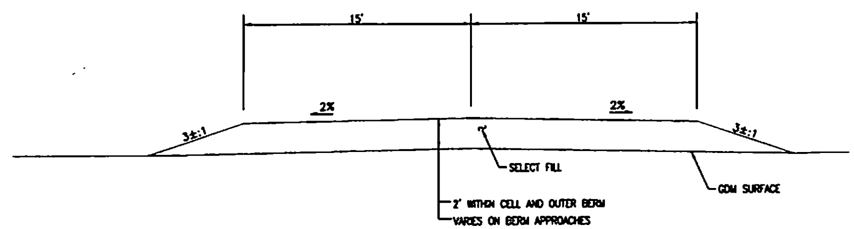
TEMPORARY STORMWATER DIVERSION FLAP (1/C-7)
NTS



TANK ACCESS ROAD TYPICAL SECTION (2/C-7)
NTS



CLEANOUT ANCHOR SLAB (3/C-7)
NTS
WRAP PIPE WITH GEOTEXTILE WHERE IN CONTACT WITH SLAB



CELL 3 ACCESS ROAD (4/C-7)
NTS

ISSUED FOR BIDDING
DATE: 6/4/2007

NO.	DATE	REVISIONS	BY	CHK

SCALE: 1=1	DRAWN: CDB
THIS BAR IS 1" AT FULL SIZE	DESIGNED: WME
PROJECT NO.: 4036070010	CHECKED: WTH

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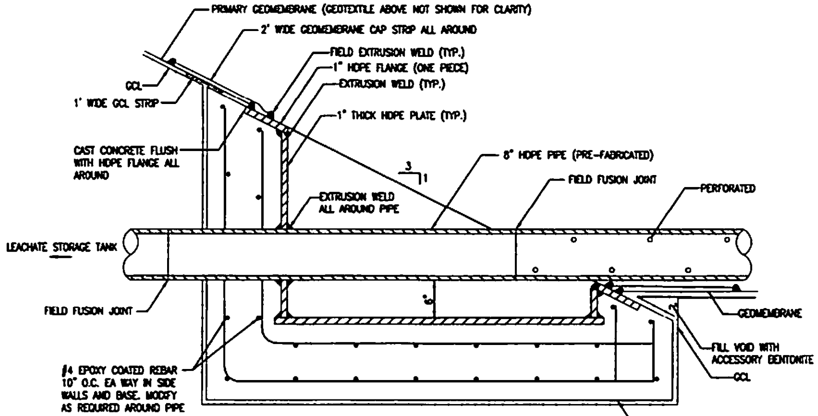
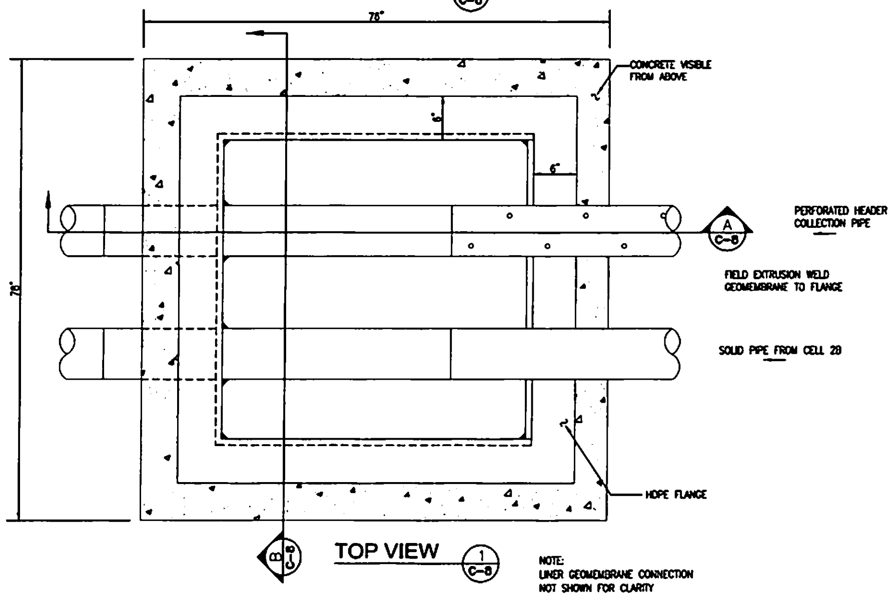
SECTIONS AND DETAILS

MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

DRAWING: C-7
SHEET: 10 OF 16
DATE: 06-04-2007

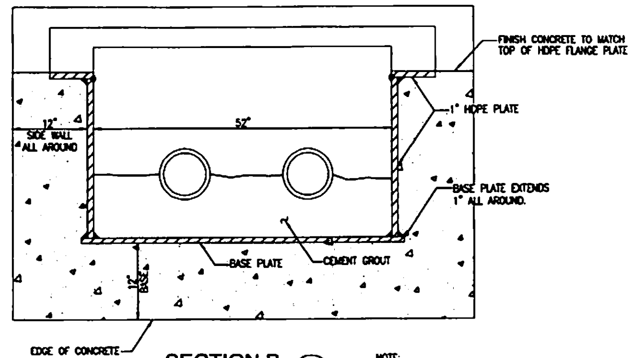


SECTION A (A / C-8)



TOP VIEW (1 / C-8)

NOTE:
LINER GEOMEMBRANE CONNECTION NOT SHOWN FOR CLARITY



SECTION B (B / C-8)

NOTE:
LINER GEOMEMBRANE CONNECTION NOT SHOWN FOR CLARITY

STRUCTURAL NOTES:

HORIZONTAL BARS TERMINATE 3 INCHES FROM FLANGE OR EXPOSED EDGE OF CONCRETE.

REINFORCING STEEL: EPOXY COATED AS SPECIFIED.

CONCRETE: AS SPECIFIED WITH MAX SLUMP OF 3 INCHES.

CLEARANCE: ALL CLEARANCES AGAINST FORMS, EARTH AND HDPE SHALL BE 3 INCHES.

TEMPORARY BRACING: TEMPORARY BRACING: PROVIDE ALL BRACING, SHORING, AND PROTECTION OF ALL WORK DURING CONSTRUCTION. DETAILS NOT SPECIFIED SHALL BE PER ACI 318.

HDPE FABRICATION NOTE:

ALL HDPE PLATES AND PIPE PENETRATION SHALL BE FACTORY EXTRUSION WELDED ON BOTH SIDE OF JOINTS. ALL WELDS SHALL BE 1" FILLET WELDS.

ISSUED FOR BIDDING
DATE: 6/4/2007

NO.	DATE	REVISIONS	BY	CHK

SCALE: 1=1
THIS BAR IS 1" AT FULL SIZE
PROJECT NO.: 4036070010
DRAWN: CDB
DESIGNED: WME
CHECKED: WTH

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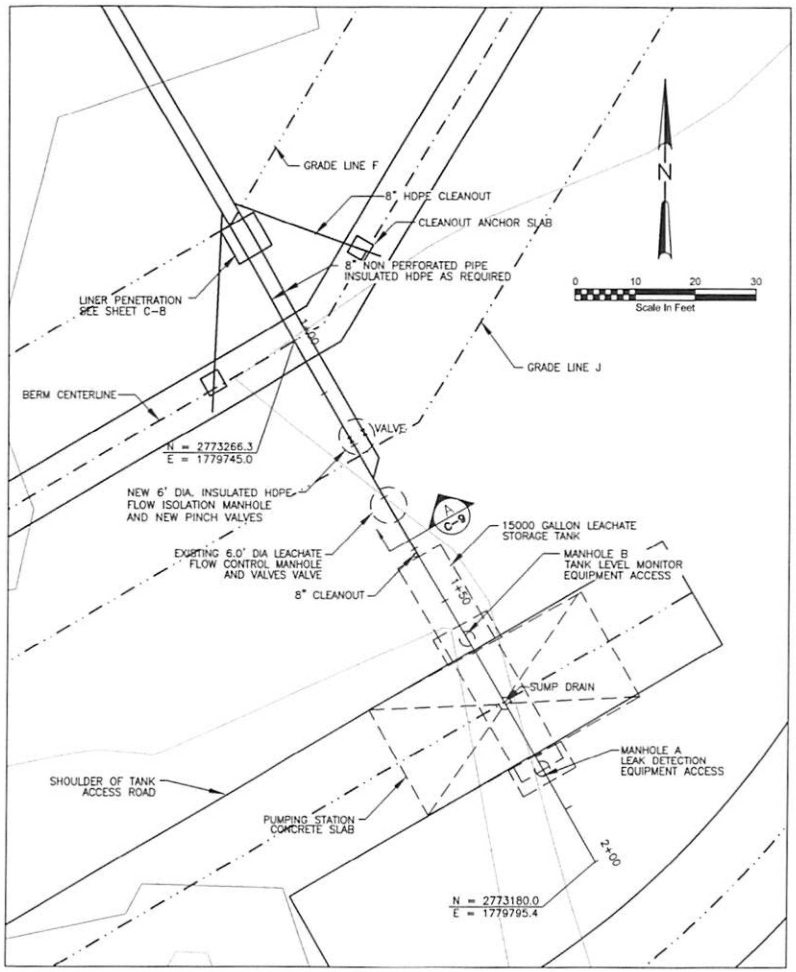
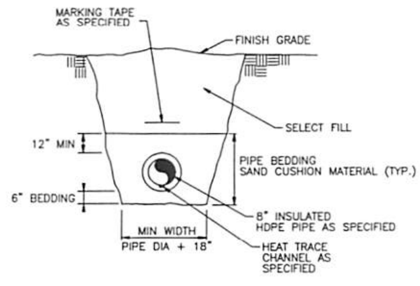
LINER PENETRATION DETAILS

MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

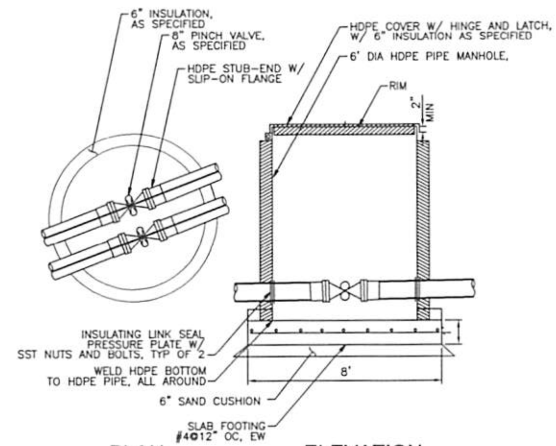
DRAWING: C-8
SHEET: 11 OF 16
DATE: 06-04-2007



LEACHATE STORAGE TANK SITE PLAN (1 / C-9)
NTS



TYPICAL LTP TRENCH FROM CELL TO TANK (A / C-9)
NTS

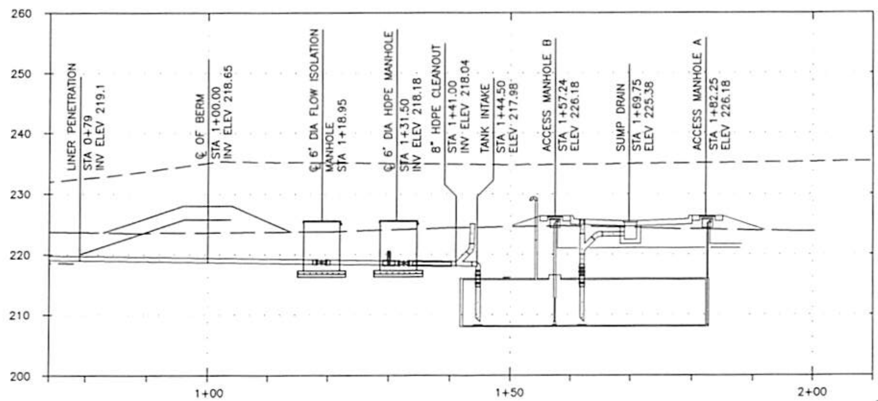


PLAN ELEVATION

TYPICAL MANHOLE (B / C-9)
NTS

NOTES:

1. FINISH GRADE PER SHEET C-1
2. CONSTRUCT NEW FLOW ISOLATION MANHOLE SIMILAR TO EXISTING FLOW CONTROL MANHOLE.
3. INSULATION AND GEOMEMBRANE OVER TANK ARE NOT SHOWN FOR CLARITY.
4. REINSTALL ALL PUMP STATION COMPONENTS AS SHOWN, SPECIFIED, AND IN THE SAME MANNER AS ORIGINAL.



LEACHATE STORAGE TANK PROFILE

ISSUED FOR BIDDING
DATE: 6/4/2007

NO	DATE	REVISIONS	BY	CHK

SCALE: 1=1	DRAWN: CDB
THIS BAR IS 1" AT FULL SIZE:	DESIGNED: XX
PROJECT NO.: 4036070010	CHECKED: XX

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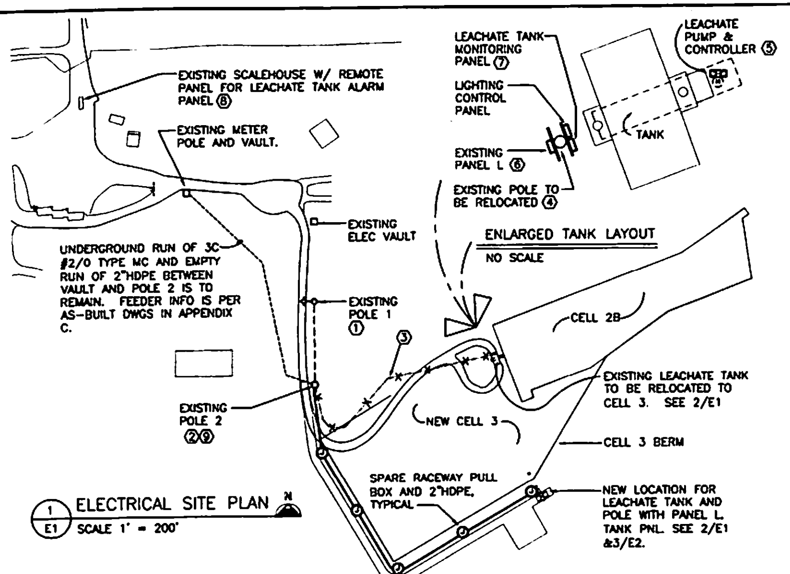
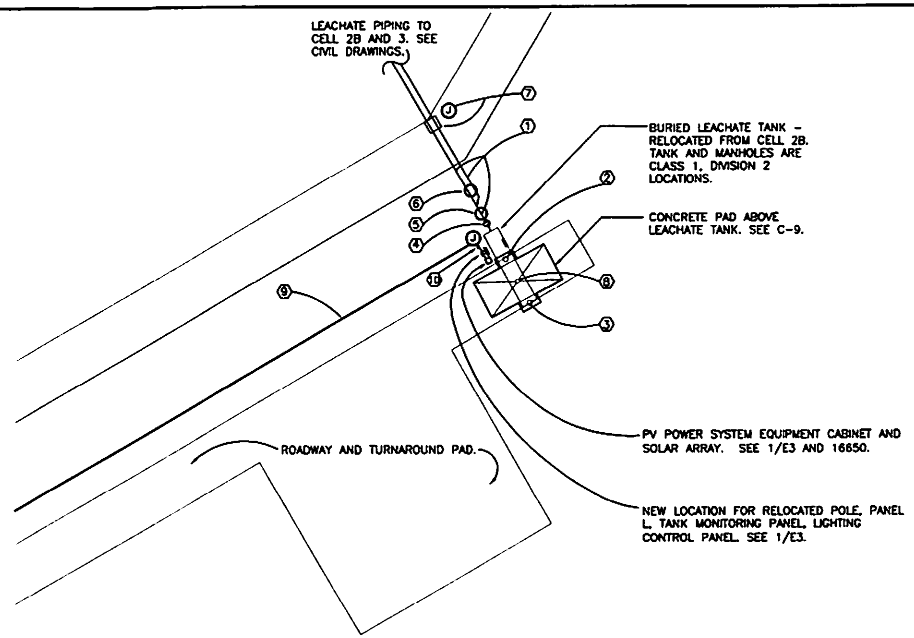
RELOCATED LEACHATE TANK SYSTEM
MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

DRAWING: C-9
SHEET: 12 OF 16
DATE: 06-04-2007



1 / E1 ELECTRICAL SITE PLAN

SCALE 1" = 200'



1 / E2 LEACHATE TANK – NEW LAYOUT @ CELL 3

SCALE: 1" = 30'

ELECTRICAL NOTES

1 EXISTING POLE #1 WITH PULL BOX, LIGHT FIXTURE AND LIGHTING CONTROLS TO REMAIN. SEE APPENDIX C – AS-BUILT DRAWING E1. RELOCATE THE TELEMETRY UNIT – SEE 1/E1.

2 EXISTING POLE #2 WITH 2-DISCONNECTS, SCADAPACK REPEATER, ANTENNA AND TRANSFORMER TO REMAIN. ADJUST REPEATER IF NEEDED TO ACCOMPLISH THE COMMUNICATION LINK BETWEEN THE LEACHATE TANK MONITORING PANEL AND THE SCALEHOUSE.

3 EXISTING UNDERGROUND RUN OF TOWARDS PANEL L AND LEACHATE PUMP MOTOR. THE CIRCUIT IS A 480 VOLT, SINGLE PHASE, 3C- #2/0 TYPE MC CABLE. REMOVE CABLE FROM THE CELL 3 CONSTRUCTION AREA. CUT BACK CONDUCTORS AT THE EXISTING PULL BOX (AS-BLT DWGS IN APPENDIX C INDICATE THIS BOX IS AT THE BASE OF POLE 2). SEE APPENDIX C – AS-BUILT DRAWING E1.

4 RELOCATE EXISTING POLE WITH PANEL L, TANK MONITORING PANEL, LIGHTING CONTROL PANEL, LIGHT FIXTURE, AND ANTENNA, AND ALARM BEACON. NEW LOCATION IS NEAR THE CELL 3 LEACHATE TANK. SEE E3. DEMO EXISTING HEAT TAPE SHED, AND WELL PUMP CIRCUITS. REMOVE HEAT TAPE TSTAT. SEE APPENDIX – AS-BUILT DRAWING E1.

5 DISCONNECT AND REMOVE EXISTING 480 VOLT, LEACHATE PUMP MOTOR, CONTROLLER, AND ASSOCIATED BRANCH CIRCUIT.

6 DISCONNECT AND REMOVE EXISTING UNDERGROUND FEEDER AND BRANCH CIRCUITS TO PANEL L. SEE APPENDIX – AS-BUILT DRAWING 2/E1. PANEL L FEEDER 3C #2/0 TYPE MC CABLE; FEEDER IS CONNECTED TO THE TRANSFORMER LOCATED ABOVE PANEL L. PANEL L BRANCH CIRCUITS CONSIST OF THE FOLLOWING:
- TWO – 20/1P HEAT TAPES;
- TWO – 20/1P RECEPTACLES;
- ONE – 20A/1P FLOODLIGHT;
- ONE – 20A/1P LEACHATE CONTROL PANEL W/TELEMETRY;
- ONE – 20/2P WELL PUMP;
- ONE – 20/2P SHED.

7 RECONNECT THE TANK PANEL SENSORS FOR LEAK DETECTION & TANK OVERFILL, AND FILL LEVEL INDICATION (25%, 50 %, 75%, 90%). PROVIDE NEW CABLES AS REQUIRED.

8 VERIFY THAT THE TANK MONITORING PANEL, ALARM BEACON, REPEAETER AND REMOTE TELEMETRY PANEL LOCATED IN THE SCALE HOUSE OPERATES PRIOR TO AND AFTER RELOCATION.

9 INTERCEPT EXISTING RUN OF 2"HDPE EMPTY SPARE CONDUIT. INSTALL NEMA 3R 12"X12"X6" PULL BOXES AND EXTEND RUN TO THE NEW LEACHATE TANK LOCATION. SEE 1/E3 & 2/E4.

① HEAT TAPE LEACHATE LINES FROM TANK TO THE LINER PENETRATION. RUN TAPE THRU MANHOLES – LEAVE 2 FULL COILED TURNS OF TAPE IN EACH MANHOLE AND WRAP VALVE ASSEMBLIES WITH HEAT TAPE.

② ACCESS TO TANK LEVEL SENSOR. RECONNECT THE SENSOR TO THE TANK MONITORING PANEL. PROVIDE NEW CABLE TO MATCH EXISTING CABLE – 2C W/ DRAIN WIRE (BLACK, WHITE) CONTROL CABLE FROM TRACETEX

③ ACCESS TO LEAK DETECTION SENSOR. RECONNECT THE SENSOR TO THE TANK MONITORING PANEL. PROVIDE NEW CABLE TO MATCH EXISTING CABLE – 4C (RED, BLACK, YELLOW, GREEN) CONTROL CABLE.

④ CLEANOUT. INSTALL HEAT TAPE ON THE CLEANOUT PIPING AS PART OF THE HEAT TAPE RUN FOR THE CELL 2B LEACHATE LINE SEE 1/E4.

⑤ LEACHATE FLOW CONTROL MANHOLE. RUN TAPE THRU MANHOLE; WRAP THE VALVES IN THE MANHOLE AND LEAVE TWO FULL COILS OF TAPE IN THE BASE FO THE MANHOLE. MANHOLE IS A CLASS 1, DIV 2 LOCATION.

⑥ LEACHATE FLOW ISOLATION MANHOLE. RUN TAPE THRU MANHOLE; WRAP THE VALVES IN THE MANHOLE AND LEAVE TWO FULL COILS OF TAPE IN THE BASE TO THE MANHOLE. MANHOLE IS A CLASS 1, DIV 2 LOCATION.

⑦ LINER PENETRATION (SEE C8) AND HEAT TAPE PULL BOX FOR ACCESS TO THE TAIL END OF TWO HEAT TAPE RUNS (CELL 2B AND CELL3 TAPES) INSTALL BOX; SEAL THE ENDS OF THE TAPES; INSTALL LABELS PER 16050. SEE 1/E3, 3/E4

⑧ SUMP PIT. INSTALL HEAT TAPE ON THE PIPING RUN FROM THE TANK TO THE SUMP – PEX IS ATTACHED TO PIPING. PENETRATE THE SUMP PIT NEAR THE TOP AND INSTALL TWO COILS OF TAPE IN THE BASE OF THE SUMP PIT. CONTINUE THE HEAT TAPE RUN TO THE BREAKOUT BOX AND TERMINATE THE RUN IN THE BREAKOUT BOX. BOTH ENDS OF THE HEAT TAPE WILL BE LOCATED IN THE BREAKOUT BOX. SEE 1/E3 AND C9.

⑨ 2" HDPE EMPTY CONDUIT FOR FUTURE USE. SEE 1/E2 & 1/E3.

⑩ BREAKOUT BOX AND SWITCH BOX FOR HEAT TAPES. SEE 1/E3.

ISSUED FOR BIDDING
DATE: 6/4/2007

STATE OF ALASKA 49th KEITH NELSON EE-7033 REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REVISIONS	BY	CHK

SCALE: AS NOTED | DRAWN: KCN | THIS BAR IS 1" AT FULL SIZE | DESIGNED: KCN | PROJECT NO.: 4036070010 | CHECKED: TED

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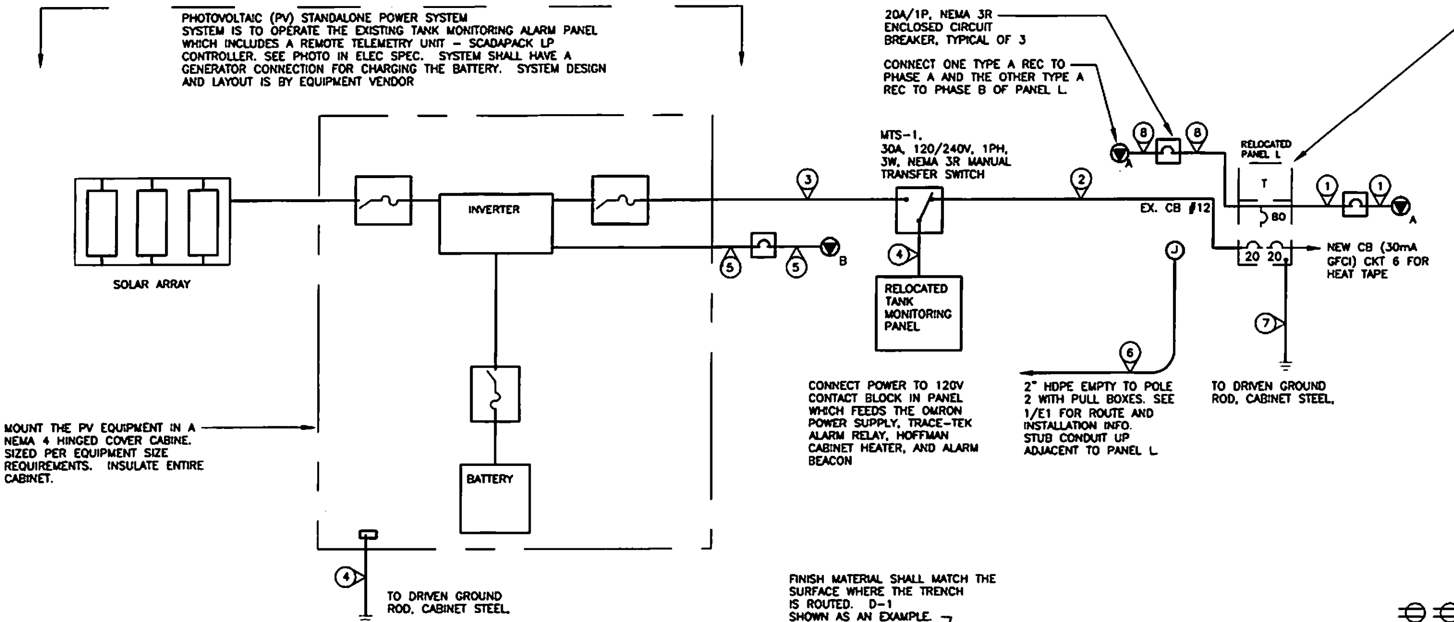
ELECTRICAL SITE PLANS

MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

DRAWING: E-1
SHEET: 13 OF 16
DATE: 06-04-2007



FEEDER NUMBER	CONDUIT AND WIRE SIZE
1	1/2"C W/ 2#10, 1#10G
2	1/2"C W/ 2#10, 1#10G
3	1/2"C W/ 2#10, 1#10G
4	1/2"C W/ 2#10, 1#10G
5	1/2"C W/ 2#10, 1#10G
6	2"HDPE EMPTY W/ PULL STRING
7	3/4"C W/ #4 BARE CU GEC
8	1/2"C W/ 2#10, 1#10G

1/E2 ONE LINE DIAGRAM
NO SCALE

DETAIL NOTES:

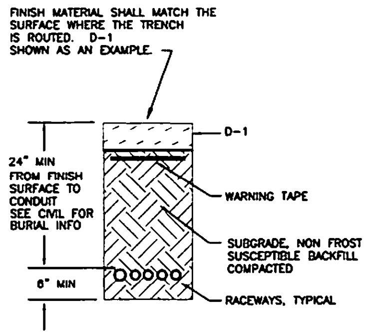
A PANEL L IS A SQUARE D MINI-POWER ZONE. THE EXISTING PANEL HAS 12 CIRCUIT BREAKER POSITIONS OCCUPIED.

B PANEL L: INSTALL A NEW 20A/1P 30mA GROUND FAULT CIRCUIT INTERRUPTER BREAKER IN CIRCUIT 6 AND CONNECT THE NEW HEAT TAPE CIRCUIT TO THE NEW BREAKER.

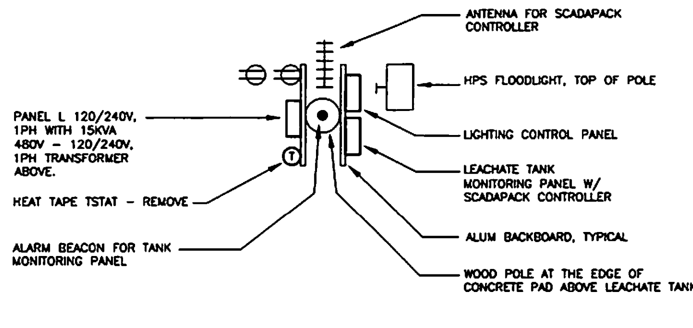
C PANEL L: REMOVE THE TWO POLE BREAKERS AND TURN THEM OVER TO THE OWNER; REMOVE ASSOCIATED CONDUIT AND WIRE. (THE CIRCUITS ARE LABELED WELL PUMP – CKT 6 AND SHED – CKT 9.) INSTALL BLANKS IN THE BREAKER POSITIONS.

D REMOVE THE EXISTING HEAT TAPE T-STAT AND ASSOCIATED CONDUIT AND WIRE. T-STAT IS MOUNTED ADJACENT TO PANEL L. LEAVE EXIST HEAT TAPE BREAKERS AS SPARE BREAKERS.

E THE REMAINING 20A/1P BREAKERS AND CIRCUITING REMAIN. INSTALL LOCKOFF HASPS ON THE TWO RECEPTACLE CIRCUITS AND ONE FLOODLIGHT CIRCUIT, AND TY-WRAP THE BREAKER IN THE OFF POSITION. REMAINING CIRCUIT BREAKERS SHALL BE LEFT IN THE OFF POSITION INCLUDING THE BREAKER FEEDING THE TANK MONITORING PANEL; LEAVE THE EXISTING BRANCH CIRCUIT WIRING IN PLACE SO THE TANK MONITORING PANEL CAN BE OPERATED BY A MOBILE GENERATOR SET.



2/E2 TRENCH DETAIL
NO SCALE



3/E2 EXISTING POLE LAYOUT
NO SCALE

ISSUED FOR BIDDING
DATE: 6/4/2007

STATE OF ALASKA 49th PROFESSIONAL ENGINEER

NO	DATE	REVISIONS	BY	CHK

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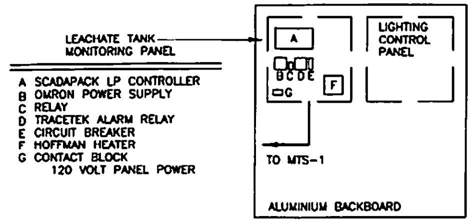
ELECTRICAL ONE LINE DIAGRAM & DETAILS

MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

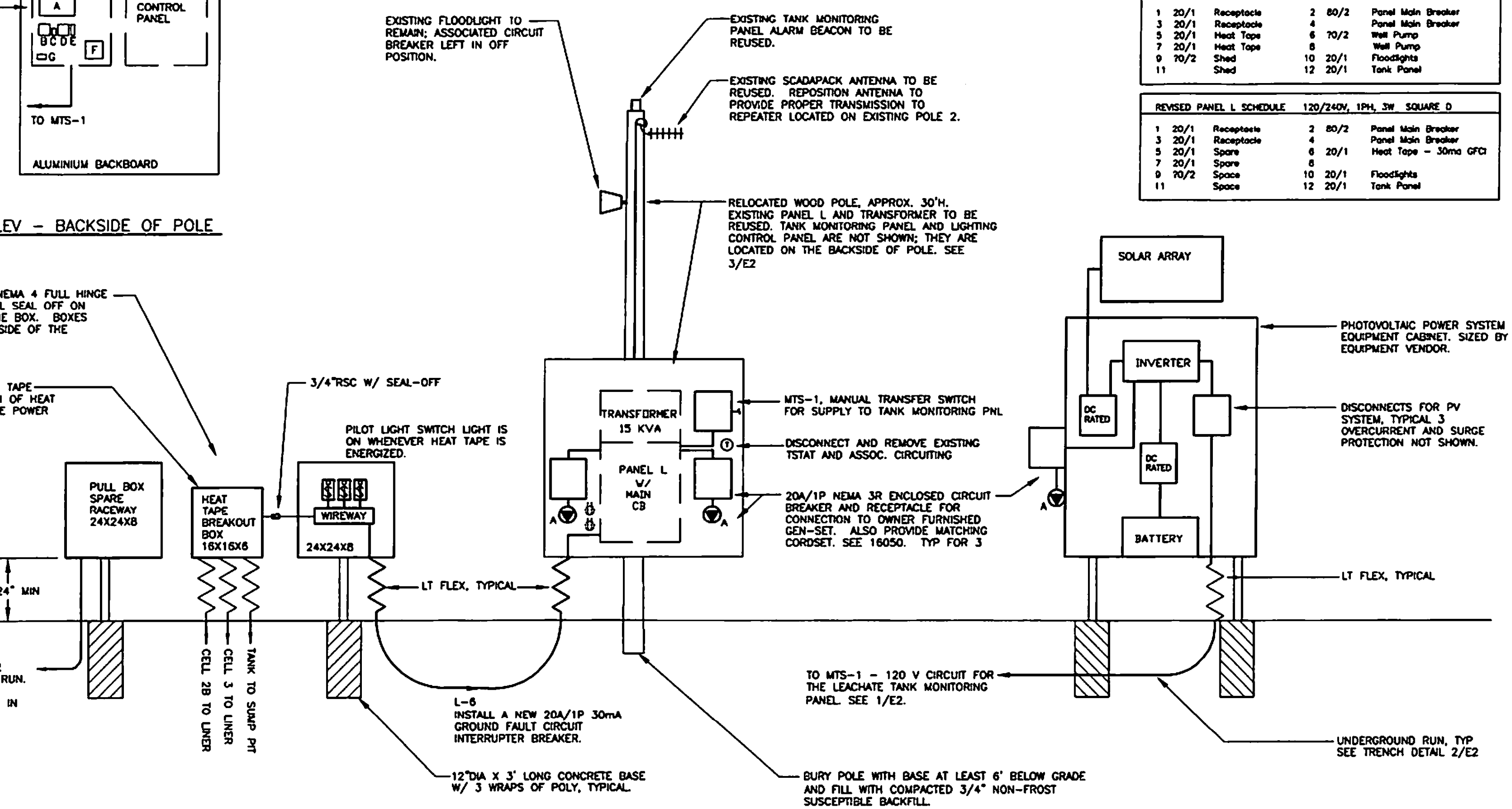
DRAWING: E-2
SHEET: 14 OF 16
DATE: 06-04-2007



ELEC EQUIP ELEV - BACKSIDE OF POLE
NO SCALE

REVISED PANEL L SCHEDULE	120/240V, 1PH, 3W SQUARE D				
1	20/1	Receptacle	2	80/2	Panel Main Breaker
3	20/1	Receptacle	4		Panel Main Breaker
5	20/1	Heat Tape	6	70/2	Well Pump
7	20/1	Heat Tape	8		Well Pump
9	70/2	Shed	10	20/1	Floodlights
11		Shed	12	20/1	Tank Panel

REVISED PANEL L SCHEDULE	120/240V, 1PH, 3W SQUARE D				
1	20/1	Receptacle	2	80/2	Panel Main Breaker
3	20/1	Receptacle	4		Panel Main Breaker
5	20/1	Spare	6	20/1	Heat Tape - 30ma GFCI
7	20/1	Spare	8		
9	70/2	Space	10	20/1	Floodlights
11		Space	12	20/1	Tank Panel



1/E3 ELECTRICAL EQUIPMENT ELEVATION
NO SCALE

DETAIL NOTES:

A SEE PHOTOGRAPHS IN 16650 FOR ADDITION INFO ON THE RELOCATED EQUIPMENT.

B MOUNT EQUIPMENT ON A UNISTRUT FRAMEWORK. FRAMEWORK IS NOT SHOWN FOR CLARITY.

C SEE E2 FOR ONE LINE DIAGRAM

ISSUED FOR BIDDING
DATE: 6/4/2007

STATE OF ALASKA 49th [professional engineer seal]

NO	DATE	REVISIONS	BY	CHK	SCALE: AS NOTED	DRAWN: KCN	MACTEC 601 East 57th Place Anchorage, AK 99518 Phone: (907) 563-8102 Fax: (907) 561-4754 www.mactec.com	ELECTRICAL EQUIPMENT ELEVATION	DRAWING: E-3
					THIS BAR IS 1" AT FULL SIZE:	DESIGNED: KCN		MATANUSKA-SUSITNA BOROUGH CENTRAL LANDFILL EXPANSION CELL 3 CONSTRUCTION	SHEET: 15 OF 16
					PROJECT NO.: 4036070010	CHECKED: TED			DATE: 06-04-2007

SYMBOLS AND MOUNTING HEIGHTS

MOUNTING HEIGHTS ARE TO BE AS LISTED BELOW UNLESS OTHERWISE INDICATED ON PLAN.

Symbol	Description	Mounting height
$ $3 $K	SWITCHES, 3 WAY, KEYED	48" AFF
	MANUAL SWITCH W/ PILOT LIGHT	48" AFF
$H	HAND-OFF-AUTO SWITCH	48" AFF
	DUPLEX RECEPT	6" ABOVE FIN TUBE 4" ABOVE BACKSPLASH 18" AFF MIN ELSEWHERE
	GFCI - GROUND FAULT CIRCUIT INTERRUPTER RECEPTACLE	
A	SPECIAL RECEPTACLE TYPE INDICATED ON PLAN/SPEC	
	TELEPHONE	
	PUSHBUTTON	48" AFF
T	THERMOSTAT	48" AFF
R	RELAY	
	DISCONNECT	
	COMBINATION MAG STARTER/DISCONNECT	
	CONTACTOR	
M	MOTOR	
	HPS LIGHT FIXTURES POLE MOUNTED	
	INCANDESCENT FIXTURE	
	EXISTING STREET LIGHTING FIXTURE	

Symbol	Description
	PANELBOARD (EXAMPLE NAME = PANEL HA-CAB1)
T	TRANFORMER (XFM)
H	CONCRETE HANDHOLE
	GUY
	SEALOFF
CO	CLEANOUT
CT	CURRENT TRANSFORMER
GEC	GROUNDING ELECTRODE CONDUCTOR
GFI	GROUND FAULT CIRCUIT INTERRUPTER
LT	LIQUIDTIGHT FLEXIBLE METAL CONDUIT
MH	MANHOLE
OIT	OPERATOR INTERFACE PANEL (PLC CONTROL SYSTEM)
PEX	CROSS LINKED PE PIPE -PROVIDED BY DIV 02625
PLC	PROGRAMMABLE LOGIC CONTROLLER (CONTROL SYSTEM)
RSC	RIGID STEEL CONDUIT
T, X	CONDUCTOR INSULATION T = THHN/THWN X = XHHW
XP	EXPLOSIONPROOF (CLASS1, DIV 2)
WP	WEATHERPROOF
	GROUND, NEUTRAL, HOT CONDUCTORS #12 IN 1/2"C INDOORS 3/4"C OUTDOOR RUNS UNLESS OTHERWISE NOTED
	DASHED EQUIPMENT INDICATES EXISTING OR FUTURE EQUIPMENT. REFER TO DRAWING NOTE.
	UNDERGROUND (U/G) CIRCUIT

GENERAL NOTES:

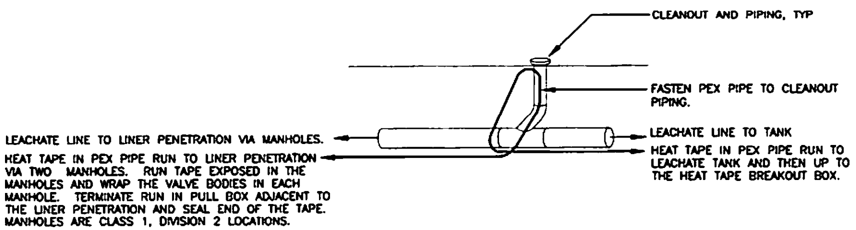
THE ELECTRICAL WORK INCLUDES THE FOLLOWING ITEMS:

A INSTALL HEAT TAPE IN PEX PIPE WHICH IS FASTENED TO THE LEACHATE LINE. THE PEX PIPE IS PROVIDED BY DIV 2. SEE CIVIL DRAWINGS. EACH END OF THE HEAT TAPE SHALL TERMINATE IN A BREAKOUT BOX; THE INTENT IS TO ALLOW ACCESS TO REMOVE AND REPLACE THE HEAT TAPE IF IT FAILS.

B THE MANHOLES AND THE LEACHATE TANK ARE CLASS 1, DIVISION 2 LOCATIONS.

C THE CELL 2B LEACHATE TANK IS TO BE RELOCATED TO SERVE CELL 3. RELOCATE AN EXISTING POLE WITH EQUIPMENT AND REINSTALL IT ADJACENT TO THE NEW TANK LOCATION.

D INSTALL A NEW PHOTOVOLTAIC POWER SYSTEM TO PROVIDE POWER TO THE RELOCATED TANK MONITORING PANEL. THE PANEL HAS A TELEMETRY UNIT WHICH COMMUNICATES TANK STATUS TO THE LANDFILL SCALEHOUSE.



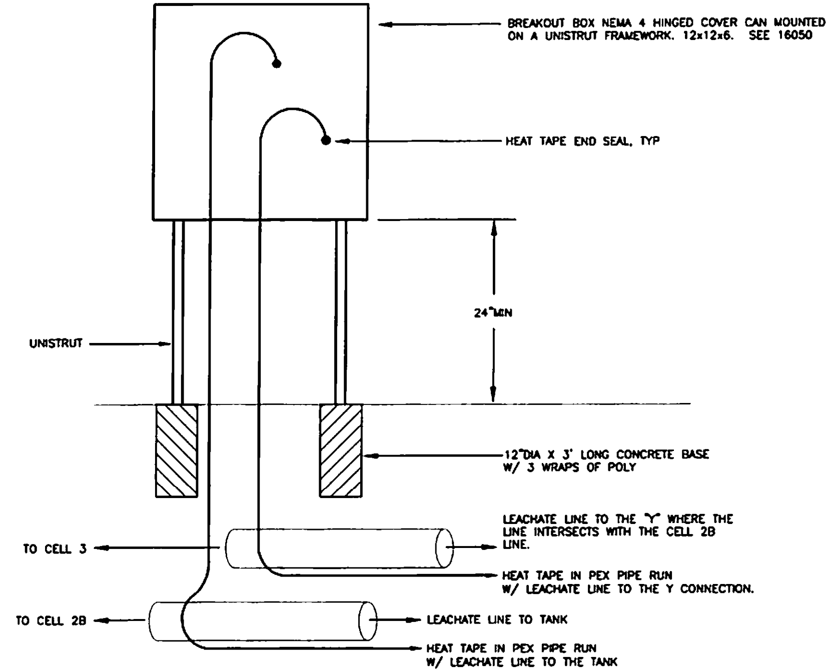
1/E4 LEACHATE LINE HEAT TAPE AT CLEANOUT

NO SCALE

DETAIL NOTES:

A HEAT TAPE IS RUN IN PEX PIPE. PEX IS PROVIDED BY DIV 2. COORDINATE THE INSTALLATION WITH THE GENERAL CONTRACTOR.

B LEACHATE PIPE INSULATION IS NOT SHOWN; PEX IS STRAPPED TO THE PIPE THEN THE ENTIRE ASSEMBLY IS INSULATED. SEE C-9.



2/E4 HEAT TAPE AT END OF RUN

NO SCALE

DETAIL NOTES:

A HEAT TAPE IS RUN IN PEX PIPE. PEX IS PROVIDED BY DIV 2. COORDINATE INSTALLATION WITH GENERAL CONTRACTOR.

B HEAT TAPE STOPS AT THE CONCRETE LINER PENETRATION. SEE 1/C4 AND C8. INSTALL BREAKOUT BOX ON THE SOUTH SIDE OF THE BERM. DO NOT PENETRATE THE GEOMEMBRAME LINER WITH THE PEX OR SUPPORTS FOR THE BREAKOUT BOX.

C LEACHATE PIPE INSULATION IS NOT SHOWN; PEX IS STRAPPED TO THE PIPE THEN THE ENTIRE ASSEMBLY IS INSULATED. SEE C-9.

ISSUED FOR BIDDING
DATE: 6/4/2007

NO.	DATE	REVISIONS	BY	CHK

SCALE: AS NOTED | DRAWN: KCN | DESIGNED: KCN | CHECKED: TED
THIS BAR IS 1" AT FULL SIZE
PROJECT NO.: 4036070010

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ELECTRICAL DETAILS
MATANUSKA-SUSITNA BOROUGH
CENTRAL LANDFILL EXPANSION
CELL 3 CONSTRUCTION

DRAWING: E-4
SHEET: 16 OF 16
DATE: 06-04-2007

Technical Memorandum

Central Landfill Cell 2A Final Cover Plan

Prepared for

Matanuska-Susitna Borough

Palmer, Alaska

August 27, 2001

CH2MHILL
301 West Northern Lights Boulevard, Suite 601
Anchorage, Alaska 99503-2662
(907) 278-2551

Contents

Attachments

1 Technical Papers

Experience with Geosynthetic Clay Liners for Landfill Closure at the Tomoka Farms Road Landfill, Dayton Beach, Florida. September 1996 SWANA Conference.

Cost Effective Alternative To An Unreinforced GCL For Landfill Final Cover Systems, Geosynthetics Conference 2001.

Geosynthetic Clay Liners Used in Municipal Solid Waste Landfills, EPA530-F-97-002, July 1997.

2 HELP Model Output Results

3 Draft Technical Specifications

TECHNICAL MEMORANDUM CH2MHILL

Central Landfill Cell 2A Final Cover Plan

PREPARED FOR: Greg Goodale/Mat-Su Borough

PREPARED BY: Henry Friedman/CH2M HILL
Kelly Merrill/CH2M HILL

DATE: August 17, 2001

Introduction

The Central Landfill, located in the Matanuska-Susitna Borough, is the third largest landfill in Alaska. It is located off the Palmer-Wasilla highway within a designated landfill reserve consisting of 620 acres. Only about 10 to 15 acres of the reserve is actively developed for landfill use at any one time. As portions of the landfill reach their final design elevation, they are closed and new expansion areas are developed.

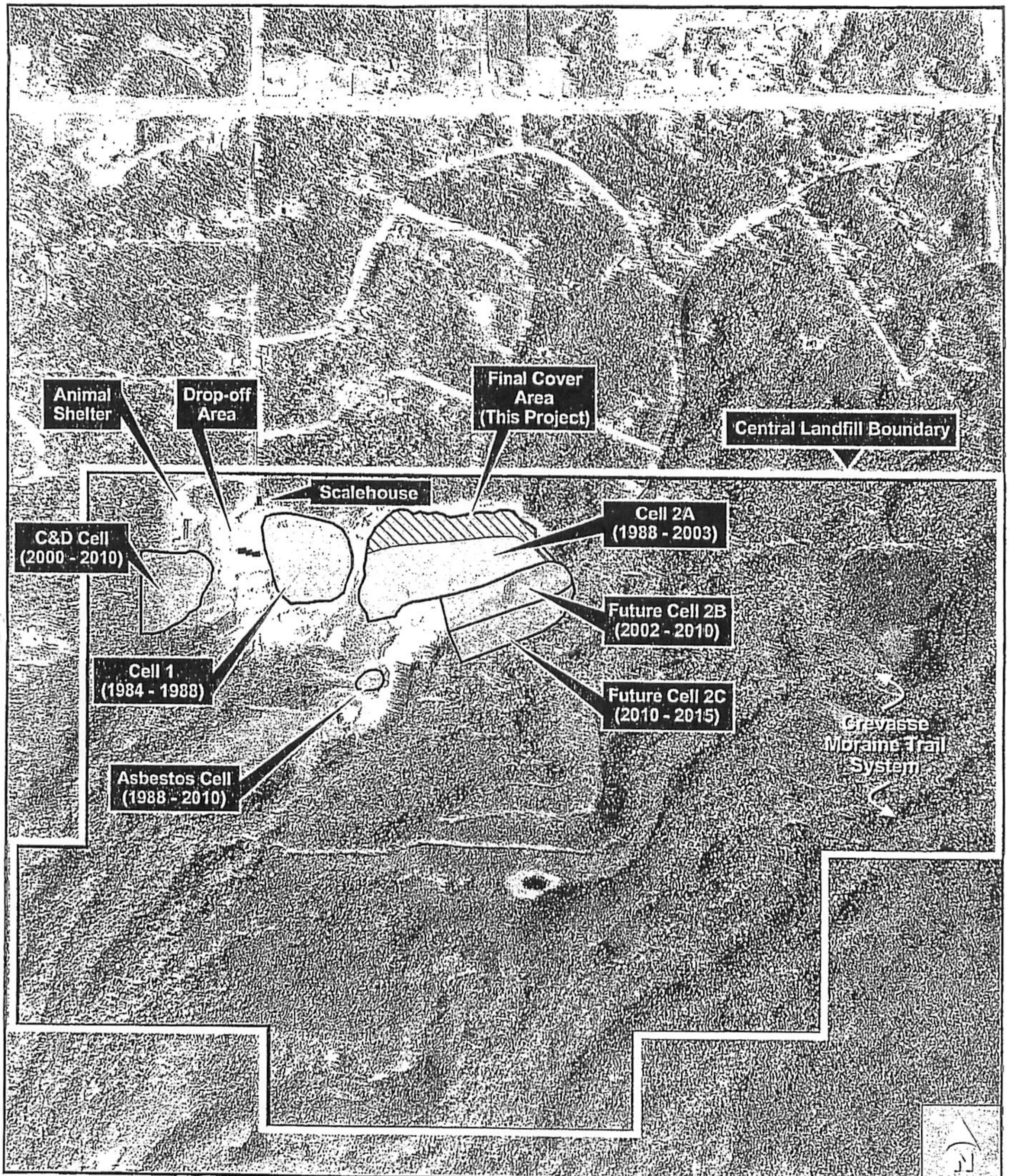
The first landfill cell (Cell 1) was closed in 1988. The currently active cell is Cell 2A, which was developed in the same year that Cell 1 was closed. Cell 2A is an unlined cell, as was permitted at the time it was developed. The northern side slopes of this cell will reach their final design elevation by 2002. The next cell in the phased development plan for Central Landfill will be a lined cell called Cell 2B. Cell 2B has been designed and is planned for construction in 2002. The location of various landfill facilities can be seen in Figure 1.

The geologic setting of the Central Landfill area is described in detail in the Central Landfill Operating Plan (CH2M HILL, February 1994). Near-surface geologic units include both glacial drift and glacial outwash deposits. Soils within these units consist primarily of relatively clean sand and gravel with frequent cobbles and boulders. The material is typically in a dense condition. A deep stratum of lacustrine silt and clay underlies the landfill site (greater than 40 feet below the existing ground surface). Measured groundwater depths in monitoring wells at the landfill have ranged from approximately 30 to 130 feet below the ground surface.

Final Cover Area

Description of Closure Area

The portion of Cell 2A that will be ready for final cover in the summer of 2002 can be seen in Figure 2. This area consists primarily of the northern side slope of Cell 2A. The total area designated for final cover in 2002 is 4 acres in size.



157050.CL.CC ExistFuture2.fh8 07/13/01 ancira

Aerial Photograph Taken May 9, 1995
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500 0 1000
SCALE IN FEET

CH2MHILL

Figure 1

Existing and Future Facilities
Central Landfill
Matanuska-Susitna Borough

Phased Facility Closure

Cell 2A and Cell 2B will be closed in a series of phases. The capping of the northern slope of Cell 2A is the first of three phases. The height of Cell 2A will remain near elevation 300 with a temporary cover until Cell 2B is constructed. Once Cell 2B is filled to the height of Cell 2A, additional waste will be placed over both cells until a final elevation of about 340 feet is reached. An additional cell (Cell 2C) is currently proposed for construction just south of Cell 2B. Cell 2C will also be brought up to the elevation of the previous cells. Other future cells are anticipated for construction south and west of Cell 2C.

The second phase of closure will include remaining side slopes that have been brought up to design grade. This second phase of closure will likely include several separate construction projects. Each closure project will cover a specific side-slope area that has reached final design grades. The closure projects will be scheduled such that the areas to be covered are large enough for practical and cost-effective construction.

The third phase of the closure will be the final cover over the top of Cells 2A, 2B, 2C, and possibly other future cells once the final design elevation is reached. A conceptual north-to-south cross-section through the cells indicating the closure phases is shown in Figure 3.

Schedule

The northern side slopes of Cell 2A are scheduled for closure construction in the summer of 2002. The closure will be performed concurrently with the construction of Cell 2B under the same contract. This scheduling will reduce costs because mob/demob expenses can be shared between the two construction tasks. Also, additional cost savings are anticipated because of economies of scale resulting from use of similar materials where appropriate in the Cell 2B bottom lining system and the Cell 2A final cover.

Closure Requirements

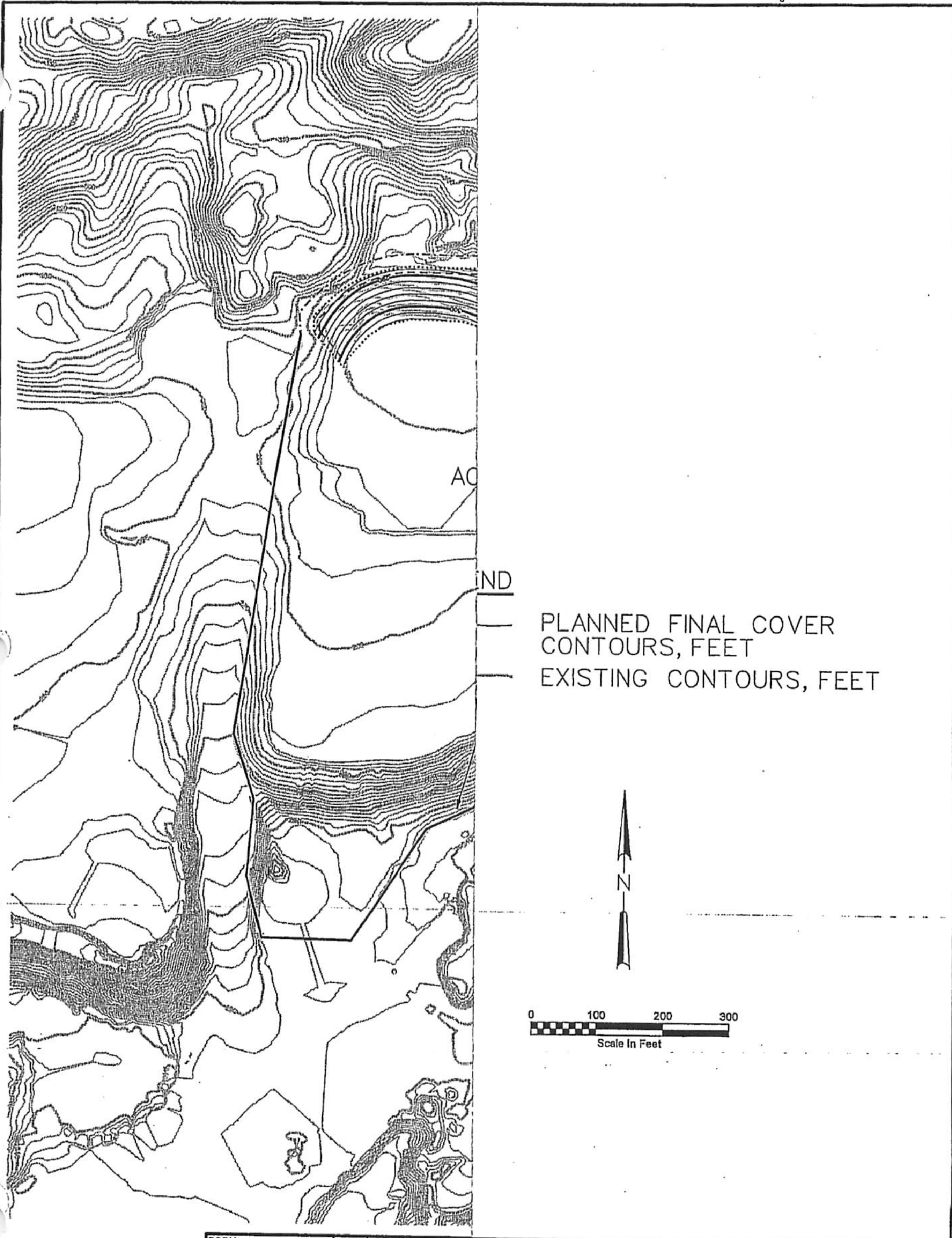
Regulatory Requirements

The prescriptive final cover as defined in Title 18, Chapter 60.3959(a) of the *Alaska Administrative Code* (AAC) for an unlined municipal landfill consists of an infiltration layer at least 18 inches thick with a permeability no greater than 1×10^{-5} centimeters per second, and an erosion layer at least 6 inches thick of earthen material capable of sustaining native plant growth.

For a lined landfill, the final cover must have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils.

Regulation 18 AAC 60.395(b) allows the department to approve an alternative final cover design that will protect public health and the environment if it includes the following:

- An infiltration layer that achieves an equivalent reduction in infiltration as the prescriptive infiltration layer, and
- An erosion layer that provides equivalent protection from wind and water erosion as the prescriptive erosion layer.

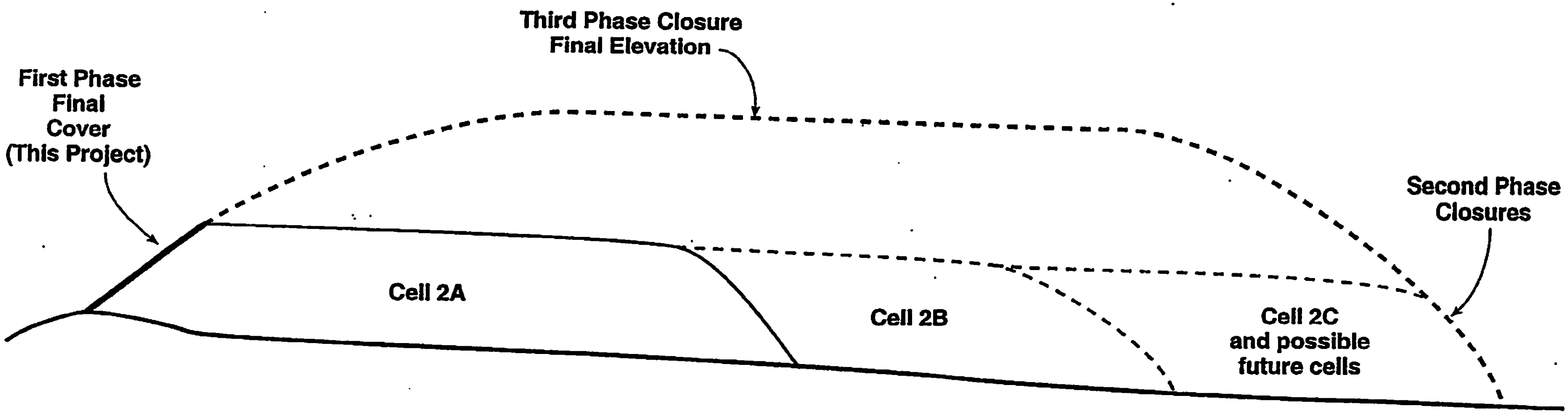


DSGN				
DR	K. BAILEY			
CHK	K. MERRILL			
APVD		NO.	DATE	

FIGURE 2
PLANNED CELL 2A
FINAL COVER AREA

SHEET	x
DWG NO.	x
DATE	JULY 2001
PROJ NO.	157050.CL.CC

Figure2 Cell2A Cover.dgn 11-JUL-2001 13:42:15



Section A (from Figure 2)
Not to Scale

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Figure 3
Final Cover Phases
Central Landfill
Matanuska-Susitna Borough

Types of Final Covers

There are two basic types of final covers including the resistive barrier and the monolith capacitance barrier. These two final cover concepts minimize infiltration through different mechanisms.

The resistive barrier consists of a very low permeable soil or synthetic membrane layer that impedes the flow of water. This type of cap is designed so that water will run off if the precipitation rate is higher than the infiltration rate. Some moisture will also evaporate from upper soil layers, reducing the amount of moisture infiltrating through the barrier layer. The prescriptive final cover is a resistive barrier cap. This type of final cover is best suited to areas of high precipitation. The major disadvantage with this type of cover is that the infiltration rate can dramatically increase once the barrier layer is breached due to cracking or a tear in the synthetic membrane liner.

A monolith capacitance barrier consists of a fine-grained soil layer thick enough to absorb and retain the seasonal accumulation of water within the final cover. Water is held in the upper layers of soil by water tension, which is a stronger force in some soils than gravitational forces; therefore, the water does not drain from these soils. Moisture held near the surface will either evaporate or be lost through evapotranspiration. This type of cap sometimes includes a capillary barrier below the absorption soil layer to minimize infiltration of water into lower layers. The monolithic capacitance barrier is best in semiarid areas with low storm intensity. The major disadvantage with this type of cover is that the infiltration rate can dramatically increase once the field capacity of the adsorption layers are exceeded.

Previously Proposed Cell 2A Final Cover

The Mat-Su Borough originally proposed the prescriptive final cover for Cell 2A using locally available silt (CH2M HILL, December 2000). The average permeability of the silt was slightly greater than 10^{-5} centimeters per second; however, leakage evaluations using the Hydrologic Evaluation of Landfill Performance (HELP) model indicated that it would perform as well as the prescriptive cover.

After reviewing the design plan, the Alaska Department of Environmental Conservation (ADEC) requested that a test plot lysimeter be constructed to verify the HELP model results and to demonstrate the final cover's effectiveness. The Borough decided against the test plot because of the costs associated with the design, construction, and operation of a test plot area on the landfill; and because the majority of the landfill will probably require a different type of final cover as future expansion areas will be constructed with a bottom liner system.

Currently Proposed Cell 2A Final Cover

The currently proposed Cell 2A final cover being presented for ADEC review and approval consists of a low-permeability resistive barrier covered with a minimum of 2 feet of local soils. The barrier layer will consist of a geosynthetic clay liner (GCL) with an average permeability of about 10^{-9} centimeters per second. The GCL will consist of a layer of bentonite clay sandwiched between two nonwoven geotextiles. The GCL will be reinforced by needlepunching through the geotextiles to provide enhanced shear strength for stability reasons.

The operational cover over the waste will be prepared to form an even surface, and if necessary, a 6-inch-thick leveling course will be placed over the operational cover to provide a smooth surface before the GCL is set in place. An 18-inch layer of onsite sand and gravel will be placed over the GCL to protect the GCL and to provide a drainage medium over the barrier layer of GCL. The leveling course, if needed, and the 18-inch drainage layer above the GCL will be specified with a maximum particle size of 1 inch to provide protection to the GCL from oversize gravels and cobbles. The grain-size distribution of the 18-inch drainage layer will also be specified to serve as an effective filter to reduce migration of fines from the surficial topsoil layer into the drainage layer.

The uppermost layer will consist of 6 inches of a silt-loam organic soil capable of sustaining vegetative growth. The final cover will be hydroseeded with ground cover species demonstrated to thrive in similar soils in local weather conditions. The hydroseeding will establish an initial grass vegetative cover to minimize erosion and improve appearance. Indigenous vegetation will be allowed to eventually become established on the final cover. The final cover will be installed on slopes inclined no steeper than 4:1 (horizontal:vertical). Figure 4 shows a typical cross-section of this proposed cover.

This type of final cover has been approved and successfully implemented for both unlined and lined landfill cells in other states. Technical papers describing similar caps used in other locations are included in Attachment 1.

Stability Issues

Static Stability

The internal stability of the proposed soil/GCL cover system on the Cell 2A side slopes was analyzed to confirm that a 4:1 (horizontal:vertical) slope would provide an adequate factor of safety against slope instability. The side-slope stability analyses were conducted for the following cases:

- Self-weight of cover system (dead loads)
- Dead loads plus loads from seepage forces in the drainage layer above the GCL during or after heavy rainfall events
- Dead loads plus equipment loads
- Dead loads plus equipment loads plus seepage forces

The static stability analyses were run using a slope height of 50 feet, which is approximately the maximum slope height in the planned Cell 2A cover area. The system components analyzed are as depicted in Figure 4. Material properties were determined from past test results on similar materials in our files and information in the literature. The analyses were conducted with the aid of the computer program SLOPBASE (Druschel, 1993).

The HELP model was used to determine appropriate seepage heights to use in the analyses. The design storm was taken as a 100-year, 24-hour storm event resulting in 2.2 inches of precipitation at the site. A maximum seepage height of 0.6 feet in the granular drainage layer above the GCL was used in the slope stability analysis based on the results of the HELP model.

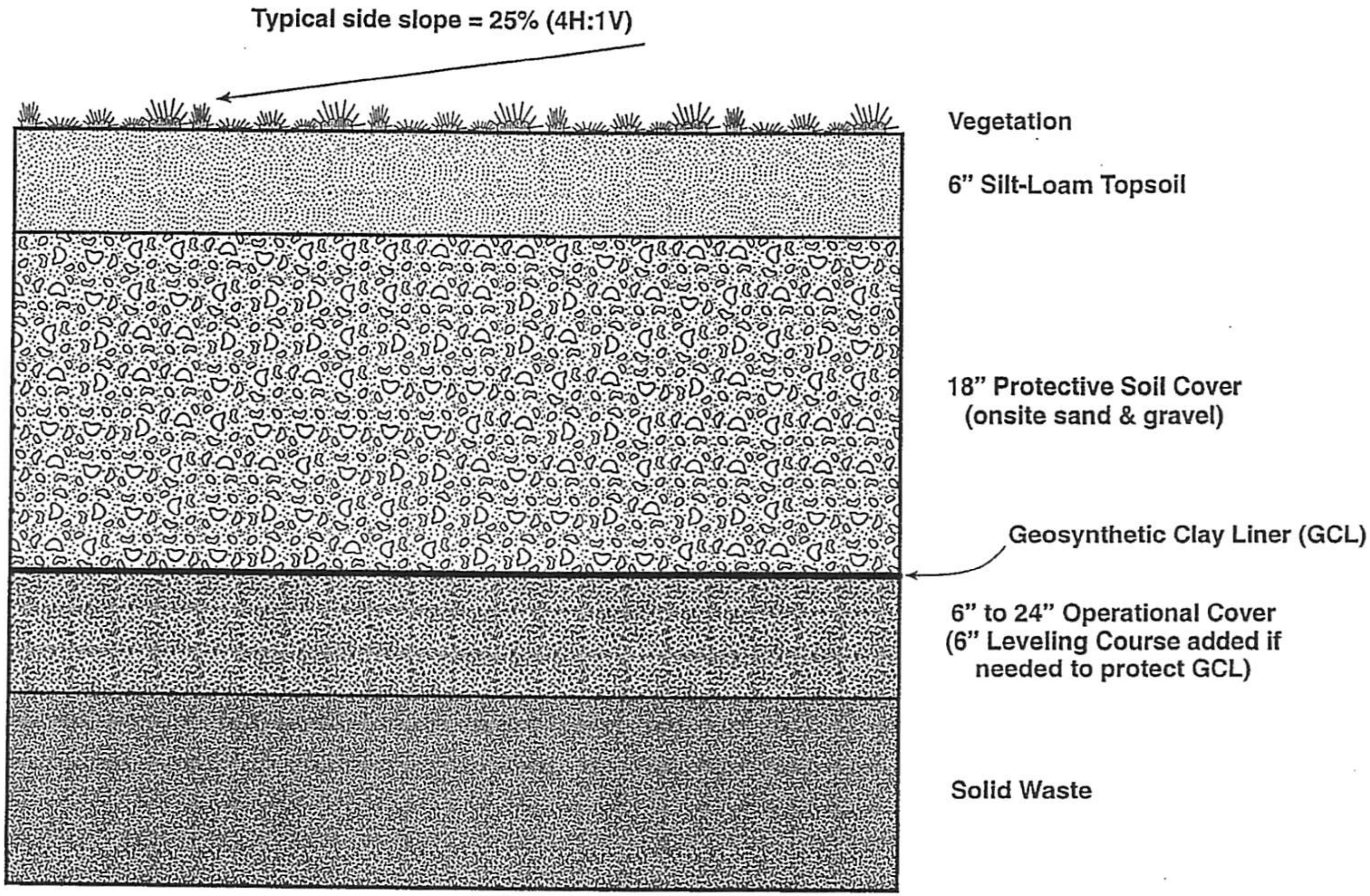

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Figure 4
Cell 2A Final Cover Cross-Section
Central Landfill
Matanuska-Susitna Borough

Equipment loads were determined using the following weight and track width values for a Caterpillar D6 dozer:

- Total weight = 45,000 pounds (lbs)
- Total track width = 10 feet (ft)
- Distributed load = 4,400 lbs/ft

The specifications will require that the D6 dozer operate on at least 12 inches of soil over the GCL to provide adequate protection for the geosynthetic layer.

Results of the static stability analyses are summarized below in Table 1:

TABLE 1
Static Stability Results–Cell 2A Cover

Case Analyzed	Static Factor of Safety
Self-weight of cover system (dead loads)	2.02
Dead loads plus loads from seepage forces in the drainage layer above the GCL during or after heavy rainfall events	1.71
Dead loads plus equipment loads	1.84
Dead loads plus equipment loads plus seepage forces	1.58

The minimum static factor of safety resulting from the analyses was about 1.6. A minimum factor of safety of 1.3 is generally considered to be acceptable with respect to static slope stability. Accordingly, static stability is considered to be adequate for the proposed cover system.

Seismic Stability

The first step in assessing the seismic stability of the Cell 2A cover was to select appropriate earthquake design criteria. U.S. Environmental Protection Agency (EPA) Landfill Regulations–Resource Conservation and Recovery Act , Subtitle D (Chapter 40, Part 258 of the *Code of Federal Regulations*)–specify that all landfill containment structures be designed to resist the maximum expected horizontal acceleration with a 90 percent or greater probability of not being exceeded over a design period of 250 years. This criterion applies to the final landfill configuration. Peak horizontal ground accelerations with a 90 percent probability of not being exceeded over the specified 250-year design period were conservatively determined for the Central Landfill site from a site-specific seismic risk assessment carried out for the Anchorage Regional Landfill (ARL) site near Eagle River (Earth Mechanics, April 1994). The Central Landfill is approximately 25 miles north of the ARL site. Current seismic hazard maps developed by the U.S. Geological Survey (USGS, 1998) indicate a similar but slightly lower seismic hazard at the Central Landfill site as compared to the ARL site to the south. Accordingly, use of the ARL seismic hazard results is considered to be appropriate and slightly conservative for the Central Landfill site. The design peak horizontal ground acceleration determined from the ARL study is 0.54g.

The same cover system analyzed for static stability as described above was also analyzed for seismic stability using the computer program PCSTABL5M (Purdue University). Average pseudostatic seismic coefficients equal to one-half the peak horizontal acceleration value were used in the analysis (Richardson and Kavazanjian, 1995). The analysis was run only for the case of self-weight of cover combined with the seismic load. Assuming that the design seismic event would occur simultaneously with a design seepage event or when equipment is on the slope would be overly conservative.

The resulting seismic factor of safety was approximately 0.9. Seismic factors of safety of 1.0 or greater using the methodology described here indicate that permanent deformations are expected to be limited to less than 1 foot under the design seismic loading (Richardson and Kavazanjian, 1995). Maximum allowable deformations of 6 to 12 inches have typically been used in practice for design of geosynthetic liner systems (Richardson and Kavazanjian, 1995). The seismic factor of safety of 0.9 indicates that cover movements may be slightly more than 1 foot under the design earthquake load. However, because the cover system is close to the surface, any damage to the GCL or other cover components can be easily repaired if such an event occurs. The risk of adverse impacts to landfill facilities or to the environment resulting from such cover movements is very low.

Erosion and Seepage Control

The proposed final cover is highly resistant to erosion. Natural slopes in the area consisting of sandy gravel soil overlain with a loess layer are found at much steeper angles without significant erosion. The proposed uppermost 6-inch layer of silty loam is the same type of soil used on adjacent farms. This soil is excellent for the establishment of vegetative cover and is resistant to erosion when vegetated.

Provisions for drainage will be provided at the toe of the slope to allow water to drain from the sandy gravel layer over the GCL in the final cover. Drainage water will be allowed to infiltrate into adjacent lands within the landfill property boundaries but outside of areas with buried waste.

Landfill Gas Venting

Landfill gas venting will be necessary because the low-permeability GCL will not allow gas to pass through freely. Gas control will consist of passive vent pipes protruding through the GCL. Bentonite clay powder will be used to fill the seam around the pipe penetration. The vent will have a shepherd's hook or cap to prevent water from entering. The vents will be connected by perforated corrugated polyethylene pipes in the operational cover material beneath the GCL. The perforated pipes and vents will be spaced at approximately 200 feet on center to provide adequate venting.

Leakage Rate Evaluation

The leakage rate of the prescriptive and proposed final cover were estimated using the HELP model, version 3.07. Site specific climatic data were entered into the program. Both the prescriptive and proposed final cover layers were entered to compare leakage rates. The two covers differ in that the proposed cover includes a GCL between the operational cover layer and the infiltration layer. In the proposed cover, the infiltration layer was modeled as a lateral drainage layer rather than a vertical percolation layer because the underlying GCL is a barrier layer. This layer configuration more closely approximates actual conditions and is consistent with design examples presented in the HELP model user guide. The HELP model output results are included in Attachment 2.

Comparison with Prescriptive

The proposed final cover for portions of Cell 2A has many advantages over the prescriptive final cover. The proposed cover will minimize leachate production compared to the prescriptive cover and is easier to construct.

The proposed final cover was estimated by the HELP model to have a lower leakage rate than the prescriptive. The prescriptive final cover for an unlined landfill was estimated to have a leakage rate of 1.99 ± 0.060 inches per year (5-year average ± one standard deviation), whereas the proposed final cover was estimated to have a leakage rate of 0.05 ± 0.02 inches per year. The leakage rate of the proposed final cover is significantly less than the rate of the prescriptive. Also, the prescriptive leakage rate has a higher standard deviation, indicating that it is more susceptible to seasonal variations than the proposed final cover.

The proposed cover's resistance to erosion is expected to be as good as, if not better, than the prescriptive cover. The uppermost layer is exactly the same in both liner scenarios; however, the infiltration layer in the proposed cover has a higher permeability, which will allow water to seep into the cover and flow above the GCL rather than tending to saturate the topsoil and infiltration layers. Subsurface drainage is preferred over surficial saturation because there is typically less erosion potential.

The sandy gravel infiltration layer in the proposed final cover is more resistant to freeze-thaw and desiccation cracking than the silt/clay infiltration layer in the prescriptive cover. Tests have shown that GCLs are also resistant to freeze-thaw and desiccation cracking. The seasonal frost depth in this area is over 12 feet deep; therefore, the cap will be subjected to repeated freeze-thaw cycles. The silt/clay infiltration layer required in the prescriptive cover would be susceptible to cracking and increasing permeability with time under these conditions.

The proposed final cover is also more resistant to damage from differential settlement than the prescriptive. The sandy gravel infiltration layer and GCL are very flexible and resistant to cracking when flexed or stretched. The silt/clay infiltration layer of the prescriptive cover is more susceptible to cracking when stressed.

The hydraulic barrier in the proposed final cover utilizes a factory made GCL with a high level of quality control. It is very difficult to maintain the same level of quality control when constructing soil liners in the field, such as the silt/clay infiltration layer of the prescriptive cover.

The proposed cover is easier to construct than the prescriptive, while still maintaining a high level of quality control and quality assurance. The GCL is fast and easy to install in a controlled and consistent manner. The 18-inch-thick silt/clay layer required in the prescriptive cover takes longer to install than a GCL and the soil gradation and moisture content must be controlled to achieve the desired low permeability. Changes in the weather can require drying or wetting of the silt/clay soil to achieve the optimum moisture content for compaction. The prescriptive cover, therefore, is more difficult to construct with the same level of quality control than the proposed GCL liner cover.

Compliance with Regulations

The proposed final cover complies with regulation 18 AAC 60.395(b) because it has a lower permeability than the prescriptive cover and it is more resistant to erosion than the prescriptive. Overall, the proposed final cover is estimated to perform better than the prescriptive cover.

Construction QA/QC

The effectiveness of the final cover will depend on how well it is constructed; therefore, quality assurance/quality control (QA/QC) procedures will be included in the construction specifications. In addition to these requirements imposed on the construction contractor, an onsite Borough representative will provide construction oversight to ensure that QA/QC procedures are followed. Quality control checks will include, but not be limited, to the following:

- GCL subgrade preparation
- GCL storage, handling, and placement
- Quality of GCL seam construction
- Cover material quality tests
- Depth and grading of cover layers
- Proper installation of gas venting structures
- Establishment of vegetation on uppermost layer

Construction Specifications

Draft technical specifications have been prepared for the construction of the final cover and are included as Attachment 3. As the Cell 2A final cover construction will be combined with Cell 2B construction, specifications relevant to both Cell 2A and 2B are included in Attachment 3.

Post-Closure Maintenance

Vegetation

The construction contract will require the contractor to water the final cover area, as needed, until the planted area is established within the first growing season. Bare spots will be re-seeded, fertilized, and watered to reestablish a vegetated cover. Some landscaping with other types of indigenous plants may be performed in the future.

Erosion and Settlement Repair

Areas of significant erosion, if present, will be regraded and vegetation will be established as described in the previous section.

Settlement areas, if present, will be filled to prevent ponding on the surface of the landfill.

Integration with Closure of Adjacent Cells in the Future

An as-built record drawing of the final cover will be prepared by the construction contractor and the drawings will be maintained with the landfill records. In addition, markers will be placed along the perimeter of the final cover so that the edge can be found when the next phase of the final cover is constructed or maintenance work is needed along the toe of the landfill.

When the next phase of the closure is implemented, the edge of the GCL in the previously closed portion of the landfill will be exposed and tied into the final cover of the adjacent section. The GCL or other type of barrier layer used in the final cover will overlap the previously closed area by at least 3 feet. Detailed design plans and specifications will be prepared before the final closure phase is constructed.

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Attachment 1
Technical Papers

EXPERIENCE WITH GEOSYNTHETIC CLAY LINERS FOR LANDFILL CLOSURE AT THE TOMOKA FARMS ROAD LANDFILL, DAYTONA BEACH, FLORIDA

by

Lee A. Powell, P.E., SCS Engineers, and James L. Griffin, Director of Solid Waste Services, Volusia County.

Technical Reviews by David Poe, P.E. and Robert Gardner, P.E.

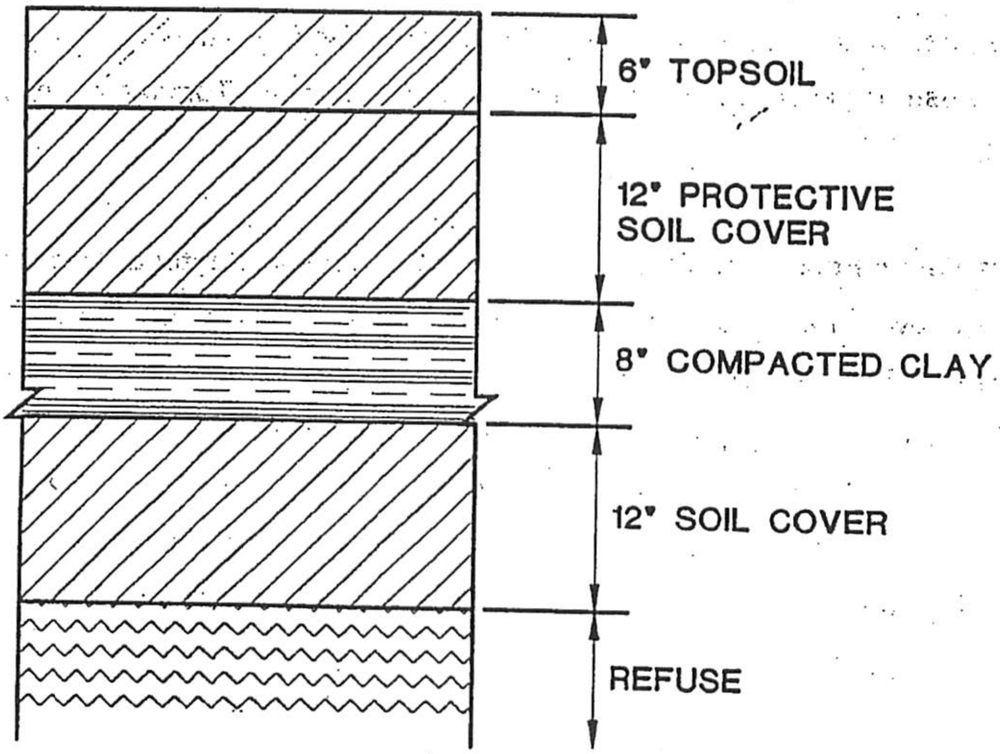
Sept 1996 SWANA Conference

PURPOSE

The purpose of this paper is to describe the experience Volusia County has had with the use of geosynthetic clay liners for closure of the Tomoka Farms Road Landfill.

Tomoka Farms Road Landfill is located on 3500 acres in Daytona Beach, Florida. The site is owned and operated by Volusia County (County) and takes in an average of 1300 tons of waste per day. The 120-acre landfill is designed as a high-rise landfill, rising approximately 100 feet above surrounding grade. The landfill has 6H:1V side slopes on three sides and 5H:1V side slopes on the western slope. There are terraces after every 20 feet of vertical rise. Built in the late 1970's, the bottom of the landfill has a polyvinyl chloride (PVC) geomembrane liner placed on top of a natural clay layer.

The operating permit for the landfill, issued by the Florida Department of Environmental Protection (FDEP), required the County to construct the final cover on the exterior surfaces as an on-going operation. The final cover was to consist of six to twelve inches of daily soil cover, eight inches of compacted clay liner (CCL), twelve inches of protective soil cover, and six inches of topsoil, as shown on Figure 1. Florida now requires compacted clay liners to be at least 18 inches thick, constructed in 6-inch thick lifts.



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SCS ENGINEERS

Figure 1. Compacted Clay Liner.

The County was in the process of constructing a CCL from the base to the first terrace on the closed-out portion of the landfill when problems arose. Intermittent rainfall, with its consequent erosion and over wetting of the clay, made closure more time-consuming and costly than anticipated. To reduce the cost of the ongoing closure construction project, the County began considering alternative cover systems.

COVER SYSTEMS

The purpose of a landfill liner system is to isolate the buried solid waste from the environment. The final landfill cover or cap is an important element of the complete liner system. Final landfill cover systems typically are made up of one or more protective soil layers and a low permeability barrier layer. Compacted clay liners (CCL) and geomembranes commonly are used for the low permeability barrier layer. However, both CCLs and geomembranes possess inherent disadvantages when installed over closed landfills.

<u>Description of Common Barrier Layer Materials</u>

Compacted Clay Liners (CCLs)--

CCLs typically are constructed in multiple lifts of six to eight inches in thickness. A 12-inch thick clay layer would normally be constructed in two six-inch lifts. An 18-inch thick layer, such as is required in Florida, would be constructed in three six-inch thick lifts. Each lift must be compacted sufficiently to achieve the project hydraulic conductivity requirements.

The relationship among compaction, moisture content, and hydraulic conductivity is unique for a specific clay and for specific types of field equipment. This relationship is usually tested in the field by construction of a "test strip" at the beginning of the project. Periodic testing of the clay source for grain size and Atterburg limits typically is required to confirm that the clay being used is the same as the clay that was tested within the test strip. Even within a single clay borrow pit, the characteristics of the clay may vary from one part of the pit to another, or from one layer of the pit to another.

Typically, project specifications require the clay to be compacted to 95 or 97 percent of the maximum dry density by either ASTM D1447 (Modified Proctor) or ASTM D698 (Standard Proctor) corresponding to the optimum moisture content. Since the surface of a closed landfill is not homogeneous, differing degrees of compaction may be achieved at different locations on the site. Typically, project specifications require that the subgrade be compacted to 90 to 95 percent of the maximum dry density. The required degree of compaction is not easily achieved over areas of compressible wastes. Controlling the moisture content of the clay is paramount. For best results, the moisture content of the clay prior to compaction should be 0 to 5 percent wet of the optimum moisture content. One rainfall can shut down a project for days while erosion is repaired and the clay dries out to proper moisture levels. However, too much sunny weather can dry out the clay, making it necessary to add moisture.

CCLs are also dependent upon field testing for quality assurance. A typical construction quality assurance plan might include four depth measurements, three field density tests, three moisture content tests, and one or two hydraulic conductivity tests per acre for each lift of installed barrier layer. Hydraulic conductivity tests can take several weeks to run, and a failing test can require excavation and reworking of the barrier layer. When only a few tests are conducted per acre, questions remain about the quality of the CCL in the areas between test sites.

Geomembrane Liners--

Geomembrane liners, such as polyvinyl chloride (PVC) and polyethylene (low and high density), are manufactured under factory quality control, thereby reducing the reliance on field quality assurance as required for CCLs. However, geomembranes do require field seaming and installation by experienced personnel. Unlike CCLs, geomembrane liners are not self-seaming, so every linear foot of seam must be tested for leakage. Additionally, pinholes, punctures or tears that occur during placement of cover soil are not easily detected and are difficult to repair.

Description of Geosynthetic Clay Liners

Geosynthetic clay liners (GCLs), previously called bentonite mats or blankets, are factory manufactured dry bentonite clay liners sandwiched between geotextiles. Most GCLs have the two geotextiles fastened together by needle punching or by stitching to increase resistence to shear. GCLs have been used in various applications for more than a decade, but they have not been widely used for landfill closures. GCLs however have many features that make them attractive for use as barrier layers at closed landfill sites:

- They are manufactured under factory quality control.
- The bentonite portion of the GCL has a very low hydraulic conductivity ($1X10^{-9}$ cm/sec or less typical).
- The bentonite used in GCLs can swell up to 10 times its initial volume when wetted. This swelling allows the GCL to be "self healing," that is, the liner seals punctures, penetrations, and other protrusions that would otherwise cause a leak in a geomembrane liner.
- The bentonite extrudes through the geotextile layers when the GCL is hydrated. This allows the GCL to be "self sealing." Consequently, no

field seaming is required other than placing the panels with a six-inch overlap between adjacent panels.

- The geotextile component of the GCL adds tensile strength to the GCL. This helps the GCL to resist the differential settlement that occurs in old landfills as the buried organic material continues to decay.
- GCLs do not depend on extensive compaction to achieve low permeability. They can easily be installed with landfill equipment, without the extensive compaction required by CCLs. This minimizes the risk of damage to underlying layers, as well as significantly reducing the time of construction. The risks associated with weather delays and damage are also significantly reduced.

PROJECT DESCRIPTION

Volusia County wanted a cover system that could be installed by County forces as an on-going part of landfill operation. Contracting out for geomembrane installation did not appear to meet that requirement. GCLs could easily be installed by County personnel and equipment, and appeared to be an attractive alternative. The County sought and obtained approval from the FDEP to test the use of GCLs for landfill closure. The cover system proposed by the County, shown in Figure 2, replaced the eight inches of clay originally permitted with GCL, covered with 18-inches of protective soil and six inches of topsoil.

Nine rolls of Claymax® GCL, produced by the James Clem Corporation, and two rolls of Bentomat® GCL, manufactured by Colloid Environmental Technologies Company (CETCO), were delivered to the Tomoka Farms Road site. The County constructed a two-foot deep anchor trench along the first terrace in the area where the GCL was to be installed. When the side slope was adequately prepared, one roll of GCL was carried to the terrace by a front end loader equipped with a special bar attachment which held the GCL roll. The GCL was hoisted over

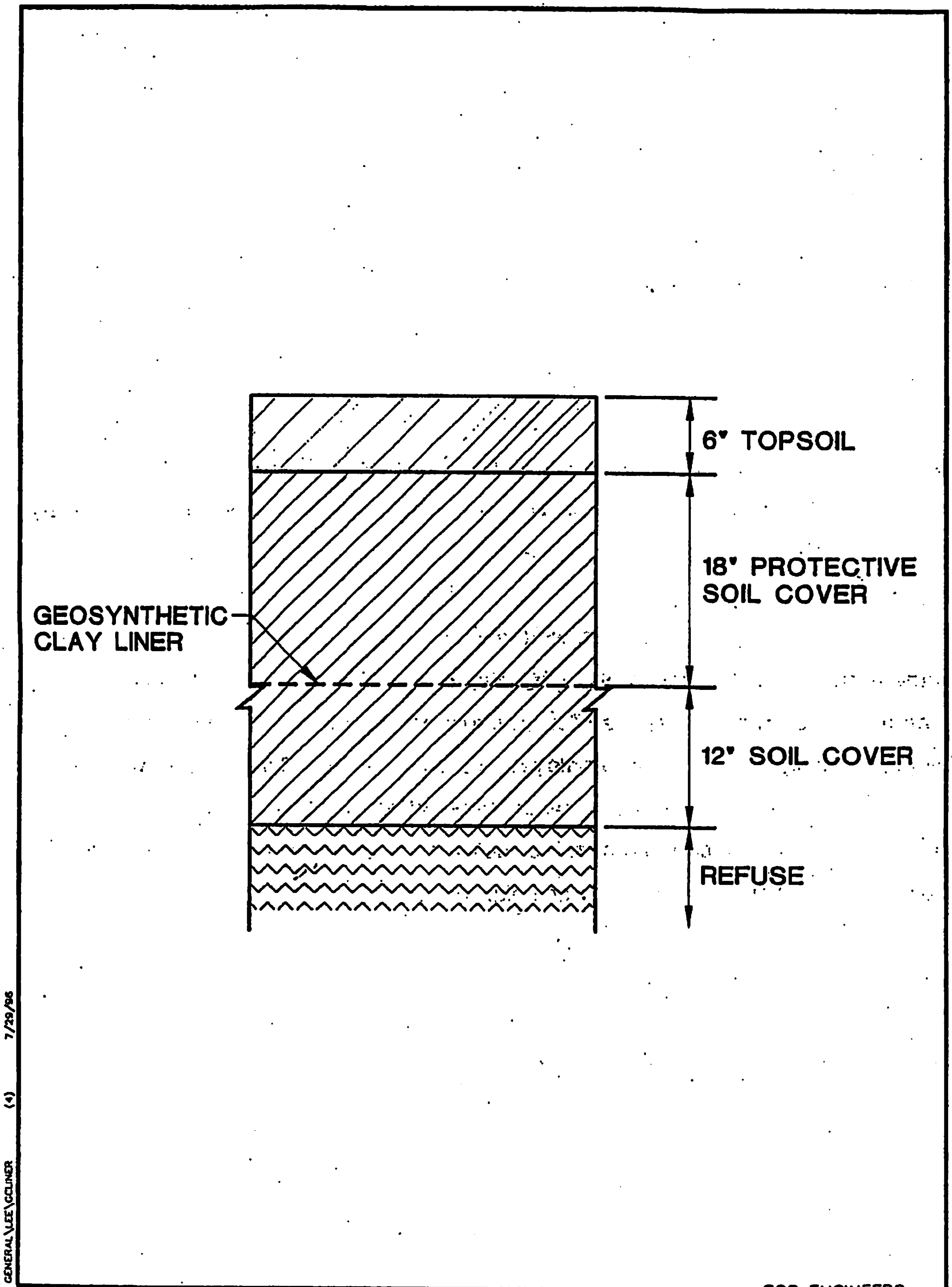

Figure 2. Geosynthetic Clay Liner.

the anchor trench and laborers walked the liner down the slope. The upper end of the GCL was placed in the anchor trench and covered with soil to hold the panel in place. The remaining panels were similarly placed, each overlapping the previous panel by six inches, and covered with two feet of soil. To ensure that the panels were properly overlapped, and to speed the installation process, the GCL manufacturers had printed overlap marks on each GCL panel six inches from the edge.

The day after the panels were installed, the County uncovered a small portion of each GCL in order to evaluate short term moisture changes. In the 24 hours subsequent to installation, the Claymax had fully hydrated and the Bentomat product was in the process of hydrating. Hydration was attributed to the relatively moist soils that were used to cover the GCL.

Based on the successful field testing, the FDEP approved the substitution of GCL as the barrier layer for closing the remaining portions of the landfill. The Construction Quality Assurance (CQA) Plan approved by the FDEP permitted the County to designate a County employee to provide on-site Construction Quality Assurance, operating under the general oversight of the County's consulting engineer. The approved CQA plan includes requirements for inspection of the subgrade, the liner, and the cover soil placed on top of the liner.

Description of GCL Installation

The areas where the GCL was to be installed were first brought to design grade, and a minimum 12-inch thick compacted soil cover was installed. Field density tests were taken by the County at a frequency of one test per acre. In place density of the compacted cover soil prior to placement of the GCL was found to vary between 95.2 and 100 percent of maximum dry density (Modified Proctor method). All subgrade was inspected and approved by the County's CQA

Inspector prior to placement of the GCL.

During the four-month period between March and June 1995, the County installed more than 48,000 square yards of GCL. All panels were inspected by the County's CQA Inspector, who also kept a daily log of all construction activity. From the anchor trench in the upper terrace, the 150-foot long panels were unrolled down the side slope to the lower terrace using a modified small back-hoe. Working only on days when no rain was expected, the County was able to install an average of 12 to 15 panels of GCL per day, in addition to completing the normal landfill operation activities. At the end of each day's installation, the exposed edge of the last panel was covered with polyethylene sheeting. When work resumed, this sheeting was peeled back and the next panel was placed with the required six-inch overlap.

Cover soil was placed on top of the GCL panels the same day as panel installation. The bulldozers spread and compacted the cover soil to a depth of 24 inches. The soil was pushed across the face of the side slope, from the upper panel to the lower panel to prevent damage to the seam overlaps. The cover soil specified was eighteen inches of a freely draining sandy soil, overlain by six inches of topsoil. Test holes were used to verify the depth of soil actually placed.

DESIGN CONSIDERATIONS RELATED TO THE USE OF GCLS FOR COVER SYSTEMS

The following design considerations and field observations were made concerning the use of GCLs at the Tomoka Farms Road Landfill:

Dehydration

With an average annual precipitation of 50 inches, dehydration is not as much of a concern at the Tomoka Farms Road Landfill as it might be at arid sites. The

Tomoka Farms Road Landfill uses the accumulated water in the stormwater ponds to irrigate the side slopes, further reducing the potential for the GCL to dehydrate. Test holes have shown that the GCL has stayed fully hydrated.

Landfill Gas

There was initial concern that landfill gas underneath the GCL could dehydrate the GCL and escape to the atmosphere, especially since the Tomoka Farms Road Landfill did not have a landfill gas management system in place at the time the GCL was installed. The County subsequently has checked for landfill gas in the areas where the GCL has been installed. To date, the County has not observed any adverse effects to the GCL from landfill. Additionally, the vegetative cover over the GCL has not been stressed as a result of fugitive landfill gas emmissions. Brown spots have occurred in several places near the base of the slope where CCL previously was installed, suggesting that the CCL has dehydrated, allowing gas to escape through the cover system. Clearly, no barrier material is a substitute for a gas management system.

Chemical Degradation

The bentonite layer in the GCL is thin, and therefore any chemical damage potentially could significantly impact the performance of the GCL. In a landfill cover system, leachate seeping out the side slopes could come in contact with the GCL. Leachate with high levels of dissolved salts, acids, alkalis, or organic contaminants such as aromatic or aliphatic compounds could impair the performance of the bentonite. However, leachate seeps are not common at the Tomoka Farms Road Landfill, and none have been observed in the areas covered by GCL. Consequently, chemical degradation of the bentonite was not considered a major concern.

Slope Stability

Hydrated bentonite has very little shear resistance, which would tend to make the

GCL unstable when installed on steep slopes. Slope stability was evaluated prior to reccommending the GCL for field testing.

In considering slope stability for the proposed GCL layer, the following were evaluated:

- Shear failure within the soil cover over the GCL.
- Shear failure at the interface between the cover soil and the GCL.
- Shear failure within the midplane of the GCL.
- Shear failure at the interface between the bottom of the GCL and the underlying soil.

The strength of each interface was calculated by the following equation:

$$S = W \cos B \tan P + C \qquad \text{(Spangler, page 294)}$$

where S = interface strength per unit slope length (lb/sf)
W = loading of cover soil (lb/sf)
B = slope angle (degrees)
P = friction angle in degrees
C = long term cohesion or adhesion

The slope angle on the western side slope at the Tomoka Farms Road Landfill was 5H:1V, or 11.3 degrees. For the analysis we assumed that the two feet of cover soil exerts a loading of 220 pounds per square feet (lb/sf). The GCL that was used at Tomoka was the Claymax "SP-500®" product, which has the two outer geotextile sheets sewn together. Although the friction angle for hydrated bentonite is very low, approaching zero degrees, the stitch bonding of the two geotextiles gives the Claymax SP-500 GCL an internal shear strength or "C" value of 500 lb/sf, as reported by the manufacturer. Of the four interfaces, the surface between the cover soil and the top of the GCL was found to be the critical or weakest interface. The shear strength per unit length or "S" for this interface was calculated to be 130 lb/sf.

The safety factor for this critical interface was calculated by the following equation:

SF = S / W sinB (Spangler, page 294)

= (130lb/sf) /(220lb/sf) (sin 11.3)

= 3.0

This was considered an adequate margin of safety. At the Tomoka Farms Road Landfill, the steepest slopes were only 5H:1V, so slope failure was not as critical a concern as it would be if the slopes were steeper. The GCL at the Tomoka Farms Road Landfill has been in place for two years with no sign of slope movement or displacement of the cover soils.

FINAL OBSERVATIONS

The use of GCLs in lieu of CCL at the Tomoka Farms Road Landfill has been successful. The County intends to continue using GCLs in the final cover system construction.

REFERENCES:

1. Spangler, M.R. *Soil Engineering*. Scranton: International Textbook Company, 1969.

COST EFFECTIVE ALTERNATIVE TO AN UNREINFORCED GCL FOR LANDFILL FINAL COVER SYSTEMS

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ABSTRACT

A geosynthetic clay liner (GCL) may be installed at a fraction of the cost of a California prescriptive standard compacted clay liner (CCL) when low-permeability material is not available on-site and soils must be either amended or imported. The engineered alternative selected for the final cover system at the 32 ha (79 acre) Hanford Landfill located in Kings County, California incorporates a new GCL product that offers a cost-effective alternative to both unreinforced GCLs and the State's prescriptive standard CCL, while exceeding applicable performance standards. Economic analyses comparing three design alternatives demonstrated a 41 to 63 percent cost savings over a prescriptive CCL cover system. This paper discusses the first use of a new, lightweight, woven/nonwoven, needle-punched GCL product in a landfill final cover application and presents results from conformance testing and construction quality assurance monitoring. Bentonite migration has been reported in unreinforced GCLs; however, at the Hanford Landfill, field observations of GCL panels exhumed approximately five weeks after initial placement indicated significant hydration, but no discernable bentonite migration.

INTRODUCTION

This paper utilizes a case study to present results of the first use of a new, lightweight, woven/nonwoven needle-punched geosynthetic clay liner (GCL) product in a landfill final cover application. The scope of work for the case study consists of the final closure of the Hanford Landfill, an unlined municipal solid waste (MSW) disposal facility located in the Central Valley of California (Figure 1). Average annual precipitation at the site is approximately 211 mm (8.29 in) and occurs as rain, 90 percent of which falls during the months of November through April. Subgrade excavation and refuse filling throughout the operating life has resulted in a nearly square, 32 ha (79 acre) footprint rising a maximum of 6.4 m (21 ft) above the surrounding flat terrain with refuse ranging from 7.6 to 12 m (25 to 40 feet) in thickness. The top of the landfill has been graded at 3 percent to form a series of alternating ridges and swales designed to drain the interior. The extreme northern and southern ridges steepen to approximately 10 percent away from the center and constitute a minor portion (4 percent) of the total landfill surface requiring closure. A 1.8 to 3.0 m (6 to 10 ft) high operational soil berm forms 3H:1V perimeter side-slopes.

Figure 1. Oblique aerial view of the Hanford Landfill taken during GCL and cover soil placement.

The combined absence of a local source for low-permeability material, low seismic activity, and the gently sloping surface of the landfill requiring placement of the final cover system provided an opportunity to explore possible benefits offered by the use of an unreinforced GCL. In this paper we present results of an economic analysis comparing various final cover system designs which led to the selection of a preferred GCL alternative, and discuss conformance testing and construction quality assurance monitoring during construction.

FINAL CLOSURE DESIGN

Final closure of MSW landfills in California is subject to requirements promulgated under California Code of Regulations (CCR) Title 27. The prescriptive standard for unlined waste management unit final cover systems in California consists of the following in ascending order:

- foundation layer consisting of 61 cm (24 in) of engineered fill, typically compacted to at least 90 percent relative density (modified proctor),

- compacted clay liner (CCL) consisting of 30 cm (12 in) of fine-grained material compacted to attain a saturated hydraulic conductivity no greater than 1 x 10^{-6} cm/sec, and

- an erosion resistant layer, typically in the form of a vegetative layer consisting of 30 cm (12 in) of soil capable of sustaining native, shallow-rooting plant growth and resisting foreseeable erosion.

Several geotechnical investigations were conducted at the Hanford Landfill to determine the suitability of on-site borrow soils for use in construction of the low-permeability clay layer and other components of the final cover system. Early investigations identified a silty-clay horizon located approximately 3 to 5 m (10 to 15 ft) below the ground surface. In addition to the onerous task of excavating this material, results of laboratory testing of undisturbed samples indicated a hydraulic conductivity that only marginally met requirements for the low-permeability layer. Hence, the on-site silty-clay material was eliminated as a potential source for low-permeability clay material. Subsequent testing of silty-clayey material exposed at the ground surface was performed to determine possible bentonite admix ratios which would allow more accessible on-site material to meet hydraulic conductivity requirements. Based on results of laboratory testing, a 3 percent bentonite admix ratio was required and was subsequently increased to 6 percent to account for variability in material and degree of mixing achieved during construction.

California allows the consideration and approval of engineered alternatives to the prescriptive standard when the prescriptive standard is not feasible and if there is a specific engineered alternative that is consistent with the performance goals addressed by the prescriptive standard, and which affords equivalent protection against water quality impairment. To establish that compliance with the prescriptive standard is not feasible, it must be demonstrated that the prescriptive standard is either unreasonably and unnecessarily burdensome and will cost substantially more than alternatives which meet the State's criteria, or is impractical and will not promote attainment of applicable performance standards.

Because the majority of slopes on the landfill surface do not exceed 3 percent, we also investigated the use of an unreinforced GCL product. We performed an economic analysis comparing three final cover system designs to assist in selection of the preferred alternative. The alternatives evaluated in the analysis included the following:

1) a prescriptive standard cover system utilizing 100 percent clay imported from the nearest commercial source,

2) a prescriptive standard cap utilizing on-site material with a 6 percent bentonite admix, and

3) an engineered alternative incorporating an unreinforced GCL.

As anticipated, the estimated cost for Alternative 1 was significantly higher than the other alternatives, with clay acquisition and transportation expenditures accounting for the cost differential. Costs, normalized to Alternative 1, are shown in Figure 2. Amending on-site soils with imported bentonite (Alternative 2) provided an estimated cost savings of 37 percent over that of Alternative 1. Alternative 3 provided a cost savings of 63 percent with respect to Alternative 1 and 41 percent with respect to Alternative 2, and was selected as the preferred engineered alternative.

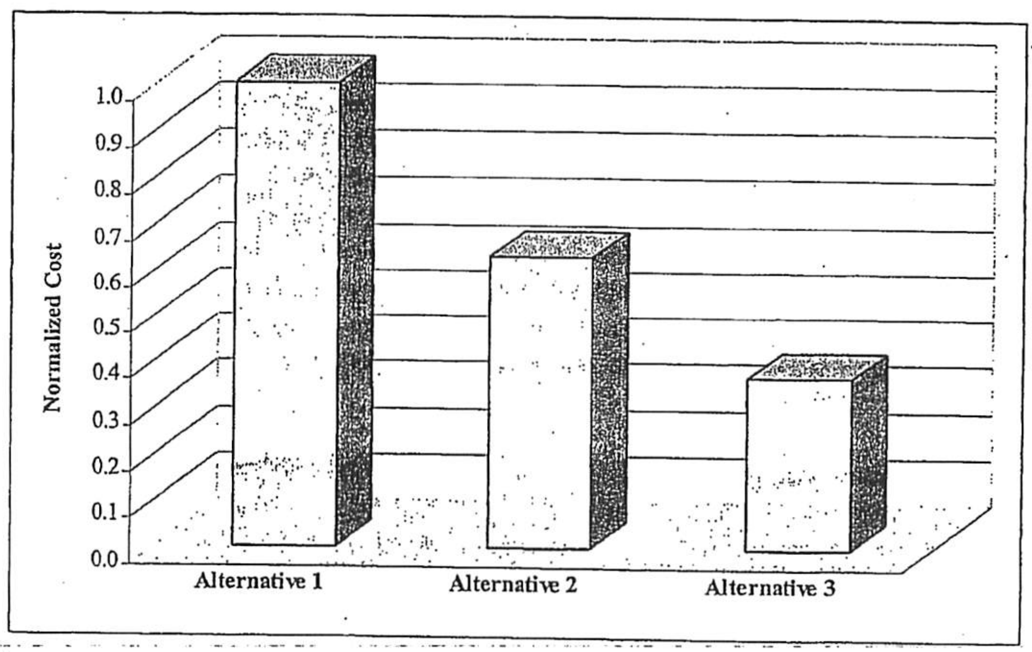

Figure 2. Relative costs for final closure alternatives described in this paper, normalized to Alternative 1.

Specifications for the engineered alternative cover on slopes less than 10 percent at the Hanford Landfill consisted of the following components in ascending order:

- a 30 cm (12 in) foundation layer placed over the existing intermediate cover and compacted to at least 90 percent relative compaction (modified proctor),

- An unreinforced GCL consisting of an approximately 3.7 kg/m^2 (0.75 lbs/ ft^2) dry weight sodium bentonite layer sandwiched between and continuously adhered to two lightweight (95 g/m^2, nominal [2.8 oz/yd^2]) woven geotextiles, and

- A 46 cm (18 in) vegetative soil layer track-walked to approximately 85 percent relative compaction (modified proctor).

Various manufacturers of GCLs have reported swelling of their products when installed in final cover systems applications in conjunction with the minimum 30 cm (12 in) vegetative layer required by the prescriptive standard. Therefore, the thickness of the vegetative layer was increased to 46 cm (18 in) to provide additional normal stress and prevent swelling of the GCL during hydration. The additional thickness also provides greater protection of the GCL against equipment damage following installation. The prescriptive standard requires a foundation layer of 61 cm (24 in) for the purpose of providing a firm and unyielding subgrade for compaction of the low permeability clay layer. However, for the GCL alternative, the main purpose of the foundation layer is to provide a smooth subgrade free of protrusions and deleterious objects which could damage the GCL. Therefore, the foundation layer thickness was reduced to 30 cm (12 in).

We petitioned the regulatory agencies and were successful in gaining approval of the preferred GCL engineered alternative. Project specifications were written to require the unreinforced GCL described above. However, the selected geosynthetics supplier proposed the use of a new, lightly needle-punched, woven/nonwoven GCL product designed specifically for the project which not only exceeded the project specifications, but also was bid at a cost savings of 4 percent to that of other bids submitted for an unreinforced GCL. The new product consists of sodium bentonite at the approximate dry weight of 3.7 kg/m^2 (0.75 lbs/ft^2) carried between a woven geotextile with a nominal weight of 95 g/m^2 (2.8 oz/ yd^2) and a nonwoven geotextile with a nominal weight of 100g/m^2 (3.0 oz/yd^2) that are lightly needle-punched together. For slopes exceeding ten percent, a standard double nonwoven needled punched (NWNP) reinforced GCL overlain by a geonet composite drainage layer was specified. Depending on the application, the authors commonly specify a minimum peel strength of 110 to 130 N (25 to 30 lbs) performed on a 10 cm (4 in) wide sample using the modified ASTM D 4632 test method. However, due to the shallow 10 percent slopes at the Hanford Landfill, the minimum acceptable peel strength was reduced to 67 N (15 lbs) using ASTM D 4632 (modified).

CQA AND INSTALLATION

Manufacturers present geosynthetic physical properties in terms of a minimum average roll value (MARV) in a particular manufacturing lot. The MARV is the value which is exceeded by 97.5 percent of the test data and is derived statistically as the average value minus two standard deviations (Koerner, 1997). Unfortunately, it can be difficult to define a manufacturing lot which can be the compilation of many tests over months or years. The average of all testing on any roll was required to be greater than the value listed in the project specifications shown in Table 1.

Table 1. GCL Specifications

Test	Method	Value	MQC[1] Testing Frequency
Base Bentonite			
Moisture Content	ASTM D 2216	25 percent (max.)	1 per 50 tons
Swell	ASTM D 5890	24 ml/2 g (min.)	1 per 50 tons
Fluid Loss	ASTM D 5891	18 ml (max.)	1 per 50 tons
Geotextiles[2]			
Mass per Unit Area	ASTM D 5261	95 g/m^2	1 per 50,000 ft^2
GCL[2]			
Grab Strength[3]	ASTM D 4632	330 N	1 per 200,000 ft^2
Bentonite Mass Per Unit Area	ASTM D 5993	3.66 kg./m^2 (oven-dried)	1 per 50,000 ft^2
Index Flux	ASTM D 5887	5 x 10^{-9} cm/sec.	1 per production-week

1 Manufacturing Quality Control.
2 Values for geotextiles and GCL are Minimum Average Roll Values (MARV) and the average of all measurements on any roll shall not be less than the MARV specified.
3 Tested in machine direction.

The manufacturer of the lightly-needled GCL reports a nominal internal shear strength of 2.4 kPa (50 lbs/ft^2) and a minimum peel strength of 22 N (5.0 lbs) for the lightly-needled GCL. Peel strengths of the lightly-needled GCL for the Hanford project ranged from 24 N to 93.0 N (5.5 lbs to 20.9 lbs) with a typical value of 44 N (10 lbs). These values exceed the internal shear strength reported for unreinforced GCL.

Lightly-needled GCL rolls were delivered to the site in standard widths of 4.72 m (15.5 ft) and lengths of either 45.7 m (150 ft) or 67.1 m (220 ft). Sample coupons of GCL delivered to the site were collected for Construction Quality Assurance (CQA) testing to verify that the product met the project specifications. A compilation of CQA test results and Manufacturing Quality Control (MQC) test results for the lightly-needled GCL are presented in Table 2.

Table 2. Combined Results of CQA Testing and MQC Testing

Material	Base Bentonite			Geotextile (MARV)[1]		GCL (MARV)[1]		
Test[2]	Moisture Content	Swell	Fluid Loss	Upper Mass	Lower Mass	Grab Strength	Bentonite Mass (dry)	Index Flux
Project Specification	25% (max)	24 ml/2 g (min)	18 ml (max)	95 g/m^2 (min)	95 g/m^2 (min)	330 N (min)	3,662g/m^2 (min)	5.0×10^{-9} cm/sec (max)
Min.	7.3	24.0	10.4	122.0	103.0	333.6	3662	1.1×10^{-9}
Max.	11.0	30.0	16.4	259.0	347.0	631.6	5714	5.0×10^{-9}
Avg.	9.2	25.5	12.5	151.3	118.9	375.0	4088	4.9×10^{-9}
s.d.	0.9	1.4	1.3	33.6	30.4	70.3	309	6.2×10^{-10}

[1] The average of all measurements on any roll shall not be less than the MARV specified.
[2] A total of 164 MQC tests and 31 CQA tests were conducted for this project.

GCL rolls were deployed using a forklift boom and steel bar inserted through the core tube (Figure 3). Panels were oriented parallel to the slope and placed with adjacent GCL panels overlapped a minimum of 30 cm (12 in) along the length and 2 feet along the width (butt-seams). For slopes greater than 10 percent, a standard reinforced GCL overlain by a geocomposite drainage layer was installed prior to vegetative layer placement (Figure 4). Because non-woven geotextiles inhibit the extrusion of internal bentonite, seams were required to be augmented with powdered bentonite at a minimum rate of 0.37 kg/m (0.25 lb/ft) in a continuous bead within 15 cm (6 in) of the edge of the lower GCL panel (Figure 5). GCL rolls held up well to the handling associated with field installation activities.

Project specifications also required that all GCL panels be covered with soil by the end of each day. Scrapers delivered borrow material to the leading edge of the vegetative layer where the soil was pushed by small bulldozers over installed GCL panels in a single 46 cm (18 in) lift. Kamatsu Model D65 bulldozers equipped with 106-cm (42-in) wide, low ground pressure tracks were used to place the soil (Figure 6). Scrapers were limited to those areas where the full 46 cm (18 in) lift had been placed. The rate of GCL installation was limited to approximately 0.93 ha/day (2.3 acres/day), the maximum amount of vegetative layer material that equipment was capable of placing in one day.

A manufacturing deficiency was identified in the lightly-needled GCL by quality assurance monitors during field installation. The deficiency was characterized by a 2.5 to 7.6 cm (1.0 to

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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	0.73	0.71	0.81	0.53	0.46	2.66
	1.96	3.28	2.17	1.63	0.80	0.69
STD. DEVIATIONS	0.68	0.47	0.40	0.30	0.51	1.64
	0.74	1.18	1.14	0.98	0.43	0.66
RUNOFF						
TOTALS	0.000	0.001	0.689	0.573	0.139	0.538
	0.041	0.135	0.361	0.214	0.081	0.020
STD. DEVIATIONS	0.000	0.003	0.694	0.544	0.189	0.721
	0.076	0.158	0.470	0.285	0.144	0.045
EVAPOTRANSPIRATION						
TOTALS	0.335	0.384	0.319	0.195	1.435	2.026
	2.126	2.161	1.532	0.704	0.283	0.214
STD. DEVIATIONS	0.034	0.083	0.041	0.210	0.485	1.017
	1.160	0.724	0.224	0.061	0.163	0.051
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0166	0.0091	0.0071	0.0053	0.2564	0.3179
	0.1462	0.0465	0.3685	0.4795	0.2903	0.0500
STD. DEVIATIONS	0.0062	0.0023	0.0015	0.0009	0.3392	0.2415
	0.2482	0.0485	0.4381	0.2326	0.2418	0.0602

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	16.44	(3.090)	59669.9	100.00
RUNOFF	2.792	(1.4374)	10136.30	16.987
EVAPOTRANSPIRATION	11.714	(1.2029)	42522.90	71.264
PERCOLATION/LEAKAGE THROUGH LAYER 3	1.99331	(0.60261)	7235.704	12.12621
CHANGE IN WATER STORAGE	-0.062	(1.3228)	-224.97	-0.377

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.16	7840.800
RUNOFF	1.074	3898.3765
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.132484	480.91678
SNOW WATER	2.54	9223.4766

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4087

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2189

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	2.2259	0.3710
2	6.4156	0.3564
3	0.2426	0.0404
SNOW WATER	0.208	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**              HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                  **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**              USAE WATERWAYS EXPERIMENT STATION                           **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\data\help3\MATSU4.D4
TEMPERATURE DATA FILE:       C:\DATA\HELP3\MATSU7.D7
SOLAR RADIATION DATA FILE:   C:\DATA\HELP3\MATSU13.D13
EVAPOTRANSPIRATION DATA:     C:\data\help3\MATSU11.D11
SOIL AND DESIGN DATA FILE:   C:\DATA\HELP3\matsulat.D10
OUTPUT DATA FILE:            C:\DATA\HELP3\Matsulat.OUT

TIME:   9:16     DATE:   7/ 5/2001

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     TITLE:  Central Landfill GCL Cover With Lateral Drainage Layer

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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
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                    TYPE 1 - VERTICAL PERCOLATION LAYER
                    EROSION LAYER - TOPSOIL
                    MATERIAL TEXTURE NUMBER   8
          THICKNESS                 =      6.00    INCHES
          POROSITY                  =      0.4630 VOL/VOL
          FIELD CAPACITY            =      0.2320 VOL/VOL
          WILTING POINT             =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT =     0.2147 VOL/VOL
          EFFECTIVE SAT. HYD. COND. =  0.369999994000E-03 CM/SEC

                                  LAYER  2
                                  --------

                     TYPE 2 - LATERAL DRAINAGE LAYER
                     INFILTRATION LAYER - ON-SITE SANDY GRAVEL
                     MATERIAL TEXTURE NUMBER   2
          THICKNESS                 =     18.00    INCHES
          POROSITY                  =      0.4370 VOL/VOL
          FIELD CAPACITY            =      0.0620 VOL/VOL
          WILTING POINT             =      0.0240 VOL/VOL
          INITIAL SOIL WATER CONTENT =     0.1004 VOL/VOL
          EFFECTIVE SAT. HYD. COND. =  0.579999993000E-02 CM/SEC
          SLOPE                     =     25.00    PERCENT
          DRAINAGE LENGTH           =    150.0     FEET
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LAYER 3

TYPE 3 - BARRIER SOIL LINER
GEOSYNTHETIC CLAY LINER (GCL)
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
OPERATIONAL COVER - GRAVEL
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	6.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0376	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER	=	81.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.723	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.022	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.984	INCHES
INITIAL SNOW WATER	=	1.383	INCHES
INITIAL WATER IN LAYER MATERIALS	=	3.501	INCHES
TOTAL INITIAL WATER	=	4.884	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Central Landfill Alaska

STATION LATITUDE	=	61.50 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	145
END OF GROWING SEASON (JULIAN DATE)	=	259
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	5.00 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	69.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	59.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR FLAGSTAFF ARIZONA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.86	0.69	0.52	0.51	0.71	1.45
2.28	2.65	2.49	1.57	1.01	0.97

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BETHEL ALASKA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
13.00	18.20	25.30	36.60	47.00	55.00
57.70	55.50	47.60	34.90	21.00	13.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BETHEL ALASKA
AND STATION LATITUDE = 61.50 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.83	50202.902	100.00
RUNOFF	0.789	2865.766	5.71
EVAPOTRANSPIRATION	10.145	36825.727	73.35
DRAINAGE COLLECTED FROM LAYER 2	2.8478	10337.624	20.59
PERC./LEAKAGE THROUGH LAYER 3	0.046833	170.004	0.34
AVG. HEAD ON TOP OF LAYER 3	0.1501		
PERC./LEAKAGE THROUGH LAYER 4	0.037241	135.185	0.27
CHANGE IN WATER STORAGE	0.011	38.592	0.08
SOIL WATER AT START OF YEAR	3.501	12708.422	
SOIL WATER AT END OF YEAR	3.512	12747.014	
SNOW WATER AT START OF YEAR	1.383	5020.605	10.00
SNOW WATER AT END OF YEAR	1.383	5020.605	10.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.011	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.72	78843.594	100.00
RUNOFF	2.306	8369.238	10.61
EVAPOTRANSPIRATION	13.255	48116.320	61.03
DRAINAGE COLLECTED FROM LAYER 2	6.0826	22079.914	28.00
PERC./LEAKAGE THROUGH LAYER 3	0.072653	263.731	0.33
AVG. HEAD ON TOP OF LAYER 3	0.3229		
PERC./LEAKAGE THROUGH LAYER 4	0.070507	255.940	0.32
CHANGE IN WATER STORAGE	0.006	22.171	0.03
SOIL WATER AT START OF YEAR	3.512	12747.014	
SOIL WATER AT END OF YEAR	3.764	13663.527	
SNOW WATER AT START OF YEAR	1.383	5020.605	6.37
SNOW WATER AT END OF YEAR	1.137	4126.263	5.23
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.72	53433.605	100.00
RUNOFF	1.680	6098.671	11.41
EVAPOTRANSPIRATION	11.566	41984.777	78.57
DRAINAGE COLLECTED FROM LAYER 2	3.5299	12813.409	23.98
PERC./LEAKAGE THROUGH LAYER 3	0.049038	178.010	0.33
AVG. HEAD ON TOP OF LAYER 3	0.1852		
PERC./LEAKAGE THROUGH LAYER 4	0.063022	228.770	0.43
CHANGE IN WATER STORAGE	-2.119	-7692.026	-14.40
SOIL WATER AT START OF YEAR	3.764	13663.527	
SOIL WATER AT END OF YEAR	2.733	9919.045	
SNOW WATER AT START OF YEAR	1.137	4126.263	7.72
SNOW WATER AT END OF YEAR	0.049	178.719	0.33
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.75	57172.516	100.00
RUNOFF	1.287	4672.295	8.17
EVAPOTRANSPIRATION	10.232	37141.043	64.96
DRAINAGE COLLECTED FROM LAYER 2	2.5955	9421.648	16.48
PERC./LEAKAGE THROUGH LAYER 3	0.042522	154.353	0.27
AVG. HEAD ON TOP OF LAYER 3	0.1382		
PERC./LEAKAGE THROUGH LAYER 4	0.037025	134.399	0.24
CHANGE IN WATER STORAGE	1.599	5803.102	10.15
SOIL WATER AT START OF YEAR	2.733	9919.045	
SOIL WATER AT END OF YEAR	3.720	13501.856	
SNOW WATER AT START OF YEAR	0.049	178.719	0.31
SNOW WATER AT END OF YEAR	0.661	2399.010	4.20
ANNUAL WATER BUDGET BALANCE	0.0000	0.026	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.17	58697.113	100.00
RUNOFF	2.002	7267.340	12.38
EVAPOTRANSPIRATION	11.498	41736.281	71.10
DRAINAGE COLLECTED FROM LAYER 2	2.4787	8997.705	15.33
PERC./LEAKAGE THROUGH LAYER 3	0.039866	144.712	0.25
AVG. HEAD ON TOP OF LAYER 3	0.1311		
PERC./LEAKAGE THROUGH LAYER 4	0.043322	157.259	0.27
CHANGE IN WATER STORAGE	0.148	538.523	0.92
SOIL WATER AT START OF YEAR	3.720	13501.856	
SOIL WATER AT END OF YEAR	4.320	15683.039	
SNOW WATER AT START OF YEAR	0.661	2399.010	4.09
SNOW WATER AT END OF YEAR	0.208	756.350	1.29
ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.73	0.71	0.81	0.53	0.46	2.66
	1.96	3.28	2.17	1.63	0.80	0.69
STD. DEVIATIONS	0.68	0.47	0.40	0.30	0.51	1.64
	0.74	1.18	1.14	0.98	0.43	0.66
RUNOFF						
TOTALS	0.000	0.001	0.646	0.533	0.122	0.123
	0.000	0.002	0.078	0.025	0.064	0.018
STD. DEVIATIONS	0.000	0.002	0.657	0.519	0.181	0.184
	0.000	0.005	0.115	0.052	0.125	0.040
EVAPOTRANSPIRATION						
TOTALS	0.335	0.384	0.319	0.195	1.350	1.866
	2.097	2.130	1.473	0.694	0.283	0.214
STD. DEVIATIONS	0.034	0.083	0.041	0.210	0.438	0.935
	1.021	0.640	0.228	0.070	0.163	0.051

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	0.0000	0.0000	0.0000	0.0000	0.4911	0.5378
	0.5237	0.1359	0.7986	0.7800	0.2275	0.0124
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.3520	0.2771
	0.7167	0.0798	0.9448	0.4720	0.2045	0.0244

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0055	0.0075
	0.0075	0.0043	0.0096	0.0096	0.0048	0.0013
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0034	0.0023
	0.0059	0.0007	0.0078	0.0039	0.0018	0.0014

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0073	0.0051	0.0045	0.0036	0.0018	0.0001
	0.0016	0.0035	0.0028	0.0038	0.0073	0.0087
STD. DEVIATIONS	0.0016	0.0008	0.0007	0.0005	0.0006	0.0002
	0.0011	0.0030	0.0018	0.0030	0.0039	0.0021

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.3071	0.3476
	0.3275	0.0850	0.5161	0.4878	0.1470	0.0078
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.2201	0.1791
	0.4482	0.0499	0.6106	0.2952	0.1321	0.0153

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	16.44	(3.090)	59669.9	100.00
RUNOFF	1.613	(0.5958)	5854.66	9.812
EVAPOTRANSPIRATION	11.339	(1.2650)	41160.83	68.981
LATERAL DRAINAGE COLLECTED FROM LAYER 2	3.50690	(1.49642)	12730.060	21.33412
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.05018	(0.01306)	182.162	0.30528
AVERAGE HEAD ON TOP OF LAYER 3	0.185	(0.080)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.05022	(0.01554)	182.311	0.30553
CHANGE IN WATER STORAGE	-0.071	(1.3269)	-257.93	-0.432

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.16	7840.800
RUNOFF	0.800	2904.5100
DRAINAGE COLLECTED FROM LAYER 2	0.19162	695.56714
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.001682	6.10436
AVERAGE HEAD ON TOP OF LAYER 3	3.715	
MAXIMUM HEAD ON TOP OF LAYER 3	7.045	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000493	1.78970
SNOW WATER	2.54	9223.4766

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2757

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0553

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	2.2754	0.3792
2	1.6397	0.0911
3	0.1800	0.7500
4	0.2252	0.0375
SNOW WATER	0.208	

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Attachment 3
Draft Technical Specifications

SECTION 02200
SITE PREPARATION

PART 1 GENERAL

1.1 DEFINITIONS

A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2 inches in diameter to a depth of 6 inches below subgrade.

D. Stripping: Removal of topsoil remaining after applicable clearing and grubbing is completed.

E. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.2 QUALITY ASSURANCE

A. Obtain ENGINEER's approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

1.3 SCHEDULING AND SEQUENCING

A. Prepare site only after adequate erosion and sediment controls are in place. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls to maximum of 2 acres.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 GENERAL

A. Clear, grub, and strip areas actually needed for excavation, staging and stockpiling operations, or site improvements within limits shown or specified.

B. Do not injure or deface vegetation that is not designated for removal.

3.2 LIMITS

A. As follows, but not to extend beyond Project limits.

1. Excavation: 5 feet beyond top of cut slopes.
2. Fill:
   a. Clearing and Grubbing: 5 feet beyond toe of permanent fill.
   b. Stripping: 2 feet beyond toe of permanent fill.
3. Roadways: Clearing, grubbing, and stripping 30 feet from centerline.
4. Overhead Utilities:
   a. Clearing and Grubbing: Entire width of easements and rights-of-way.
   b. Scalping and Stripping: Wherever grading is required.
5. Other Areas: As shown.

B. Remove rubbish, trash, and junk from entire area within Project limits. Dispose of these materials in the Central Landfill, active Cell 2A, as approved by the OWNER.

3.3 CLEARING

A. Clear areas within limits shown or specified.

B. Fell trees so that they fall away from facilities and vegetation not designated for removal.

C. Cut stumps not designated for grubbing flush with ground surface.

D. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

E. All trees to be placed in the C&D Cell shall be hydroaxed.

3.4 GRUBBING

A. Grub areas within limits shown or specified.

3.5 STRIPPING

A. Strip areas within limits to minimum depths shown or specified. Do not remove subsoil with topsoil.

3.6 TREE REMOVAL OUTSIDE CLEARING LIMITS

A. Remove Within Project Limits:

1. Dead, dying, leaning, or otherwise unsound trees that may strike and damage Project facilities in falling.
2. Trees designated by OWNER.

B. Cut stumps off flush with ground, remove debris, and if disturbed, restore surrounding area to its original condition.

3.7 SALVAGE

A. Saleable log timber may be sold to CONTRACTOR's benefit. Promptly remove from Project site.

3.8 DISPOSAL

A. Clearing, Grubbing, and Stripping Spoils:

1. Place spoils at the Central Landfill C&D Cell in uniform lift thickness in locations as approved by OWNER.

END OF SECTION

SECTION 02315
FILL AND BACKFILL

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society for Testing and Materials (ASTM):
   a. C117, Standard Test Method for Materials Finer Than 75-Micrometers (No. 200) Sieve in Mineral Aggregates by Washing.
   b. C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. D75, Standard Practice for Sampling Aggregates.
   d. D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
   e. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
   f. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
   g. D2922, Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
   h. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   i. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

1.2 DEFINITIONS

A. Relative Compaction:

1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D1557.
2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by ENGINEER.

B. Optimum Moisture Content:

1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.
2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

C. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.

D. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

E. Completed Course: A course or layer that is ready for next layer or next phase of Work.

F. Lift: Loose (uncompacted) layer of material.

G. Geosynthetics: Geotextiles, geogrids, or geomembranes.

H. Well-Graded:

1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

I. Influence Area: Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:

1. 1-foot outside outermost edge at base of foundations or slabs.
2. 1-foot outside outermost edge at surface of roadways or shoulder.
3. 0.5-foot outside exterior at spring line of pipes or culverts.

J. Borrow Material: Material from required excavations or from designated borrow areas on or near site.

K. Selected Backfill Material: Materials available onsite that ENGINEER determines to be suitable for specific use.

L. Imported Material: Materials obtained from sources offsite, suitable for specified use.

M. Structural Fill: Fill materials as required under structures, pavements, and other facilities.

N. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.

O. Processed Materials: Materials processed onsite for specified use. Materials specified for use on Project may be either processed from onsite materials or imported. However, the CONTRACTOR shall be solely responsible for determining the suitability of onsite soils to meet these specifications after processing. Any onsite processing operations shall be subject to review and approval by the ENGINEER prior to commencing operations.

1.3 SUBMITTALS

A. Quality Control Submittals:

1. Catalog and manufacturer's data sheets for compaction equipment.
2. Certified test results from independent testing agency.
3. Work plan for any onsite materials processing operations, including crushing, screening, washing, and other processing operations. Include site plan, equipment locations, haul routes, processing methods, water source and disposal methods, and other information as requested by the ENGINEER.

1.4 QUALITY ASSURANCE

A. Notify ENGINEER when:

1. Areas are ready for fill placement, and whenever filling operations are resumed after a period of inactivity.
2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
3. Fill material appears to be deviating from Specifications.

1.5 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in 02200, SITE PREPARATION; 02316, EXCAVATION; and 02319, SUBGRADE PREPARATION, prior to placing fill or backfill.

PART 2 PRODUCTS

2.1 SOURCE QUALITY CONTROL

A. Gradation Tests:

1. As necessary to verify compliance with these specifications. All tests shall be the CONTRACTOR's responsibility, including obtaining samples and retaining a qualified independent testing laboratory to conduct the tests.
2. Test representative samples of the following materials taken from each 1,500 tons of materials or as otherwise determined by the ENGINEER. Provide test results to ENGINEER within 48 hours after sampling unless otherwise approved by the ENGINEER.
   a. Earthfill.

b. Select Earthfill.
c. Sand Leveling Course.
d. Granular Drainage Material.
e. Leachate Collection Gravel.
f. Base Course
g. Cover Material.

B. Provide other test results as required to demonstrate that materials meet these Specifications, as approved by the ENGINEER.

C. Samples: Collect all samples in accordance with ASTM D75. Clearly mark to show source of material and intended use.

2.2 EARTHFILL

A. Well-graded granular material free from rocks larger than 8 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials. Material shall contain no more than 10 percent by weight passing a No. 200 sieve. Material shall be sufficiently well-graded such that placed material can be compacted to form a firm, unyielding surface.

2.3 SELECT EARTHFILL

A. Same as Earthfill, except that maximum particle size shall be 3 inches.

2.4 SAND LEVELING COURSE

A. Granular material free from dirt, clay balls, organic material, trash, ash, snow, ice, and other deleterious materials. Sand Leveling Course shall conform to the aggregate quality requirements of Section 703-2.03 of the ADOT&PF Standard Specifications for Highway Construction (1988 Edition), Aggregate D-1 for Untreated Base.

B. Clean and well-graded from coarse to fine (ASTM D422) within the limitations of the following table:

Sand Leveling Course Gradations

U.S. Standard Sieve	Percent Passing
½-inch	100
No. 4	80 to 100
No. 10	60 to 100
No. 40	40 to 90
No. 100	0 to 30
No. 200	0 to 10

C. Sand Leveling Course shall be sufficiently well-graded within the specified limits that material placed on a 4:1 (horizontal:vertical) slope can be compacted to form a firm, unyielding surface.

2.5 GRANULAR DRAINAGE MATERIAL

A. Granular material free from dirt, clay balls, trash, ash, organic material, and other deleterious material. Material shall be washed and screened as required to provide a free-draining material. The material shall have a minimum permeability of 1×10^{-1} cm/sec, as determined by ASTM D2438. A minimum of two permeability tests shall be run on representative samples of the material prior to ENGINEER approval.

B. Granular Drainage Material shall conform to the aggregate quality requirements of Section 703-2.03 of the ADOT&PF Standard Specifications for Highway Construction (1988 Edition), Aggregate D-1 for Untreated Base.

C. Material shall consist of clean coarse sand or fine gravel, graded within the limitations of the following table (ASTM D422). Material must meet both the permeability specification and the gradation specification.

Granular Drainage Material Gradations	
U.S. Standard Sieve	**Percent Passing**
3/8-inch	100
No. 4	45 to 90
No. 8	25 to 55
No. 16	5 to 35
No. 30	0 to 15
No. 50	0 to 8
No. 100	0 to 4
No. 200	0 to 2

2.6 LEACHATE COLLECTION GRAVEL

A. Gravel free from dirt, clay balls, trash, ash, organic material, and other deleterious materials. Material shall be washed and screened, as required to provide a free-draining material meeting the specified gradation.

B. Leachate Collection Gravel shall conform to the aggregate quality requirements of Section 703-2.03 of the ADOT&PF Standard Specifications for Highway Construction (1988 Edition), Aggregate D-1 for Untreated Base.

C. Material shall consist of fractured, angular, clean gravel, well-graded within the following limitations (ASTM D422):

Leachate Collection Gravel Gradations	
U.S. Standard Sieve	**Percent Passing**
1-inch	100
¾-inch	80 to 100
3/8-inch	10 to 40
No. 4	0 to 4
No. 200	0 to 2

2.7 BASE COURSE

A. Granular material consisting of clean, hard, durable crushed rock or crushed gravel, free from dirt, clay balls, trash, ash, organic material, and other deleterious materials.

B. Base Course shall conform to all requirements of Section 703-2.03 of the ADOT&PF Standard Specifications for Highway Construction (1988 Edition), Aggregate D-1 for Untreated Base.

C. Gradation as required for D-1 aggregate, as follows:

Base Course Gradation	
U.S. Standard Sieve	**Percent Passing**
1-inch	100
¾-inch	70 to 100
3/8-inch	50 to 80
No. 4	35 to 65
No. 8	20 to 50
No. 40	8 to 30
No. 200	0 to 6

2.8 COVER MATERIAL

A. Cover Material shall consist of clean, well-graded, durable sand and gravel, free from dirt, clay balls, organic material, trash, ash, snow, ice, and other deleterious materials. Material shall have a maximum particle diameter of 1 inch, with no more than 5 percent by weight passing a No. 200 sieve. Cover Material shall conform to the aggregate quality requirements of Section 703-2.03 of the ADOT&PF Standard Specifications for Highway Construction (1988 Edition), Aggregate D-1 for Untreated Base.

2.9 TOPSOIL

A. Topsoil shall consist of a natural, friable, sandy, silty loam, capable of sustaining vegetative growth. Topsoil shall be obtained from well-drained areas, free from objects larger than 2 inches maximum dimension, and free of subsoil, roots, grass, other foreign matter, hazardous or toxic substances, and deleterious material that may be harmful to plant growth or may hinder grading, planting, or maintenance.

2.10 SOIL/BENTONITE MIXTURE

A. Soil:

1. Imported material or material processed from onsite excavation free from roots, organic matter, frozen material, debris, rocks or slag larger than 1 inch, and other deleterious material.
2. Low plasticity or nonplastic silty or sandy soil.
3. Gradation: Material having 90 percent or more by weight passing U.S. No. 4 sieve and between 5 and 50 percent by weight passing U.S. No. 200 sieve in accordance with ASTM D422.

B. Bentonite

1. Free-flowing, semigranular, high swelling, sodium montmorillonite clay (bentonite) free of additives.
2. Manufacturers and Products:
   a. American Colloid Co.; Volclay.
   b. Federal Ore and Chemicals, Co.; Federal Bentonite.
   c. International Mineral and Chemical Co.; Imclay Bentonite.
   d. NL Baroid Co.; National Bentonite.
   e. Wyo-Ben Co.; Envirogel.

2.11 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

PART 3 EXECUTION

3.1 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and other buried facilities even.

D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:

1. Fill or backfill to an elevation 2 feet above top of item to be laid.
2. Excavate trench for installation of item.
3. Install bedding, if applicable.
4. Install item.
5. Backfill envelope zone and remaining trench; before resuming filling or backfilling specified in this section.

F. Tolerances:

1. Final Lines and Grades: Within a tolerance of 0.1-foot unless dimensions or grades are shown or specified otherwise.
2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

G. Settlement: Correct and repair any subsequent damage to adjacent facilities, caused by settlement of fill or backfill material.

3.2 ACCESS RAMP

A. Fill with select earthfill as shown on the drawings. Place select earthfill in lifts of 12-inch maximum thickness and compact each lift with minimum three passes of suitable compaction equipment as approved by the ENGINEER.

3.3 BASE COURSE

A. Under Facilities: Within Influence Area beneath structures, slabs, conduits, duct banks, travel areas, other facilities, and as shown on the Drawings, backfill with Base Course, unless otherwise shown. Place Base Course in Lifts of 6-inch maximum thickness and compact each Lift to minimum of 95 percent Relative Compaction.

3.4 EARTHFILL AND SELECT EARTHFILL

A. Outside Influence Areas Beneath Structures, Slabs, Piping, and Other Facilities: Unless otherwise shown, place Earthfill as follows:

1. Maximum 12-inch-thick Lifts.
2. Place and compact fill across full width of embankment.
3. Compact to minimum 90 percent Relative Compaction as determined in accordance with ASTM D1557.
4. Dress completed embankment with allowance for topsoil, crest surfacing, and slope protection, where applicable.

B. For all other areas not identified above, place Select Earthfill to lines and grades shown on Drawings. Compact in maximum 8-inch-thick horizontal lifts to 95 percent relative compaction unless otherwise shown.

3.5 PLACING SAND LEVELING COURSE OR COVER MATERIAL BELOW GEOSYNTHETICS

A. Place Sand Leveling Course or Cover Material on subgrade prepared in accordance with Section SUBGRADE PREPARATION and approved by the ENGINEER.

B. Place Sand Leveling Course or Cover Material to the lines and grades shown in the Drawings in one uniform and continuous lift unless otherwise approved by the ENGINEER.

C. The Sand Leveling Course or Cover Material shall provide a smooth, firm, unyielding surface on which to place the geosynthetics.

D. The CONTRACTOR shall provide and maintain a means of continually observing the depth of the Sand Leveling Course or Cover Material, such as survey markers, spaced at no more than 50 feet on center each way, until placement is complete. Sharpened stakes or other materials that may damage the geosynthetics will not be allowed. All markers shall be removed after final grading is complete.

E. The Sand Leveling Course or Cover Material shall be compacted to at least 95 percent relative compaction unless otherwise approved by the ENGINEER. Blading and rolling shall continue until the surface is smooth and free of irregularities. The Sand Leveling Course or Cover Material shall be maintained in the specified condition until the overlying geosynthetics are in place.

3.6 PLACING GRANULAR DRAINAGE MATERIAL OR COVER MATERIAL OVER GEOSYNTHETICS

A. General:

1. All underlying geosynthetics shall be inspected and approved by the ENGINEER before placement of the Granular Drainage Material or Cover Material.
2. Place Granular Drainage Material over Geosynthetics with sufficient care to avoid damage to the Geosynthetics.
3. Place only by back dumping and spreading.
4. Dump only on previously placed material.
5. While operating equipment, avoid sharp turns, sudden starts or stops that could damage Geosynthetics.
6. Anchor trenches for geosynthetics shall be completely backfilled and compacted before placement of Granular Drainage Material or Cover Material on side slopes.

B. Hauling: Operate hauling equipment or other heavy construction equipment on minimum of 3 feet of Granular Drainage Material or Cover Material over geosynthetics or pipes.

C. Spreading over Geosynthetics:

1. Spreading equipment shall be track mounted, low ground pressure, D-6 bulldozer or lighter (operating weight to total track width ratio of 4,400 pounds per foot or less).
2. Operate spreading equipment on minimum of 12 inches of fill over Geosynthetics.
3. Limit distance material falls onto the Geosynthetics to maximum of 2 feet.
4. Flatten small wrinkles of Geosynthetics in the same direction as that of the spreading operation. Wrinkles greater in height than 2 inches or spaced so close together that when combined will be greater in height than 2 inches shall be corrected in a manner approved by the ENGINEER.
5. Maintain proper overlap of unseamed Geosynthetics.
6. Avoid overstressing Geosynthetics and seams.
7. Spreading equipment shall not be used on sideslope areas during or just after heavy rainfall.

D. Compaction: Compact Granular Drainage Material or Cover Material only after uniformly spread to full thickness shown. Compact with two complete passes over the entire surface by the tracks of the bulldozer, or approved equivalent method.

E. Geosynthetic Damage:

1. Mark punctures, tears, or other damage to Geosynthetics, so repairs may be made.
2. Clear overlying fill as necessary to repair damage.
3. Repairs to Geosynthetics shall be made by respective installers as specified in respective specification section for each geosynthetic.
4. CONTRACTOR shall be responsible for making repairs to any geosynthetics damaged during placement of the Granular Drainage Material or Cover Material at no cost to the OWNER.

3.7 PLACE LEACHATE COLLECTION GRAVEL

A. Geosynthetics and Granular Drainage Material underlying the Leachate Collection Gravel shall be inspected and approved by the ENGINEER before placement of the Leachate Collection Gravel.

B. Leachate Collection Gravel shall be placed around leachate collection pipe as shown on the Drawings. No Leachate Collection Gravel shall be placed directly on the primary bottom liner. Special care shall be taken to place and compact Leachate Collection Gravel under the pipe haunches and adjacent to the pipe wall so as to provide complete, uniform lateral support of the pipe.

C. If any portion of Leachate Collection Gravel materials does not meet the specified requirements, the CONTRACTOR shall remove such material and replace with material that meets the Specifications at the CONTRACTOR's sole expense.

D. Method of placing and spreading materials shall be approved by the ENGINEER and shall ensure uniform distribution of the material and prevent damage to the underlying geosynthetics. Approval does not absolve the CONTRACTOR of responsibility for damage to underlying components. Construction traffic for placement of the Leachate Collection Gravel will not be permitted to travel on exposed geosynthetics.

E. Compaction of Leachate Collection Gravel shall be accomplished by tamping with blunt pieces of wood during dumping or other methods approved by the ENGINEER.

3.0 in) wide bentonite void running longitudinally along affected GCL rolls and was determined to be related to over-tensioning of the lower woven geotextile during manufacturing, requiring a minor modification of manufacturing operational procedures. Effected rolls were rejected and replaced with approved material.

FIELD PERFORMANCE

Bentonite creep has been reported in unreinforced GCLs under low normal confining loads (LaGatta et al., 1997). LaGatta et al. (1997) concluded that unreinforced GCL suffered bentonite migration, which was influenced in part by the lack of confinement from needle-punched fibers. Field observations of lightly-needled GCL panels exhumed approximately five weeks after initial placement at the Hanford Landfill indicated significant hydration, but no discernable bentonite migration. The presence of needle-punched fibers may be helping to inhibit bentonite migration, providing potentially better performance than unreinforced GCL.

Due to a construction-sequencing problem caused by a staking error, a number of lightly-needled GCL panels were required to be exhumed and replaced. Approximately five weeks after placement, the panels were exhumed with a backhoe and examined. Consistent with the observations of Daniel et al. (1998) and Bonaparte et al. (1997), the GCL had undergone significant hydration by absorbing moisture from the surrounding soils. The GCL was carefully examined for installation damage, and bentonite migration. Other than damage caused by the backhoe teeth during exhumation, the GCL panels were intact and in good condition. Although the panels appeared fully hydrated, no signs of tensile strain, swelling, or lateral shearing were observed. It should be noted that only a visual inspection was conducted and no mass per unit area or moisture content measurements were performed on the exhumed GCL. These observations suggest that the 18-inch thick soil cover provided sufficient normal stress to prevent swelling of bentonite during hydration and prevent differential normal loads which can result from heavy vehicle wheel loads over the final cover (Richardson and Marr, 1999; and Richardson, 1996).

CONCLUSION

Based on the authors' experience with cover system designs prepared for other landfill closures, a prescriptive final cover system incorporating a CCL is typically more economical than a GCL engineered alternative when suitable low-permeability clay material is available on-site.. For this case study, construction of the prescriptive standard would have required import of clay or amendment of on-site soils. The cost savings incurred through substitution of a GCL for a CCL was the primary basis for selection of a geosynthetic alternative for the Hanford Landfill. A new, lightly-needled GCL product was developed for this project that provided a higher internal shear strength; a lower potential for bentonite migration; and high installation survivability at a slightly lower-cost than an unreinforced GCL product.

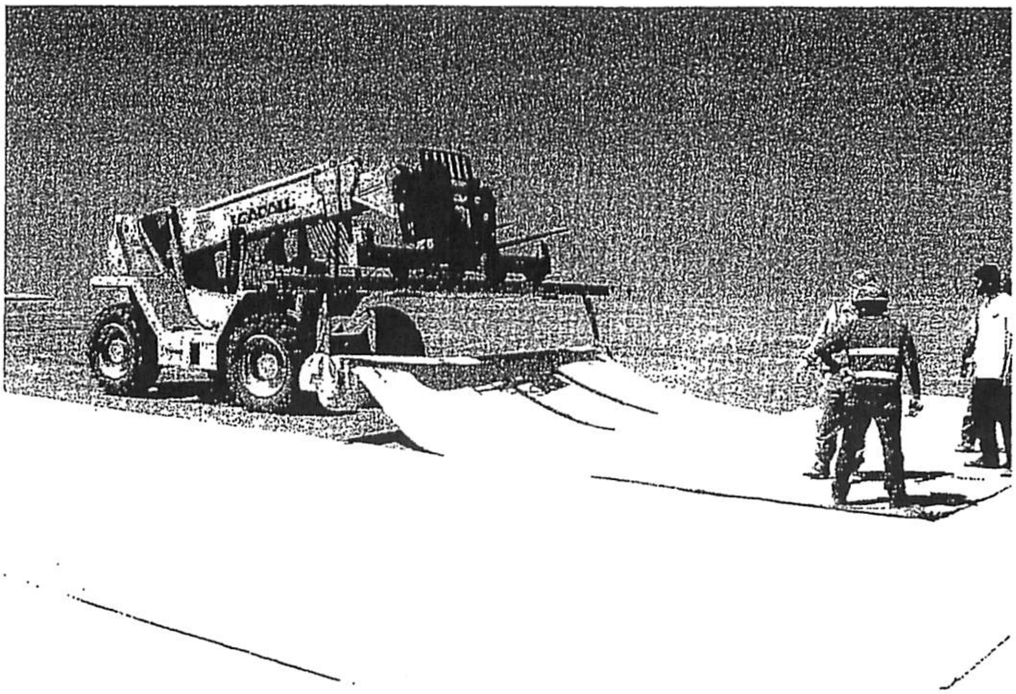

Figure 3. GCL installation over prepared subgrade.

Figure 4. Placement of standard double NWNP reinforced GCL and overlying geonet composite drainage layer on 10 percent refuse slope.

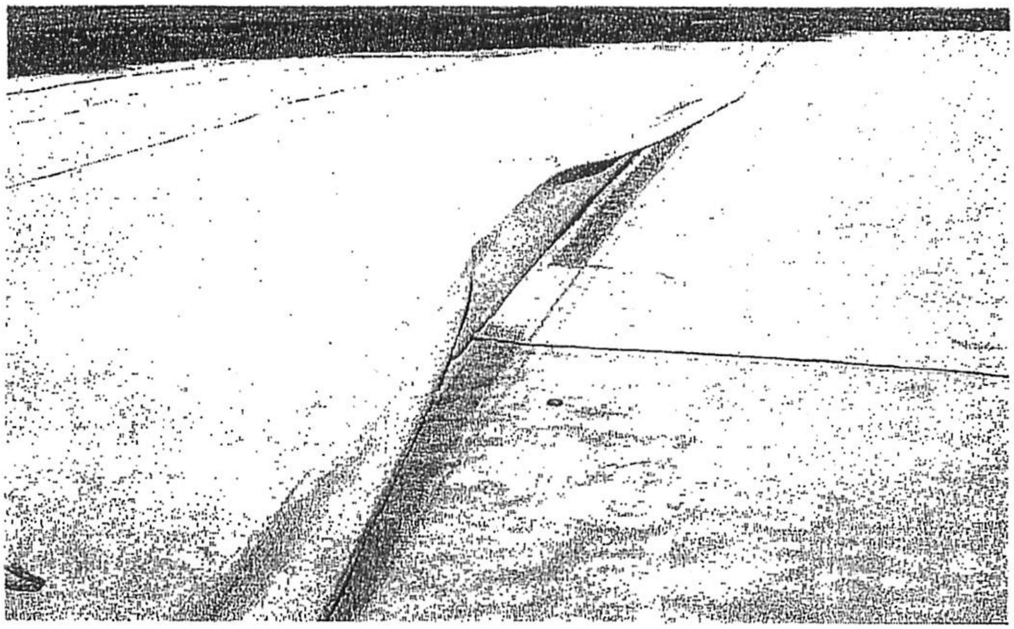

Figure 5. Bentonite powder augmenting GCL seams. Photo taken prior to hand application of bentonite at butt-seam. Note lens cap for scale.

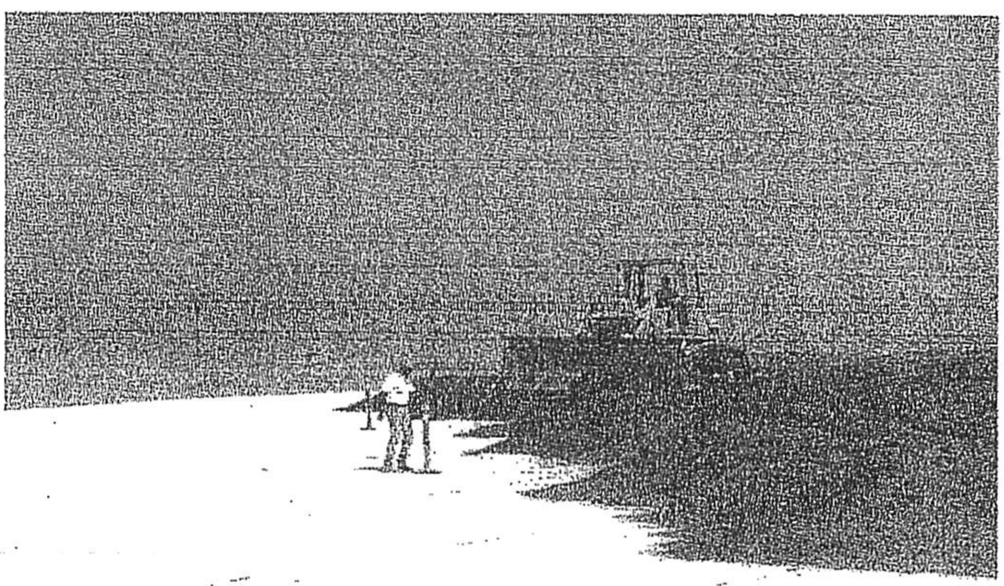

Figure 6. Vegetative Soil layer placement over GCL on 3 percent refuse slope.

A manufacturing deficiency identified during placement of GCL panels further emphasizes the importance of a rigorous quality assurance program during the installation of new geosynthetic products.

ACKNOWLEDGMENTS

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United States Environmental Protection Agency
Solid Waste and Emergency Response (5306W)
EPA530-F-97-002
July 1997

EPA

Geosynthetic Clay Liners Used in Municipal Solid Waste Landfills

This fact sheet describes new and innovative technologies and products that meet the performance standards of the Criteria for Municipal Solid Waste Landfills (40 CFR Part 258).

Geosynthetic clay liners (GCLs) represent a relatively new technology (developed in 1986) currently gaining acceptance as a barrier system in municipal solid waste landfill applications. Federal and some state regulations specify design standards for bottom liners and final covers. Alternative technologies are allowed, however, if they meet federal performance standards. GCL technology is an alternative that performs at or above standard federal performance levels.

GCL technology offers some unique advantages over conventional bottom liners and covers. GCLs, for example, are fast and easy to install, have low hydraulic conductivity (i.e., low permeability), and have the ability to self-repair any rips or holes caused by the swelling properties of the bentonite from which they are made. GCLs are cost-effective in regions where clay is not readily available. A GCL liner system is not as thick as a liner system involving the use of compacted clay, enabling engineers to construct landfills that maximize capacity while protecting area ground water.

Before using a GCL in a landfill barrier system, remember there currently are no standard methods for comparing GCL products or installation systems. In addition, GCL performance properties, including the ability of GCL liner systems to effectively prevent landfill leaching, have not yet been firmly established.

This emerging technology is currently in use at a number of sites across the nation. This fact sheet provides information on this technology and presents case studies of successful applications.

GCL Technology

Materials

A GCL is a relatively thin layer of processed clay (typically bentonite) either bonded to a geomembrane or fixed between two sheets of geotextile. A geomembrane is a polymeric sheet material that is impervious to liquid as long as it maintains its integrity. A geotextile is a woven or nonwoven sheet material less impervious to liquid than a geomembrane, but more resistant to penetration damage. Both types of GCLs are illustrated in Figure 1. Although the overall configuration of the GCL affects its performance characteristics, the primary performance factors are clay quality, amount of clay used per unit area, and uniformity.

Bentonite is an extremely absorbent, granular clay formed from volcanic ash. Bentonite attracts positively charged water particles; thus, it rapidly hydrates when exposed to liquid, such as water or leachate. As the clay hydrates it swells, giving it the ability to "self-heal" holes in the GCL. In laboratory tests on bentonite, researchers demonstrated that a hole up to 75 millimeters in diameter will seal itself, allowing the GCL to retain the properties that make it an effective barrier system.

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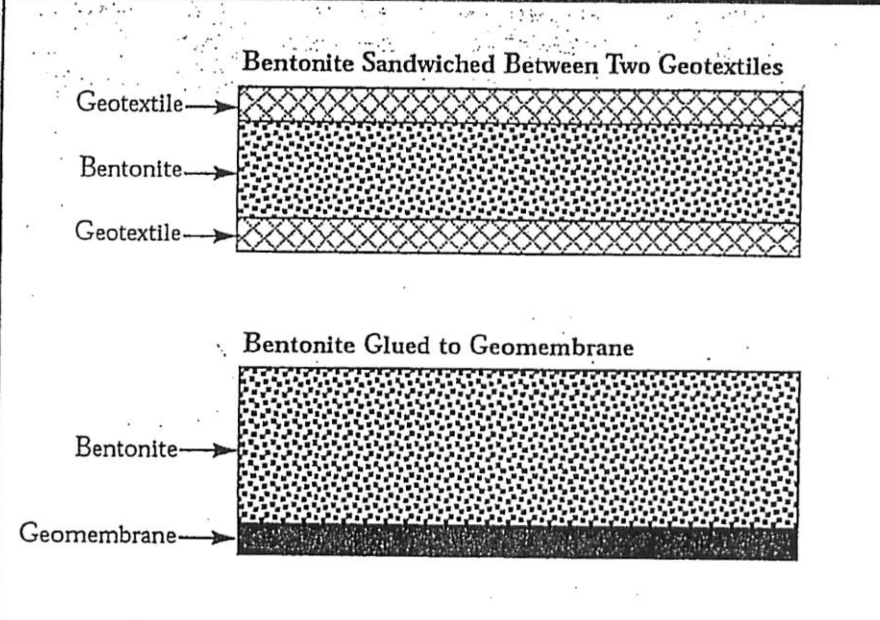
Figure 1. General Configurations of GCLs



Bentonite is affixed to synthetic materials in a number of ways to form the GCL system. In configurations using a geomembrane, the clay is affixed using an adhesive. In geotextile configurations, however, adhesives, stitchbonding, needlepunching, or a combination of the three, are used. Although stitchbonding and needlepunching create small holes in the geotextile, these holes are sealed when the installed GCL's clay layer hydrates. Figure 2 shows cross-section views of the three separate approaches to affixing bentonite to a geotextile.

Properties and Characteristics

An important criterion for selecting an effective landfill barrier system is hydraulic conductivity. Before choosing a barrier system, the landfill operator should test the technology under consideration to ensure that its hydraulic conductivity, as well as other characteristics, are appropriate for the particular landfill site.

Hydraulic Conductivity

GCL technology can provide barrier systems with low hydraulic conductivity (i.e., low permeability), which is the rate at which a liquid passes through a material. Laboratory tests demonstrate that the hydraulic conductivity of dry, unconfined bentonite is approximately 1×10^{-6} cm/sec. When saturated, however, the hydraulic conductivity of bentonite typically drops to less than 1×10^{-9} cm/sec.

The quality of the clay used affects a GCL's hydraulic characteristics. Sodium bentonite, a naturally occurring compound in a silicate clay formed from volcanic ash, gives bentonite its distinct properties. Additives are used to enhance the hydraulic properties of clay containing low amounts of sodium bentonite.

Hydraulic performance also relates to the amount of bentonite per unit area and its uniformity. The more bentonite used per unit area, the lower the system's hydraulic conductivity. Although the amount of bentonite per unit area varies with the particular GCL, manufacturers typically use 1 pound per square foot. As a result, the hydraulic conductivity of most GCL products ranges from about 1×10^{-5} cm/sec to less than 1×10^{-12} cm/sec. That is, the permeability of finished GCL products depends on a combination of factors, including the type and amount of bentonite, the amount of additives, the type of geosynthetic material, and the product configuration (i.e., the method of affixing the geosynthetic to the clay).

Shear Strength and Other Characteristics

Depending on the particular configuration of the barrier system, GCL technology can provide considerable shear strength (i.e., the maximum stress a material can withstand without losing structural integrity). In particular, a geotextile-backed GCL, with bentonite affixed via stitchbonding, provides additional internal resistance to shear in the clay layer. Needlepunching yields an even stronger, more rigid barrier. In addition, needlepunching requires the use of a nonwoven geotextile on at least one side. These GCL configurations provide enhanced interface friction resistance to the adjoining layer, an important consideration for landfill slopes.

Both needlepunching and stitchbonding, however, tend to increase the cost of the GCL product. Needlepunching, in particular, adds to a GCL's cost, because nonwoven geotextiles are generally more expensive than woven geotextiles.

Before selecting a final barrier system, landfill operators should consider other important performance characteristics, such as free and confined swelling (i.e., whether the clay will provide a uniform barrier) and rate of creep, which measures the resistance to barrier deformation.

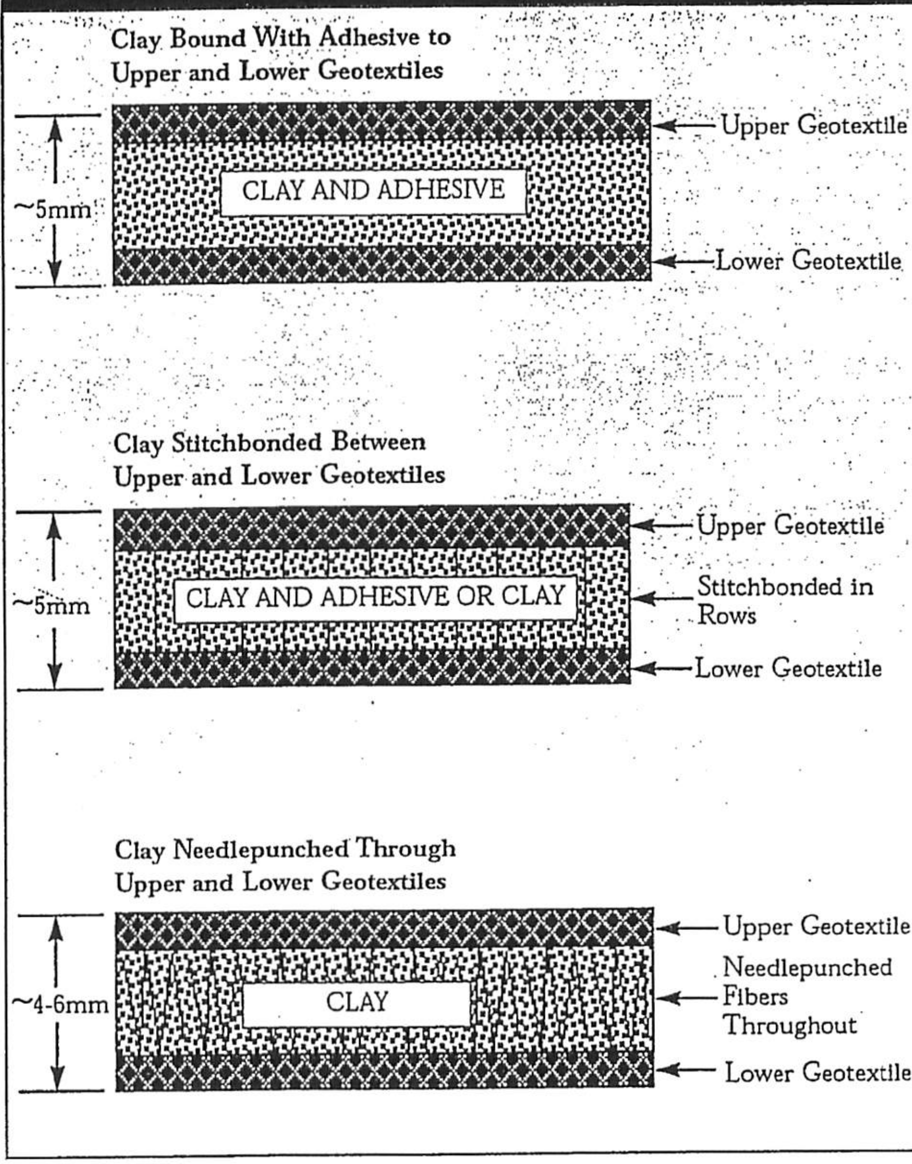
Testing

GCL configurations for barrier systems are based on the design specifications of each specific project. The American Society for Testing and Materials (ASTM) developed standardized laboratory tests for assessing mass per unit area (ASTM D-3776), hydraulic conductivity (ASTM D-5084), and direct shear (ASTM D-5321).

Researchers at the Geosynthetic Research Institute at Drexel University (in Philadelphia, Pennsylvania) and the Geotechnical Engineering Department at the University of Texas (in Austin) developed tests to measure shear strength, as well as confined swelling, rate of creep, and seam overlap permeability. These test methods have been adopted by ASTM. Additionally, the bentonite industry developed a test to measure free swell (USP-NF-XVII).

Test values for hydraulic conductivity depend on the degree of effective overburden stress around the GCL during testing. The higher the effective overburden stress, the lower the hydraulic conductivity. When comparing two different bentonite products, both must be subjected to the same degree of effective overburden stress.

Figure 2. Affixing Bentonite to Geotextiles



Available GCL Products

Product Types

The following types of GCL products are currently available:

- Geotextile type:
  - Bentofix® (activated sodium bentonite as primary ingredient and affixed by needlepunching to a woven or nonwoven upper geotextile and a nonwoven lower geotextile).
  - Bentomat® (sodium bentonite as primary ingredient and affixed by needlepunching to a woven or nonwoven upper geotextile and a nonwoven lower geotextile).
  - Claymax® (sodium bentonite as primary ingredient mixed with water-soluble adhesive and bonded or stitchbonded to a woven upper and lower geotextile).
- Geomembrane type:
  - Gundseal® (sodium bentonite as the primary ingredient mixed with an adhesive and bonded to a blend of high density polyethylene and very low density polyethylene).

Table 1 lists information on variations of these product types by manufacturer, and Figure 3 presents cross-section views of these product configurations.

In general, manufacturers ship GCL products in rolled sheets ranging from 13 to 18 feet wide and from 100 to 200 feet long. GCLs range in thickness from 0.2 to 0.3 inches.

Table 1. Principal GCL Products Available in the United States				
Manufacturer & Product Name	Upper Geosynthetic[a]	Lower Geosynthetic[a]	Bonding Method	Standard Roll Width x Length (feet)
Fluid Systems, Inc. (FSI) (Germany)				
Bentofix NS	woven	nonwoven	needlepunched	(15.2 x 100)
Bentofix WP	woven	nonwoven	needlepunched	(15.2 x 100)
Bentofix NW	nonwoven[b]	nonwoven	needlepunched	(15.2 x 100)
Colloid Environmental Technologies Company (CETCO) (United States)				
Claymax 200R	woven	woven	adhered	(13.83 x 150)
Claymax 500SP	woven	woven	adhered and stitchbonded	(13.83 x 150)
Claymax 506SP	woven	woven	adhered and stitchbonded	(13.83 x 150)
Bentomat "ST"	woven	nonwoven	needlepunched	(15.3 x 125)
Bentomat "N"	nonwoven	nonwoven	needlepunched	(15.3 x 125)
GSE Environmental (United States)[c]				
Gundseal HD 20	none[d]	HDPE[e]	adhered	(17.5 x 200)
Gundseal HD 30	none[d]	HDPE	adhered	(17.5 x 200)
Gundseal HD 30	none[d]	HDPE/VLDPE[f]	adhered	(17.5 x 200)
Gundseal HD 60	none[d]	HDPE/VLDPE	adhered	(17.5 x 170)
Gundseal HD 80	none[d]	HDPE/VLDPE	adhered	(17.5 x 150)
Gundseal HD 40	none[d]	textured HDPE	adhered	(17.5 x 200)
Gundseal HD 60	none[d]	textured HDPE	adhered	(17.5 x 200)
Gundseal HD 80	none[d]	textured HDPE	adhered	(17.5 x 200)

[a] These properties vary by product and application.

[b] Nonwoven layer is scrim (a woven, open-mesh reinforcing fabric made from continuous-filament yarn) reinforced.

[c] All Gundseal products can be manufactured in 8-foot widths and with leachate-resistant bentonite. Products with backings that are 40 mils or greater can be manufactured with VLDPE as the lower geosynthetic material.

[d] Can be manufactured with a nonwoven, 0.75-ounce-per-square-yard geotextile as the upper geosynthetic material.

[e] High density polyethylene.

[f] Very low density polyethylene.

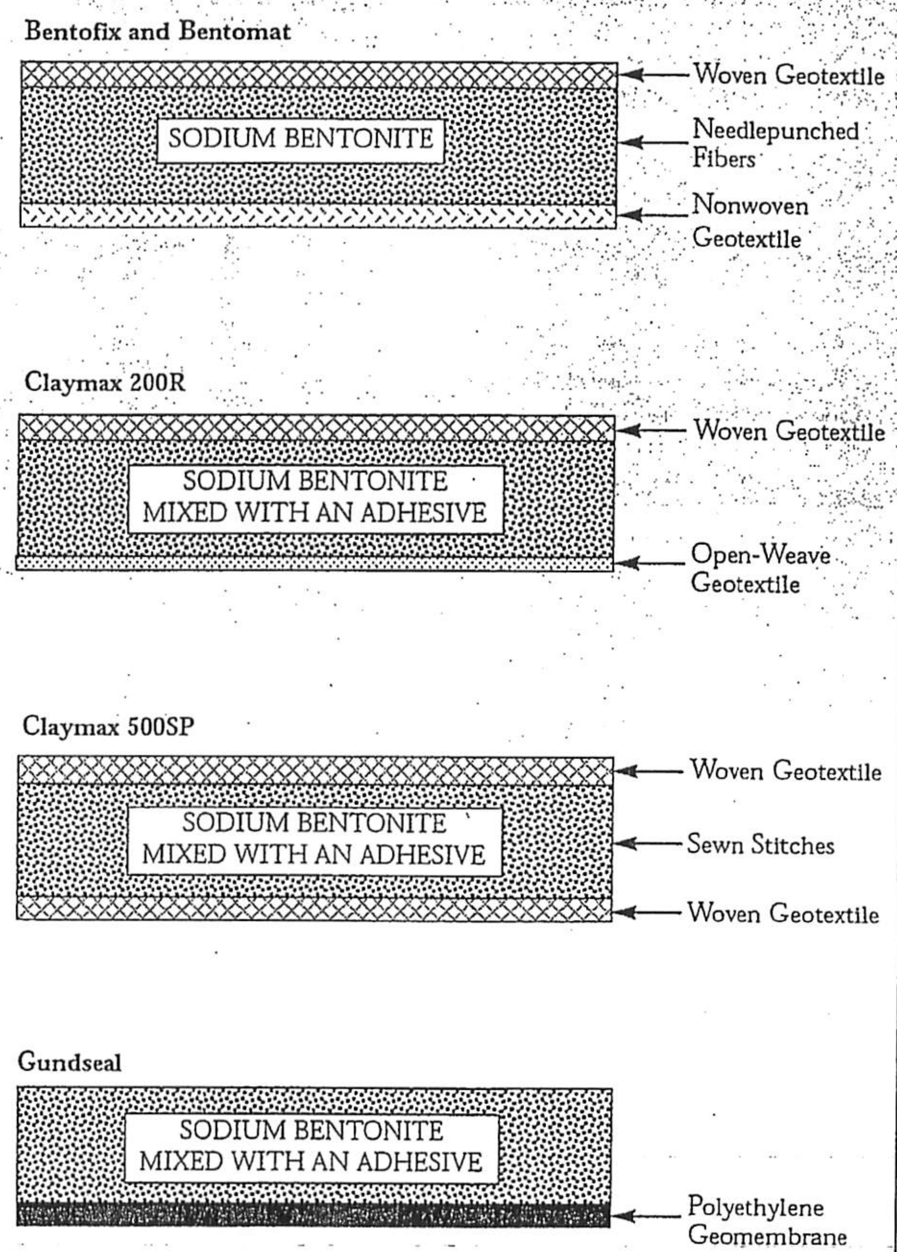
Installation

Landfill operators can install all available GCL products much faster and more easily than compacted clay liners. Unlike compacted clay liners, however, GCLs are more susceptible to damage during transport and installation. Care should be taken during and after installation to avoid hydration. Hydration results in unconfined swelling of the bentonite and causes the geotextile layers to pull apart, undermining the integrity of the GCL configuration.

Manufacturers usually specify individual GCL installation procedures. Basic procedures, however, call for rolling out the large GCL sheets onto the site subgrade, which should be smooth (e.g., free of stones and grade stakes), well compacted, and dry. Once installers cover the GCL with soil, the GCL hydrates by drawing moisture from the soil. As a result, when laying out the GCL, installers must allow enough seam overlap at adjoining sheets to guard against the potential opening of the barrier system. Currently, the recommended amount of seam overlap and other seaming considerations vary with the particular GCL product. Thus, installers should follow the manufacturer's instructions for the particular product.

GCL manufacturers, and some private engineering firms, provide training for GCL installers. Among other considerations, instructions typically emphasize techniques for minimizing potential damage to the GCL during installation. The National Institute for Certification of Engineering Technologists in Alexandria, Virginia, offers a certification program in quality assurance and quality control inspection of GCL installations.

Figure 3. Available GCL Products



Costs

As of 1994, the cost of an installed GCL ranged from $0.42 to $0.60 per square foot. Factors affecting the cost of a GCL include:

- Shipping distance
- Size of the job
- Market demand
- Time of the year

In general, GCL barrier systems are especially cost-effective in areas where clay is not readily available for use as a liner material.

Issues To Be Addressed

This emerging technology requires additional field and laboratory testing to further assess its effectiveness as a landfill barrier system in terms of the key performance factors discussed below. Improved product design and installation standards must also be established.

Performance Factors

Further research is needed into the following key performance factors of GCLs:

Hydraulic Conductivity

Available data on the hydraulic conductivity of various GCL configurations are gathered exclusively under laboratory conditions. Data from field tests should be collected to establish product design values.

Bearing Capacity

A study by the Geosynthetic Research Institute provides the basis for allaying some concerns about the bearing capacity of hydrated GCLs, but more research is needed. The study demonstrated that an adequate layer of cover soil (according to the product manufacturers' recommendations), placed on GCLs during installation, prevents a decrease in liner thickness with the application of a load. Without a sufficient soil layer, GCLs become compressed, raising their hydraulic conductivity (i.e., making them more permeable) and reducing their effectiveness as a barrier.

Slope Stability

Research is ongoing on the slope stability of GCLs used in landfill sidewall applications to determine whether this use of GCLs provides sufficient resistance to internal shear and physical displacement. Additional data are needed to support the preliminary results of a U.S. Environmental Protection Agency field study indicating good stability of GCL technology following capping operations. This study mimicked the construction stresses all four GCL products (see Figure 3) are subjected to during capping. Constructed in November 1994, the study site used five plots of GCL placed at a 3 to 1 slope and eight plots placed at a 2 to 1 slope. All plots had a 3-foot-thick soil cap. Researchers collected information on the soil and clay moisture of the GCL using internal probes, and they measured the GCL for physical displacement. Results to date indicate good slope stability for all plots.

Long-Term Reliability

The geotextile or geomembrane in GCL products remains durable for long periods of time.

Freeze and Thaw Cycles

Freeze and thaw cycles do not affect GCLs used in landfill bottom liner applications because these systems are installed below the frost line. Limited laboratory data indicate that the hydraulic conductivity of GCLs is not affected by freeze and thaw cycles. Laboratory tests performed on a bentonitic blanket indicate that hydraulic conductivity before freezing of 2×10^{-11} cm/sec was unaltered after five freeze and thaw cycles. Full-scale field tests still must be conducted, however, to corroborate the laboratory data, especially for GCL technology used as an infiltration barrier in landfill caps.

Design and Installation Standards

The following issues must be addressed to encourage the further development of GCL technology as a landfill barrier system:

Material Properties and Additional Testing Methods

To allow design engineers to develop more precise site specifications, a list of important performance properties for materials used in GCL products, as well as minimum performance values, must be established. Additional testing procedures must be developed, and all methods should be standardized to facilitate the realistic comparison of different GCL products.

Construction and Installation Procedures

Standardized practices must be developed to address GCLs' vulnerability to the following:

- System stress from inclement weather after installation.
- Potential for lack of hydration of bentonite clay in arid regions.
- Punctures in the barrier system (reducing the barrier potential of both the clay and the geosynthetics).
- System decay caused by biological intruders, such as burrowing animals and tree roots (potentially affecting both the clay and the geosynthetics).

Additionally, a standardized quality assurance and quality control program must be developed.

Case Studies

The following case studies illustrate some of the uses of GCL technology as a barrier system in landfills. Currently available information from these sites relates to installation only; long-term performance is still being assessed. Only one of the studies concerns the use of GCL technology in bottom liner applications, because this use is relatively new. The other two studies focus on cap system applications, which represent a slightly more established use of the technology. The case studies represent sites in three different geographic regions and involve three different GCL products.

GCL Landfill Liner: Broad Acre Landfill Pueblo, Colorado

Broad Acre Landfill installed a liner system in 1991 that included:

- A 60-mil Gundseal GCL
- 1 foot of compacted clay

According to landfill operators, the Gundseal was easy to work with. They installed 200,000 square feet in 1 week. Workers installed the liner with the bentonite side down (i.e., the geomembrane side up). As of February 1996, landfill officials reported that the liner was functioning effectively. No releases of leachate have been detected by the ground-water monitoring system.

GCL Landfill Cap: Whyco Chromium Landfill Thomaston, Connecticut

During July 1989, Whyco Chromium Landfill installed a Claymax 200R GCL in a cap system that included the following (from top to bottom):

- 6 inches of topsoil
- 24 inches of earthen material
- Geogrid (for tensile strength)
- Geotextile
- Polyvinyl chloride geomembrane (30-mil thickness)
- Claymax
- Geotextile

The landfill site occupies 41,000 square feet, and workers installed the Claymax product in 1 day. Thus far, the cap is functioning well.

GCL Landfill Cap: Enoree Landfill Greenville, South Carolina

In August 1994, the first phase of closure at the Enoree Landfill involved installing the following cap system:

- 6 to 12 inches of new and native soil
- 18 inches of compacted clay
- Bentofix GCL

Enoree staff capped approximately 26 acres of the landfill in 6 weeks. Landfill officials report that the cap is functioning effectively.

The mention of publications, products, or organizations in this fact sheet does not constitute or imply endorsement or approval for use by the U.S. Environmental Protection Agency.

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EPA

United States
Environmental Protection Agency
(5306W)
Washington, DC 20460

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Attachment 2
HELP Model Output Results

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07   (1 NOVEMBER 1997)                  **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
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TEMPERATURE DATA FILE:       C:\DATA\HELP3\MATSU7.D7
SOLAR RADIATION DATA FILE:   C:\DATA\HELP3\MATSU13.D13
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OUTPUT DATA FILE:            C:\DATA\HELP3\matsu23.OUT

TIME:   8:49     DATE:  11/14/2000

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     TITLE:  Central Landfill Cell 2a Prescriptive Final Cover

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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
                      EROSION LAYER - TOPSOIL
                      MATERIAL TEXTURE NUMBER   8
          THICKNESS                  =      6.00  INCHES
          POROSITY                   =    0.4630 VOL/VOL
          FIELD CAPACITY             =    0.2320 VOL/VOL
          WILTING POINT              =    0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT =    0.2141 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.369999994000E-03 CM/SEC

                                  LAYER  2
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                      INFILTRATION LAYER - PRESCRIPTIVE
                      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 =    0.3592 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.900000032000E-05 CM/SEC
```

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
OPERATIONAL COVER - GRAVEL
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	6.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0448	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER	=	91.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.591	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.310	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.132	INCHES
INITIAL SNOW WATER	=	1.383	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.019	INCHES
TOTAL INITIAL WATER	=	9.402	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Central Landfill Alaska

STATION LATITUDE	=	61.50	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	145	
END OF GROWING SEASON (JULIAN DATE)	=	259	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	5.00	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	69.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	59.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR FLAGSTAFF ARIZONA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.86	0.69	0.52	0.51	0.71	1.45
2.28	2.65	2.49	1.57	1.01	0.97

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BETHEL ALASKA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
13.00	18.20	25.30	36.60	47.00	55.00
57.70	55.50	47.60	34.90	21.00	13.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BETHEL ALASKA
AND STATION LATITUDE = 61.50 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.83	50202.902	100.00
RUNOFF	1.178	4274.850	8.52
EVAPOTRANSPIRATION	10.763	39071.199	77.83
PERC./LEAKAGE THROUGH LAYER 3	1.888526	6855.349	13.66
CHANGE IN WATER STORAGE	0.000	1.489	0.00
SOIL WATER AT START OF YEAR	8.019	29109.656	
SOIL WATER AT END OF YEAR	8.020	29111.145	
SNOW WATER AT START OF YEAR	1.383	5020.605	10.00
SNOW WATER AT END OF YEAR	1.383	5020.605	10.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.72	78843.594	100.00
RUNOFF	5.044	18308.488	23.22
EVAPOTRANSPIRATION	13.605	49386.602	62.64
PERC./LEAKAGE THROUGH LAYER 3	3.008100	10919.402	13.85
CHANGE IN WATER STORAGE	0.063	229.121	0.29
SOIL WATER AT START OF YEAR	8.020	29111.145	
SOIL WATER AT END OF YEAR	8.329	30234.607	
SNOW WATER AT START OF YEAR	1.383	5020.605	6.37
SNOW WATER AT END OF YEAR	1.137	4126.263	5.23
ANNUAL WATER BUDGET BALANCE	0.0000	-0.016	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.72	53433.605	100.00
RUNOFF	3.101	11257.097	21.07
EVAPOTRANSPIRATION	11.984	43502.625	81.41
PERC./LEAKAGE THROUGH LAYER 3	1.758300	6382.629	11.94
CHANGE IN WATER STORAGE	-2.124	-7708.746	-14.43
SOIL WATER AT START OF YEAR	8.329	30234.607	
SOIL WATER AT END OF YEAR	7.293	26473.406	
SNOW WATER AT START OF YEAR	1.137	4126.263	7.72
SNOW WATER AT END OF YEAR	0.049	178.719	0.33
ANNUAL WATER BUDGET BALANCE	0.0000	0.001	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.75	57172.516	100.00
RUNOFF	2.168	7868.554	13.76
EVAPOTRANSPIRATION	10.607	38505.184	67.35
PERC./LEAKAGE THROUGH LAYER 3	1.402120	5089.697	8.90
CHANGE IN WATER STORAGE	1.573	5709.061	9.99
SOIL WATER AT START OF YEAR	7.293	26473.406	
SOIL WATER AT END OF YEAR	8.254	29962.174	
SNOW WATER AT START OF YEAR	0.049	178.719	0.31
SNOW WATER AT END OF YEAR	0.661	2399.010	4.20
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.17	58697.113	100.00
RUNOFF	2.472	8972.500	15.29
EVAPOTRANSPIRATION	11.611	42148.906	71.81
PERC./LEAKAGE THROUGH LAYER 3	1.909488	6931.441	11.81
CHANGE IN WATER STORAGE	0.177	644.251	1.10
SOIL WATER AT START OF YEAR	8.254	29962.174	
SOIL WATER AT END OF YEAR	8.884	32249.086	
SNOW WATER AT START OF YEAR	0.661	2399.010	4.09
SNOW WATER AT END OF YEAR	0.208	756.350	1.29
ANNUAL WATER BUDGET BALANCE	0.0000	0.016	0.00

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3.8 OTHER AREAS

A. Unless otherwise shown, place earthfill as follows:

1. Maximum 12-inch thick lifts.
2. Place and compact fill across full width of embankment.
3. Compact each lift with minimum 3 passes of suitable compaction equipment as approved by the ENGINEER.

3.9 SITE TESTING

A. Gradation:

1. One sample from each 1,500 tons of finished product or more often as determined by ENGINEER, if variation in gradation is occurring, or if material appears to depart from Specifications.
2. If test results indicate material does not meet Specification requirements, terminate material placement until corrective measures are taken.
3. Remove material placed in Work that does not meet Specification requirements.

3.10 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by ENGINEER as follows:

1. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
2. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
   a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Earthfill.
   b. Steep Slopes (Steeper than 3:1):
      1) Correct overexcavation by transitioning between overcut areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.
      2) Backfilling overexcavated areas is prohibited unless, in ENGINEER's opinion, backfill will remain stable, and overexcavated material is replaced as compacted earth fill.

B. CONTRACTOR shall repair unauthorized overexcavated areas at his sole expense.

3.11 MIXING AND PLACING SOIL/BENTONITE

A. Combine bentonite with specified soil material in a 50/50 ratio (1 part bentonite to 1 part soil by volume). Add sufficient water and mix to achieve a homogeneous mix free of lumps or clods, as approved by the ENGINEER.

B. Place approved soil/bentonite mix at locations and to thicknesses shown on the Drawings.

C. Compact exposed surface of soil/bentonite with light hand compaction equipment to protect soil/bentonite from moisture changes.

3.12 TIRE HAULING AND PLACEMENT

A. The work under this section consists of providing all operations necessary for hauling used tires from a stockpile on the landfill site and placing the tires in a single layer in the Cell 2B solid waste disposal area as directed by the Engineer.

B. Used tires will be stockpiled on the landfill site by the OWNER through summer 2001. Tires will range in size from those used on small passenger vehicles to those tires used for large earthmoving equipment. Tires will be delivered to the stockpile by the OWNER by dumping and not stacking. There will be no attempt to segregate the tires in the stockpile by type or size by the OWNER. Tires with rims shall remain in the stockpile location and shall not be placed in Cell 2B.

C. Place tires in a single layer in the Cell 2B solid waste disposal area after installation of the Granular Drainage Material and Leachate Collection Gravel is completed and approved. The tires shall be placed on the base of the cell beginning at the toe of the west containment berm and working to the east. Tire placement shall continue in this manner, as approved by the ENGINEER, until the tire stockpile is depleted. No tires shall be placed on the cell side slopes. Each tire shall be in contact with adjacent tires at a minimum of four points.

D. Operate tire hauling equipment or other heavy construction equipment on minimum of 3 feet of Granular Drainage Material over the liner or pipes. CONTRACTOR shall be responsible for any damage to the lining system or pipes occurring during the tire haul and placement.

3.13 TOPSOIL PLACEMENT

A. Topsoil shall only be placed on the Cell 2A final cover area and on other disturbed areas where shown on the Drawings.

B. Do not place topsoil when subsoil or topsoil is frozen, excessively wet, or otherwise detrimental to the Work.

C. Spread topsoil evenly on the designated areas to a depth that, after settlement and compaction, is a nominal 6 inches.

D. Uniformly distribute to within 1/2 inch of final grades. Fine grade topsoil eliminating rough or low areas and maintaining levels, profiles, and contours of subgrade.

E. Remove stones exceeding 2 inches, roots, sticks, debris, and foreign matter during and after topsoil placement.

F. Remove surplus subsoil and topsoil from site.

END OF SECTION

SECTION 02316
EXCAVATION

PART 1 GENERAL

1.1 DEFINITIONS

A. Common Excavation: Removal of material not classified as rock excavation.

1.2 SUBMITTALS

A. Shop Drawings:

1. Excavation Plan, Detailing:
   a. Methods and sequencing of excavation.
   b. Proposed locations of stockpiled excavated material.
   c. Proposed onsite and offsite spoil disposal sites.
   d. Traffic/haul plan addressing interface with landfill operations and other contractors.

1.3 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation. No reimbursement will be made for unauthorized overexcavation quantities.

1.4 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.5 SEQUENCING AND SCHEDULING

A. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 02200, SITE PREPARATION, prior to excavating.

B. The CONTRACTOR shall perform whatever work is necessary to prevent flow and accumulation of surface water, groundwater, snow, or ice in all excavations. Avoid settlement or damage to adjacent property. Dispose of water in a manner that will not damage adjacent property. When dewatering open excavations, dewater from outside the structural limits and from a point below the bottom of excavation. Design dewatering system to prevent removal of fines from existing ground. All work associated with snow and ice removal, pumping, or dewatering shall not be paid for directly, but shall be considered as an incidental obligation of the CONTRACTOR.

C. Excavation Support: Install and maintain shoring, sheeting, bracing, or sloping, as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work. Install and maintain shoring, sheeting, bracing, and sloping, as required by OSHA and other applicable governmental regulations and agencies. The CONTRACTOR shall be solely responsible for making all excavations in a safe manner.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1-foot except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable.

B. Do not overexcavate without written authorization of ENGINEER. Unauthorized overexcavation quantities will not be reimbursed.

C. Remove or protect obstructions as shown and as specified in Section 01500, CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS, Article PROTECTION OF WORK AND PROPERTY.

3.2 UNCLASSIFIED EXCAVATION

A. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered. If waste is encountered within Cell 2B excavation limits, CONTRACTOR shall move waste into Cell 2A as directed by the ENGINEER.

3.3 EMBANKMENT AND CUT SLOPES

A. Shape, trim, and finish cut slopes to conform with lines, grades, and cross-sections shown, with proper allowance for topsoil or slope protection, where shown.

B. Remove stones and rock that exceed 3-inch diameter and that are loose and may roll down slope. Remove exposed roots from cut slopes.

C. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.

3.4 STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material at onsite locations approved by the OWNER.

B. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.

C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

D. Do not stockpile excavated material adjacent to trenches and other excavations unless excavation sideslopes and excavation support systems are designed, constructed, and maintained for stockpile loads.

E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could induce excessive settlement.

3.5 DISPOSAL OF SPOIL

A. Place spoils from clearing, grubbing, and stripping operations in C&D Cell in uniform lift thickness in locations as approved by the OWNER.

END OF SECTION

SECTION 02319
SUBGRADE PREPARATION

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society for Testing and Materials (ASTM):
   a. D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
   b. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

1.2 DEFINITIONS

A. Optimum Moisture Content: As defined in Section 02315, FILL AND BACKFILL.

B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.

C. Relative Compaction: As defined in Section 02315, FILL AND BACKFILL.

D. Relative Density: As defined in Section 02315, FILL AND BACKFILL.

E. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.

F. Proof-Rolling: Testing of subgrade by compactive effort to identify areas that will not support the future loading without excessive settlement.

1.3 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Sections 02200, SITE PREPARATION, and 02316, EXCAVATION, prior to subgrade preparation.

1.4 QUALITY ASSURANCE

A. Notify ENGINEER when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Prepare subgrade when unfrozen and free of ice and snow.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 GENERAL

A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.

B. Bring subgrade to proper grade and cross-section and uniformly compact surface.

C. Do not use sections of prepared ground surface as haul roads. Protect prepared subgrade from traffic.

D. Maintain prepared ground surface in finished condition until next course is placed.

3.2 COMPACTION

A. All subgrade areas: Three passes with three-wheeled power vibratory roller weighing approximately 10 tons, or other suitable compaction equipment as approved by the ENGINEER.

3.3 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.4 TESTING

A. Proof-roll subgrade with equipment specified in Article COMPACTION to detect soft or loose subgrade or unsuitable material, as determined by ENGINEER.

3.5 CORRECTION

A. Soft or Loose Subgrade:

1. Adjust moisture content and recompact, or

2. Over excavate as specified in Section 02316, EXCAVATION, and replace with suitable material from the excavation, as specified in Section 02315, FILL AND BACKFILL.

B. Unsuitable Material: Over excavate as specified in Section 02316, EXCAVATION, and replace with suitable material from the excavation, as specified in Section 02315, FILL AND BACKFILL.

END OF SECTION

SECTION 02340
SOIL STABILIZATION

PART 1 GENERAL

1.1 DEFINITIONS

A. Maintenance Period: Begin maintenance immediately after each area is planted and continue for a period of 4 weeks after all planting under this section is completed.

B. Satisfactory Stand: Grass or section of grass that has:

1. No bare spots larger than 3 square feet.
2. Not more than 10 percent of total area with bare spots larger than 1 square foot.
3. Not more than 15 percent of total area with bare spots larger than 6 square inches.

1.2 SUBMITTALS

A. Quality Control Submittals:

1. Manufacturer's Product Data and Installation Instructions: Commercial products.
2. Seed certifications.
3. Copies of delivery invoices or other proof of quantities of mulch and fertilizer.

1.3 DELIVERY, STORAGE, AND PROTECTION

A. Seed:

1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
2. Keep dry during storage.

B. Hydroseeding Mulch: Mark package of cellulose fiber mulch to show air dry weight.

1.4 SEQUENCING AND SCHEDULING

A. ENGINEER's acceptance of Construction Period Stormwater Pollution Prevention Plan required prior to starting earth disturbing activities.

B. Prepare topsoil as specified in Section 02315, FILL AND BACKFILL, before starting Work of this section.

C. Complete soil preparation, seeding, fertilizing, and mulching within 10 days after final grades have been reached.

D. Notify ENGINEER at least 3 days in advance of:

1. Materials delivery.
2. Start of planting activity.

E. Seeding: Perform between May 15 and August 15.

1.5 MAINTENANCE

A. Operations:

1. CONTRACTOR tasks during maintenance period shall include:
   a. Watering: Keep seeded surface moist.
   b. Washouts: Repair by filling with topsoil, fertilizing, seeding, and mulching.
   c. Mulch: Replace wherever and whenever washed or blown away.
   d. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.
   e. Reseed during next planting season if scheduled end of maintenance period falls after September 15.
   f. Reseed entire area if satisfactory stand does not develop by July 1 of the following year.
2. Inspect, repair, and replace as necessary all erosion control measures during the time period from start of construction to completion of construction.

2 PART 2 PRODUCTS

2.1 FERTILIZER

A. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose.

B. Fertilizer shall have the following minimum percentage of plant food by weight and be applied at a rate of 450 lbs./acre:

1. Summer Hydroseed Mix:
   a. Nitrogen: 20 percent.
   b. Phosphoric Acid: 20 percent.
   c. Potash: 10 percent.

2.2 SEED

A. Fresh, clean new-crop seed of the following composition applied at the rate of 1 lb./1,000 square feet:

		Proportion by Weight (percent)
1.	Arctared Red Fescue	60
2.	Norcoast Bering Hair Grass	30
3.	Annual Rye Grass	10

2.3 MULCH

A. Cellulose Fiber Mulch:

1. Specially processed wood or paper fiber containing no growth or germination inhibiting factors.
2. Dyed a suitable color to facilitate inspection of material placement.
3. Manufactured such that after addition and agitation in slurry tanks with water, the material fibers will become uniformly suspended to form a homogenous slurry.
4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.
5. Apply at 1,500 lbs./acre or as otherwise recommended by the manufacturer.

2.4 TACKIFIER

A. Derived from natural organic plant sources containing no growth or germination-inhibiting materials.

B. Capable of hydrating in water, and to readily blend with other slurry materials.

C. Cellulose Fiber: Add as tracer, at rate of 150 pounds per acre.

D. Manufacturers and Products:

1. Chevron Asphalt Co.; CSS-1.
2. Terra; Tack AR.
3. J-Tack; Reclamare.
4. Or as otherwise approved by the ENGINEER.

2.5 STRAW BALES

A. Machine baled clean salt hay or straw of oats, wheat, barley, or rye, free from seed of noxious weeds, using standard baling wire or string.

2.6 POSTS FOR STRAW BALES

A. 2 inch by 2 inch untreated wood or commercially manufactured metal posts.

PART 3 EXECUTION

3.1 SOIL PREPARATION

A. Before start of hydroseeding, and after surface has been shaped and graded, and lightly compacted to uniform grade, scarify soil surface to minimum depth of 1 inch.

3.2 SEEDING

A. Prepare 1-inch depth seed bed; obtain ENGINEER's acceptance prior to proceeding.

B. Apply by hydroseeding method on moist soil, but only after free surface water has drained away. Prevent drift and displacement of mixture into other areas.

C. Apply at rates specified in Part 2, PRODUCTS, of this specification.

3.3 MULCHING

A. Apply uniformly on disturbed areas that will remain undisturbed for 7 days or more, as requested by ENGINEER, and on seeded areas.

B. Application: Sufficiently loose to permit penetration of sunlight and air circulation, and sufficiently dense to shade ground, reduce evaporation rate, and prevent or materially reduce erosion of underlying soil.

1. Cellulose Fiber: 1,500 pounds per acre or as otherwise recommended by the manufacturer.

3.4 TACKIFIER

A. Apply on areas mulched.

B. Spray on after mulch is in place, or combine in hydroseed mix with all other slurry constituents.

C. Apply in quantities sufficient to equal retention properties of a CSS-1 asphalt emulsion being applied at rate of 400 gallons per acre.

3.5 STRAW BALES

A. If required by Stormwater Pollution Prevention Plan, embed minimum of 4 inches in flat-bottomed trench.

B. Place with ends tightly abutting or overlapped. Corner abutment is not acceptable.

C. Install so that bale bindings are oriented around the sides and not over the top and bottom of the bale.

D. Use two posts for each bale. Drive posts through the bale until top of post is flush with top of bale.

E. Wedge loose straws in any gaps between bales.

3.6 FIELD QUALITY CONTROL

A. Upon completion of maintenance period and on written notice from CONTRACTOR, ENGINEER will, within 15 days of receipt, determine if a satisfactory stand has been established.

B. If a satisfactory stand has not been established, ENGINEER will make another determination upon written notice from CONTRACTOR following the next growing season.

END OF SECTION

SECTION 02667
GEOSYNTHETIC CLAY LINER (GCL)

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society for Testing and Materials (ASTM):
   a. ASTM D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
   b. ASTM D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   c. ASTM D4643, Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
   d. ASTM D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
   e. ASTM D5084, Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
   f. ASTM D5199, Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
   g. ASTM D5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
   h. ASTM D5321, Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
   i. ASTM D5890, Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.
   j. ASTM D5891, Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners.
   k. ASTM D5993, Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners.

1.2 DEFINITIONS

A. Geosynthetic Clay Lining (GCL): Flexible panel made of layer of domestic, natural, high swelling sodium bentonite clay (montmorillonite) encapsulated between two geotextiles.

B. Geotextile: Nonwoven permeable manmade textile used with geotechnical engineering related materials.

C. Minimum Average Roll Value (MinARV): Minimum of a series of average roll values representative of product furnished.

D. Maximum Average Roll Value (MaxARV): Maximum of a series of average roll values representative of product furnished.

E. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

1.3 SUBMITTALS

A. Shop Drawings (submit at least 4 weeks prior to shipment of materials to site):

1. Product Data:
   a. Montmorillonite content by weight, typical moisture content, and swell index values.
   b. Recommended sealing compound.
   c. Repair adhesive.
2. Factory test results demonstrating conformance with all the requirements of this section.
3. Layout and installation drawings.
4. Panel joining methods.
5. Handling and storage instructions.

B. Samples:

1. At least 8 weeks prior to shipment of GCL, provide a sample of GCL (3 feet by roll width) to be used by ENGINEER for shear strength testing that will be done at ENGINEER's discretion. The GCL sample shall be from a typical GCL roll planned for use on the project and for which factory test results and material certifications have been provided to the ENGINEER. Identification numbers, such as the roll number, shall be included with the sample provided.
2. On request from ENGINEER, 2 square yards of material from each shipment.

C. Quality Control Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01300, SUBMITTALS.
2. Factory test results on actual materials to be used on the project, certified by manufacturer demonstrating conformance with the requirements of this specification.

D. Contract Closeout Submittals:

1. Record documents: Include scaled layout and installation drawings with lot and roll numbers, identity and location of each repair, location of samples taken for testing, and other data as may be requested by the ENGINEER.
2. All quality control test results.

3. Special guarantee.

1.4 QUALITY ASSURANCE

A. Prior to packaging finished product, manufacturer shall inspect surface of each roll by using strong light source on one side of panel and observing other side for zones of inadequate bentonite distribution or by using other reliable methods, such as physical measurements or sampling, to detect deficiencies in uniformity of bentonite distribution. Deficient rolls shall be rejected.

B. Each roll shall be labeled with length, width, and weight, along with lot number and date of manufacture.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store GCL in dry, protected facility or in protected area on pallets off ground and covered with heavy, waterproof membrane that allows free flow of air between membrane and materials. Protect GCL materials from water and freezing. Replace GCL materials that are damaged or contaminated with dust, dirt, or excess moisture at the CONTRACTOR's own expense.

1.6 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with OWNER named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of OWNER, removal and replacement of Work specified here that is found defective during period defined below, commencing on the date of Substantial Completion.

1. Manufacturing Defects: 20 years on a pro rata basis.
2. Installation Defects: 5 years.

PART 2 PRODUCTS

2.1 MANUFACTURERS AND PRODUCTS

A. Needle-punched GCL products; double nonwoven geotextiles:

1. Colloid Environmental Technologies Co. (CETCO), Arlington Heights, IL; Bentomat DN.
2. Approved equivalent.
3. Use of manufacturers and products listed here does not release the manufacturer or CONTRACTOR from full compliance with the provisions of this section.

2.2 GEOSYNTHETIC CLAY LINING

A. Panels of bentonite and encapsulating geotextiles manufactured shall perform as continuous lining. Panels shall contain at least 0.8 pounds per square foot of high-swelling sodium bentonite clay at 0 percent moisture content, or equivalent weight at other moisture content using ASTM D5993.

B. Bentonite shall contain:

1. High quality natural sodium bentonite without chemical resistance enhancers or polymers.
2. 90 percent typical montmorillonite content by weight.
3. Minimum Bentonite Swell Index of 24 mL/2g when tested pursuant to ASTM D5890.
4. Maximum fluid loss of 18 mL when based on ASTM D5891 test standard.

C. GCL shall be manufactured so that bentonite shall be continuously contained throughout GCL and to support geotextile so that no displacement of bentonite occurs when material is unrolled, moved, cut, torn, or punctured. To contain granular bentonite, GCL materials shall be stabilized by process of needle-punching through top and bottom layers of geotextile and bentonite.

D. Encapsulating geotextile materials shall be nonwoven fabrics.

E. Manufactured GCL products shall meet the following material properties:

Property	Requirement	Test Method
Bentonite Content, Mass/Unit Area, lb/sq ft at 0% moisture content, MinARV	0.8	ASTM D5993
Bentonite Moisture Content, %, max.	12	ASTM D4643
Bentonite Swell Index, mL/2g, MinARV	24	ASTM D5890
Bentonite Fluid Loss, mL, MaxARV	18	ASTM D5891
Nonwoven Cover Geotextile Weight oz/sq yd, MinARV	6.0	ASTM D5261
Peel Strength, lbs., MinARV	35	ASTM D4632—modified
Grab Strength, lbs, Tested Dry, MinARV	150	ASTM D4632
Grab Elongation, %, Tested Dry, MaxARV	100	ASTM D4632
Index Flux, $m^3/m^2/sec$, max. at 5 psi	$1x10^{-8}$	ASTM D5887

Property	Requirement	Test Method
Permeability with Water, under 400 lb/sq ft Normal Load, cm/sec, MaxARV	5×10^{-9}	ASTM D5084
Finished GCL Roll Width, Feet, MinARV	14	Linear Measurement
Finished GCL Roll Length, Feet, MinARV	See Par. 2.2.F of this section	Linear Measurement

F. Each roll shall be labeled with the length, width, and weight, along with the lot number and date of manufacturer. Minimum GCL roll length shall be 220 feet for all side slope areas where the slope length is equal to or greater than 205 feet. Shorter roll lengths may be used for sideslopes where the slope length is less than 205 feet, although roll lengths must be sufficient to avoid horizontal seams on the sideslopes for such cases and to provide for necessary top of slope anchorage and toe of slope overlap as shown and specified without horizontal seams.

2.3 BENTONITE SEALING COMPOUND

A. Bentonite sealing compound in powder or granular form shall be same product used in manufacture of GCL materials.

B. Sealing compound shall be applied to seal overlaps, around penetrations and structures shown on Drawings and under repair patches. Manufacturer shall recommend minimum amount of sealing compound to use in each instance in order to effect adequate seal.

C. The sealing compound shall be furnished by the manufacturer of the GCL product furnished for this Project.

2.4 REPAIR ADHESIVE

A. Repair adhesive for securing GCL patches shall be nontoxic adhesive as recommended by GCL manufacturer.

PART 3 EXECUTION

3.1 GENERAL

A. Inspect GCL materials delivered to project site for damage. Inventory by quantity, lot number, roll number, panel size, and weight. Provide updated copy of inventory to ENGINEER when each shipment is delivered to the Project site prior to placement of any material from that shipment.

B. Remove only quantity of material from storage that is to be installed during current work day.

3.2 SUBGRADE PREPARATION

A. Surface on which GCL is to be installed shall be prepared in accordance with Section 02319, SUBGRADE PREPARATION and as indicated on Drawings.

B. Surface on which GCL is to be placed shall be maintained in firm, clean, dry, and smooth condition during GCL installation.

3.3 PLACEMENT OF GEOSYNTHETIC CLAY LINING

A. Only those GCL panels that can be anchored and covered in the same day by the geomembrane shall be unwrapped and placed in position.

B. Place GCL surface on underlying soil with surface of GCL in contact with soil as recommended by manufacturer.

C. GCL panels shall not be dragged over surface, except for slight adjustments as may be necessary for obtaining correct overlap of panels. Rolled-up panels shall not be allowed to unroll unrestrained down slope.

D. Anchor trench for area to receive GCL shall be prepared as shown on Drawings before installation of GCL begins.

E. Panels shall be placed to provide minimum overlap of 6 to 9 inches on longitudinal seams and 24 inches on transverse seams or as shown on the Drawings or as specified. On the Cell 2B sideslopes, a maximum of one transverse seam per GCL panel will be allowed. No transverse seams will be allowed on the Cell 2A cover sideslopes. Sideslope transverse seams will be allowed only where the slope length is equal to or exceeds 205 feet. Provide a minimum overlap of 5 feet for all transverse seams on the sideslopes. Transverse seams shall be placed as close to the toe of slope as possible given the minimum specified roll length for long slopes. Seam overlap on slopes shall be shingled so that the direction of flow is from the top panel onto the bottom panel. On all sideslopes, the panels shall be placed with the long dimension (roll length) running perpendicular to the contours from the anchor trench at the slope crest to the slope toe, unless otherwise approved by the ENGINEER.

F. GCL panels shall not be installed in standing water, while it is raining or when rain may begin before panels can be covered with geomembrane and protected. GCL shall be "dry" when installed and "dry" when geomembrane is installed over it. If the GCL is hydrated partially or in full during installation by natural or man-made causes, the hydrated portion of GCL shall be replaced at the CONTRACTOR's sole expense. The need for GCL replacement due to hydration will be determined at the ENGINEER's sole discretion.

G. GCL shall be laid smooth without creases or wrinkles and without stretching material to fit area. GCL shall be free of tension or stress upon completion of installation.

H. GCL shall be covered with required geomembrane cover as it is installed without getting more than two panel widths or 24 feet beyond cover system over GCL material. GCL is to be completely covered and protected at end of each shift or workday.

I. Leading edge and panels of GCL left uncovered shall be protected with heavy, waterproof membrane or tarp that is adequately secured and protected with sandbags or other ballast.

3.4 SEAMING GCL PANELS

A. Mark overlaps 6 and 9 inches from panel edge longitudinally on GCL to assist in obtaining proper overlap.

B. Prior to lapping, remove dirt, gravel, or other debris from overlap area. Apply 1/4 pound of sealing compound per lineal foot of seam or as otherwise recommended by manufacturer, whichever, represents greatest amount of bentonite. Where soil and sand encroaches lap areas after initial application of bentonite sealant, additional bentonite sealant in amount of 1/4 pound per lineal foot evenly shall be spread across longitudinal seam area.

C. Seam overlap on all slopes shall be shingled so that direction of flow is from top panel onto bottom panel.

D. Hot Weather Installation:

1. Provide compensation for shrinkage when ambient temperatures are greater than 85 degrees F. At minimum, longitudinal overlap should be increased to 12 inches and transverse overlap should be increased to 36 inches.
2. Dimensions to use for overlapping during temperatures greater than 85 degrees F shall be approved by ENGINEER.

3.5 PATCHING AND REPAIRS

A. Irregular shapes, cuts, or tears in GCL shall be overlapped with additional layer of GCL material minimum of 12 inches in all directions from defect.

B. Patch seams parallel to slope and secure with repair adhesive recommended by manufacturer.

C. Patches and repairs shall not be allowed on slopes greater than 7H:1V.

D. Complete panels shall be removed and replaced with undamaged panels when damage is extensive as determined by ENGINEER.

3.6 PLACEMENT OF OVERLYING MATERIALS

A. Equipment shall not operate directly on GCL, except to minimum extent necessary to deploy specified geosynthetic materials on GCL, as approved by ENGINEER. Deploy geosynthetic materials with equipment and by methods approved by ENGINEER.

B. The GCL shall be covered as it is installed, as the GCL installation is accepted for cover by the installation superintendent and the ENGINEER. The intent of the Specification is to cover the GCL as it is installed without getting more than two panel widths or 24 feet beyond the cover system over the GCL material. In any event, the GCL is to be completely covered and protected at the end of each shift or workday. The CONTRACTOR shall be fully responsible to protect the GCL from damage, shrinkage, or prehydration and shall replace all affected materials at the CONTRACTOR's sole expense.

C. To prevent premature hydration or shrinkage in hot weather, only the amount of GCL that can be anchored, inspected, repaired, and covered in the same day shall be installed.

D. The CONTRACTOR shall ensure that moisture and surface water runoff collected on completed sections of the liner or cover systems or draining from other areas does not drain or seep into the liner or cover system and expose the GCL to moisture at any time. Any GCL exposed to moisture, as determined by the ENGINEER, either covered with HDPE or not, shall be removed and replaced at the CONTRACTOR's expense.

E. Any leading edge or panels of GCL left uncovered shall be protected with a heavy, waterproof membrane or tarp which is adequately secured and protected with sandbags or other ballast.

F. Equipment used to installed the cover materials shall not operate directly on the GCL.

3.7 FIELD QUALITY CONTROL

A. Conformance Testing:

1. Conformance testing shall be the sole responsibility of the CONTRACTOR and shall be performed on samples taken from GCL rolls delivered to the site. The conformance sampling and testing shall occur at a frequency of one per 50,000 square feet. The following tests shall be performed by a qualified third party Geosynthetic Quality Control laboratory retained by the CONTRACTOR to determine GCL characteristics. Additional tests may be performed by the ENGINEER

to verify material conformance with specifications at the discretion of the ENGINEER.

a. Bentonite Content: Mass/Unit Area; ASTM D5993.
b. Grab Tensile and Elongation: ASTM D4632.
c. Peel Strength: ASTM D4632.

2. Where optional procedures are noted in the test method, the requirements of these specifications shall prevail.
3. Sampling Procedures:
   a. Sample across the entire width of the roll excluding the first 3 feet.
   b. Cut sample 3 feet long by width of roll unless otherwise specified.
   c. Mark longitudinal direction of roll on the samples with an arrow.
4. For each sample taken, provide a corresponding sample to the ENGINEER. Provide lot number, roll number, and location for each sample.
5. Provide test results to the ENGINEER prior to installation and as required in Article SUBMITTALS.

END OF SECTION

11	3,939,000	July 2048	May 2053	4.8
12	4,396,000	May 2053	December 2057	4.6
LANDFILL SECTION 3				
13	4,513,000	December 2057	January 2062	4.1
14	5,555,000	January 2062	September 2066	4.6
15	5,873,000	September 2066	April 2071	4.6
TOTAL	**41,825,000**	**April 2005**	**April 2071**	**66.0**

1.4.4 Cell Capacity and Service Life with Valley Fills

The valleys between landfill sections would be filled in conjunction with the filling of each cell. Following the completion of Landfill Section 1, valley filling would begin in Cell 8 in Landfill Section 2. Each cell in Section 2 would be filled over the north interior berm up to the final grade. After all the cells in Section 2 were full, Section 3 and the south interior valley would be filled in a similar manner. This would extend the life of Cells 8 through 15 by up to one year each. Table 1-7 presents the capacity of each cell with the valley fills and the year in which each would be filled.

TABLE 1-7
Matanuska-Susitna Borough Central Landfill Development Plan with Valley Fills

Cell Number	Waste and Cover Soil Volume (yd^3)	Start Date	End Date[5]	Cell Life (Years)
LANDFILL SECTION 1				
2A and 2B	765,000	April 2005 [6]	October 2009	4.5
3	1,167,000	October 2009 [7]	January 2015	5.2
4	1,289,000	January 2015	September 2019	4.7
5	1,674,000	September 2019	September 2024	5.2
6	1,864,000	November 2024	October 2029	4.8
7	2,309,000	October 2029	November 2034	5.1
LANDFILL SECTION 2				
8	2,724,000	November 2034	December 2039	5.1
9	3,344,000	December 2039	April 2045	5.3
10	3,944,000	April 2045	July 2050	5.3

[5] Note that there is always overlap between the end date of the old cell and start date of the new cell. This is because the new cell needs to be in place and ready to accept waste before the old cell is closed. For example, Cell 3 construction will begin in 2007, even though waste placement in Cells 2A and 2B will not be complete till 2009.

[6] This is not the actual start date for refuse filling in this cell, but the date of aerial photography that was used to determine the remaining capacity of the cell.

[7] Depending on operational decisions, filling of Cell 3 may begin as early as late 2007.

11	4,679,000	July 2050	October 2055	5.3
12	4,941,000	October 2055	July 2060	4.7
		LANDFILL SECTION 3		
13	6,062,000	July 2060	October 2065	5.2
14	6,597,000	October 2062	December 2070	5.2
15	8,464,000	December 2070	January 2077	6.1
TOTAL	**49,795,000**	**April 2005**	**January 2077**	**71.8**

1.5 MSW Landfill Development Drawings

Drawings showing the bottom grade, final grade, typical cross sections, and landfill cell sequencing are provided in Section 5.

1.6 MSW Landfill Items for Refinement during Final Design

Review of the landfill bottom grading plan, final grading plan and cross-sections indicates several instances where the conceptual design could be refined during final design to optimize air space volume and soil excavation and embankment, as summarized in the following paragraphs.

1.6.1 Perimeter Road Alignment on the West and North Sides of Cell 2A

The horizontal and vertical alignment of the perimeter road on the west and north sides of Cell 2A should be adjusted to better match the existing landfill horizontal limits and existing ground elevations. While having only a negligible effect on total excavation and air space volumes, this adjustment would prevent the perimeter berm road from being constructed over the existing landfill and would also preserve existing vegetation in the buffer area north of Cell 2A.

1.6.2 Adjustment of Berm Roads to Match Existing Topography

The perimeter berm roads should be located close to the site property boundaries without creating excessive cut or full slopes. Adjusting both the horizontal and vertical alignment to take better advantage of the topography in a few localized areas on the east and south sides would reduce several areas where fill slopes extend out considerable distances to catch existing ground.

Table C-2
Matanuska-Susitna Central Landfill
Estimated Life of MSW Cells w/ Valley Fills

Year	Cell	Cell Volume: Total Volume above Bottom Liner (cubic yards)	Used for final cover (cubic yards)	Net volume at beginning of year (cubic yards)	Used for waste and cover soil (cubic yards)	Net volume at end of year (cubic yards)	Cumulative Net Volume Used (cubic yards)	Start/Full Dates	Cell Life (Years)
EXISTING LANDFILL AREA									
2005	2A+2B	815,000	49,900	765,100	119,040	646,060	119,040	Apr-05	
2006				646,060	156,558	489,502	275,598		
2007				489,502	163,646	325,856	439,244		
2008				325,856	173,027	152,829	612,271		
2009				152,829	152,829	0	765,100	Oct-09	4.50
FUTURE LANDFILL SECTION 1									
2009	3	1,209,000	41,700	1,167,300	34,166	1,133,134	799,266	Oct-09	
2010				1,133,134	200,128	933,007	999,393		
2011				933,007	212,636	720,371	1,212,029		
2012				720,371	223,059	497,312	1,435,088		
2013				497,312	237,652	259,661	1,672,739		
2014				259,661	250,160	9,501	1,922,899		
2015				9,501	9,501	0	1,932,400	Jan-15	5.22
2015	4	1,318,000	28,900	1,289,100	250,248	1,038,852	2,182,648	Jan-15	
2016				1,038,852	267,462	771,390	2,450,110		
2017				771,390	274,967	496,423	2,725,077		
2018				496,423	281,846	214,576	3,006,924		
2019				214,576	214,576	0	3,221,500	Sep-19	4.70
2019	5	1,722,000	47,900	1,674,100	76,651	1,597,449	3,298,151	Sep-19	
2020				1,597,449	301,859	1,295,590	3,600,010		
2021				1,295,590	312,699	982,890	3,912,710		
2022				982,890	324,374	658,517	4,237,083		
2023				658,517	336,673	321,844	4,573,756		
2024				321,844	321,844	0	4,895,600	Nov-24	5.19
2024	6	1,912,000	47,600	1,864,400	27,963	1,836,437	4,923,563	Nov-24	
2025				1,836,437	362,731	1,473,706	5,286,294		
2026				1,473,706	374,822	1,098,883	5,661,117		
2027				1,098,883	386,705	712,178	6,047,822		
2028				712,178	399,213	312,965	6,447,035		
2029				312,965	312,965	0	6,760,000	Oct-29	4.84
2029	7	2,386,000	77,200	2,308,800	99,589	2,209,211	6,859,589	Oct-29	
2030				2,209,211	426,105	1,783,106	7,285,694		
2031				1,783,106	440,051	1,343,054	7,725,746		
2032				1,343,054	454,453	888,601	8,180,199		
2033				888,601	469,327	419,274	8,649,526		
2034				419,274	419,274	0	9,068,800	Nov-34	5.11
FUTURE LANDFILL SECTION 2									
2034	8	2,772,000	47,600	2,724,400	65,414	2,658,986	9,134,214	Nov-34	
2035				2,658,986	500,551	2,158,435	9,634,765		
2036				2,158,435	516,934	1,641,501	10,151,699		
2037				1,641,501	533,852	1,107,649	10,685,551		
2038				1,107,649	551,325	556,325	11,236,875		
2039				556,325	556,325	0	11,793,200	Dec-39	5.12
2039	9	3,405,000	61,000	3,344,000	13,044	3,330,956	11,806,244	Dec-39	
2040				3,330,956	588,004	2,742,952	12,394,248		
2041				2,742,952	607,248	2,135,704	13,001,496		
2042				2,135,704	627,123	1,508,581	13,628,619		
2043				1,508,581	647,648	860,933	14,276,267		
2044				860,933	668,845	192,088	14,945,112		
2045				192,088	192,088	0	15,137,200	Apr-45	5.31

Central Landfill 2010 Permit Application
Attachment K

Appendix C
Estimated Capacity of MSW Cells

Year	Cell	Cell Volume: Total Volume above Bottom Liner (cubic yards)	Used for final cover (cubic yards)	Net volume at beginning of year (cubic yards)	Used for waste and cover soil (cubic yards)	Net volume at end of year (cubic yards)	Cumulative Net Volume Used (cubic yards)	Start/Full Dates	Cell Life (Years)
2045	10	4,017,000	73,200	3,943,800	498,647	3,445,153	15,635,847	Apr-45	
2046				3,445,153	713,342	2,731,810	16,349,190		
2047				2,731,810	736,689	1,995,121	17,085,879		
2048				1,995,121	760,800	1,234,321	17,846,679		
2049				1,234,321	785,700	448,620	18,632,380		
2050				448,620	448,620	0	19,081,000	Jul-50	5.28
2050	11	4,766,000	87,000	4,679,000	362,795	4,316,205	19,443,795	Jul-50	
2051				4,316,205	837,972	3,478,232	20,281,768		
2052				3,478,232	865,398	2,612,834	21,147,166		
2053				2,612,834	893,722	1,719,113	22,040,887		
2054				1,719,113	922,972	796,140	22,963,860		
2055				796,140	796,140	0	23,760,000	Oct-55	5.28
2055	12	5,068,000	127,300	4,940,700	157,040	4,783,660	23,917,040	Oct-55	
2056				4,783,660	984,377	3,799,284	24,901,416		
2057				3,799,284	1,016,594	2,782,689	25,918,011		
2058				2,782,689	1,049,866	1,732,823	26,967,877		
2059				1,732,823	1,084,227	648,596	28,052,104		
2060				648,596	648,596	0	28,700,700	Jul-60	4.75
FUTURE LANDFILL SECTION 3									
2060	13	6,157,000	95,400	6,061,600	471,117	5,590,483	29,171,817	Jul-60	
2061				5,590,483	1,138,036	4,452,447	30,309,853		
2062				4,452,447	1,156,660	3,295,788	31,466,512		
2063				3,295,788	1,175,588	2,120,200	32,642,100		
2064				2,120,200	1,194,825	925,375	33,836,925		
2065				925,375	925,375	0	34,762,300	Oct-65	5.19
2065	14	6,706,000	109,400	6,596,600	289,004	6,307,596	35,051,304	Oct-65	
2066				6,307,596	1,234,251	5,073,346	36,285,554		
2067				5,073,346	1,254,449	3,818,897	37,540,003		
2068				3,818,897	1,274,977	2,543,920	38,814,980		
2069				2,543,920	1,295,841	1,248,079	40,110,821		
2070				1,248,079	1,248,079	0	41,358,900	Dec-70	5.19
2070	15	8,627,000	163,000	8,464,000	68,968	8,395,032	41,427,868	Dec-70	
2071				8,395,032	1,338,600	7,056,432	42,766,468		
2072				7,056,432	1,360,505	5,695,927	44,126,973		
2073				5,695,927	1,382,769	4,313,158	45,509,742		
2074				4,313,158	1,405,397	2,907,761	46,915,139		
2075				2,907,761	1,428,396	1,479,365	48,343,535		
2076				1,479,365	1,451,771	27,594	49,795,306		
2077				27,594	27,594	0	49,822,900	Jan-77	6.08

Note: Net landfill airspace volume available for waste and daily cover with valley fills is 49,720,000 cubic yards.

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3.2 *HELP Model Design Data*

HELP model design data were chosen to represent the various depths of waste fill and soil cover conditions. The material parameters were chosen to simulate the conditions currently in-place in the landfill cells and those that are expected to be in-place in the future as the landfill builds out into Cell 4. For each of the landfill scenarios modeled, representative soil and geosynthetic layer properties, layer thickness, slopes, evaporative zone depth, and other parameters were selected for input into the HELP model. Representative properties of materials were selected from the HELP model database, which provides an extensive database of recommended typical soil and waste properties cross referenced to the Unified Soil Classification System (USCS) and waste characteristics. Classification/parameters most closely matching the anticipated or actual layer type were selected from the HELP model's soil matrix options. Table 3 presents a summary of the HELP model input parameters. The footnotes associated with the table explain the use of HELP model parameters or site-specific data.

TABLE 3
MSB Central Landfill HELP Modeling Parameters Summary – Cell 2 and Cell 3
Leachate Generation and Storage Needs Evaluation

		Classification					
Layer Description	Thickness (inches)	Soil Texture #[a]	Layer Type[b]	Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/sec)
Cover Soil	Varies	2	1	0.437	0.062	0.024	5.8×10^{-3}
Waste (MSW)	Varies	18	1	0.168	0.292	0.077	1.0×10^{-3}
Granular Drainage Material (GDM)	24	21	2	0.397	0.032	0.013	1.0×10^{-1}[c]
HDPE Geomembrane[d]	0.06	35	4	---	---	---	2.0×10^{-13}
GCL	0.25	17	3	0.750	0.747	0.400	3.0×10^{-9}

TABLE 3
MSB Central Landfill HELP Modeling Parameters Summary – Cell 2 and Cell 3
Leachate Generation and Storage Needs Evaluation

		Classification					
Layer Description	Thickness (inches)	Soil Texture #[a]	Layer Type[b]	Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/sec)

NOTES:
[a] HELP soil texture number for standard soil, municipal waste, and geosynthetic material characteristics. HDPE geomembrane=35; waste=18, sand= 2, bentonite mat=17 (also known as a geosynthetic clay liner, GCL).
[b] HELP layer type and function: 1) vertical percolation layer, 2) lateral drainage layer, 3) barrier soils, and 4) geomembrane liners.
[c] The hydraulic conductivity value for the GDM is based on technical specifications for Cell 2B and Cell 3 requiring a minimum of 1 x 10^{-1} cm/sec.
[d] In addition to the listed layers, there is a non-woven cushion geotextile between the GDM and theHDPE Geomembrane for Cell 3, which has an angular (crushed) GDM layer opposed to round gravel used in Cell 2B construction. This layer does not influence the leachate conveyance or generation rate values in the HELP model, and therefore, was not includes as a layer in the HELP modeling parameters.

Maximum anticipated depth of leachate:

3.5 Head Buildup by Leachate Recirculation

The HELP model was run assuming that up to 90 percent of the leachate collected is recirculated back into the waste body. This scenario was run as a worst case condition in terms of the potential for leachate to build-up and to check that the predicted leachate head buildup would not exceed a maximum of 12 inches, as required by regulation.

The model was run for all three existing cells with the average waste height that is anticipated to be in place when recirculation starts (25 feet in Cell 2B, 50 feet in Cell 3 Phase I and 25 feet in Cell 3 Phase II). Twenty-five feet of waste is assumed to be the minimum amount of waste that needs to be in-place before leachate recirculation can take place. The results of this HELP modeling indicate that with 90 percent of the leachate being recirculated, the head buildup on the liner will be no more than 8 inches, well below the 12-inch maximum. The head buildup in the no-recirculation scenario is compared to head buildup in the recirculation scenario in Table 4.

TABLE 4
Maximum Head Buildup Summary, Recirculation vs. No Recirculation
Leachate Generation and Storage Needs Evaluation

Area	No Recirc (in)	With Recirc (in)
Cell 2B	4.1	8.0
Cell 3 Phase I	1.7	3.2

TABLE 4
Maximum Head Buildup Summary, Recirculation vs. No Recirculation
Leachate Generation and Storage Needs Evaluation

Area	No Recirc (in)	With Recirc (in)
Cell 2B	4.1	8.0
Cell 3 Phase I	1.7	3.2
Cell 3 Phase II	1.6	3.6

SECTION 02664B

GEOMEMBRANE INSTALLATION

PART 1 – GENERAL

1.01 WORK INCLUDED

A. A fixed quantity of Geomembrane products are to be provided by the OWNER (See Appendix B - Section 02664A)

B. Install 80-mil thick high-density polyethylene (HDPE) textured geomembrane (textured both sides) as a component of the Cell 3 composite liner system

C. Provide quality control services

1.02 RELATED SECTIONS

A. Division 1 – General Requirements

B. Section 01720 – Construction Surveys

C. Section 02315 – Subgrade Preparation and Sand Cushion Layer

D. Section 02661B - Geotextile Installation

E. Section 02663B – Geosynthetic Clay Liner Installation

F. Appendix B – Section 02664A – Geomembrane Supply

1.03 DEFINITIONS

A. Bridging: The condition when geomembrane becomes suspended over its subgrade due to contraction of the material or poor installation.

B. Construction Quality Assurance Inspector (CQA Inspector): The CQA representative of the OWNER, who is responsible for on site implementation of CQA procedures defined by the CQA Manual. CQA programs provide verification that CQC activities and programs are conducted as required by these specifications.

C. Construction Quality Control (CQC): The Installers QC program that is responsible for observing and documenting activities related to quality control during installation and seaming of the geosynthetic components of the lining system.

D. Extrudate: The molten polymer that is emitted from an extruder during seaming using either extrusion fillet or extrusion flat methods. The polymer is initially in the form of a ribbon rod, bead or pellets.

E. Geomembrane: An essentially impermeable membrane used as a solid or liquid barrier. Synonymous term for flexible membrane liner (FML).

F. Geomembrane Subsurface: The soil or geosynthetic surface on which the geomembrane lies.

G. GRI: Geosynthetic Research Institute.

H. Installer: The party responsible for field handling, transporting, storing, deploying, seaming, temporary restraining (against wind), and installation of the geomembrane.

I. Panel: The unit area of geomembrane that will be seamed in the field. If the geomembrane is not fabricated into panels in a factory, a panel is identified as a roll or portion of a roll without any seams.

J. OWNER: Matanuska-Susitna Borough or their duly authorized OWNER.

1.04 INSTALLER QUALIFICATION SUBMITTALS

A. Submit, two weeks prior to installation:

1. Name of company that will install geomembrane.

2. Resume of installation supervisor/field engineer that will be assigned to the project.

3. Resumes of personnel that will perform seaming operations.

4. Company qualifications documenting that :

a. Successfully completed at least five projects of similar scope, complexity and size.

b. Successfully installed a minimum of 5,000,000 square feet HDPE geomembrane

5. Personnel qualifications documenting that:

a. Supervisor has worked in similar capacity on at least 2 jobs of similar scope, complexity, and size.

b. Master Seamer has successfully completed a minimum of 5,000,000 square feet HDPE geomembrane seaming using welding techniques described in this Section.

c. Other seamers have successfully completed a minimum of 1,000,000 square feet HDPE geomembrane seaming using welding techniques described in this Section.

1.05 CQC SUBMITTALS

A. Submit, two weeks prior to installation:

1. Name of individual(s) that will perform CQC services.

2. Resume of installation CQC personnel that will be assigned to the project and that will perform CQC sampling and testing.

1.06 INSTALLER SHOP DRAWINGS

A. Submit, two weeks prior to installation:

1. Shop drawings showing the panel layout indicating field seams and details not conforming to the Construction Drawings. Upon acceptance, use these drawings for installation of geomembrane.

1.07 QUALITY ASSURANCE (PERFORMED BY OWNER)

A. The OWNER will engage and pay for the services of a CQA Inspector and a CQA Laboratory for monitoring the quality and installation of the geomembrane.

B. The CQC shall collect triplicate samples at each destructive test location, and provide the CQA Inspector with 2 samples – one for CQA Laboratory analysis, and one for archives.

1.08 CONFORMANCE TESTING (MATERIALS)

A. The materials supplier and the CQA Inspector provided conformance QC and QA testing on geomembrane supplied for this project.

B. Copies of conformance records are available to the installer if desired.

1.09 DELIVERY, STORAGE, AND HANDLING

A. OWNER-provided geomembrane rolls are stored on site.

B. Geomembrane rolls are stored to protect them from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage.

C. Installer shall use appropriate handling equipment to deploy geomembrane rolls. Appropriate equipment includes cloth chokers and spreader bars. Do not drag rolls or panels on ground surface.

D. Do not fold geomembrane material; folded material will be rejected and replaced at no additional cost to the owner.

1.10 CUSTODY TRANSFER

A. Geomembrane materials are in the custody of the OWNER. Within one day of the Notice to Proceed, or within one day of the OWNER receipt of all the supplied materials, whichever is first, The CONTRACTOR shall attend a custody transfer meeting. At this meeting, the CONTRACTOR shall inspect the supplied materials and accept transfer of the materials. The CONTRACTOR will then be solely responsible for the storage, handling, protection, and quality of the geomembrane for use in the work.

1.11 INSTALLATION SUBMITTALS (INSTALLER)

A. Submit quality control documentation prepared during installation, including material inventories, copies of seam test results, and trial seam tests.

B. On a daily basis and prior to installation, submit subgrade acceptance certificate signed by the installation supervisor for each area to be covered by the geomembrane.

C. Upon completing entire installation submit installation warranties.=

1.12 GEOMEMBRANE AS-BUILT SURVEY

A. Perform as-built survey of the completed geomembrane in accordance with Section 01720.

B. Survey shall be presented on drawings of appropriate scale showing locations of all panels, seams, repairs, patches, and destructive seam test samples. Each surveyed item shall labeled on the drawings.

C. Geomembrane as-built survey data shall be submitted as work is completed.

1.13 INSTALLATION WARRANTY

A. Provide installation warranty for complete liner system. Provide a minimum one-year warranty for the workmanship on the installed liner system, following the date of liner system final acceptance.

B. Submit a sample of the proposed installation warranty at least 21 days before the scheduled installation.

C. Submit the final signed, notarized installation warranty before the project completion date.

PART 2 – PRODUCTS (INSTALLATION)

2.01 EXTRUDATE ROD OR BEAD

A. Made from same resin type as the geomembrane.

B. Containing 2 to 3 percent carbon black.

C. Manufacturer to match geomembrane products supplied by Owner.

PART 3 – EXECUTION (INSTALLER)

3.01 EXAMINATION OF GEOMEMBRANE SUBSURFACE

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the work. Notify the OWNER of such conditions and proposed corrective actions before correcting unsatisfactory conditions. Do not proceed until unsatisfactory conditions are corrected.

B. Verify in writing to the OWNER that the GCL surface on which the geomembrane will be installed is acceptable. Installation without written acceptance means acceptance.

C. Verify that no particles project from the GCL surface that could puncture the geomembrane.

3.02 PREPARATION

A. Repair damage caused to GCL during deployment.

B. Round edges of anchor trenches or cushion with geotextiles.

3.03 PERFORM TRIAL SEAM WELDS AS FOLLOWS

A. Perform trial welds on samples of geomembrane to verify the performance of welding equipment, welding personnel, seam welding methods, and weather conditions.

B. Do not begin production seam welding until equipment and welders have successfully completed trial welds.

C. Frequency of trial welds:

1. Minimum of two trial welds per day per equipment and per welder with one prior to the start of work and one at mid shift.

2. When directed by the CQC technician.

D. Make trial welds in the same surroundings and environmental conditions as the production welds, i.e., in contact with subgrade.

E. Make trial weld sample at least 2 feet long and 12 inches wide.

F. Allow welds to cool and then cut excesses material from the ends of the welds.

G. Using a cutting die cut four 1-inch wide specimens spaced evenly along the length of the weld.

H. Using a calibrated tensiometer, the CQC will test specimens for peel adhesion, and bonded seam strength (ASTM D6392). Specimens shall be alternated for peel, shear, peel, and shear. Both sides of double-wedge welds shall be tested for peel strength. Tests shall be run at a separation rate of two inches per minute.

I. A trial weld is considered passing when results conform to the latest version of GRI GM19 Table 1(a) for 80 mil HDPE geomembrane as summarized below.

Property	Test Designation	Required Test Results (3)
Wedge Weld (1) and (2)	ASTM D6392	
Peel Strength		121 lb/in.
Peel Separation		25 percent maximum
Shear Strength		160 lb/in.
Extrusion Weld (2)	ASTM D6392	
Peel Strength		121 lb/in.
Peel Separation		25 percent maximum
Shear Strength		160 lb/in.

Notes:
1. Both sides of the double-wedge weld shall be tested for peel properties.
2. 2 of 2 specimens must pass all criteria
3. Acceptable break (failure) codes per ASTM D6392 are
   Wedge weld = AD and AD-Brk <25%
   Extrusion Weld = AD1, AD2 and AD-WLD (as long as strength is achieved)

J. Repeat the trial weld in its entirety when any of the trial weld specimens fail in either peel or shear.

K. When repeated trial weld fails, do not use welding apparatus and welder until deficiencies or conditions are corrected and two consecutive successful trial welds are achieved.

3.04 DEPLOYMENT

A. Give careful consideration to the timing and temperature during deployment. Focus on verifying that there is no bridging or stresses in the geomembrane and there are no wrinkles in the geomembrane that will fold over when covered with soil.

B. Ideally, deployment, welding, and covering should all occur at the same temperature. In a practical sense, strive to perform these activities within as narrow a temperature range as practical, and avoid these activities during peak hot or cold conditions.

C. Panel Identification: Assign to each panel an identifying code number or letter consistent with the approved panel layout drawing. The coding is subject to approval by the CQC and the CQA Inspector.

D. Repair damage to subgrade or other underlying materials prior to completing deployment of geomembrane.

E. Do not deploy more panels in one shift than can be welded or secured during that same shift.

F. Do not deploy in the presence of excessive moisture, precipitation, ponded water, or high winds.

G. Do not damage geomembrane when handling with equipment, due to leakage of hydrocarbons, or any other means.

H. Do not wear shoes that can damage geomembrane.

I. Unroll geomembrane panels using methods that will not damage, stretch or crimp geomembrane. Protect underlying surface from damage.

J. Place ballast on geomembrane that will prevent wind from lifting and moving the geomembrane. Restore to its original position GCL material that is displaced by shifting geomembrane to preserve the GCL overlap integrity. If the geomembrane has been observed to move due to wind, the CQC or the CQA Inspector can require that geomembrane panels be cut open to verify that the GCL materials have not been shifted due to wind action on the geomembrane.

K. Use ballast that will not damage geomembrane.

L. Protect geomembrane in areas of heavy traffic by placing a protective cover over the geomembrane.

M. Do not allow any vehicular traffic directly on geomembrane.

N. Remove wrinkled or folded material.

O. Install material to account for shrinkage and contraction while avoiding wrinkles. Install material stress-free with no bridging before it is covered. Add material as needed to avoid bridging.

P. Before wrinkles fold over, attempt to push them out. For wrinkles that cannot be pushed out, cut them out and repair cuts prior to burial.

Q. Do not allow textured surfaces to be dragged over the installed GCL. Use a smooth geosynthetic slip sheet or rub sheet as necessary to reduce friction damage during deployment.

R. Visually inspect geomembrane for imperfections. Mark faulty or suspect areas for repair.

3.05 SEAM LAYOUT

A. Orient seams parallel to line of a maximum slope, i.e., orient down, not across slope.

B. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.

C. Keep horizontal seams (seams running approximately parallel to slope contours) at least 6 feet away from toe or crest of slope, unless approved by OWNER.

D. Use seam-numbering system compatible with panel number system.

E. Shingle panels on all slopes and grades to promote drainage over the seam not into the seam.

3.06 WELDING EQUIPMENT

A. Maintain sufficient operating seaming apparatus to continue work without delay.

B. Use power source capable of providing constant voltage under combined line load.

C. Provide protective lining and splash pad large enough to catch spilled fuel under electric generator, if generator is positioned on geomembrane.

D. Provide extrusion welders equipped with gauges showing temperatures in extruder apparatus and at nozzle.

E. Provide hot wedge welder meeting the following requirements:

1. Vehicular mounted
2. Automated variable speed capability
3. Equipped with devices for adjusting temperatures at the wedge
4. Pressure controlled by springs, pneumatics, or other system that allows for variation in sheet thickness
5. Rigid frame fixed position equipment is not acceptable.

3.07 TEST EQUIPMENT

A. Installer CQC shall provide calibrated tensiometer capable of measuring seam strength. Tensiometer must be calibrated and accurate within 2 ppi.

B. Installer shall provide dies for cutting seam samples.

3.08 GENERAL WELDING PROCEDURES

A. At least one master seamer shall be present during all production welding to supervise all other seamers.

B. Do not commence welding until trial weld test sample, made by that equipment, passes.

C. Clean seam area surfaces of grease, moisture, dust, dirt, debris, or other foreign material.

D. Overlap panels a minimum 3 inches for extrusion and 4 inches for hot wedge welding.

E. Construct weld with adequate material width on each side of weld to allow peel and shear testing.

F. Extend welding to the outside edge of all panels and to the outside edge of panels placed in anchor trenches and under termination berms.

G. If required for firm support, provide a firm subsurface under the seaming area.

H. Cut fish mouths or wrinkles along the ridge of the wrinkle in order to achieve a flap overlap. Extrusion weld the cut fish mouths or wrinkles where the overlap is less than 3 inches. When the cut is greater than 3 inches, install an oval or round patch extending a minimum of 6 inches in all directions beyond the cut.

3.09 EXTRUSION TYPE OF WELDING

A. Use procedures to tack bond adjacent panels together that do not damage geomembrane and allow CQC and CQA tests to be performed.

B. Purge welding apparatus of heat-degraded extrudate before welding.

C. Bevel top edges of geomembrane a minimum of 45° and full thickness of geomembrane before extrusion welding.

D. Clean seam-welding surfaces of oxidation by disc grinder or equivalent not more than 30 minutes before extrusion welding. Change grinding discs frequently. Do not use clogged discs.

E. Do not remove more than 4 mils of material when grinding.

F. Grind across, not parallel to, welds.

G. Cover entire width of grind area with extrudate.

H. When restarting welding, grind ends of all welds that are more than five minutes old.

I. Extrusion-weld a repair patch over all tee and cross-seam intersections.

3.10 HOT WEDGE WELDING

A. Place smooth insulating plate or fabric beneath hot welding apparatus after usage.

B. Protect against moisture build-up between panels.

C. If welding cross seams, conduct field test welds at least every two hours, otherwise, once prior to start of work and once at mid-day.

D. Bevel edges of top and bottom panels on cross seams.

E. Do not weld on geomembrane until equipment has passed trial weld test.

F. Extrusion-weld a repair patch over all tee and cross-seam intersections.

3.11 INSTALLATION QUALITY CONTROL

A. CQC shall log the following every four hours:

1. Temperature on the geomembrane surface being welded.
2. Extrudate temperatures in barrel and at nozzle (extrusion welder).
3. Operating temperature of hot wedge (hot wedge welder) and any pressure adjustments made.
4. Preheat temperature.
5. Speed of hot wedge welder in feet per minute.

B. Weld only when ambient temperature, measured 6 inches above the geomembrane, is between 40°F and 104°F.

C. If seaming at ambient temperatures below 40°F (5°C) or above 104°F (40°C), demonstrate and certify that such methods produce seams that are entirely equivalent to seams produced at ambient temperatures above 40°F (5°C) and below 104°F (40°C). Certify the overall quality of the geomembrane is not adversely affected. Perform work under contract change order that states the seaming procedure will not cause any physical or chemical modification to the geomembrane, which will generate short or long-term damage to the geomembrane.

D. Seaming below temperatures of 32° F must be performed under cold weather welding procedures approved by the OWNER.

3.12 NON-DESTRUCTIVE TESTING (PERFORMED BY INSTALLER)

A. All non-destructive testing is to be witnessed and documented by the CQC.

B. Non-destructively test all welded seams over their full length using a vacuum test unit, air pressure (for double fusion seams only), spark testing, or other approved methods.

C. Perform testing as the seaming progresses and not at the completion of all the field seaming.

D. Provide notification of all required repairs to CQC and then complete all required repairs in accordance with this specification.

3.13 NON-DESTRUCTIVE VACUUM TESTING

A. Equipment

1. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom porthole, or valve assembly, and a vacuum gauge.

2. A vacuum pump assembly equipped with a pressure control.

3. A rubber pressure/vacuum hose with fittings and connections.

4. A soapy solution and an applicator.

B. Vacuum Box Test Procedures.

1. Place the box over the wetted seam area (soapy solution).

2. Ensure that a leak-tight seal is created.

3. Energize the vacuum pump and reduce the vacuum box pressure to approximately 10 inches of mercury, i.e., five-psi gauge.

4. Examine the geomembrane through the viewing window for the presence of soap bubbles for a period of not less than ten seconds.

5. Mark areas where soap bubbles appear and repair in accordance with repair procedures described in this Section.

3.14 NON-DESTRUCTIVE AIR PRESSURE TESTING FOR DOUBLE WEDGE WELD

A. Equipment:

1. An air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining a pressure over 60 psi and mounted on a cushion to protect the geomembrane.

2. A rubber hose with fittings and connections.

3. A sharp hollow needle or other approved pressure feed device.

4. A pressure gauge with an accuracy of plus or minus one psi.

B. Test Procedures.

1. Seal both ends of the welded seam to be tested.

2. Insert needle or other approved pressure feed device into the tunnel created by the weld.

3. Energize the air pump to a minimum pressure of 35 psi and maintain this pressure for 5 minutes, then close the valve. Then, allow five minutes relaxation time. During the relaxation time the air pressure cannot drop more than 2 psi.

4. If loss of pressure exceeds 2 psi, or otherwise approved, or does not stabilize, locate faulty area and repair in accordance with repair procedures described in this Section.

5. Puncture opposite end of seam to release air. If blockage is present, locate and test seam on both sides of blockage.

6. Remove needle or other approved pressure feed device and then repair the penetration holes.

7. If the testing equipment is not able to hold the 35-psi pressure (i.e., leaking needle) reduce the pressure in 2 psi increments, but no less than 30 psi, until the equipment can sustain the pressure.

3.15 SPARK TESTING BOOTS AROUND PENETRATIONS OR OTHER DIFFICULT AREAS OR AS AN ALTERNATIVE TO VACUUM TESTING.

A. Equipment and Materials.

1. 24-gauge copper wire.

2. Low-amperage electric detector, 20,000 to 30,000 volt, with brush-type electrode capable of causing visible arc up to 3/4 inch from copper wire.

B. Spark Testing Procedures.

1. During extrusion welding, place a copper wire within 1/4 inch of the edge of extrusion weld.

2. Pass electrode over seam area and observe for spark. If a spark is detected perform a repair.

3.16 FIELD DESTRUCTIVE SEAM TESTING

A. CQC shall perform destructive seam testing.

B. Perform peel and shear tests on two specimens obtained from each end of a seam welded between panels (4 specimens per seam).

C. Perform peel tests on one specimen taken from each butt seam.

D. Additional destructive test specimens may be obtained at the discretion of the CQC or CQA Inspector due to suspected contamination of the weld area, excess crystalline, offset welds, or other suspected defects.

E. Perform peel and shear tests in compliance with ASTM D6392. All destructive peel and shear tests are considered passing when all specimens from each test location meet results listed in paragraph 3.3 of this Section.

F. If any field test sample fails, follow failed test procedures outlined in this Section.

3.17 FAILED WELD PROCEDURES

A. Follow these procedures when there is a destructive test failure. Follow one of the following two options:

1. First option:

a. Reconstruct the seam between any two passing test locations. Do not extrusion weld the flap.

2. Second option:

a. Trace the weld at least 10 feet minimum towards the opposite end of the seam from the location of the failed specimen.

b. Obtain specimens at this location for additional field tests. Obtain specimens as described above.

c. If this additional test specimen meets seam quality requirements, then repair the seam between passing seam specimen locations or the passing specimen location and the end of the seam.

d. If any specimen fails to meet seam quality requirements, repeat the process to establish the zone in which the seam must be repaired.

B. Butt Seams: If a peel test taken from a butt seam fails, cap the entire butt seam. Obtain a peel specimen from the cap and perform peel test. If the peel test from the cap specimen fails, repeat the capping until a passing test is obtained from a specimen of the cap weld.

C. Whenever a sample fails, perform additional trial seams for that welder and welding apparatus.

3.18 ACCEPTABLE WELDED SEAMS

A. The weld passes all non-destructive tests.

B. The weld is bracketed by two locations from which all specimens have passed destructive tests.

C. For reconstructed seams exceeding 50 feet, a specimen taken from within the reconstructed weld passes destructive testing and all non-destructive tests pass.

3.19 SEAMS THAT CANNOT BE NON-DESTRUCTIVELY TESTED

A. If the weld cannot be tested, cap strip the weld. The welding and cap-stripping operations must be observed by the CQC for uniformity and completeness.

3.20 DEFECT AND REPAIR PROCEDURES

A. Examine all welds and non-weld areas of the geomembrane for defects, holes, blister, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane must be clean at the time of the examination.

B. Repair and non-destructively test each suspect location regardless if it is in a weld area or discovered in the panel. Do not cover geomembrane at locations that have been repaired until test results with passing values are available.

C. Extrusion weld a patch over all "cross" or "tee" welds and specimen locations.

D. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

E. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. Agreement upon the appropriate repair method will be determined between the CQA Inspector, CQC, and Installer. Acceptable repair procedures may include:

1. Patching: Used to repair large holes (over 3/8-inch diameter), tears (over 2 inches long), undispersed raw materials, contamination by foreign matter, and to cover cross and tee connections.

2. Abrading and re-welding: Used to repair small sections of seams.

3. Spot welding or seaming: Used to repair small tears (less than 2 inches long), pinholes or other minor localized flaws.

4. Capping: Used to repair large lengths of failed seams.

5. Removing the seam and replacing with a strip of new material.

F. In addition, satisfy the following procedures:

1. Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than one (1) hour prior to the repair.

2. Clean and dry all surfaces at the time of repair.

3. The repair procedures, materials, and techniques must be accepted in advance of the specific repair by the CQA Inspector, CQC and installer.

4. Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches.

5. Unless otherwise instructed by the OWNER, cut geomembrane below large caps to avoid water or gas collection between the sheets.

G. Verification of repair:

1. Number and log each repair.

2. Non-destructively test each repair using methods specified in this Section.

3. Destructive tests may be required at the discretion of the CQA Inspector or CQC.

4. Reconstruct repairs until tests indicate passing results.

3.21 LEAK LOCATION INSPECTION

A. The Contractor shall retain the services of a Leak Location Subcontractor. The Leak Location Subcontractor shall meet the following requirements

   1. Demonstrate successful inspection services equivalent to those required for 10,000,000 sq ft of geomembrane.

   2. Demonstrate 5 years experience of services equivalent to those required for the leak location inspection.

   3. Provide a minimum of 5 references for liner inspections of facilities similar to this project.

   4. The following leak location service providers are tentatively approved subject to verification of the above qualifications:

      a. Leak Location Services, Inc (210-408-1241)

      b. Enviroscan, Inc (717-396-8922)

      c. I-Corp International, Inc (561-369-0795)

B. The Contractor shall be responsible for site preparations and coordination as required by the Leak Location Subcontractor including:

   1. Providing adequate water to obtain required soil moisture content in geomembrane soil cover material, as determined by the Leak Location Subcontractor

   2. Providing electrical power.

   3. Maintaining insulating air gap between the soil cover material and the surrounding subgrade.

   4. Contractor shall take all precautions necessary to prevent shock hazards to workers from leak location survey.

   5. Leak location survey shall be completed following complete installation of soil cover layer(s) over the geomembrane except for repairs to liner as identified during the leak location survey.

C. Leak Location Performance Test: The preparations, operation of the leak location system, and leak location survey parameters shall be verified by performing tests over a test hole placed in the geomembrane. The test parameters and procedures shall be:

   1. A test hole with a diameter of 0.25 inches shall be made in the geomembrane. A punch or other suitable instrument shall be used to remove rather than displace the material in the hole. Burrs must be removed from the edges or bottom of the test hole. The test hole must be made in an area where the geomembrane has intimate contact with underlying soil. Test hole shall be located at least 50 feet from the edge of the geomembrane. The location of this test hole shall be recorded and

documented.

2. The Leak Location Subcontractor shall conduct a test survey over the test hole to establish the survey spacing parameters based on an evaluation of the signal to noise ratio.

3. The Contractor shall submit the plan for the Leak Location Performance Test to be reviewed and approved by the Engineer. Leak Location Subcontractor shall not start the leak location performance test prior to plan approval.

D. The leak location data shall be taken on survey lines spaced no farther apart than twice the leak detection distance determined for a 0.25 inch-diameter leak as determined in the performance test. The measurement electrode spacing shall be no less that used for the performance test. The spacing between measurements shall be no more than that used for the performance test. Data shall be recorded, plotted and analyzed for leak signals.

E. The installer shall uncover and inspect areas identified by the Leak Location Contractor as possible defects in the geomembrane liner. Defects shall be repaired by the installer. Suspected defect areas and or repairs shall not be covered prior to inspection by the Engineer.

F. All potential geomembrane liner defects identified during the leak location survey shall be repaired and noted on the record drawings by the Contractor.

G. Additional leak location survey data shall be collected near the located leak after the leak is repaired or electrically isolated to ensure no additional leaks are present. The survey data shall be repeated on the two closest survey lines for a distance extending 20 feet before and beyond the leak. If another leak signal is detected, this process shall be repeated until no additional leaks are detected.

H. A report documenting the electrical leak location surveys shall be submitted within 14 days of the completion of each leak survey. The reports shall document the methodology used, the locations and descriptions of the leaks, and a diagram of the facility showing the approximate leak locations.

3.22 GEOMEMBRANE ACCEPTANCE

A. OWNER will accept geomembrane installation when:

1. The installation is finished.

2. All required CQC and Installer records have been received.

3. Test reports verifying completion of all field seams and repairs, including associated testing and leak location inspections are found to be in accordance with project requirements.

4. Written certification documents, installers warranty, as-built documentation, and record drawings have been received and accepted by the OWNER.

END OF SECTION 02664B

Int Team
D-13-100638

Central Landfill
Operating and Maintenance Plan

Matanuska-Susitna Borough
October 2010

Central Landfill 2010 Permit
Application
Attachment N

CENTRAL LANDFILL
OPERATING PLAN
October 2010

CONTENTS Page

1.1 INTRODUCTION

1.1.1 OBJECTIVES

This Operating Plan has been developed for Central Landfill as a revision to the 2006 Central Landfill Operating Plan. Specific objectives of this operating plan are as follows:

- The primary goal of this Operating Plan is to provide guidance for achieving sanitary, environmentally acceptable solid waste disposal operations within the Borough's Central Landfill.
- The secondary goal of this Operating Plan is to maximize the user life of the landfill site by enhancing operational efficiency, standardizing procedures for daily operations, and establishing policies for handling of special wastes, including a separate cell specifically designed to accept construction and demolition (C&D) waste.
-

This Operating Plan will be amended, as necessary, to reflect changes in the design and operation of the facility.

1.1.2 PLAN IMPLEMENTATION

This Operating Plan will serve as a guide for directing the Borough's Contractor in performing operations and maintenance services at Central Landfill. The present contract between the Matanuska-Susitna Borough and Alaska Construction and Paving runs through September 2013.

1.1.3 REVIEW AND UPDATING OF OPERATING PLAN

This Operating Plan is based on the current facility design and operation. The current design includes the Central Landfill's first lined cell, which began accepting waste in June of 2004. Any change in the design or procedures will necessitate a modification in this plan to reflect those changes.

Since the maximum term of a State of Alaska Solid Waste Disposal Permit is limited to 5 years, it is recommended that this plan be revised so as to be in phase with the permit renewal. This will also allow for the inclusion of future lined cells and changes in operational practices.

Hydro-geological studies (July, 1993, by Steve R. Rowland, P.E.) concluded that, "the existing Central Landfill is located in an area which is geologically and hydro-geologically, relatively, well suited for landfilling."

1.2 LANDFILL SITE CONDITIONS

1.2.1 SITE DESCRIPTION

Central Landfill is located at Milepost 3 of the Palmer-Wasilla Highway, between the City of Palmer and Wasilla, Alaska. The site is located at the southern end of North 49th State Street, accessible from the north via the Palmer-Wasilla Highway . A map showing the location can be seen on Sheet 1 of the permit application drawings. The 620-acre site is legally described as:

S ½ Section 1, E ½ SE ¼ Section 2, NE ¼ NE ¼, E ½ NW ¼ NE ¼ Section 11, N ½ NW ¼, N ½ SW ¼ NW ¼, N ½ SE ¼ NW ¼, NW ¼ NE ¼ of Section 12, Township 17 North, Range 1 East, Seward Meridian, Alaska.

Active landfilling is currently limited to an approximately 160-acre section of the property, and is shown in Sheet 3 of the permit drawings.

This section of the site has been developed by construction of two existing unlined landfill cells, scales, transfer site, maintenance/equipment area, groundwater monitoring wells, and gas monitoring wells as shown on the Sheet 3 and 4 of the permit drawings. Sheet 3 also shows the location of the C&D Cell located on the western edge of the landfill's active area as well as the lined Cells 3 and 2B which is located south of the Cell 2A.

Fill operations in the first cell, located in the northwest corner of the site, began in 1980. Use of this cell ended in the summer of 1987, when operations began in a second cell located immediately east of the original fill area. Closure of Cell 1 was completed in 1988. In fall 1987, operations began in the currently active Cell 2A.

The existing fee collection system was established in 1993 following construction of scales and scale house. The on-site transfer facility (360 cubic yard capacity), which became operational January 1, 1994, serves the general public and eliminates all but commercial vehicle access to the working face of the landfill. There are recycling drop-off bins and a household hazardous materials drop-off area to the west of the scale house located in the Household Hazardous Waste Facility which also houses the administrative personnel.

1.2.2 GEOMORPHIC AND GEOLOGIC DESCRIPTION

Surface forms throughout the site can be classified as ice disintegration features (kames, kettles, and eskers) composed of both ice contact stratified drift and pro-glacial pitted outwash deposits. Many of the features may also be defined as disintegration ridges or hummocky ablation drift. The active landfill area appears to be at the margin of two types of glacial drift deposits with kame and esker features being predominate to the south of the active landfill and hummocky topography to the north. Drill logs and inspection of large excavations on the property and adjacent properties confirm the surficial features and indicate that till deposits and a large glacial lake deposit are buried beneath the stratified drift and coarse pitted outwash deposits. Bedrock was logged in one well located immediately to the west of the landfill at an elevation of approximately 18 feet below sea level. Materials encountered in the drill holes located around the site are typical of the glacial drift deposits described. The stratigraphic sequences and gradations are extremely varied on a small scale but appear to show some general consistency over the entire depositional sequence.

Of primary significance is what appears to be a relatively consistent unit of lake type lucustrine sediment. This unit was encountered in all deep test borings and monitor wells located on the landfill property and also in many of the domestic wells in the vicinity of the landfill. In the domestic wells nearest the north boundary of the landfill property, this deposit is logged as 120 to 150 feet thick. Test borings in the landfill area extended into the clay unit as much as 70 feet without penetrating the sediment. MW-16 located 2000 feet south of the active landfill was over-bored to a depth of 278 feet (elevation 1.9 feet above sea level) and encountered a 45-foot thick unit of clayey sand and gravel which appears to be the southern extension of the clay unit. Grain size analysis of representative samples indicates that the sediments are predominately lean clay and silty clay with some fine silt and sand stratification. Penetration tests performed in the clay unit show that it is over consolidated. This is likely due to having been overridden during one or more glacial advances.

Subsurface stratigraphy is depicted graphically in cross-section drawings attached to the July 1993 Hydrogeologic Investigation report.

1.2.3 ENVIRONMENTAL DESCRIPTION

CLIMATE

Central Landfill is located in a transitional climate zone where temperature variations, precipitation, cloudiness, humidity, and surface winds are milder than in maritime or mountainous zones. The mountains located to the south tend to bar the moist Pacific air, moderating the amount of precipitation. The mountains to the north and east protect the area from cold air from the Interior.

Mean annual temperature for the area is about 35F, with a range of about -38F to 87F. Average annual precipitation is about 16 inches: 47 inches of snow and 10 inches of rain. September is typically the wettest month. March is typically the driest month, averaging only 0.5 inches. Maximum snow accumulation occurs in December, averaging nearly 12 inches.

VEGETATION AND WILDLIFE

The existing 160-acre landfill site is characterized by mixed stands of cottonwood and birch forest, interlaced with other vegetative communities such as meadows, herbaceous and shrubby vegetation, and willow/alder thickets.

During the spring, the coastal areas south of Central Landfill serve as resting and staging areas for hundreds of thousands of migratory waterfowl. Numerous waterfowl remain to nest. Two species of swan, three species of geese, and several duck species and shorebirds utilize the adjacent areas. Bald eagles are commonly observed in or near the landfill site. Other raptors seen in the area include golden eagles, red-tailed and rough-legged hawks, merlins, goshawks, and hawk owls. Ravens and seagulls are common residents of the landfill site.

The most visible large mammals in the area are moose. The Palmer Hay Flats, located to the south, provides both wintering and calving habitat. Black bear, mink, and red fox have been observed in the area. Fur bearing, Muskrats are abundant throughout the general area. Other common species include snowshoe hares, meadow voles, and masked shrews.

LAND USE

Central Landfill property is currently classified as reserve-use lands, with current and future use of the land dedicated for use as a sanitary landfill site. Formal classification of the land occurred in August 1989. Private residences are located adjacent to the site and a residential subdivision is located to the north of the site. Other existing uses of the property adjacent to the existing active portion of the landfill include cross-country skiing. The Borough maintains a number of popular ski trails along the perimeter of the existing fill areas, known as the Crevasse Moraine Trail System. The site also provides habitat for a wide range of wildlife species.

1.2.4 REGULATORY CONSTRAINTS

Municipal solid waste disposal is governed by federal, state and local regulations. A brief summary of the major regulatory constraints is provided below.

FEDERAL REGULATIONS

Existing federal regulations concerning solid waste (MSW) landfills are codified in 40 CFR 257. These are minimum requirements that must be incorporated into solid waste regulations promulgated at the state level. The federal government does not directly handle enforcement of these requirements; that role is delegated to the individual states as part of their mandate to implement these standards.

A more comprehensive set of regulations governing MSW landfills has been adopted by the U.S. Environmental Protection Agency (EPA) under Subtitle D of the Resource Conservation and Recovery Act (RCRA). These regulations are codified in 40 CFR 258. As with existing regulations, these requirements have been incorporated into State of Alaska regulations (18 AAC 60), and the Alaska Department of Environmental Conservation (ADEC) is responsible for carrying our design review, permitting, inspections, and enforcement.

STATE REGULATIONS

ADEC is the state agency responsible for administration and enforcement of the requirements of 18 AAC 60, Solid Waste Management. The commissioner of ADEC is designated by EPA as the director of the state solid waste management program, not the solid waste program manager. The state of Alaska received full approval from EPA of their municipal solid waste management program in early 2000, therefore, the municipal landfill portion of the state regulations supersede the federal 40 CFR 258 regulations.

Specific requirements for operation of Central Landfill are addressed in the Borough's current waste disposal permit (No. SW1A007-10) as renewed or amended.

LOCAL REGULATIONS

The Matanuska-Susitna Borough has promulgated municipal ordinances, relating to solid waste issues. Applicable local requirements defined in the Matanuska-Susitna Borough Municipal Code include the following:

- Chapter 8.04, Sanitary Fill Sites.
- Chapter 8.20, Solid Waste Disposal.
- Chapter 10.12, Abatement of Abandoned Vehicles.

1.2.5 UTILITIES

A 400 amp, single-phase pedestal mounted electrical service is in-place just north and west of the scale house. The distribution panel is located in the scale house and controls power to the scales, all-exterior lighting (including the access roads, transfer station, and working face) and heat to the hazardous materials collection area. Natural gas service is located at the scale house to provide heat to the building. Telephone services extend to the gatehouse used by the Matanuska-Susitna Borough gate attendants. The drinking water well located to the north of the animal control facility also supplies water to the scalehouse. A septic system is located to the east of the scalehouse.

Three phase power is connected to the Household Hazardous was facility as well as natural gas service. This facility also has a drinking water well which is located to the north east of the facility. This building also has its own septic system which is located to the North west of the facility.

1.2.6 SITE ACCESS AND CONTROL

Good public access is provided by the Palmer Wasilla Highway, also North 49th State Street, a paved secondary roadway connecting the landfill site to the Palmer-Wasilla Highway (located north of the site). On-site access roads consist of paved roadways and well-maintained gravel roadways leading to the active fill area and to the transfer facility. Perimeter fencing provides site control. There are three separate lockable gates that are located near to the North 49th State Street entrance.

1.3 PHASED FILL OPERATIONS

1.3.1 OBJECTIVES

A number of specific short term and long term objectives have been identified for the phased fill operations, and this operating plan will be used for guidance in implementing management practices to meet those objectives. Construction-specific goals are as follows:

Short Term

- Provide sufficient volume capacity within the current active area for refuse disposal area until an additional lined Cell is ready to accept waste.
- Continue operations of the construction and demolition cell.
- Attempt to achieve a compaction rate of at least 1000 pounds per cubic yard.
- Adequately compact and cover solid wastes disposed of on a daily basis without excessive use of cover material. Continue to utilize alternative daily cover when appropriate.
- Conserve on-site soil cover material and coordinate development of cover borrow sources with planned phases of cell construction.
- Construct the finished fill with appropriate grade and configuration for planned post-closure use.

Long Term

- Provide sufficient volume of lined cell capacity within planned expansion area to provide refuse disposal through 2016 for Cell 3.

- Promote waste reduction and recycling through practices, public education and by example.

- Continue operations of the construction and demolition cell during the life of the solid waste permit.

- Adequately compact and cover solid wastes disposed of in Cell 3 on a daily basis without excessive use of cover material. Utilize alternative daily cover when appropriate.

- Conserve on-site soil cover material and coordinate development of cover borrow sources with planned phases of cell construction.

- Construct a finished fill with appropriate grade and configuration for planned post-closure use.

- Develop plans for design and construction of landfill expansion with lined cells.

1.3.2 FILL METHOD

The active refuse disposal area of the Central landfill is an area-type fill operation. Daily solid waste is disposed of the active face by spreading and compacting with cover material spread and compacted over it. Native soils excavated from other portions of the site are used as daily cover material. Alternative daily cover consisting of tarps is also used on a regular basis.

Refuse is offloaded on top of the active cell, and pushed onto the working face in layers with on-site equipment. Each layer is compacted as the filling progresses over the course of the day, or until the compacted wastes reach a height of 8 to 10 feet. At that time, and at the end of each day's operation, a 6 to 12 inch layer of cover material is placed over the completed fill. Cover material is typically imported from borrow areas in other areas of the site, or obtained from previously constructed stockpiles.

The length of the fill is dependent upon daily volumes received and the efficiency of the landfill equipment "pushing" the refuse. The working face is generally maintained at a horizontal to vertical slope of 4:1 or less. Modern landfill compaction equipment performs well on moderate grades, but tends to be less effective at slopes of more than 3: 1.

A completed daily fill, including the cover material, is sometimes referred to as a cell. This daily cell is not to be confused with the landfill development area, also referred to as a cell. Subsequent filling operations proceed from these previously completed daily cells, placed adjacent to one another, until a lift has been completed. Typical lifts are constructed in increments of approximately 10 feet of vertical fill and are composed of several layers of daily cell construction. Effective planning of lift construction minimizes the cover soils used and maximizes the fill volume of the final landfill envelope. Successive lifts are placed on top of one another until the final grade is reached, at which point a final cover is provided.

C&D Disposal

Central landfill C&D Cell is an area-type fill operation. C&D waste is deposited, spread and compacted as needed during the working day to minimize wind blown litter. C&D waste is offloaded at the toe of the active C&D cell working face, and pushed onto the working face in layers with on-site equipment. Each layer is compacted as the filling progresses over the course of the day until the compacted wastes reach a height of 8 to 10 feet. After reaching the prescribed fill height, the working face moves forward as the next series of lifts are placed. At least once per month, a 6 to 12 inch layer of cover material is placed and compacted over the completed fill. Compacted soil cover may be placed more frequently depending upon the types and amounts of C&D waste deposited in the cell. Cover must be applied shortly after deposition of light objects that could be blown out of the cell by wind. It may be advisable to direct waste containing light objects to the municipal cell if it is windy. Cover material is typically imported from borrow areas in other areas of the site, or obtained from previously constructed stockpiles.

The length of the fill is dependent upon daily volumes C&D waste received and the efficiency of the landfill equipment "pushing" the waste. The working face is generally maintained at a horizontal to vertical slope of 4:1 or less.

Effective planning of lift construction minimizes the cover soils used and maximizes the fill volume of the final landfill envelope. Successive lifts are placed on top of one another until the final grade is reached, at which point a final cover is provided.

1.3.3 FILL PLAN

Current fill operations are occurring in Cell 3 and are expected to continue there until fill elevation reaches the elevation of the adjacent cells 2A and 2B to an elevation of 340 feet above sea level.

Final filling over both areas will result in a cumulative capacity of approximately 1.93 million cubic yards. Final contours and drainage paths for the completed fill are shown in the Memo from Technical Field Services. The location of future cells has been further outlined with the completion of a new sequencing plan (Central Landfill Future Cell Sequencing Plan, Onsite Leachate Treatment Evaluation, and Closure Cost Evaluation, CH2M Hill, 2006).

The development plan will be re-evaluated on an annual basis to take into account the actual quantities of refuse being filled and the amount of cover material excavated. The annual topographic mapping will be checked to confirm that the operational fill plan is being followed via the placement of fill in the designated area.

Lined Cell 3

Care must be exercised when applying the first layer of waste in the lined Cell 3 in order to avoid damaging the liner. Although a two-foot soil drainage layer exists over the liner, some objects could penetrate the layer and puncture the liner. In addition, only municipal waste from packer trucks was placed as the first layer. The steel wheeled compactor will not be operated in the lined cell until at least 6 feet of waste was placed in the cell.

Waste must be filled across the floor of 3 from north west to North east. Piling waste too high next to Cell 2A without extending the toe of waste south across Cell 2B could result in unstable conditions that could result in a landslide of waste.

Separation of Cell 2A and Cell 3

As waste is filled in both Cell 2A and 3, the operations contractor will construct a berm consisting of cover material between the cells. This separation berm will be maintained between Cell 2A and Cell 3 as subsequent lifts are constructed. The berm will be constructed at a 1:1 (horizontal to vertical) slope from the landfill base to the top of the fill.

1.4 WASTE DISPOSAL OPERATIONS

This section presents technical guidance for the day-to-day operation of Central Landfill, including construction of a refuse lift and cell, methods of compaction, sequencing of lifts, and placement of interim and daily cover within the site. Methods of construction and interim stages of the landfill development are discussed herein.

This information is directed toward activities directly associated with daily municipal refuse disposal operations. Special waste issues are discussed in Section 1.5 of this document, while Landfill closure is addressed in Section 1.7.

1.4.1 OPERATING HOURS

Central Landfill is open to the public from 7:00 a.m. to 6:00 p.m., Monday - Friday and 9:30 a.m. to 4:30 p.m., Saturday & Sunday. Commercial haulers and private citizens are allowed to deposit refuse throughout the 11 hour operating day. The majority of landfilling activities occur within the authorized operating hours. Additional activity, such as emergency equipment repair, planned equipment repair or maintenance, or arrival of special refuse loads, may infrequently occur outside of the stated operation hours. The frequency of these activities is expected to be negligible in comparison to normal operating requirements.

The facility entrance gate is locked when the permittee or their designee are not at the facility for the purpose of access control.

Refuse Disposal

For operational efficiency, refuse commercial haulers are encouraged to time their off-loading during the period of 7:30 a.m. to 4:00 p.m. Off-loading in later portions of each day is confined to a smaller area of the refuse working face than during the peak use periods, and compaction and cover placement timed to assure completion by the end of the shift.

Spreading and compacting of refuse at the working face occurs throughout the work shift. The final 2 hours of each shift are dedicated to placement of daily cover material and maintenance of prior fill areas. Scheduling of on-site equipment maintenance or repairs should consider historic peak use periods and level of effort to assure completion of compaction and cover material placement at the end of each day.

C&D Disposal

For operational efficiency, commercial C&D Waste haulers are encouraged to time their off-loading during the period of 7:30 a.m. to 4:00 p.m. Off-loading in later portions of each day is confined to a smaller area of the C&D Cell working face than during the peak use periods.

Spreading and compacting of C&D waste at the working face of the C&D Cell occurs throughout the work shift. Several hours of each shift, seven days a week, are dedicated to final daily compaction and placement of cover material as needed for litter control. On a monthly basis the contractor shall ensure placement and compaction of sufficient cover material to result in a 6-inch thick layer of compacted soil being placed over the preceding months, in-place C&D Waste. Scheduling of on-site equipment maintenance or repairs should consider historic peak use periods and level of effort required to assure completion of compaction and cover material placement.

1.4.2 DISPOSAL PRACTICES

UNLOADING REFUSE WASTES

Passenger vehicles and light trucks will be routed to the public disposal wall. Commercial haulers and large vehicles will be routed directly to the working face. The control and coordination of these incoming vehicles is an important issue for operational efficiency and site safety. Gate personnel and highly visible direction signs along the interior access roads will direct incoming vehicles.

Trucks arriving while the first truck is unloading will take up succeeding positions along the working face.

Private Citizens hauling their own waste to the landfill are to be directed to the public disposal wall, away from active equipment operation. Signage clearly indicates areas for use by small-quantity private haulers, and sufficient separation maintained from the large commercial trucks to avoid crossover by either vehicle type.

As large vehicles unload and leave the working face, the operator will push the refuse up the face of the cell, spreading and compacting the refuse in lifts no more than 3 feet thick. Construction of a cell from the bottom up generally results in better compaction and less litter dispersal.

By permit, the working face at Central Landfill is limited to less than 200 feet. The number of vehicles that must be accommodated determines actual width. For operating efficiency, the width of the working face is limited to reduce litter dispersal and concentrate spreading and compaction efforts of the landfill equipment to a smaller area.

The maximum width of 200 feet is expected to be sufficient to accommodate peak incoming traffic for future operations.

Salvaging of refuse is not allowed at the Central Landfill.

UNLOADING C&D WASTES

All vehicles carrying C&D Waste, including passenger vehicles, light trucks, commercial haulers and large vehicles will be routed directly to the C&D Cell working face. The control and coordination of these incoming vehicles is an important issue for operational efficiency and landfill site safety. Gate personnel and highly visible direction signs along the interior access roads will direct incoming vehicles. Vehicles arriving while another vehicle is unloading will take up succeeding positions along the C&D Cell working face.

Private citizens and generators of small quantities of C&D Waste will be encouraged to keep their C&D Waste separate from their MSW, by being offered a disposal cost savings. If it is determined to be necessary, signage will be used to indicate the area of the C&D Cell working face set aside for use by small-quantity private haulers. In any event, separation maintained from the large commercial trucks to avoid crossover by either vehicle type.

As large vehicles unload and leave the working face, the operator will push the refuse up the face of the cell, spreading and compacting the refuse in lifts no more than 3 feet thick. Construction of a cell from the bottom up generally results in better compaction and less litter dispersal.

Based upon current estimated volumes of C&D Waste, it is estimated that a 75-foot wide working face will be of sufficient width to allow vehicles room to off-load the C&D Waste. The number of vehicles that must be accommodated determines actual width. For operating efficiency, the width of the working face will be limited to reduce litter dispersal and concentrate spreading and compaction efforts of the landfill equipment to a smaller area.

Salvaging of C&D Waste is allowed by the general public after they have filled out a MSB waiver.

REFUSE COMPACTION

Wastes are compacted at the working face to an initial density of approximately 1,000 pounds per cubic yard using a steel-wheeled compactor. The slope of the working face is kept at 4:1 or flatter to ensure adequate compaction. Wastes are pushed onto the working face in layers not more than 2 feet thick. Each layer receives between 3 and 5 passes from a compactor. The completeness of the compaction can be judged in the field by noting when the "spring-back" of the refuse has been reduced to a minimum. Another test for adequate compaction is to note when the compactor cleats do not sink into the refuse, but instead are visible "walking" on the refuse as they pass over it.

C&D WASTE COMPACTION

Wastes are compacted at the working face to an initial density of approximately 800 pounds per cubic yard using a steel-wheeled compactor or a D7 or equal Bull Dozer. The slope of the working face is kept at 4:1 or flatter to ensure adequate compaction. Wastes are pushed onto the working face in layers not more than 3 feet thick. Each layer receives between 3 and 5 passes.

1.4.3 TYPES OF WASTE ACCEPTED

Central Landfill receives primarily municipal solid wastes consisting of household and commercial refuse as well as construction and demolition (C&D) wastes. These wastes are disposed of in accordance with the procedures described in this section.

A number of special waste types are collected or disposed of at the landfill, which require special handling and procedures. These wastes include:

- Bulk wastes and "white goods" (washers, refrigerators, etc.).
- Construction-demolition debris.
- Asbestos.
- Road kills and euthanized animals.
- Tires.
- Lead-acid batteries
- Anti-Freeze
- Paints and solvents
- Hospital wastes (properly pre-treated and containerized).
- Used Oil.
- Contaminated soil
- Junk Vehicles

Materials, which are not accepted for disposal, include:

- Hazardous wastes [as defined in 40 CFR 261, in quantities in excess of 100 kilograms (25gallons); must be disposed of in accordance with 40 CFR 262, Standards Applicable to Generators of Hazardous Waste.]
- Sewage sludge.
- Septage.
- Compressed gas cylinders (unless empty with the valve removed).

These materials are prohibited from land disposal by federal, state, or local regulation, and are handled best by recycling or recovery, or pose an immediate health risk or danger for landfill personnel.

BULK WASTES AND "WHITE GOODS"

Bulk wastes such as discarded furniture, telephone poles, wood debris are disposed of at the C&D disposal area.

Bulk wastes are placed as low in a lift as possible to ensure that they are well bedded before daily cover is applied. Large pieces of electrical equipment are checked for the presence of PCB-containing capacitors, which must be removed prior to landfilling. The waste generator must certify that their waste is free of PCB oil.

"White goods," such as enamel-coated stoves, washers, and dryers are placed in a separate area for recycling.

Refrigerators and freezers must be empty of Freon gases before they can be disposed. It is a violation of federal law to vent or allow these gases to escape into the atmosphere. The gas must be extracted from these appliances by a certified technician before they can be landfilled.

Most refrigerators and freezers are sent to a scrap metal recycler after the Freon has been removed and are typically not landfilled.

CONSTRUCTION DEMOLITION DEBRIS

Waste quantities are dependent on the amount of construction activity occurring within the Borough, and can vary drastically from year to year. Central Landfill C&D Cell will receive various types of "inert wastes." These wastes will be disposed of in accordance with the procedures described in this section and include:

- Construction/Demolition debris from private, commercial, and/or governmental sources.
- Clearing and grubbing materials i.e. root balls and large diameter trees.
- Yard Waste.
- Coal power plant ash.
- Auto fluff (from auto salvage operations).
- Concrete and pavement rubble.
- Sheet rock

On-site salvage activities by the general public is allowed within the C&D area by members of the public who have a signed MSB waiver on file in the scalehouse. Salvaging is only allowed while the Contractor is not actively compacting or consolidating materials. Recycling bins are located near the gatehouse for public convenience and to minimize salvaging by the operator at the face. Used oil and batteries are accepted in the Household Hazardous Waste Facility to reduce quantities going into the landfill.

ASBESTOS

Asbestos-containing wastes are accepted and disposed of at Central Landfill. Special handling and disposal procedures for asbestos are as follows:

- The generator must provide the landfill operator with a completed disposal authorization form. The landfill operator will then issue a letter of authorization to the asbestos generator.

- The generator must provide notification to the landfill operator 24 hours in advance of delivery of any asbestos-containing materials to the landfill.

- The waste load must be accompanied by an Asbestos Disposal Authorization, a letter format authorization from the Matanuska-Susitna Borough to use the disposal area (including instructions and prohibitions concerning use of the disposal area).

- Incoming wastes must be logged at the landfill gate to identify the date of delivery, name of transporter and demolition contractor, place of origin, type of asbestos and volume or weight of wastes delivered.

Wet asbestos wastes must be delivered in sealed, leak-proof containers, drums, or double plastic bags identified with the proper warning label(s) that state:

DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD

Non-friable asbestos-containing materials are not required to be packaged or labeled, unless handling risks the release of asbestos fibers.

All Asbestos-containing wastes will be offloaded in a specially designated portion of the landfill in the presence of a landfill employee. Asbestos containers and non-friable materials will be placed carefully at the asbestos disposal area to avoid breakage and the release of asbestos fibers. The wastes must be covered with at least 6 inches of soil cover by the end of the workday.

ROAD KILLS AND EUTHANIZED ANIMALS

Central Landfill has a designated disposal area for animal carcasses resulting from road kills and euthanizations carried out by area veterinary hospitals and clinics.

Incoming animal carcasses are to be identified by the disposer at the landfill gate. The hauler will be directed to a designated area near the working face for animal disposal. After placement of the carcasses in the designated area, the carcasses are to be immediately covered with 6 to 12 inches of cover material.

TIRES

Tires are currently disposed of in the C&D cell of the landfill and are handled similar to bulk wastes. Tires will be placed as low in a lift as possible to ensure that they are well bedded before daily cover is applied. Tires will be well mixed with other C&D materials to minimize the presence of voids inside and around the tires.

HOSPITAL WASTES

Infectious wastes and other medical wastes are generated by Mat-Su Regional Medical Facility, the Pioneer Home, various area clinics, and private medical practices. Infectious wastes must be autoclaved or treated in an incinerator, retort, or other approved process to render them sterile before being transported to the landfill. Those wastes must then be kept in sealed, properly labeled containers until they are disposed of. All sharp objects such as needle, blades, and glass must be segregated from the general medical waste stream and stored in impervious plastic, glass, or other puncture-proof containers capable of maintaining their structural integrity from the point of storage to deposition at the disposal site.

Incoming wastes are to be identified at the landfill gate by the hauler and inspected by landfill personnel. Improperly treated or packaged hospital wastes are to be turned away at the gate and returned to the source for corrective action.

Spreading and compacting of these wastes is not to occur in areas of the working face accessible to the general public. Hospital wastes are to be placed low in the lift and other municipal refuse immediately placed over it to prevent exposure of personnel or the public to the material.

1.4.4 COVER MATERIAL

COVER AND SOILS USAGE

ALTERNATIVE DAILY COVER

Approved alternative daily cover may be used at intervals appropriate to the given conditions. These may include films, tarps, foams or other acceptable to the operating permit. These types of cover systems must be used in a manner that is consistent with the operating permit.

REFUSE DISPOSAL

Cover soil is spread and compacted to a minimum thickness of 6 inches over all municipal solid waste disposed of each day. No waste is left uncovered at the end of the day. Daily cover serves a number of important purposes:

- Prevents rodent and flies from feeding and breeding in and around the refuse disposal area.
- Minimizes the potential for fires in the refuse.
- Controls blowing litter from the working face.
- Controls odors from the working face.
- Reduces moisture reaching the fill and aids the effectiveness of the surface run-on/run-off controls.

Daily cover is placed to an average loose, uncompacted thickness of about 12 inches. The soil is compacted by the weight of the loader/dozers used in its placement. Following initial compaction of the soil cover and infiltration of some of the soil cover into the underlying waste lift, the compacted daily cover thickness will be not less than 6 inches on average.

C&D WASTE DISPOSAL

Spreading and compacting of C&D waste at the working face of the C&D Cell occurs throughout the daily work shift. On a monthly basis the landfill contractor will cover all C&D materials placed during the month. The contractor shall ensure compaction and placement of cover material as needed for litter control.

Cover soil serves a number of important purposes:

- Minimizes the potential for fires in the C&D Waste.
- Controls blowing litter from the C&D Cell working face.
- Aids the effectiveness of the surface run-on/run-off controls.

SOURCES

All soil used for daily cover will be excavated from on-site borrow areas. The preferred material for daily cover application is glacial outwash, which is available on site. This soil is generally a granular, free-draining material. It is, therefore, relatively easy to excavate, haul, and compact on top of each daily cell. Because of its porous nature, it does not tend to confine landfill gas movement.

The operator shall avoid undercutting slopes or creating steep slopes that could pose a landslide safety hazard. If slopes become too steep, earth should be pushed from the top of the slope down until a less steep slope is obtained.

STOCKPILING AND BORROW OPERATIONS

Stockpiling of glacial outwash materials for daily and interim cover for use during winter operations is sometimes required at the Central Landfill. Stockpiled material for winter use should be covered with a tarp to prevent precipitation from entering the material. If the material is fairly dry, it will still be workable in the winter. It will be necessary to anchor the tarp down with tires roped together over the tarp.

Sources and stockpile areas will be planned and located concurrent with the development of individual fill areas. The following constraints will be observed:

Soil stockpiling will occur inside of the perimeter buffer zone and where noise and visual impacts on adjacent property owners are minimized.

Whenever possible, soils will be taken directly from an excavation (borrow) area and immediately used in landfill operations rather than being stockpiled.

Material stockpiled for winter use should be relatively dry with minimal fines.

1.4.5 LANDFILL EQUIPMENT

The landfill process at Central Landfill consists of six basic operations:

1. Construction and maintenance of access roads and trails to various areas within the site, including snow removal and dust control.

2. Depositing of refuse by Regulatory Commission of Alaska (RCA) certificated haulers, transfer boxes, and other commercial/private haulers, and at the active working face.

3. Spreading the refuse into lifts.

4. Compacting the refuse.

5. Covering the compacted refuse with soil material.

6. Excavation, hauling, and stockpiling of on-site cover material.

These operations require different types of heavy construction equipment. Typical construction equipment used in landfill operations includes bulldozers, compactors, loader, and scrapers. Bulldozers are used for initial pushing and spreading of refuse into lifts and ripping of soil during cover material extraction. Landfill compactors are primarily used for final compaction of the refuse, though they can also be used to assist with spreading refuse. Loaders, scrapers, or dump trucks are used to excavate, haul, and spread daily cover materials.

- Equipment types for Central Landfill are as follows:

- A track-type bulldozer, equivalent in size to a Caterpillar D7, to push, spread, and compact refuse at the working face; the bulldozer is also used to help loosen and move cover material.

- A solid waste compactor, equivalent in size to a Caterpillar 826 landfill compactor, with chopper wheels, for final spreading and compacting of refuse at the working face.

- A heavy-duty loader, equivalent in size to a Caterpillar 966, for excavation of daily cover material.

- A heavy-duty dump truck with at least a 20 cubic yard capacity for hauling and placement of daily cover material.

In addition to these minimum disposal equipment needs, other heavy equipment may be periodically needed for proper site maintenance, including:

- A motor grader for on-site road maintenance.

- Belly-dump trucks to haul gravel for construction and maintenance of interior access roads.

- A water truck for dust control on interior access roads.

- A self-propelled vibratory compactor for construction of permanent, temporary, and interior access roads.

1.4.6 SITE ACCESS AND ROAD MAINTENANCE

ON-SITE ROADS

Three types of access roads will be used within Central Landfill. These access roads are defined as follows:

- Permanent access roads: Paved roads and all weather gravel roads designed to carry heavy traffic and loadings. These roads consist of two lanes of sufficient width (minimum 12-feet per lane) and loading strength to handle commercial haulers and transfer box loads. The roads are also subject to frequent, though short-term loadings by landfill equipment. The grades of these roads are maintained at 8 percent or less, with a minimum cross slope of 2 percent to drain surface water.

- Temporary access roads: Graveled roadways leading from the permanent access roads into the current fill area. These roads are approximately 20 feet wide and, for safety reasons, are designed for one-way traffic whenever possible. The grades of these roads are maintained at 10 percent or less. One-way roads will be graded to drain with a cross slope of at least 3 percent.

- Interior access roads: Haul roads constructed of native material placed on prior cells or natural soils leading directly to the working face. As cell construction proceeds along a lift, the material used in constructing the interior road will be incorporated back into the fill as cover soil.

The subgrade over which the permanent and temporary access roads are constructed may be undisturbed earth, refuse, or fill. The depth of rock stabilization and road base materials is governed by the integrity of the subgrade. When roads are constructed on a stable subgrade of rock or till, a road section consisting of 24 inches of gravel base material is acceptable. If the subgrade material has a high moisture content and is soft or subject to a relatively high degree of settlement, a deeper section of gravel is required to increase the stability and load capacity of the road.

Proper turn-around space should be maintained to accommodate the largest commercial vehicles using the landfill. The normal traffic pattern to the working face requires the truck driver to maneuver the vehicle to a common staging area and then back the truck in a rear-turning movement toward the active unloading area.

Movable traffic signs will be provided to separate truck traffic from the general public, as well as routes used by heavy earthmoving equipment.

ROAD MAINTENANCE

Maintenance of roads is required to be routinely performed on site. Smooth, well-graded driving surfaces allow vehicles to travel at recommended speeds without undue wear and damage. The road maintenance program used at Central Landfill includes: Periodic inspection, Periodic road grading, plowing, resurfacing, and litter control and cleanup.

A proper road maintenance program contributes to a positive public image. When conditions warrant, all-weather access roads (permanent and temporary) are graded to maintain a smooth surface and desired slopes. Additional road base material is applied to maintain a good wearing surface. Road conditions are regularly inspected, and necessary repairs made promptly.

During periods of dry weather, dust control may be required, and may be done by spraying the road surfaces with water. Winter operations require that access roads be maintained clear of snow.

1.4.7 SUPPORT FACILITIES

EXISTING FACILITIES

The 12' x 40' scale house includes space for scale attendants and office space for the Solid Waste Supervisor, each of who are full-time employees of the Matanuska-Susitna Borough. The scale house has bathroom and sink facilities for the exclusive use of the employees.

The 20' x 30' Administration Building east of the scale house is used by other departments within the Borough.

The 60'100' Household Hazardous Waste facility west of the scale house is used for Household Hazardous Waste collection, processing and for consolidation of materials prior to shipping as well as the mixing of latex paint. All activities associated with hazardous waste management are conducted in this facility. This facility also houses the administrative personnel, one Administrative Secretary I, Solid Waste Project Manager, Environmental Technicians, Abandoned Vehicle personnel, Transfer Site Supervisor and the Solid Waste Division Manager.

Secure storage containers are used to shelter the monthly hazardous waste collection programs and recycling bins are available.

The 3 eighty foot truck scales and associated computerized systems measure and record the weights of incoming and outgoing vehicles and generate billing information through a link with the Borough's mainframe computer system at its Palmer office. The general public access the landfill via the two truck scales located at the main gate. Most commercial haulers access the landfill via the third eighty foot truck scale located to the west of the main gate.

The general public is charged per load fees, cubic yard, for cars and pickups on windy days.

The three bay transfer facility accommodates three 120 cubic yard trailers for the general public to use for depositing solid waste. The drop off area and trailer area are covered.

On the west edge of the property adjacent to the C&D area is a 60' x 80' equipment warm storage facility. It is used by the Borough to store equipment and may be made available to the landfill contractor through coordination with the contract administrator.

1.4.8 STAFFING

PERSONNEL REQUIREMENTS

Staff needs for Central Landfill are based on waste quantities handled at the landfill, as well as staff responsibilities for landfill operations. The following employee classifications are currently employed by the Borough

Solid Waste Division Manager. This is a managerial and technical category. This individual is assigned total responsibility for landfill operation, environmental controls and their operation and maintenance, conformance with phased filling plans, permit compliance, and control of daily fill operations.

Solid Waste Project Manager. This is a primarily technical and project management position. This individual specifies work and sees each project through to completion including cell construction. The Project Manager is the contract administrator for the landfill operations contractor.

Environmental Technician. This is a technical position. This person oversees the hazardous waste program and also assists the Manager with oversight of the ground water and gas monitoring programs. This position is also responsible for conducting inspections and site evaluations.

Solid Waste Transfer Site Supervisor. This person is primarily responsible for the scheduling and customer service for the scalehouse and transfer site employees. This position is also responsible for running reports for materials analysis and for evaluating training requirements for division staff.

Solid Waste Utility Worker. This individual is responsible for identification of suspect loads, verification of permits for asbestos disposal, hazardous waste screening and general maintenance for the landfill and disposal areas.

Gatehouse Attendant. This individual is responsible for electronic record keeping associated with the landfill scales, fee collection, directing commercial/private haulers to the active fill area and general on-site record keeping.

The operations contractor will provide staff for the following services:

Waste screening
Waste compaction and cover
Excavation of cover material
Road maintenance
Road construction

The Borough also contracts with firms to provide staff for engineering design services, groundwater monitoring and analysis, household hazardous waste transportation, surveying and mapping.

1.4.9 SITE SAFETY

SAFETY PROCEDURES

General safety procedures to be used at the landfill include:

- Conduct a weekly walk-around safety inspection by a member of management and an employee who works at the site. Inspections will help provide safe working conditions for employees and functional safety equipment that is ready when needed.

- Conduct staff meetings providing the results of the weekly walk-around inspection, review hazards identified, and answer safety-related questions from employees.

- Provide personal protective gear for the safe handling of solid waste.

- Ventilate enclosed work areas, including trenches deeper than 3 feet, manholes, or any confined space.

- Prohibit eating, drinking, or smoking while working on the landfill. Require washing of the hands and face prior to work breaks.

- Prohibit smoking within 50 feet of any trenching or piping.

- Conduct periodic reviews of the safety procedures to assess their effectiveness. Make appropriate amendments to remedy any unsafe practices.

SAFETY EQUIPMENT

Solid waste personnel work in all types of weather, with many different types of heavy equipment, and with a variety of materials presenting diverse hazards. For this reason, safety equipment must be used and maintained in a sanitary and reliable condition. Personal protective equipment (for eyes, face, head, hearing, and extremities), protective clothing, respiratory devices, and other protective equipment must be worn whenever hazards of processes or environment are capable of causing injury. Employees whose duties are performed in high traffic areas, such as the working face, shall wear vests of highly visible materials and brightly colored hard hats when they are not inside equipment or truck cabs.

First aid kits will be located at the scale house, hazardous waste facility, administration building, and in all crew trucks and landfill equipment. The size and quantity of first aid kits required at Central Landfill will be determined by the number of personnel normally dependent on each kit.

First aid kits are kept up to date by a contractor who specializes in first aid kit maintenance. In addition, eyewashes will also be accessible to landfill employees for use in the event of exposure to injurious materials which is located in the hazardous waste facility.

Most importantly, all employees will be familiarized with the operation and location of emergency equipment during annual safety training.

OPERATIONS SAFETY

Transporting and unloading solid wastes is a serious area of safety concern. Uncontrolled dust, differing flows and directions of traffic and operational equipment, and equipment operation angles pose dangers to those in the vicinity of the working face. For these reasons, safeguards are to be provided on landfill equipment to protect the operator and the vehicle. Landfill equipment is to be provided with seatbelts and enclosed rollover protective cabs to protect the operator from accidents, weather, and flying debris. Filtered forced-air ventilating systems in the cabs should be provided for safe, dust-free airflow to the equipment operators.

Landfill personnel who direct the placement of the delivery vehicles must take care to maintain sufficient clearance between the vehicle and the landfill equipment. Landfill operating equipment will be furnished with an audible backup signal. In addition, highly visible clothing and a hard hat must be worn at all times while outside of the vehicle.

1.4.10 WINTER OPERATIONS

Planning for winter landfill operations is an essential part of solid waste disposal practices in Alaska. Freezing cold temperatures decrease the ability of oil and grease to provide proper lubrication, increasing equipment wear. Frozen refuse and cover soil increase the difficulty in compacting and covering the waste. Snow must be removed from roads and working areas to allow vehicle access for off-loading the solid waste. Removed snow must be stockpiled so as to avoid becoming nuisance water or leachate during the spring thaw. Disposal of fireplace ashes increase the potential for landfill fires. The cold presents a health hazard to workers through potential exposure to hypothermia and frostbite. The following practices are followed for winter landfill operations:

- Equipment has plug-in heaters or protected storage
- Equipment has cabs with heaters
- Personnel have warm weather clothing
- An area is designated for discharge of "HOT" or burning loads of refuse
- Incoming waste is inspected for "HOT" loads
- Snow removed from working areas is stockpiled to prevent the generation of run-on and leachate
- Traffic is kept off borrow areas to minimize frost penetration
- Winter soil cover stockpiles are covered with tarps for protection from rain, snow and frost (See following discussion.)

WINTER SOIL COVER

During winter months, the development of sufficient quantities of on-site cover material is limited by the susceptibility of the soil to freezing conditions. This susceptibility is directly related to the amount of fine-grained particles contained within the soil. The greater the amount of fine-grained particles in the soils, the greater the more susceptible the soil is to freezing and the greater will be the potential depth of frost penetration. Because the soils at the Central Landfill contain only small amounts of fine-grained soil and are relatively free draining, frost penetration is easily controlled.

In the event that there will be a need for the development of additional soil cover stockpiles during the winter, designated landfill borrow areas are protected to the extent possible. Dozers equipped with ripper teeth will be used to break through the frost and replenish the stockpile material.

1.4.11 OPERATOR TRAINING

The MSB requires as part of its contract with the landfill operations contractor that at least one person on staff complete the Solid Waste Association of North America (SWANA) Manager of Landfill Operations (MOLO) course. In addition the MSB requires that at least one person on staff has current MOLO certification. MSB Utility workers and scale house attendants are offered training through the SWANA Training for Sanitary Landfill Operations Personnel (TSLOP) course. Various other training courses are attended such as the OSHA 8 hour refresher course for hazardous waste workers and DOT transport of hazardous waste course. A course put out by Caterpillar Inc. is also used for the training of landfill equipment operators.

1.5 HOUSEHOLD HAZARDOUS WASTE COLLECTION PROGRAM

The Matanuska-Susitna Borough has an established a twice a week collection program for Household Hazardous Waste and Conditionally Exempt Small Quantity Generator (HHW/CESQG) wastes. The program is overseen by the Boroughs Environmental Technicians who receive, package, and manifest all eligible hazardous materials collected at the HHW/CESQG collection site. A Contractor reviews manifest and packaged material then transports and disposes of all Hazardous waste to licensed disposal facilities.

The Contractor supplies all materials, labels, and documentation, necessary to fulfill their responsibilities, including the removal of all hazardous wastes collected from the site, for the appropriate treatment, recycling, storage and/or disposal at TSD's of their choosing. These sites must be fully permitted by the EPA and state environmental agency. The Contractor is responsible for providing lawful disposal of all materials collected. They are also required to submit to the Borough copies of all manifests and waste treatment/disposal certificates.

The HHW aggressively promotes a program of reuse for household hazardous wastes that may have a usable quantity remaining in the original container.

1.5.1 HAZARDOUS MATERIALS SCREENING

The disposal of hazardous waste, as defined in 40 CFR 261, in municipal solid waste (MSW) landfills is prohibited by federal law. Wastes defined in 40 CFR 261, in quantities in excess of 100 kilograms (25 gallons), must be disposed of in accordance with 40 CFR 262, Standards Applicable to Generators of Hazardous Waste. Disposal of such materials in Central Landfill is prohibited by the State of Alaska under the regulations of 18 AAC 60.020 and the facility's Solid Waste Permit.

The Matanuska-Susitna Borough does not accept hazardous materials from small quantity generators at Central Landfill, and is working with local small-quantity generators of hazardous waste (e.g., pesticides, solvents) to ensure their proper disposal. The Borough is also working to familiarize the public with the role they cam play in reducing inputs of household-generated hazardous wastes to the landfill. Specific actions by the Borough are as follows:

- Encourage responsible management of hazardous wastes at their source, i.e., before entering the solid waste stream.
- Screening for and excluding hazardous wastes from the solid waste stream at the landfill gatehouse.
- Conducting collection of household hazardous/CESQG at Central Landfill twice a week.
- Conducting an educational program for children through the school system.
- Provide employee training in hazardous waste recognition.
- A used oil collection program
- A antifreeze collection program
- A battery collection program
- A latex paint collection program

1.5.2 SCREENING OF INCOMING WASTES

The first line of defense against incoming hazardous wastes is at the point of pickup. Since a significant portion of the solid waste disposed of at Central Landfill enters the site in transfer boxes, where the incoming wastes are not readily accessible for inspection at the landfill gate, screening at the source is currently being done with gate house attendants at all the remote transfer sites to screen incoming loads. RCA certificated haulers and other large quantity haulers must be alert to the potential presence of hazardous materials and the types of containers in which hazardous wastes are typically disposed of, such as pesticide containers, 55-gallon drums, or electrical transformers.

At the landfill gate and all remote transfer sites, large or potentially suspect loads are visually checked for the presence of drums or other containers, which might contain hazardous wastes. All drums and containers over 25 gallons are to be opened and verified to be empty prior to acceptance at the landfill. If contents of smaller containers are of unknown or suspect nature, the individual presenting the waste will be directed to other disposal agencies, such as the monthly collection program, a hazardous-material transporter, or required to provide documentation supporting its classification as a non-hazardous material.

In addition to inspecting vehicles suspected of containing prohibited items, the Borough will implement a random hazardous waste inspection program. Vehicles will be randomly selected for full inspection of loads. A record of the inspections will be maintained in the operating record.

1.6 ENVIRONMENTAL PROTECTION MEASURES

The primary environmental protection measures proposed for Central Landfill} include:

- Visual Monitoring
- Gas migration monitoring.
- Groundwater monitoring.
- Surface drainage control.
- Hazardous waste control.

Additional areas of concern include bird, animal, and vector control, litter and dust control, and fire/explosion emergencies.

1.6.1 MONITORING

Visual, gas, and groundwater monitoring is addressed in the Central Landfill Monitoring Plan.

LEACHATE PREVENTION

Settlement areas will be backfilled to prevent ponding on closed portions of the landfill.

Potential leachate migration from the existing landfill would likely be limited to the unconfined aquifer, which by its nature would severely limit its movement. It is likely that if any leachate did precipitate to the unconfined aquifer, it would accumulate in depressions or pockets on the confining layer.

1.6.2 SURFACE DRAINAGE CONTROLS

The 160-acre site currently under development does not have any flowing streams or intermittent, through-flowing drainages. Surface water run-on to the site is limited. Ponding of runoff may occur within depressions or kettle features during breakup, while underlying soils are still frozen.

Surface water controls used in landfill operations should be viewed similar to short-term construction projects. Settlement can cause problems as the landfill proceeds through various phases, and surface water runoff patterns will change with the topography of the site. The drainage system is therefore simple and easily modified to handle changing conditions.

In active fill areas, temporary ditches and grading of the surrounding area will be used to maintain positive drainage away from the working face and away from completed cells.

Surface runoff will be directed toward natural depressions located down gradient of the landfill allowing the water to infiltrate into the native soils. This approach is consistent with existing drainage characteristics of the site.

Snow storage areas will be designated so that runoff is directed toward a natural drainage away from the landfill.

1.6.3 HAZARDOUS WASTE CONTROL

Screening for hazardous waste is conducted at the transfer sites and at Central Landfill. As discussed in Section 1.5, a monthly collection program for household hazardous waste is conducted at Central Landfill.

In the event of a hazardous waste release, the landfill contractor will immediately contact the Matanuska-Susitna Borough Public Works Department. Notification of Alaska Department of Environmental Conservation and other regulatory agencies will be performed as required.

Remediation of a hazardous waste spill or release will be conducted by the Borough's landfill contractor. All work will be directed by Borough personnel in coordination with Alaska Department of Environmental Conservation. Larger spills or releases may require the services of a specialized contractor set up to handle the volume. A full reporting of the incident and all remediation efforts will be made to Alaska Department of Environmental Conservation.

1.6.4 BIRD, ANIMAL, AND VECTOR CONTROL

Primary vector control will be accomplished by minimizing the exposed working face and maintaining scheduled daily cover. This will limit accessibility of food sources within the refuse and make the landfill less attractive to vectors and other animals.

Bird control is not reported to be a problem at Central Landfill. No control measures beyond control of the working face width and maintenance of daily cover are planned at this time.

1.6.5 LITTER CONTROL

The first line of defense against liter is to maintain a daily routine of covering as soon as possible after refuse is deposited. Some paper will escape from the working face in spite of these efforts. Portable litter control fences located near the working face have been used with some success at Central Landfill, depending upon wind conditions and variability. Fencing welded onto an old truck trailer can provide a mobile litter fence that can be positioned near the working face. More permanent fencing can be established down wind of the active cells as shown in the permit drawings.

Several areas that are patrolled and, as necessary, cleaned up by a litter crew include:

- The landfill perimeter, both inside and outside the landfill fence; blowing paper will tend to collect inside the landfill fence.

- The access road to the landfill, where arriving refuse haul vehicles may cause some litter.

- Drainage ditches on site.

MS13 8.20.010 prohibits the hauling of unsecured and uncovered loads, which result in littering of roadways.

Such loads entering the scales at the landfill are assessed a $10.00 fee if they carry less than 5 cubic yards and $30 for vehicle that carry loads greater than 5 cubic yards.

1.6.6 FIRE, EXPLOSION, AND EMERGENCIES

FIRE CONTROL EQUIPMENT

The availability and readiness of firefighting equipment can significantly minimize the damages caused by fire. Fire extinguishers are located at all buildings on the site and on all pieces of equipment to control accidental fires.

Fire protection is provided by Central Matanuska-Susitna Station No. 51 (Lakes Fire-hall, located on Trunk Road). Backup services would be provided by Central Matanuska-Susitna Station No. 52 (Lakes Fire-hall, located on Bogard Road). Additional support, if needed, is available from the City of Palmer.

1.6.7 FIRE AND EXPLOSION

Burning Refuse

If a load of burning wastes is brought on site, the transfer vehicle will be routed immediately to a designated area away from the working face, where the load will be dumped and the fire extinguished with soil cover, not with water. The cooled waste materials will be incorporated into the landfill after ascertaining that no sparks or "hot spots" remain.

If a fire occurs in the wastes and the location and limits of the fire can be readily assessed, the wastes may be treated in place with soil cover. Soil is stockpiled near the working face at all times to be available for fire control. Water would be used only as a last resort. However, if a subsurface fire exists and the location and extent is uncertain, the wastes will be excavated as soon as possible. The burning wastes will be spread so that they can be covered with soil or saturated with water.

Equipment Fires

At the first sign of a fire in the equipment, the operator should immediately cut the engine off, evacuate the vehicle, and use a fire extinguisher on the machine or activate any built-in fire suppression system. A second operator will alert the Division Manager or his designee to summon emergency assistance, and then provide assistance with an additional fire extinguisher.

Fire Response Procedures

1. Immediately call 911 for emergency assistance.

2. Contact the Solid Waste Division Manager or his designee for assistance.

3. If the fire is small, attempt to extinguish it with soil or a hand-held fire extinguisher, whichever is appropriate

4. When the emergency is over, clean up the affected area, put the response equipment back in readiness, and restock response supplies.

GENERAL EMERGENCY RESPONSE

The safety of all individuals involved in the operations and maintenance of the landfill depends upon the ability to quickly identify and react properly to an emergency situation.

An emergency directory will be provided at the facility. The directory should be updated annually by operations personnel to keep telephone numbers and addresses current. The directory will be posted in prominent locations and be readily available in the landfill files. All employees should be familiar with the directory, emergency response information, and the safety checklist.

The procedures to follow in the event of an accidental injury or poisoning, in addition to the safety elements described earlier in this chapter, include:

1. Administer first aid at the scene of the accident, if appropriate.

2. Immediately contact 911 for emergency medical aid and notify the supervisor in charge or the landfill office.

3. Make certain that the entrance road is open to prevent delay of emergency equipment arriving at the scene of the accident.

4. Maintain area at the site of the accident free from personnel and/or traffic congestion.

5. The landfill operator will complete an accident report form and submit it to the Solid Waste Division Manager

1.7 LANDFILL CLOSURE PLANNING AND MAINTENANCE

This section describes the maintenance, final closure, and post-closure procedures, which will apply to Central Landfill. The following topics are addressed:

Regulatory and procedural requirements for final closure.

- Post-closure regulatory requirements, including inspections of environmental control systems (surface drainage systems, landfill cover, etc.) and environmental monitoring for landfill gas, groundwater, and surface water.

- Pre- and post-closure maintenance practices.

1.7.1 POST-CLOSURE USE ALTERNATIVES

Closed portions of the landfill that are not used for landfill facilities will be restored to wildlife habitat. Once they are fenced off from active portions of the landfill facility they may be open to the public for recreational use.

Post-closure use will be periodically reviewed during the life of Central Landfill to ensure that other beneficial uses or opportunities, which may arise are explored.

1.7.2 CLOSURE REQUIREMENTS

REGULATORY CONSTRAINTS

State regulation 18 AA 60.395 defines the closure requirements, which are applicable to Central Landfill. As the owner of this facility, the Matanuska-Susitna Borough is responsible for construction of a final cover layer over the fill, revegetation, and long-term maintenance, repair, and monitoring of the landfill site.

FINAL CLOSURE

The components to be considered for closure of this site include:

- Final grade.
- Final cover requirements and construction parameters.
- Surface water drainage.
- Landfill gas and leachate controls (if required).
- Post-closure operations and maintenance (O&M) and final use designation.

Landfill closure and installation of a final cover will occur progressively as sections of the landfill reach final design grade. The final cover will be constructed to minimize infiltration of precipitation into the underlying refuse and protect against erosion.
Construction of the final cover will begin with final grading and shaping of the landfill surface as shown in the permit drawings. On-site borrow material will be used to fill low areas and achieve positive drainage. The final cover system will be constructed in two phases, consisting

of an interim cover and a final top cover. Interim cover will be placed as grading is completed on those areas adjacent to the active landfill but that will not be disturbed by the daily activity.

A separate design will be prepared for the final cover.

1.7.3 MAINTENANCE

State regulation 18 AA 60.397 requires that the owner of a landfill maintain its cover and environmental controls throughout its operating life and for at least 30 years after closure. A shorter or longer period may be designated at the department's discretion. The Borough is responsible for maintaining the integrity of the final cover and any environmental controls or monitoring devices present at the site, and as required in the permit. O&M efforts will address the following:

- Landfill cover and vegetation.
- Gas monitoring devices.
- Groundwater monitoring wells.
- Surface water drainage controls.
- Site controls (fences, gates, etc.).

The entire landfill final cover envelope will be inspected on a semi-annual basis.

Gas monitoring probes and groundwater monitoring wells will be periodically inspected for damage or tampering. Wells and probes will be secured with lockable caps, and positive surface drainage maintained away from their casings.

Surface drainage controls will be inspected at the same time as the cover inspection is performed. Repairs to drainage structures, including removal of excess vegetation or silt, regrading of settled structures, or modification of drainage paths, will be made on an as needed basis to maintain positive drainage away from the completed fill areas.

Site access roads will be maintained in adequate condition to allow access for required inspections and necessary repairs. Site controls such as fences and gates, which may be designated to remain will be periodically checked for damage and necessary repairs. These inspections will be carried out concurrent with the cover inspections. Monitoring will continue in accordance with the approved plan, as amended for post-closure monitoring.

1.8 RECORDKEEPING

1.8.1 WASTE QUANTITIES

Waste quantity records are important for proper management of the landfill site. Uses for this information include:

- Increased ability to forecast future waste quantities.
- Better management of existing fill areas and planning development of new fill areas.
- Forecasting of equipment needs and scheduling of major maintenance.

- A basis for cost allocation for financial planning.

Central Landfill has had a computerized system for determining waste quantities received at the site since October 1993 with the installation of scales. Weight records are cross-referenced with monthly topographic surveys to determine waste quantities. The computerized record keeping system provides:

- Automatic recording of scale information in a computerized system operated at the landfill gate.
- Summarized tonnage records on a daily or monthly basis.
- Maintains separate tonnage records for major waste haulers and transfer station deliveries for planning purposes, as well as running totals of number of loads received and average tonnage per load.

1.8.2 OPERATION RECORDS

State regulation 18 AAC 60.235 requires the owner or operator of a landfill facility to maintain an "operating record". The operating record must consist of the following:

1. The permit application and the permit
2. Hazardous waste screening inspection records, training procedures, and notification procedures
3. Any demonstration, certification, finding, monitoring, testing, or analytical data required by the monitoring plan
4. Financial assurance documentation
5. This operating plan
6. As-build drawings of the landfill

Upon request, the Borough will allow an ADEC representative to inspect the operating record.

LANDFILL GAS MONITORING PROGRAM

CENTRAL LANDFILL – Palmer, Alaska

MATANUSKA-SUSITNA BOROUGH

The Matanuska-Susitna Borough's (MSB) gas monitoring plan provides site-specific gas monitoring and quality control protocols for the landfill gas monitoring program at the Central Landfill (CLF) in accordance with current Alaska Department of Environmental Conservation (ADEC) regulations, 18 AAC 60.350 Solid Waste Management.

1.0 PROJECT AND OVERVIEW

The purpose of the CLF gas monitoring program is to ensure that the concentration of methane gas generated by the facility does not exceed 25 percent of the lower explosive limit for methane in facility structures, excluding gas control or recovery system components, and does not exceed the lower explosive limit at the facility property boundary.

Monitoring

The gas program has been conducted since 1995 and currently includes quarterly sampling of 13 water monitoring wells; gas monitoring wells GW-1 and GW-2; ambient air at 200' intervals along the northern facility perimeter between the animal control building and entrance to Crevasse Moraine trailhead; and the crawl spaces of the landfill scale house and the animal control facility.

The gas monitoring program will include six (6) additional site perimeter sample points to be installed in 2013. Specifications and drawings shall be submitted to the ADEC for approval prior to installation. Once installed, the gas probes shall be identified as GP-1 through GP-6 and shall be sampled quarterly along with ambient air at surface locations along the northern facility perimeter. New probes shall include 2" diameter PVC casing with threaded top cap, protective casing and locking caps.

Any additional gas collection, venting or testing systems added as part of the future Research Development and Demonstration project in the active fill area shall also be an amendment to this plan. These systems are not necessary at this time, and will be designed and installed at a later date.

Closed Cell 2A shall be capped and vegetated in 2012 and 2013 and design and construction shall include gas control venting and control systems as well as sampling probes. Specific gas monitoring procedures shall an amendment to this plan.

Program Management and Responsibilities

The MSB Solid Waste Manager is the designated project manager. All work associated with the landfill gas monitoring program is performed by the MSB water/gas consultant or in-house by the Solid Waste Manager or the Environmental Technician. The project manager is responsible for authorizing changes to the scope of work and will compile and submit reports to the ADEC.

The project manager is available at the following address and phone number:

Solid Waste Manager
Matanuska-Susitna Borough
350 E. Dahlia Avenue
Palmer, AK 99645
907-746-2841

To ensure the quality of sample data, a qualified person will collect all analytical samples. A qualified person has a thorough understanding of environmental sample collection, familiarity with the Quality Assurance Project Plan (QAPP) and /or Monitoring Plan, and the ability to effectively execute the plan.

2.0 FIELD ACTIVITIES

The field work will consist of measuring gas concentrations at all the identified sampling points during each of the four quarterly monitoring events, or more frequently.

The MSB consultant currently utilizes a Landtec GA-90 Gas Analyzer field instrument to measure barometric pressure, methane concentration, carbon dioxide concentration, and oxygen concentration. The MSB is in the process of purchasing a GEM 5000 for use on-site. This instrument will measure methane, carbon dioxide, oxygen, carbon monoxide and hydrogen sulfide. On-site equipment and trained MSB personnel will provide the mechanism to take measurements as often as necessary without waiting for a consultant to travel from Anchorage. It is anticipated that the consultant will continue to conduct quarterly sampling in conjunction with the water monitoring program and the MSB to conduct supplemental sampling.

Landfill Gas Monitoring Methodology

The first task in the monitoring effort is to charge the batteries and field calibrate the instruments in the office in accordance with the manufacturer's Operations Manuals. Monitoring of each specific location is detailed below.

Monitoring Wells

The monitoring wells included in the gas monitoring program have variable types of completion, but gas monitoring is performed in the same manner for all wells. The landfill gas is measured by removing the well cap, inserting tubing down into the well casing then activating the sample pump.

Gas Probes

The gas probes will consist of 2-inch Schedule 80 PVC pipe with 0.040 inch slotted screen at variable depths. Gas probes each have a valve that is closed at all times. Landfill gas is measured by attaching sample tubing to a valve and the valve is opened as the sample pump is activated.

Passive System Vents

The passive system vents, to be installed at a later date, will have sample ports where tubing can be attached and pump activated.

Buildings/Areas

The buildings include the crawl spaces of the landfill scale house and Animal Control building structures. Equipment will also be utilized in any on-site vaults or confined spaces, as needed. Confined spaces are monitored remotely with sample tubing.

Field Recordkeeping

Monitoring location conditions, results and any conditions that prevented monitoring (e.g. frozen lock, meter malfunction) will be recorded on the field log form.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

For purposes of obtaining quality data, the monitoring program is to be representative of environmental conditions at the site. Comparability will be maintained by consistency in monitoring conditions, selection of monitoring instruments and procedure and data reporting units.

If there are anomalies in field calibration of equipment, monitoring will not occur until issues are resolved and field calibration is within specified ranges. The GEM 5000 shall be inspected annually by the manufacturer (or representative) as recommended by the operations manual to assure optimum operation.

4.0 REPORTING

Regulations require that the concentration of methane gas generated by the facility does not exceed 25% of the lower explosive limit (LEL) for methane in facility structures, excluding gas control or recovery system components. Methane gas has an LEL of 5.1% by volume at 20 degrees Celsius.

Data for monitoring wells and walkthrough building/areas will be compared to the regulatory requirement for this comparison. Data for gas probes and passive system vents are compiled for use in compliance with the ADEC RD&D permit requirements.

Quarterly gas monitoring data will be provided to ADEC electronically within 30 days of collection if there has been no violation of the regulatory limit for explosive gases.

If methane gas levels exceed the regulatory limits, the Borough shall immediately notify the ADEC by telephone and in writing, and shall take all necessary steps to reduce or dissipate the concentrations of methane to ensure the public health, safety and welfare.

Central Landfill Monitoring Plan

October 2010

Central Landfill 2010 Permit
Application
Attachment O

Contents

Figure

1. Introduction

The monitoring programs described in this plan have been developed to comply with current federal and state municipal landfill regulations. State solid waste regulations cited in this plan are dated through September 5, 2010. The Central Landfill is a Class I landfill.
The Matanuska-Susitna Borough Central Landfill monitoring plan consists of three separate monitoring programs required by state and federal regulations for municipal solid waste landfills (MSWLFs). These monitoring programs include the following:

- Landfill visual monitoring
- Landfill gas monitoring
- Groundwater monitoring

A visual monitoring program is required by 18 *Alaska Administrative Code* (AAC) 60.800. A methane gas monitoring program is required by 40 *Code of Federal Regulations* (CFR) 258.23(b) and 18 AAC 60.350. A groundwater quality monitoring program is required by 18 AAC 60.820 and 40 CFR 258.50.

In addition, the monitoring programs include a sampling and analysis quality assurance (QA) program as required by 18 AAC 60.830 and 40 CFR 258.53(a), a groundwater statistical analysis plan as required by 18 AAC 60.830(h) and 40 CFR 258.53(g), a reporting plan as required by permit, and a corrective action plan as required by 18 AAC 60.860 and 40 CFR 258.55 through 258.58.

2. Background

Setting

The landfill is located on a 620 acre parcel of land designated for landfill use. The property is located one-half mile south of the Palmer-Wasilla Highway. Residential subdivisions are located immediately to the north and west of the property. Land to the south and east is essentially undeveloped. The developed landfill area, including closed sections comprises approximately 40 acres in the north portion of the landfill property.

The surficial character of the landfill site is typified by steep sloped ridges, hummocks and isolated basins. The topographic relief over the site is approximately 200 feet. The surface elevation of the landfill site varies from approximately 140 feet to 300 feet above sea level. The mean elevation decreases from north to south.

Hydrogeology

The hydrogeology of the Central Landfill was characterized in the *Hydrogeologic Investigation and Monitor Well Installation Central Landfill* report dated July 1993 (Rowland, 1993). A conceptual hydrogeologic model for the Central Landfill site was described in the report. The site model was based on soil borings and monitoring well data generated as part of the hydrogeologic site investigation and a review of previous investigations. Test boring data is contained in the report titled *Installation and Abandonment of Landfill Monitoring Wells, Matanuska-Susitna Borough* (Rowland, 1992). Copies of well logs for the existing monitoring wells are included in Appendix A.

The hydrogeologic investigation report describes two primary aquifers. The upper unconfined aquifer consists of typically silty sand and, gravel underlain by a thick clay or silty clay unit at depth from 30 to 195 ft.(depending on surface elevation). The unconfined aquifer in the vicinity of the active landfill was typically of such low permeability (1 to 50 centimeters per day) that free groundwater was not readily apparent when the wells were drilled.

The clay confining layer which varies in thickness from 45 to over 100 feet was encountered in all test borings and monitor well borings which would indicate that it underlies the entire site as a continuous unit. The confining layer is essentially impermeable with lab as a permeability rates which equates to 0.7 to 0.015 feet per year. This unit acts a retarder to downward movement of water. The surface of the clay unit is fairly flat beneath the active area of the landfill, but in general slopes to the south at a gradient of about 2% or less. The gradient becomes much steeper near the southern limit of the property.

The confined sand and gravel aquifer beneath the clay unit would be considered the local usable source with regard to well production. Where encountered, this aquifer typically has sufficient yield for domestic use. Estimated permeability rates for this unit vary from 75 to 4000 cm/day. Review of off-site domestic wells completed in this aquifer and results of monitoring one well drilled into this aquifer to the south of the active landfill indicates that the confined aquifer is artesian with sufficient head to prevent significant downward movement of water from the unconfined aquifer.

Groundwater recharge of the shallow aquifer likely occurs from regional infiltration of precipitation and snowmelt. The recharge area for the confined aquifer is the area north and northwest of the landfill site, most likely in the Wasilla Creek and Walby Lake area or even as far north as the Little Susitna River.

In summary, it appears that the existing Central Landfill is located in an area which is geologically and hydrogeologically relatively well suited for this type of use. The northern portion of the property, including the current active landfill area is probably the most desirable for landfilling since the unconfined aquifer in this area is of minimal thickness and consists of material with very low permeability rates. Also, in this area the confining layer appears to be the thickest.

Potential leachate migration from the existing landfill would likely be limited to the unconfined aquifer which by its nature would severely limit its movement. It is likely that if leachate denser than water did percolate to the unconfined aquifer it would accumulate in depressions or pockets on the confining layer.

3. Visual Monitoring Program

The purpose of the landfill visual monitoring program is to provide for early detection of potential problems or violations. Items requiring improvement will be addressed on an as-needed basis.

A visual inspection of the active landfill will be conducted at least once a month by the landfill operator or other Borough staff familiar with the Central Landfill permit and operating plan. The staff person will review the site for compliance with applicable requirements of the operating permit and solid waste regulations.

The visual monitoring program will be conducted by observing landfill structures and noting site conditions. Items for review will include, but will not be limited to, the following:

- Size of working face appropriate for the quantity of waste received
- Protection of liner and perimeter berms around the lined cell
- Slippage of the flexible liner or damage to its anchor
- Erosion, a tear, a crack, or other damage to the visible portion of a liner
- Litter accumulation and control measures
- Fire prevention
- Adequacy of daily cover, intermediate cover, and final cover on areas that have received permanent closure
- Safe storage of recyclables and hazardous materials
- Drainage of surface water and grading to prevent ponding and surface water run-on into designated areas of the fill
- Facility structures at the landfill, such as monitoring wells, signs, barriers, fencing, access gates, and other structures
- Landfill equipment condition
- Leachate collection and storage facility

Sample visual monitoring forms are attached in Appendix B.

4. Gas Monitoring Program

The objective of the landfill gas monitoring program is to prevent an explosive hazard that could be created by the accumulation of methane gas from the decomposition of waste in the landfill. Early detection of methane accumulation can be accomplished by sampling strategic locations on a routine basis. Explosive hazards can be minimized by taking corrective action if gas accumulation is detected during the sampling program.

Background

The Central Landfill can be expected to produce methane gas at a moderate rate. Two gas monitoring wells were installed in 1991 in the closed landfill Cell 1. Sample information indicates that gas is produced in the landfill year-round. Previous test results indicate that the gas dissipates to safe levels below the lower explosive limit.

The gas production rate at this landfill appears to be low, and gas accumulation is not likely unless special conditions exist. Gases dissipate rapidly to safe levels below explosive concentrations above and around the perimeter of the landfill. Enclosures such as basements, sumps, electrical boxes, underground utility conduits, and onsite sheds can trap methane gas and allow the concentration to reach explosive levels. Enclosures at and near the landfill are, therefore, the most appropriate areas to sample for methane gas accumulation.

Requirements

Regulations (40 CFR 258.23 and 18 AAC 60.350(a)(1)) do not allow the concentration of methane gas to exceed 25 percent of the lower explosive limit (LEL) in landfill facility structures (excluding gas control structures designed to convey or recover gas). Also, methane gas from the landfill is not allowed to exceed the LEL at or beyond the facility property boundary. Regulations require routine methane monitoring. The frequency of monitoring must be based on site-specific conditions, and monitoring must be performed at least quarterly.

Monitoring Program

The Central Landfill gas monitoring program is designed to detect the potential accumulations of methane gas at concentrations described in the regulations. The designation of monitoring locations is based on the following:

- Soil conditions
- The hydrogeologic and geologic conditions surrounding the Central Landfill
- The hydraulic conditions surrounding the Central Landfill
- The locations of facility structures and property boundaries

Ambient concentrations of air will be monitored with a combustible gas/explosion meter calibrated to read between zero and 100 percent of the LEL for methane gas. An oxygen indicator will also be used in conjunction with an explosion meter if oxygen is required to obtain an accurate reading. An oxygen indicator will not be used if the methane gas meter is capable of reading actual gas concentrations without oxygen. A moisture filter will be used if wet conditions or high humidity are present at the time of sampling. Sampling equipment will be checked before each field sampling exercise to ensure proper operation and calibration.

Areas of potential gas accumulation will be checked by inserting the tip of the sampling hose into the area to be sampled. Enclosed spaces will not be entered before being tested. Also, to the extent possible, doors and covers to enclosed spaces will be left closed during sampling to prevent the escape of gases that may have accumulated in these areas.

The following areas are to be sampled within the landfill facility:

- The crawl space under the scalehouse building (insert sample hose into the crawl space beneath the scalehouse).
- The crawl space under the animal control building (insert sample hose into the crawl space beneath the scalehouse).

The following areas are to be sampled at the facility boundary or beyond:

- Ambient air at the entrance gate
- Ambient air at a 200 foot interval along the facility perimeter starting at the animal control building and ending at the entrance to Crevasse Moraine trail head
- Ambient air at each of the groundwater monitoring well locations

There are currently two additional structures at the Central Landfill (Office and Hazmat Buildings) that are not being monitored because they are both elevated structures and do not have crawl spaces which could allow for the accumulation of landfill gas. It is not realistic to expect gas to migrate to, or accumulate in the sub floor of these structures. In Chapter 3, Subpart C, Operating Criteria Section 3.5.3 Explosive Gases Control 40 CFR §258.23 (EPA Solid Waste Disposal Facility Technical Criteria) says "Structures with basements or crawl spaces are more susceptible to landfill gas infiltration. Elevated structures are typically not at risk."

Monitoring frequency will be quarterly. Air monitoring for explosive gas will take place in conjunction with groundwater well monitoring in March, June, September, and December.

Monitoring data will be entered onto a report form, and the information will be maintained in the landfill operating record. Gas monitoring report forms are included in Appendixes C.

Reporting and Corrective Action

If methane gas levels exceeding the limits specified in the regulations are detected, the Borough will take immediate action to protect human health and will notify the Solid Waste Program Manager at the Alaska Department of Environmental Conservation (ADEC) Regional Office in Anchorage by phone at (907) 269-7802. Immediate action will include the following:

- Posting warning signs at the location of concern
- Restricting access to the area of concern to exclude unauthorized individuals
- Venting the area of concern, if prudent

Within 7 days of detection, a note will be placed in the operating record indicating the location of gas accumulation exceeding the regulatory limit, the concentration of methane gas, and a description of the steps taken to protect human health.

Within 60 days of detection, a long term remediation plan for methane gas releases will be implemented, and the ADEC regional office will be notified that the plan has been implemented. The plan, describing the nature and extent of the problem and proposed remedy, will be entered into the operating record.

The plan will be modified, as necessary, to meet state or federal regulations and to adjust to changes at the landfills.

5. Groundwater Quality Monitoring Program

The objective of the groundwater quality monitoring program is to evaluate conditions around the Central Landfill to determine whether leachate is migrating beyond the landfill to the extent that groundwater quality standards are being violated. Early detection of elevated parameters that are characteristic of waste can be used to determine whether a design or operational change is warranted to prevent a groundwater quality violation. If necessary, facility changes can be implemented to minimize subsurface migration of leachate.

Regulatory Requirements

Federal regulations 40 CFR 258.50 through 258.55 specify groundwater monitoring requirements for all municipal landfills. The director of a federally approved MSWLF program may suspend some or all of the groundwater monitoring requirements if the requirements are not necessary to detect potential water quality violations. The State of Alaska obtained full approval of their MSWLF program on March 15, 2000; therefore, the state has the authority to suspend any of the federal groundwater monitoring requirements. Alaska regulations 18 AAC 60.820 through 60.860 specify groundwater monitoring requirements for landfills.

This groundwater monitoring plan is designed to comply with the current state groundwater monitoring requirements; last amended on September 5, 2010.

Well Design and Locations

There are currently 14 groundwater monitoring wells at the landfill: MW-1, MW-8, MW-9, MW-10, MW-11, MW-13, MW-14, MW-15, MW-16, MW-17, MW-19, MW-20, MW-21, and MW22. Wells 2 through 7, Well MW-12, and Well 18 have been removed or plugged and abandoned (Rowland, 1992, Shannon & Wilson, 2000). Wells MW-10, MW-13, and MW-14 will be decommissioned in Spring 2011 prior to construction of the new landfill cells. At that time Well MW-15 will also be decommissioned due to presumed damage to the well cap and/or screen. Additional replacement wells will be placed downgradient of current and future landfill cells. A summary of installation dates and current status is shown in Table 1. All elevations are in feet above mean sea level.

The locations of these wells are shown in Figure 1. Monitoring well logs are attached in Appendix A. The existing wells are placed where they are most likely to detect contamination from the landfill.

Table 1

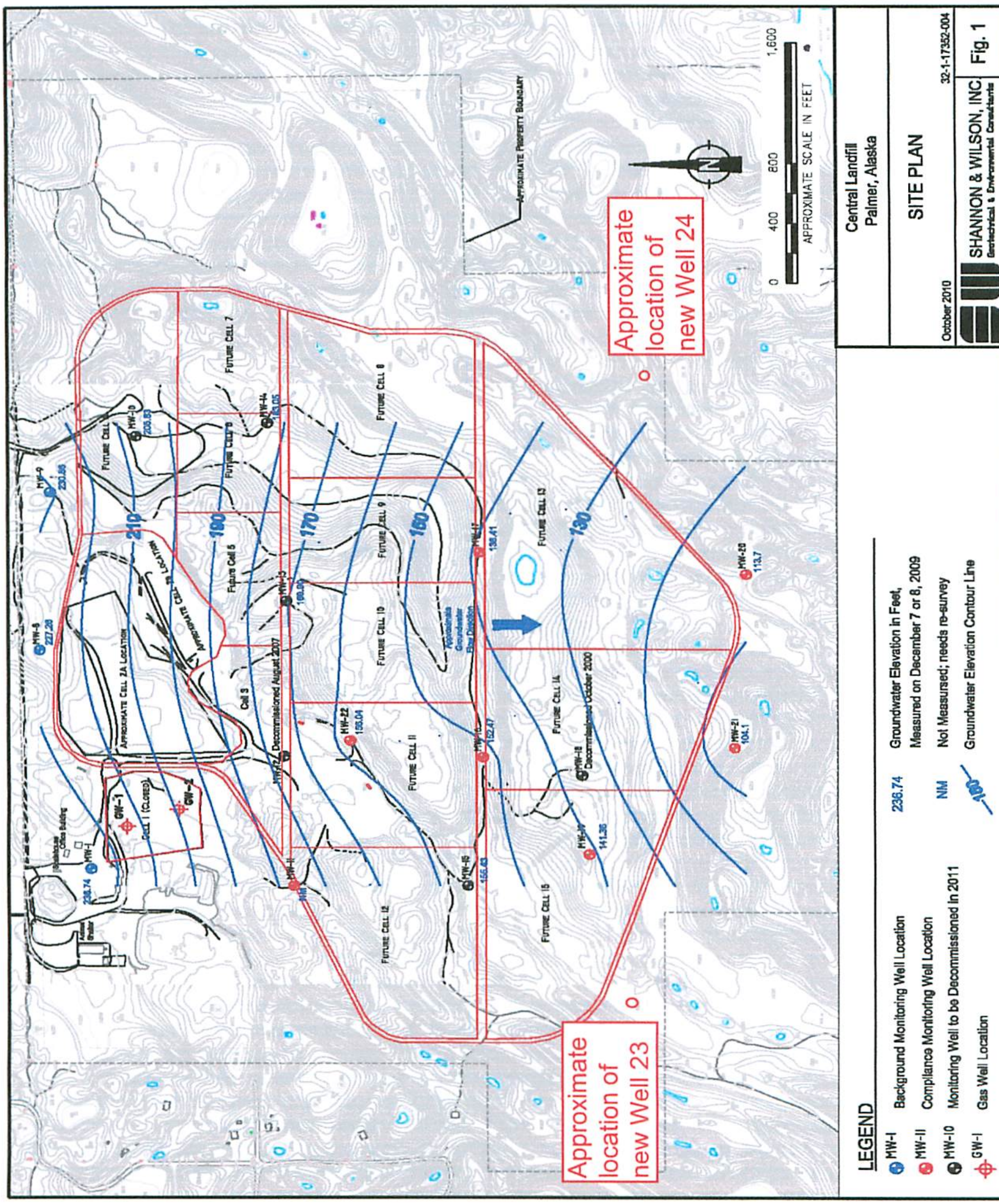
Summary of Groundwater Wells

Well #	Date Installed	Status	Total well length[a]	Top of casing elevation	Ground surface elevation
1	February 1986	Active	94.0	302.92[b]	303.3
2	February 1986	Abandoned August 1992			
3	February 1986	Removed August 1992			
4	February 1986	Removed August 1992			
5	November 1988	Removed August 1992			
6	November 1988	Removed August 1992			
7	November 1988	Abandoned August 1992			
8	August 1992	Active	40.5	255.62	253.6
9	March 1992	Active	88.6	279.98	276.4
10	March 1992	To be decommissioned in 2011			
11	March 1992	Active	130.3	280.11	278.3
12	March 1993	Abandoned August 2007			
13	March 1993	To be decommissioned in 2011			
14	March 1993	To be decommissioned in 2011			
15	March 1993	To be decommissioned in 2011			
16	March 1993	Active	173.0	282.88	279.9
17	March 1993	Active	138.6	226.56	224.0
18	October 1997	Abandoned October 2000			
19	October 2000	Active	70.0	182.6	180.0
20	March 2006	Active	131.0	248.1	245.1
21	March 2006	Active	60.0	168.9	165.9
22	November 2007	Active	108.45	260.41	256.50

[a]The total well length is from the top of casing to the bottom of the well (not bottom of the hole boring)

[b]The original elevation for the top of casing for MW-1 was 302.4, but the casing was extended in August 1993 to elevation 308.57, and in August 1994 the casing was cut off below grade and put in a concrete box and the surrounding area was paved. The current top of casing elevation is 302.92.

Figure 1


Approximate location of new Well 24
Approximate location of new Well 23
0 400 800 1,600
APPROXIMATE SCALE IN FEET
Central Landfill
Palmer, Alaska
SITE PLAN
October 2010
32-1-17352-004
SHANNON & WILSON, INC.
Geotechnical & Environmental Consultants
Fig. 1
LEGEND
MW-I Background Monitoring Well Location
MW-II Compliance Monitoring Well Location
MW-10 Monitoring Well to be Decommissioned in 2011
GW-I Gas Well Location
238.74 Groundwater Elevation in Feet, Measured on December 7 or 8, 2009
NM Not Measured; needs re-survey
Groundwater Elevation Contour Line

Monitoring Wells MW-1, MW-8, and MW-9, are upgradient to all landfill cells and may be considered to be the background wells. Monitoring Wells MW- 16 through MW-22 are downgradient from the active and closed waste cells. Monitoring Wells MW-20 and MW-21 are furthest downgradient from waste areas and water quality is not allowed to exceed the standards in these wells.

Other than the mentioned problems, the wells are in good condition, with adequate sanitary seals and well cap locks.

Monitoring Frequency

State MSWLF regulation 18 AAC 60.850(b)4 requires sampling at least once per year. The regulation specify that the frequency will be based on consideration of the lithology of the unsaturated zone and aquifer, hydraulic conductivity of the aquifer, groundwater flow rates, distance to the monitoring devices, and other compliance issues.

The current plan is to sample wells in March, June, September, and December. The exact date of sampling may vary depending on weather and site conditions.

Groundwater Monitoring Parameters

The federal and state MSWLF regulations require detection monitoring of groundwater for parameters listed in Appendix I of 40 CFR 258. These analytic requirements can be met by analyzing for total metals by using EPA Method 6010 and for volatile organic compounds (VOCs) by using U.S. Environmental Protection Agency (EPA) Method 8260 or other similar methods. State municipal landfill regulations amended through September 5, 2010, list all parameters in 40 CFR 258, Appendix I, and several other parameters to chose from in Table J listed in 18 AAC 60.840. All parameters listed in 40 CFR 258, Appendix I, are included in this monitoring plan. Samples will be analyzed using the methods described in the most recent edition of EPA publication SW-846, *Test Methods for Evaluating Solid Waste.* Selected parameters in Table J will be sampled.

Assessment monitoring was initiated in the June 2000 monitoring event by analyzing ground water samples from Monitoring Wells MW-12, MW-13, MW-16 and MW-17 for the Appendix II parameters. The current assessment monitoring program includes quarterly analysis of Select table J parameters, Appendix I, methyl tertiary-butyl ether (MTBE), and dichlorodiflouromethane (an appendix II parameter). Analysis of the complete Appendix II list of parameters is conducted annually for four wells (Monitoring Wells MW-11, MW-16, MW-17, and MW-22), during the second quarterly monitoring event. The Appendix II parameters detected in the second quarterly monitoring event are also included in the fourth quarterly monitoring event sampling program.

Other parameters that will be measured in the field for all wells during each sampling event include static water level before purging, specific conductivity, temperature, and pH. These parameters are listed in Table 2.

TABLE 2
Field Parameters

Parameter	Recommended EPA Method[a]
Water level	Water level indicator measuring tape
Temperature	170.1 Calibrated field thermometer
pH	150.1 Calibrated field meter
Specific conductance	120.1 Calibrated field meter

[a]*Test Methods for Evaluating Solid Waste,* EPA SW-846, current edition, as amended; and *Methods for Chemical Analysis of Water and Wastes,* EPA-600/4-79-020, current edition, as amended.

All wells will be sampled for total metals and will not be filtered. Past monitoring results indicate that the high metal content in these wells is associated with sediment in the samples.

Well Sampling

The following wells will be sampled for one or more of the following sets of parameters, shown on Table 3. Procedures in the Quality Assurance Program will be followed for all sampling activities.

	Background		Detection Monitoring	Assessment Monitoring	Wells to be Decommissioned
Table 3	MW-1 MW-9	MW-8	MW-19 MW-20 MW-21	MW-11 MW-16 MW-17 MW-22	MW-10 MW-13 MW-14 MW-15
March	Appendix I and Table J	Appendix I and Table J	Appendix I and Table J	Field parameters GW elevation	Not applicable
June	Appendix I and Table J	Appendix I and Table J	Appendix I and Table J	Appendix II	Not applicable
September	Appendix I and Table J	Appendix I and Table J	Appendix I and Table J	Field parameters GW elevation	Not applicable
December	Appendix I and Table J	Appendix I , Table J, and **any Apx II parameters detected at the facility**	Appendix I and Table J	Appendix I and **any Apx II parameters detected at the facility**	Not applicable

Comments:
Table J parameters include Chloride, DRO, GRO, Mercury, pH, and TDS.
-Appendix I parameters include total metals and 47 VOCs, as listed in 40 CFR 258. The total metals include: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, silver, thallium, vanadium, and zinc.

Sample Containers

A list of parameters, analytical methods, required volumes, preservatives, and holding times is included in Tables 4, 5, and 6.

Table 4: Table J Parameters

ANALYTE	METHOD	SAMPLE CONTAINER/SIZE	PRESERVATIVE [1]	HOLDING TIME
Chloride	EPA 300.0	Nalgene / 60 mL	None	28 days
pH	SM 4500	Nalgene / 60 mL	None	Analyze Immediately
Total Dissolved Solids (TDS)	SM 2540C	HDPE / 250 - 500 mL	None	7 days
Total Mercury	EPA 245.1	HDPE / 250 - 500 mL	HNO_3	28 days
Gasoline Range Organics (GRO)	AK 101	Amber VOA Vials / (3) 40mL	HCl	14 days
Diesel Range Organics (DRO)	AK 102	Amber Glass / (2) 1 L	HCl	7 days

Table 5: 40 CFR 258 Appendix I Parameters

ANALYTE	METHOD	SAMPLE CONTAINER/SIZE	PRESERVATIVE [1]	HOLDING TIME
Volatile Organic Compounds (VOCs)	EPA 8260B	Amber VOA vials / (3) 40 mL	HCl	14 days
Total Metals [2]	EPA 200.7	HDPE / 250 - 500 mL	HNO_3	180 days

Table 6: 40 CFR 258 Appendix II Parameters

ANALYTE	METHOD	SAMPLE CONTAINER/SIZE	PRESERVATIVE [1]	HOLDING TIME
Total Metals [3]	EPA 200.7/245.1	HDPE / 250 mL	HNO_3	180 days; 28 days for Hg
Organochlorinated Pesticides / Polychlorinated Biphenyls (OCP/PCB)	EPA 8081B/8082A	Amber Glass / (2) 1 L	None	7 days
Organochlorinated Herbicides (OCH)	EPA 8151A	Amber Glass / (2) 1 L	None	7 days
Volatile Organic Compounds (VOCs)	EPA 8260B	Amber VOA Vials / (3) 40mL	HCl	14 days
Semi-Volatile Organic Compounds (SVOCs)	EPA 8270D	Amber Glass / (2) 1 L	None	7 days
Cyanide	SM 4500	Nalgene / 250 mL	NaOH	14 days
Sulfide	SM 4500	HDPE / 250 mL	NaOH and Zinc Acetate	7 days

1 Sample temperature shall be maintained at 4°C plus or minus 2°C
2 Total Metals for 40 CFR 258 Appendix I Parameters include: Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Ni, Se, Ag, Tl, V, and Zn
3 Total Metals for 40 CFR 258 Appendix II Parameters include: Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Hg, Ni, Se, Ag, Tl, Sn, V, and Zn.

6. Evaluation and Reporting of Monitoring Results

Proper evaluation of the analytic data for water quality is necessary to interpret the meaning of the information. Data review is conducted in context with the following:

- A review of sampling procedures, field conditions, and analytic procedures and methods
- A review of sample locations and factors that could affect sample results at the locations
- A review of site conditions at the time of sampling that could affect samples
- A review of laboratory instrumentation and data quality control checks
- A statistical or graphical analysis of current and historical data

Statistical Analysis of Groundwater Results

The objectives of the statistical analysis of the Central Landfill groundwater data are to evaluate spatial, seasonal, or other temporal trends, to select appropriate statistical procedures for future analyses. The primary goal of the statistical evaluation is to quantify characteristics up-gradient and down-gradient from the landfill. Statistical analysis is only required for detection monitoring programs.

Monitoring Well MW-8 will be considered the main up-gradient background source and Wells MW-1 and MW-9 are also designated as background wells.

Statistical methodologies used to analyze the groundwater data from Central Landfill have been developed in accordance with 40 CFR Part 258.53 and are based on guidance documents issued by the EPA (USEPA, 1989 and USEPA, 1992).

Checks for Data Distribution

The first statistical analysis of groundwater quality data was performed on the data from the Fourth Quarter 1999 monitoring event and was published in the March 2000 report prepared by Shannon & Wilson. The first step of the statistical evaluation was to summarize the sample size and percentage of non-detectable results for each constituent from each well to identify candidate constituents and candidate statistical procedures. Summary statistics consisting of average (mean), standard deviation, and skewness were computed for each detected constituent form each well, and probability correlation coefficients were computed to quantify the degree to which the data are normally distributed (normality).

A significant number of the constituent data sets from the Central Landfill fail the tests of normality or have such a large percentage of non-detectable results that non-parametric statistical methods are required. Non-parametric methods are those that do not rely on assumptions regarding the underlying distribution of the data to arrive at valid statistical conclusions.

Many of the groundwater sample results in the past have been reported as non-detectable, or below the specified limit of quantitation (LOQ). In order to compute descriptive statistics and to perform certain statistical tests, one half of the specified detection limit are used in place of the non-detectable results and results below the LOQ. In those constituent sets in which non detection limits were specified, only the detectable results were used. Duplicate sample results will not be considered in the statistical analysis.

Tolerance Interval Comparison

The tolerance interval method of groundwater contamination detection and compliance (USEPA, 1992) are used to statistically evaluate constituents in background (up-gradient) and compliance (down-gradient) monitoring wells at the landfill. For detection monitoring of a particular constituent, and upper 95% tolerance interval with a 95% confidence level is first computed from the results of tests in the background well. This means that one has a confidence level of 95 percent that the tolerance interval will contain (cover) at least 95 percent of the distribution of observations from the background well data. Thus, random observations from the same distribution as the background well data (uncontaminated compliance wells) would exceed the upper tolerance limit less than 5 percent of the time.

Since the data is more likely to be log-normal, the tolerance intervals are calculated after first transforming the data to the natural logs of the concentrations. If the log transformed data passed the tests of normality, the respective tolerance interval are constructed using parametric techniques. If the data fails either test of normality, or contained greater than 50 percent non-detectable results, a non-parametric tolerance interval is constructed. It is important to note that in cases where a non-parametric tolerance interval is used, the average coverage is dependent on the number of samples used to construct the tolerance interval. Generally, at least 19 samples are required to provide an average coverage of 95 percent when using a non-parametric tolerance interval.

Although a tolerance interval has been constructed and listed for each well for a particular parameter, the background tolerance interval is of most interest for detection monitoring. The tolerance interval calculated for the background wells is used to evaluate whether or not a compliance well exceeds the background concentration for a particular parameter. When the natural log of the mean of the compliance well results exceeds the natural log of the background well's tolerance interval for a given parameter, the concentration of that parameter in that well is considered to "statistically exceed" background concentrations.

This statistical analysis is based on the assumption that water quality in the background wells is representative of uninfluenced water quality in down-gradient wells.

Assessment Monitoring and Corrective Action

Groundwater assessment monitoring is required by 40 CFR 258.55 whenever a statistically significant increase over background for one or more of the constituents listed in Appendix I of the federal MSWLF regulations has been detected in a groundwater monitoring well located at or beyond the point of compliance. All procedures within 40 CFR 258.56

State regulation 18 AAC 60.860 requires a site subject to corrective action monitoring to follow the corrective action procedures in the federal regulations (40 CFR 258.55 through 258.58).

The Mat-Su Borough initiated its assessment monitoring program according to the provisions listed above in June 2000. Samples from Wells MW-12, MW-13, MW-16 and MW-17 were analyzed for the Appendix II parameters. Based on statistical analysis, 20 parameters (including Table J, Appendix I and Appendix II parameters) in one or more compliance wells statistically exceed background concentrations.

The Central Landfills current assessment monitoring program includes quarterly analysis for select Table J parameters, Appendix I parameters, methyl tertiary-butyl ether (MTBE), and dichlorodifluoromethane (and Appendix II parameter). Analysis of the complete Appendix II list of parameters is conducted annually for four wells (MW-11, MW-16, MW-17, and MW-22), during the second quarter sampling event. The Appendix II parameters detected in the second quarterly monitoring event are also included in the fourth quarterly monitoring event sampling program. Results from the assessment monitoring are evaluated according to the approved groundwater protection standards for this site (Shannon & Wilson, February 2010).

Reporting

The Borough will submit a monitoring report, in an approved format including the appropriate analyses. This will be submitted to the Department no later than 60 days after the sampling data has been received form the laboratory.

A statistical analyses report will be submitted following each year in which monitoring is required. The annual summary report with statistical analyses will be submitted in March or April. The current address of ADEC is:

Alaska Department of Environmental Conservation
Solid Waste Management Program
555 Cordova Street
Anchorage, Alaska 99501

7. References

State of Alaska Department of Environmental Conservation, September 5, 2010, "18 AAC 60, Solid Waste Management."

Steve R. Rowland, P.E., October 1992, *Installation and Abandonment of Landfill Monitoring Well, Matanuska-Susitna Borough.*

Steve R. Rowland, P.E., July 1993, *Hydrogeologic Investigation and Monitor Well Installation, Central Landfill.*

U.S. Environmental Protection Agency. *Methods for Chemical Analysis of Water and Wastes.* EPA-600/4-79-020, current edition, as amended.

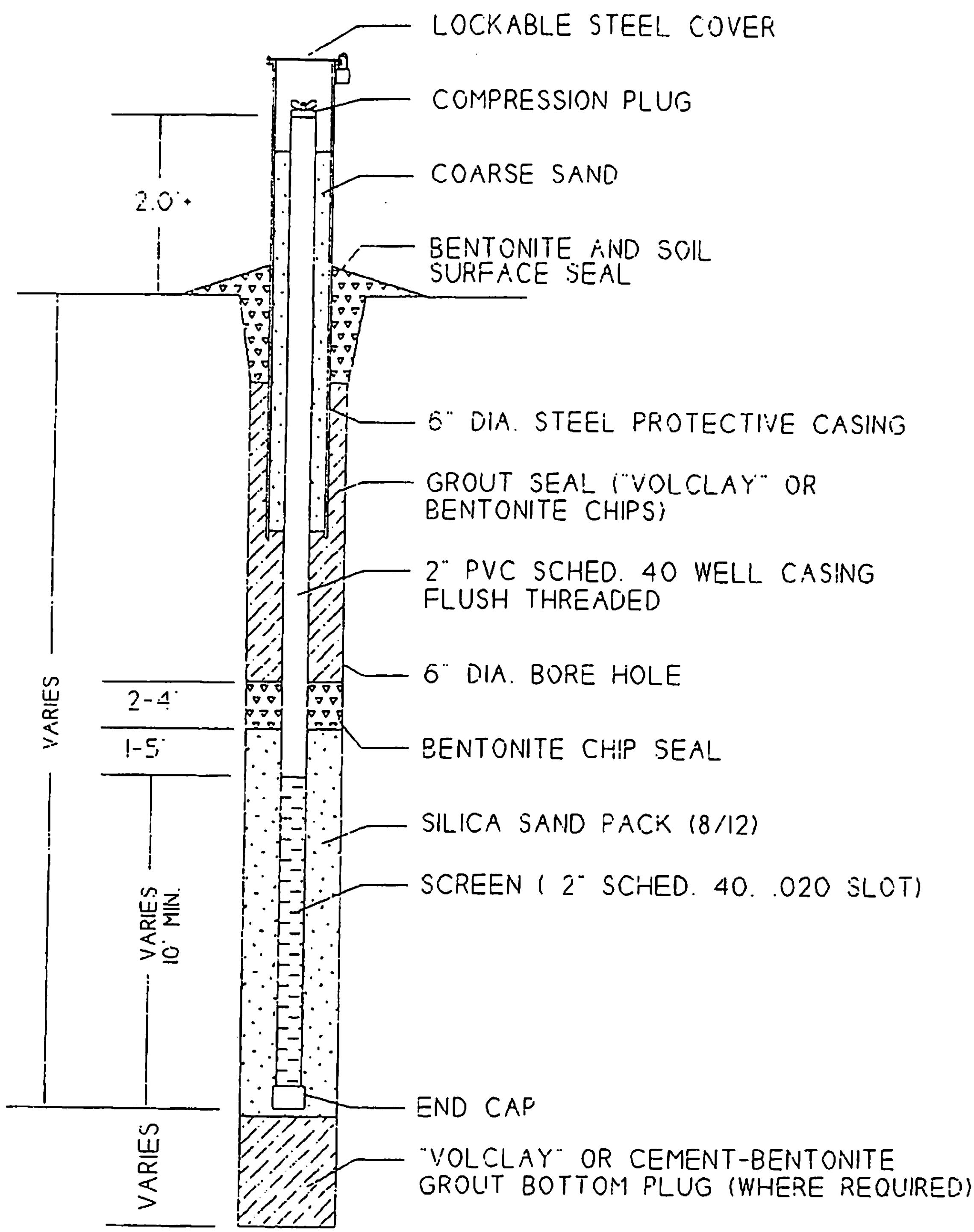
U.S. Environmental Protection Agency. April 1989. *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance.*

U.S. Environmental Protection Agency. July 1992. *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Draft Addendum To Interim Final Guidance.*

U.S. Environmental Protection Agency. *Test Methods for Evaluating Solid Waste.* EPA SW-846.

U.S. Environmental Protection Agency, July 1, 2009 "40 CFR Part 258, Criteria for Municipal Solid Waste Landfills."

Appendix A
Groundwater Well Logs



MONITOR WELL TYPICAL DETAIL

CENTRAL LANDFILL

DATE: JUNE 23, 1993 BY: STEVE R. ROWLAND

DESCRIPTIVE LOGS OF MONITOR WELLS AT CENTRAL LANDFILL

MW # 1

Local Well No. 1
USGS ID No. 613531 149122301
Date completed: Feb. 26, 1986

Well Depth: 93 feet
Water Level: 64 feet below lsd (land surface datum)
Finish: 15-slot stainless steel screen (88-93 feet)

Depth Interval	Description of Materials
0 - 6	Gravel and sand, frozen
6 - 51	Sand, gravel and small cobbles (varies thru interval), with intermittent zones of loess (wind-blown silt); dry
51 - 70	Sand and gravel, w/ clay lenses, and w/ cobbles from 65-70; damp
70 - 82	Silt, sandy w/ clay; heaving below 77
82 - 84	Gravel, broken cobbles; a little water
84 - 87	Silt; "runny"
87 - 94	Gravel, broken cobbles; water (very dirty)

JAN. 2000 STATIC @ 66' BELOW TOP OF CASING
TOTAL DEPTH 90'

GEOLOGIC LOG OF MONITOR WELL

PROJECT	Monitor well installation	PROJECT #	9233	CLIENT	Mat-Su. Borough
PROPERTY	CENTRAL LANDFILL	STA or COORD.	NA		
WELL No	8	DATE BEGUN	8-14-92	DATE END	8-14-92

Equip. Type	CME 75 Auger Drill	Coord North	2774616.0
Contractor	Discovery Drilling, Inc	Coord South	1779735.0
Operator	Clifford Cormier	Elev. Ground	253.62
Geologist	Steve R. Rowland, P.E.	Elev. Collar	255.62
Assistants		Total Depth	39.5 ft.

Scale (ft) Vert. Sec	Sample Interval	Blows/ft 340# hmr		Monitor Well record	Graphic Log	USCS	Material Description	Depth
0						ML	SILT and SILT with trace fine sand, dark brown - tan, firm, dry	5.5
	1	30				GP	Coarse sandy GRAVEL with numerous cobbles, statified with finer sandy GRAVEL and gravelly SAND, brown, dense, dry	
10	2	81						
	3	63						
20	4	78						
	5	104					Groundwater encountered at 30.5 feet while drilling.	30.0
30	6	40	▼			SP-SM	Stratified fine SAND and silty SAND with trace to some gravel, gray, dense, saturated. Well yield less than 0.5 gpm due to high percentage of fine material in water bearing strata	
	7	50						37.0
	8	41				SP	SAND, fine to coarse, olive, moderately dense, saturated	39.5
40								
50								

NOTE. Set monitor well to 38.0 ft.
PVC casing extends to 2.0 ft above original ground.
All samples collected using a 3 in. split spoon sampler

sheet 1 of 1

by SRR

9233 clfmw08 7/20/93

GEOLOGIC LOG OF MONITOR WELL NO. 9

PROJECT	Central Landfill	BORING NO.	9	ELEV. GRND	276.4
LOCATION	Palmer Alaska	PAGE	1 of 2	ELEV. COLLAR	279.98
CLIENT	Mat-Su Borough	DATE BEGUN	3-25-93	TOTAL DEPTH	95.0
DRILLED BY	Tester Drilling	DATE END	3-26-93	COORD. NORTH	2774550.4
LOGGED BY	Steve Rowland	EQUIP. TYPE	Drilltech D40K	COORD. EAST	1780511.3
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc. Info	Well record	Graphic Log	U.S.C.S	Material Description	Depth
								0.0
						ML	SILT & organic debris, brown, firm, moist	8.0
10						GP,SP	Stratified sandy GRAVEL and gravelly SAND with occasional to numerous cobbles, brown to gray, very dense, dry.	
20	1							25.0
30								
40	2					GP-GM	Coarse sandy GRAVEL with numerous cobbles and trace silt, brown, dense to very dense, moist to wet	44.0
50	3					SP	Groundwater encountered while drilling. Flow tested with air at 3 to 5 gallons per minute. Water level measured at 44.6 feet on 6/11/93 (Elev. 231.8) Coarse to fine SAND with occasional trace to some gravel, olive, moderately dense to loose, wet to saturated Yields 2 to 5 gpm below 50.0 feet.	
60								
70								70.0

continued on sheet 2

fig: B-1

by SRR

Steve R. Rowland, P.E.

9233 clfmw09 6\14\93

GEOLOGIC LOG OF MONITOR WELL NO. 9

PROJECT	Central Landfill	BORING NO	9	ELEV GRND	276.4
LOCATION	Palmer Alaska	PAGE	2 Of 2	ELEV COLLAR	279.98
CLIENT	Mat-Su Borough	DATE BEGUN	3-25-93	TOTAL DEPTH	95.0
DRILLED BY	Tester Drilling	DATE END	3-26-93	COORD. NORTH	2774550.4
LOGGED BY	Steve Rowland	EQUIP TYPE	Drilltech D40K	COORD EAST	1780511.3
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert Sec	Sample Interval	Blows/ft 340# hmr	Misc Info	Well record	Graphic Log	USCS	Material Description	Depth
	4					SP	Coarse to fine SAND with occasional trace to some gravel, olive, moderately dense to loose, wet to saturated	70.0
80	5		LL-27 PI-5	85.0		SC-SM CL-ML	Stratified clayey fine SAND & Silty fine SAND, gray, dense, wet Becomes dryer with depth and clay content increases. Does not produce water. Hydraulic conductivity: 3.37 (10E -7 cm/sec)	76.0
90							total depth	95.0
100								
110								

Rowland P.E

fig B-1 by SRR

9233 clfmw09 6\14\93

GEOLOGIC LOG OF MONITOR WELL NO. 10

PROJECT	Central Landfill	BORING NO	10	ELEV GRND.	233.2
LOCATION	Palmer Alaska	PAGE	1 of 1.	ELEV COLLAR	235.86
CLIENT	Mat-Su Borough	DATE BEGUN	3-3-93	TOTAL DEPTH	56.5
DRILLED BY	Tester Drilling	DATE END	3-3-93	COORD. NORTH	2774044.8
LOGGED BY	Steve Rowland	EQUIP. TYPE	Driltech D40K	COORD. EAST	1781250.3
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec	Sample Interval	Blows/ft 340# hmr	Misc. Info.	Well record	USCS	Material Description	Depth
					ML	SILT & organic debris, brown, soft to firm, dry to moist	0.0–4.0
10	1				GP	Coarse sandy GRAVEL with numerous cobbles, brown, very dense, dry	4.0–15.5
20, 30	2, 3				SM	Silty gravelly SAND, brown, dense to moderately dense, dry to saturated below 34 feet Groundwater encountered while drilling. Very low yield: not able to develop flow Water level measured at 33.6 feet on 6/11/93 (elev. 199.54)	15.5–37.0
	4				CL	Lean CLAY, gray, hard, wet to saturated, plastic	37.0–40.0
40, 50	5, 6, 7	104	LL-20 PI-2	54.0	GC ML	Clayey sandy GRAVEL & sandy SILT with gravel, occasional cobbles, gray, very dense, moist to dry Hydraulic conductivity: 1.49 (10E -8 cm/sec)	40.0–56.5
60, 70						total depth	56.5

Sheet 1 of 1

Fig B-2 by SRR

Steve R Rowland P.E

9233 clfmw10 6\14\93

GEOLOGIC LOG OF MONITOR WELL NO. 11

PROJECT	Central Landfill	BORING NO	11	ELEV. GRND.	278.3
LOCATION	Palmer Alaska	PAGE	1 of 2	ELEV COLLAR	280.11
CLIENT	Mat-Su Borough	DATE BEGUN	2-26-93	TOTAL DEPTH	115.25
DRILLED BY	Tester Drilling	DATE END	2-26-93	COORD NORTH	2773136.9
LOGGED BY	Steve Rowland	EQUIP TYPE	Driltech D40K	COORD EAST	1778162.0
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc. Info	Well record	Graphic Log	U.S.C.S.	Material Description	Depth
						ML	SILT & organic debris, brown, soft, moist	0.0
10, 20, 30						GP	Coarse sandy GRAVEL with numerous cobbles and occasional boulders, gray to brown, dense to very dense, dry	1.5
						SP	Gravelly SAND, olive dense, dry, occasional cobbles	34.2
40, 50, 60, 70						GP	Coarse sandy GRAVEL with numerous cobbles, trace silt, brown, dense, dry to slightly moist	37.0
								70.0

continued on sheet 2

Fig B-3 by SRR

Steve R. Rowland, P.E

8233 clfmw11 6\14\93

GEOLOGIC LOG OF MONTOR WELL NO. 11

PROJECT	Central Landfill	BORING NO	11	ELEV. GRND.	278.3
LOCATION	Palmer Alaska	PAGE	2 of 2	ELEV. COLLAR	280.11
CLIENT	Mat-Su Borough	DATE BEGUN	2-26-93	TOTAL DEPTH	115.25
DRILLED BY	Tester Drilling	DATE END	2-26-93	COORD. NORTH	2773136.9
LOGGED BY	Steve Rowland	EQUIP. TYPE	Driltech D40K	COORD. EAST	1778162.0
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc. Info	Wel record	Graphic Log	U.S.C.S.	Material Description	Depth
						GP		70.0
80						GP-GM	Sandy GRAVEL with trace silt, numerous cobbles and boulders, brown dense, dry to slightly moist	75.0
90						GM	Sandy GRAVEL with some silt, numerous cobbles, gray, dense, dry	90.0
100						SP	Fine to medium SAND, olive, dense, dry	100.0
110						GP,SP	Sandy GRAVEL & gravelly SAND, gray, very dense, dry	103.0
120						GP-GM	Groundwater encountered while drilling. Not able to develop significant yield using air. Water level measured at 115.25 feet on 6/11/93 (ELEV. 163.05) Sandy GRAVEL with trace silt, numerous cobbles and boulders, brown, dense, dry to saturated below 115 feet.	112.0
						CL	Gravelly lean CLAY, gray, very hard, moderately plastic, moist to wet Groundwater yield coated below 124.0 feet	124.0
130				128.5			total depth	128.0

NOTE: For additional information, refer to Geologic Log of Test Boring No. 2

MW No. 11 was drilled within 10 feet of TB No. 2

GEOLOGIC LOG OF MONITOR WELL NO. 13

PROJECT	Central Landfill	BORING NO.	13	ELEV. GRND.	241.6
LOCATION	Palmer Alaska	PAGE	1 of 2	ELEV. COLLAR	243.86
CLIENT	Mat-Su Borough	DATE BEGUN	3-1-93	TOTAL DEPTH	94.0
DRILLED BY	Tester Drilling	DATE END	3-2-93	COORD. NORTH	2773176.8
LOGGED BY	Steve Rowland	EQUIP. TYPE	Driltech D40K	COORD. EAST	1780060.3
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc. Info.	Well record	Graphic Log	U.S.C.S	Material Description	Depth
								0.0
						ML	SILT & organic debris, brown, soft, moist	3.5
10, 20, 30, 40	1					GP	Coarse sandy GRAVEL with numerous cobbles and occasional boulders, brown to gray below 10 feet, very dense, dry Occasional strata of gravelly SAND	43.5
50	2					SP	Fine to coarse SAND with trace gravel, olive, dense, dry	54.0
						GP	Coarse sandy GRAVEL with numerous cobbles, gray, dense, dry to slightly moist	60.0
60	3					GP-GM	Coarse sandy GRAVEL with trace silt & numerous cobbles, tan, very dense, dry	68.0
70						SM	Silty Gravelly SAND, light brown, very dense, dry to saturated	70.0

continued on sheet 2

fig: B-5

by: SRR

Steve R. Rowland, P.E.

9233 clfmw13 6\15\93

GEOLOGIC LOG OF MONITOR WELL NO. 13

PROJECT	Central Landfill	BORING NO	13	ELEV GRND	241.6
LOCATION	Palmer Alaska	PAGE	2 of 2	ELEV COLLAR	243.86
CLIENT	Mat-Su Borough	DATE BEGUN	3-1-93	TOTAL DEPTH	94.0
DRILLED BY	Tester Drilling	DATE END	3-2-93	COORD NORTH	2773176.8
LOGGED BY	Steve Rowland	EQUIP TYPE	Driltech D40K	COORD EAST	1780060.3
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc Info	Well record	USCS	Material Description	Depth
	4				SM	Groundwater encountered while drilling. Not able to develop significant yield using air. Water level measured at 72.52 feet on 6/11/93 (ELEV. 169.08)	70.0
	5				SC	Clayey SAND, gray, very dense, moist to dry	74.0
80	6		LL-27 PI-6				78.0
90	7			94.0	CL CL-ML	Lean CLAY & silty CLAY, gray, very hard, moderately plastic, moist to wet becomes dry below 87.0 feet. Hydraulic conductivity: 2.56 (10E -8 cm/sec)	
						total depth	94.0
100							
110							
120							
130							

Fig B-5 by SRR

Steve R Rowland P E

9333 clfmw13 6\15\93

GEOLOGIC LOG OF MONITOR WELL NO. 14

PROJECT	Central Landfill	BORING NO	14
LOCATION	Palmer Alaska	PAGE	1 of 2
CLIENT	Mat-Su Borough	DATE BEGUN	3-5-93
DRILLED BY	Tester Drilling	DATE END	3-5-93
LOGGED BY	Steve Rowland	EQUIP TYPE	Driltech D40K
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.

ELEV GRND	227.4
ELEV COLLAR	230.22
TOTAL DEPTH	93.0
COORD NORTH	2773280.7
COORD EAST	1781250.3

Scale (ft) Vert Sec	Sample Interval	Blows/ft 340# hmr	Misc Info	Well record	Graphic Log	USCS	Material Description	Depth
								0.0
						ML	SILT. brown-tan. firm. dry	5.0
10, 20, 30	1					GP	Coarse sandy GRAVEL with numerous cobbles and occasional boulders brown to gray below 12 feet. very dense. dry Occasional strata of gravelly SAND	31.0
						GP-GM SP-SM	Gravelly SAND & sandy GRAVEL with occasional cobbles & trace silt. brown. moderately dense to dense. slightly moist	36.0
40	2					SP	Fine to medium SAND with trace gravel. olive. dense. dry to slightly moist	42.5
						GP-GM	Sandy GRAVEL with trace silt & occasional cobbles. brown. moderately dense. moist to wet	45.0
50	3					SM	Silty Gravelly SAND. brown. moderately dense. dry to wet	52.5
60	4		LL-28 PI-7			CL	Groundwater encountered while drilling. Not able to develop significant yield using air Water level measured at 53.12 feet on 6/11/93 (ELEV. 174.28) Lean CLAY. gray. very hard. wet then becomes dry to slightly moist below 55 feet. plastic Hydraulic conductivity: 3.73 (10E -8 cm/sec)	65.0
70						SC	Clayey SAND with some gravel. gray. very dense. moist to saturated	70.0

continued on sheet 2

Fig B-6 by SRR

Steve R Rowland P E

9233 clfmw14 6\17\93

GEOLOGIC LOG OF MONITOR WELL NO. 14

PROJECT	Central Landfill	BORING NO.	14	ELEV. GRND.	227.4
LOCATION	Palmer Alaska	PAGE	2 of 2	ELEV. COLLAR	230.22
CLIENT	Mat-Su Borough	DATE BEGUN	3-5-93	TOTAL DEPTH	93.0
DRILLED BY	Tester Drilling	DATE END	3-5-93	COORD. NORTH	2773280.7
LOGGED BY	Steve Rowland	EQUIP. TYPE	Driltech D40K	COORD. EAST	1781250.3
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc Info.	Well record	Graphic Log	U.S.C.S	Material Description	Depth
	5							70.0
						SC	Clayey SAND with some gravel. gray. very dense. moist to saturated	77.0
80	6			83.5		GP,SP	Sandy GRAVEL & gravelly SAND with trace clay & numerous cobbles. gray. very dense. saturated Yields some water Grades to clean sandy GRAVEL below 83 feet.	
90							total depth	93.0

Scale: 80, 90, 100, 110, 120, 130

GEOLOGIC LOG OF MONITOR WELL NO. 15

PROJECT	Central Landfill	BORING NO.	15	ELEV. GRND	277.8
LOCATION	Palmer Alaska	PAGE	1 of 3	ELEV. COLLAR	280.71
CLIENT	Mat-Su Borough	DATE BEGUN	3-24-93	TOTAL DEPTH	158.0
DRILLED BY	Tester Drilling	DATE END	3-25-93	COORD NORTH	2772127.6
LOGGED BY	Steve Rowland	EQUIP. TYPE	Driltech D40K	COORD EAST	1778161.6
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc. Info.	Well record	Graphic Log	U.S.C.S.	Material Description	Depth
								0.0
						ML	SILT, brown-tan, firm, dry	
								5.0
10								
20								
30						GP,SP	Stratified coarse sandy GRAVEL with numerous cobbles and gravelly SAND brown to gray, very dense, dry	
	1							
40								
50								
60	2							
70								70.0

continued on sheet 2

Steve R Rowland, P.E

Fig. B-7 by SRR

8233 clfmw15 8\17\93

GEOLOGIC LOG OF MONITOR WELL NO. 15

ROJECT	Central Landfill	BORING NO.	15	ELEV. GRND.	277.8
LOCATION	Palmer Alaska	PAGE	2 of 3	ELEV. COLLAR	280.71
NT	Mat-Su Borough	DATE BEGUN	3-24-93	TOTAL DEPTH	158.0
DRILLED BY	Tester Drilling	DATE END	3-25-93	COORD NORTH	2772127.6
LOGGED BY	Steve Rowland	EQUIP. TYPE	Driltech D40K	COORD. EAST	1778161.6
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc Info.	Well record	Graphic Log	U.S.C.S	Material Description	Depth
						GP.SP	Stratified coarse sandy GRAVEL with numerous cobbles and gravelly SAND, brown to gray, very dense, dry	70.0
80	3					SP	Fine to medium SAND, brown to olive, moderately dense, dry	71.5
90								
100								
110	4					GP-GM	Sandy GRAVEL with numerous cobbles & trace silt, brown, dense, dry	102
120	5					SP	Stratified gravelly SAND & SAND with trace gravel, dry to saturated below 125 feet. Groundwater encountered while drilling. yields greater than 20 gpm between 130 & 140 feet Water level measured at 124.64 feet on 6/11/93 (ELEV. 153.16)	112
130								
						SM	Gravelly SAND with some silt, brown, dense, saturated	139
								140

continued on sheet 3

GEOLOGIC LOG OF MONITOR WELL NO. 15

PROJECT	Central Landfill	BORING NO	15	ELEV. GRND	277.8
LOCATION	Palmer Alaska	PAGE	3 of 3	ELEV COLLAR	280.71
CLIENT	Mat-Su Borough	DATE BEGUN	3-24-93	TOTAL DEPTH	158.0
DRILLED BY	Tester Drilling	DATE END	3-25-93	COORD NORTH	2772127.6
LOGGED BY	Steve Rowland	EQUIP TYPE	Drilltech D40K	COORD EAST	1778161.6
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (Ft) Vert Sec	Sample Interval	Blows/ft 340# hmr	Misc Info	Well record	Graphic Log	USCS	Material Description	Depth
						SM	Gravelly SAND with some silt, brown, dense, saturated	140
150	6 7		LL-17 PI-4			CL CL-ML	Lean CLAY & sandy silty CLAY with trace gravel, gray, very hard, wet to dry below 156.0 feet. Hydraulic conductivity: 7.37 (10E -7 cm/sec)	143.5
160				158.0			total depth	158.0
170								

Fig B-7 by SRR

Steve R Rowland P E

9233 clfmw15 6\17\93

GEOLOGIC LOG OF MONTOR WELL NO. 16

PROJECT	Central Landfill	BORING NO.	16	ELEV. GRND.	279.9
LOCATION	Palmer Alaska	PAGE	1 of 4	ELEV. COLLAR	282.88
CLIENT	Mat-Su Borough	DATE BEGUN	3-13-93	TOTAL DEPTH	278.0
DRILLED BY	Tester Drilling	DATE END	3-19-93	COORD. NORTH	2772035.8
LOGGED BY	Steve Rowland	EQUIP TYPE	Driltech D40K	COORD. EAST	1779015.9
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc. Info.	Well record	Graphic Log	U.S.C.S.	Material Description	Depth
						ML	SILT, brown-tan, firm, dry	0.0
						GP,SP	Stratified coarse sandy GRAVEL with numerous cobbles and gravelly SAND brown to gray, very dense, dry	2.5
								70.0

Scale: 10, 20, 30, 40, 50, 60, 70

continued on sheet 2

Fig: B-8 by: SRR

Steve R Rowland, P.E.

GEOLOGIC LOG OF MONTOR WELL NO. 16

PROJECT	Central Landfill	BORING NO	16	ELEV GRND.	279.9
LOCATION	Palmer Alaska	PAGE	2 of 4	ELEV COLLAR	282.88
CLIENT	Mat-Su Borough	DATE BEGUN	3-13-93	TOTAL DEPTH	278.0
DRILLED BY	Tester Drilling	DATE END	3-19-93	COORD NORTH	2772035.8
LOGGED BY	Steve Rowland	EQUIP. TYPE	Driltech D40K	COORD EAST	1779015.9
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (Ft) Vert Sec.	Sample Interval	Blows/Ft 340# hmr	Misc. Info	Well record	Graphic Log	U.S.C.S	Material Description	Depth
								70.0
80						GP.SP	Stratified coarse sandy GRAVEL with numerous cobbles and gravelly SAND brown to gray, very dense, dry	80.0
90, 100, 110						GP-GM	Sandy GRAVEL with numerous cobbles & trace silt, brown, dense, dry	112.0
120	1					SP	Fine to medium SAND, olive, moderately dense, dry to slightly moist becoming moist below 123 feet. Static water level record at 122.0 feet on 3/19/93 thru 3/22/93 for lower confined aquifer prior to being sealed off with grout.	128.0
130	2					SP	Groundwater encountered while drilling. Yields greater than 20 gpm Water level measured at 128.5 feet on 6/11/93 (ELEV. 151.40) Water level measured at 130.0 feet on 3/25/93 Gravelly SAND, olive, dense, saturated	138.0
140	3					GP	Sandy GRAVEL with numerous cobbles, brown, dense, saturated	140

continued on sheet 3

Steve R. Rowland, P.E.

Fig. B-8 by. SRR

9233 clfmw16 6\17\93

GEOLOGIC LOG OF MONITOR WELL NO. 16

PROJECT	Central Landfill	BORING NO	16	ELEV. GRND.	279.9
LOCATION	Palmer Alaska	PAGE	3 of 4	ELEV. COLLAR	282.88
CLIENT	Mat-Su Borough	DATE BEGUN	3-13-93	TOTAL DEPTH	278.0
DRILLED BY	Tester Drilling	DATE END	3-19-93	COORD. NORTH	2772035.8
LOGGED BY	Steve Rowland	EQUIP. TYPE	Driltech D40K	COORD. EAST	1779015.9
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc. Info	Well record	Graphic Log	U.S.C.S.	Material Description	Depth
								140.0
150						GP.SP	Stratified coarse sandy GRAVEL with numerous cobbles and gravelly SAND brown to gray, very dense, dry	
								162.0
170				170.0		SP SP-SM	Fine to medium SAND with occasional trace silt & gravel, brown, dense, saturated	
								182.0
190	4					SP-SM GP-GM	Stratified gravelly SAND & sandy GRAVEL with trace silt, brown, dense, saturated	
								195.0
200	5					SC.GC	Clayey GRAVEL & clayey SAND, gray, very dense, wet to dry below 205 feet.	
210								210

continued on sheet 4

Fig: B-8 by: SRR

Steve R. Rowland, P.E.

9233 clfmw16 6\17\93

GEOLOGIC LOG OF MONTOR WELL NO. 16

PROJECT	Central Landfill	BORING NO	16	ELEV GRND	279.9
LOCATION	Palmer Alaska	PAGE	4 of 4	ELEV COLLAR	282.88
CLIENT	Mat-Su Borough	DATE BEGUN	3-13-93	TOTAL DEPTH	278.0
DRILLED BY	Tester Drilling	DATE END	3-19-93	COORD NORTH	2772035.8
LOGGED BY	Steve Rowland	EQUIP TYPE	Driltech D40K	COORD EAST	1779015.9
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert Sec	Sample Interval	Blows/ft 340# hmr	Misc Info	Well record	Graphic Log	USCS	Material Description	Depth
								210
220						SC,GC	Clayey GRAVEL & clayey SAND, gray, very dense, wet to dry below 203 feet.	223.0
230	6		NP			ML	Silty GRAVEL with some sand, gray, very dense, dry to moist Hydraulic conductivity: 1.45 (10E -4 cm/sec)	240.0
240, 250, 260, 270	7					SP SP-SM	Fine to coarse SAND with occasional trace silt, olive, dense, saturated Extreme sand heave while drilling. Yields in excess of 30 gpm mixed sand and water during test flow with air.	
						SP	Gravelly SAND, olive, dense, saturated Yields greater than 50 gpm.	
280							total depth	278.0

Steve R Rowland, P.E

Fig B-8 by SRR

9233 clfmw16 6\17\93

GEOLOGIC LOG OF MONITOR WELL NO. 17

PROJECT	Central Landfill	BORING NO	17	ELEV. GRND.	224.0
LOCATION	Palmer Alaska	PAGE	1 of 2	ELEV. COLLAR	226.56
CLIENT	Mat-Su Borough	DATE BEGUN	3-8-93	TOTAL DEPTH	136.0
DRILLED BY	Tester Drilling	DATE END	3-10-93	COORD. NORTH	2772056.1
LOGGED BY	Steve Rowland	EQUIP. TYPE	Driltech D40K	COORD. EAST	1780382.5
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec	Sample Interval	Blows/ft 340# hmr	Misc. Info.	Well record	Graphic Log	U.S.C.S.	Material Description	Depth
								0.0
						ML	SILT, brown-tan, firm, dry	2.5
10, 20	1					GP,SP	Stratified coarse sandy GRAVEL with numerous cobbles and gravelly SAND brown to gray, very dense, dry	30.0
30, 40, 50, 60, 70	2					GP GP-GM	Coarse sandy GRAVEL with numerous cobbles & occasional trace silt, gray to tan, very dense, dry to saturated below 87 feet	70.0

continued on sheet 2

fig: B-9 by: SRR

Steve R. Rowland, P.E.

8233 clfmw17 6\18\93

GEOLOGIC LOG OF MONITOR WELL NO. 17

PROJECT	Central Landfill	BORING NO.	17	ELEV. GRND.	224.0
LOCATION	Palmer Alaska	PAGE	2 of 2	ELEV. COLLAR	226.56
CLIENT	Mat-Su Borough	DATE BEGUN	3-8-93	TOTAL DEPTH	136.0
DRILLED BY	Tester Drilling	DATE END	3-10-93	COORD. NORTH	2772056.1
LOGGED BY	Steve Rowland	EQUIP. TYPE	Driltech D40K	COORD. EAST	1780382.5
DRILLER	Tim Tester	DRILL METHOD	Reverse Circ.		

Scale (ft) Vert. Sec.	Sample Interval	Blows/ft 340# hmr	Misc. Info.	Well record	Graphic Log	U.S.C.S.	Material Description	Depth
70–103						GP GP-GM	Coarse sandy GRAVEL with numerous cobbles & occasional trace silt. gray to tan. very dense. dry to saturated below 87 feet Groundwater encountered while drilling. Yields greater than 10 gpn at 100 feet below ground surface. Water level measured at 87.7 feet on 6/11/93 (ELEV. 136.62)	70.0
103–130	3					SP	Medium to coarse SAND. olive. dense. saturated	103.0
130–133						GP	Coarse sandy GRAVEL with numerous cobbles. gray. dense. saturated	130.0
133–136				136		GC	Clayey GRAVEL. gray. very dense. saturated to moist No groundwater production below 133.0 feet.	133.0
							total depth	136.0

Scale: 80, 90, 100, 110, 120, 130, 140

MATERIAL DESCRIPTION	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.	Penetration Resistance (340 lb. weight, 30" drop) ▲ Blows per foot
Medium to light brown, slightly silty, sandy GRAVEL; damp; GW-GM			S1	10/23/2000		
Light brown, slightly gravelly, silty SAND; damp	52.0		S2	10/19/2000		
Hard, gray SILT; moist	70.0		S3			
Bottom of Boring Boring Completed 10/19/2000	72.0					

Depth, Ft.: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75

Penetration Resistance scale: 0, 25, 50, 75, 100 (top); 0, 100, 200, 300, 400 (bottom)

LEGEND

- • Sample Not Recovered
- Ⅰ 2" O.D. Split Spoon Sample
- Ⅲ 3" O.D. Split Spoon Sample
- Surface Seal
- Solid Casing and Annular Sealant
- Well Screen and Filter Sand
- Cuttings Backfill
- ⊻ Ground Water Level At Time of Drilling
- ▼ Static Ground Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. USC letter symbol based on visual classification.

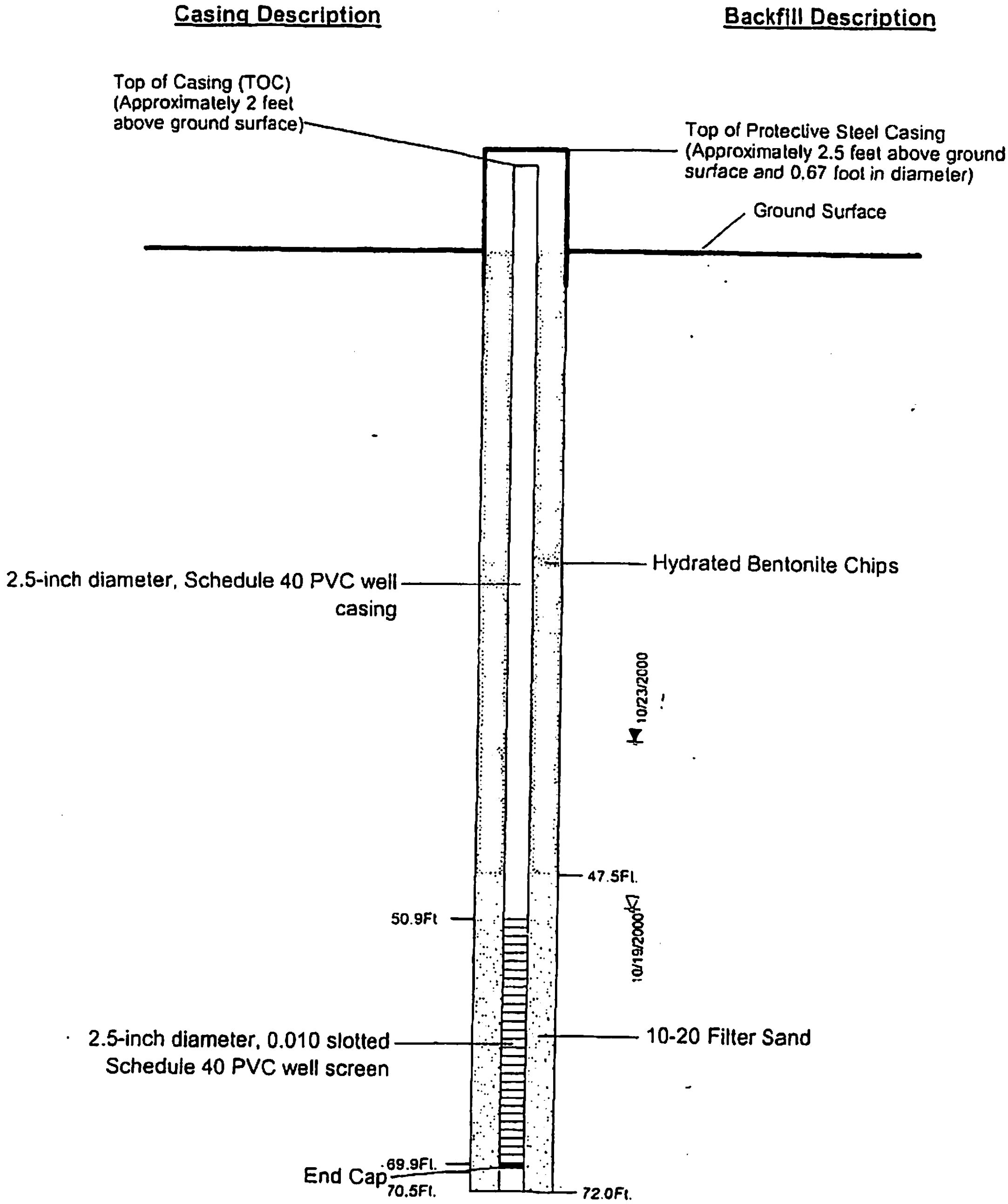
Central Landfill
Palmer, Alaska

LOG OF BORING NO. B19

November 2000 | Y-6185-11

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. 3



LEGEND

- Ground Water Level At Time of Drilling
- Static Ground Water Level

NOTE: All joints used threaded connections

Central Landfill
Palmer, Alaska

MONITORING WELL MW-19
CONSTRUCTION DETAIL

November 2000 Y-6185-11

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

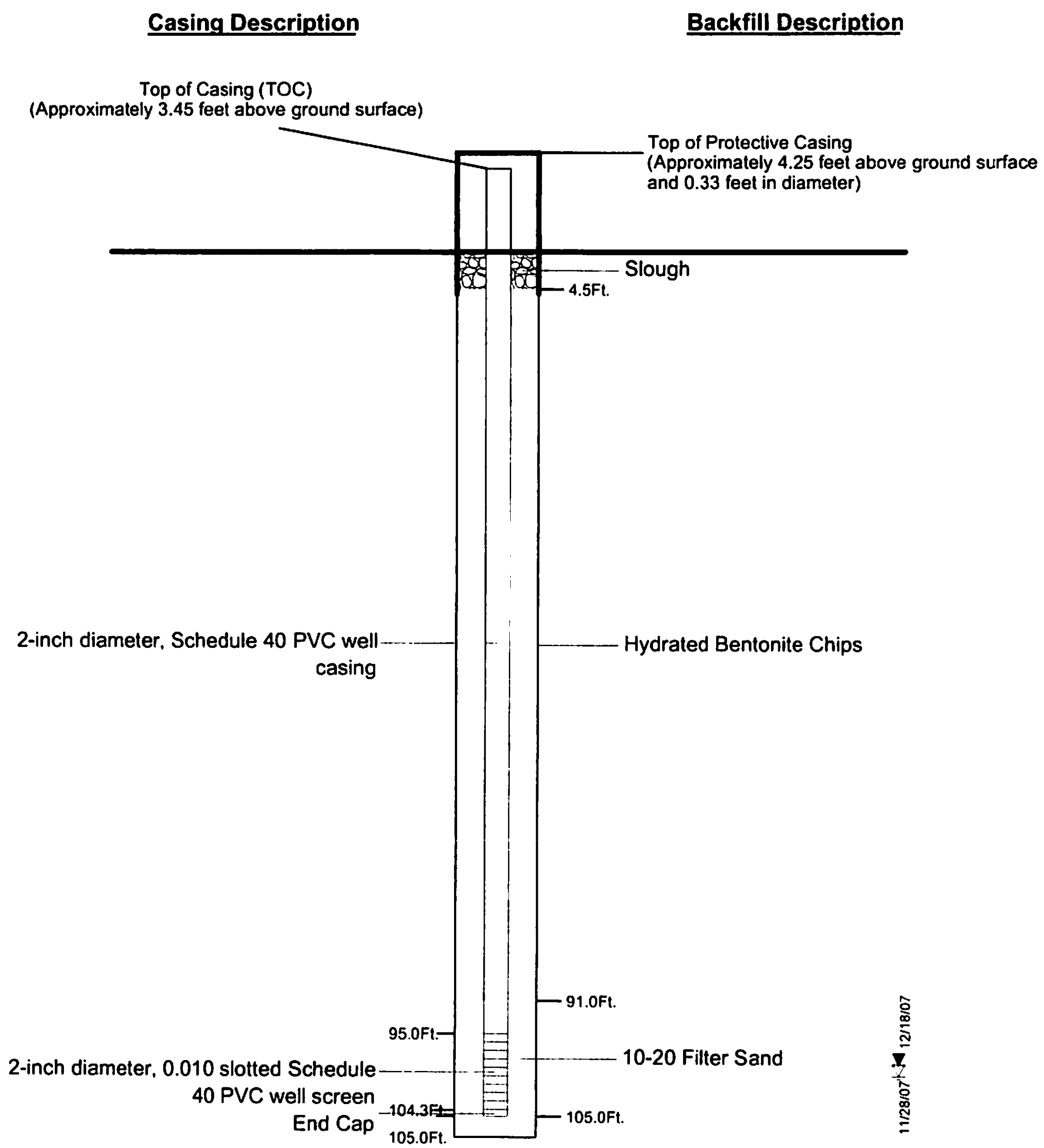
Fig. 4

1061673

Shannon & Wilson, Inc.
5430 Fairbanks Street, Suite 3
Anchorage, Alaska 99518
(907) 561-2120
Fax (907) 561-4483

				ADEC Selected Table J Parameters				Appendix I Parameters		Appendix II Parameters				
				Chloride, pH, Total Dissolved Solids	Diesel Range Organics & Residual Range Organics	Gasoline Range Organics	Total Mercury	Appendix I VOCs (8260), Dichlorodifluoromethane, & MTBE	Appendix I Total Metals: Ag, As, Ba, Be, Cd, Co, Cr, Cu, Ni, Pb, Sb, Se, Tl, V, Zn	Select Appendix II SVOCs: Acetophenone, m+p Cresols (3-,4-Methyl phenol), and Phenol	Cyanide	Sulfide	Tin	Dissolved Metals: As, Ba, Cd, Cr, Hg, Pb
Date	**Time**	**Sample ID** (16721-)	**Total Containers**	HDPE No Pres	Amber HCl	VOA Vials HCl	HDPE HNO_3	VOA Vials HCl	HDPE HNO_3	Amber No Pres	HDPE NaOH	NaOH & Zn Acetate	HDPE HNO_3	HDPE HNO_3
4/5/2006	15:30	MW-20	15	X	X	X	X	X	X					
4/5/2006	17:10	MW-21	15	X	X	X	X	X	X					
4/5/2006	15:25	Trip Blank	3					X						

Relinquished By:		**Project Information**	
Signature: [signature]	Date: 4/6/06	Project Number: 32-1-16721-021	Contact: Ben Heavner
Print Name: Randy Hessong	Time: 13:03	Project Name: Central Landfill	Sampler: Randy Hessong
Company: Shannon & Wilson, Inc.		Special Instructions:	
Received By:		**Sample Receipt**	
Signature: [signature]	Date: 4/6/06	Temp Blank: 5.6°C	Sample Matrix: Water
Print Name: Bryan J. Arnold	Time: 1304	Cooler Temperature Upon Arrival: 6.0°C	
Company: SGS		**Standard TAT & Excel EDD Required**	



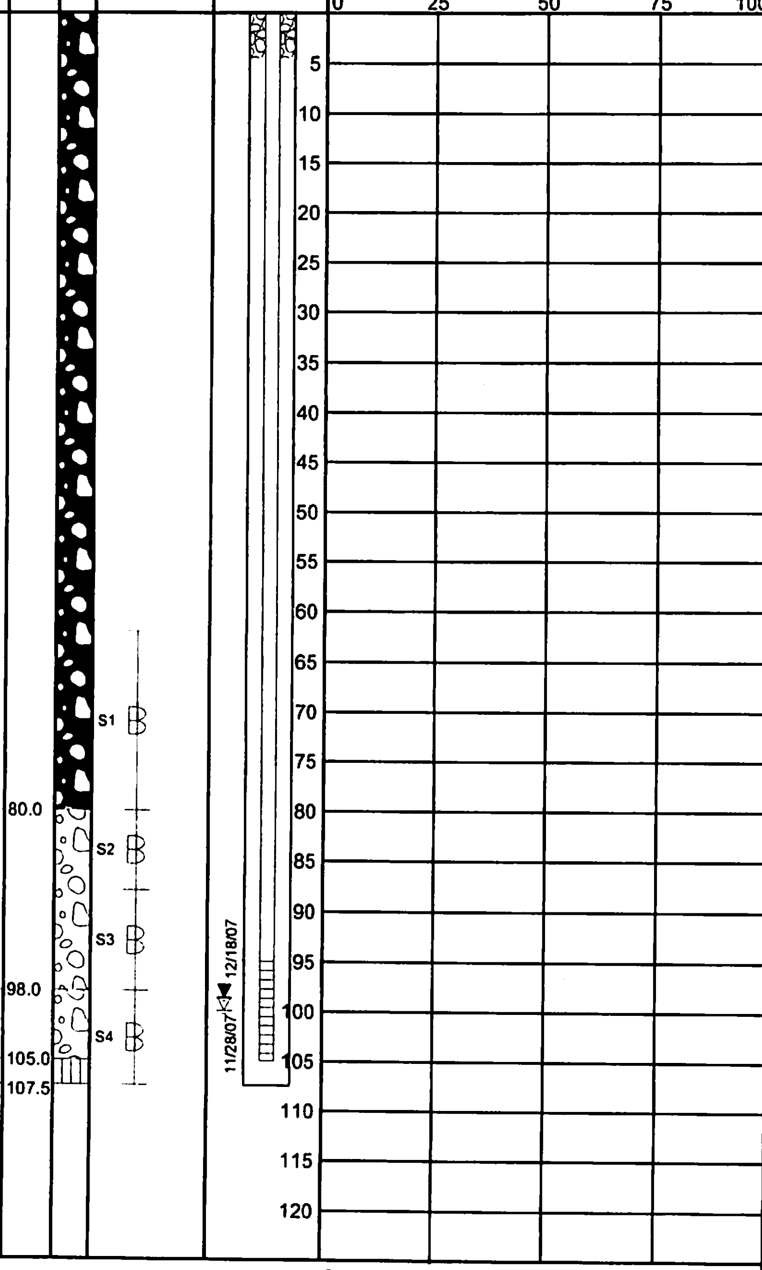
LEGEND

- ▽ Ground Water Level ATD
- ▼ Static Ground Water Level

NOTE: All joints use threaded connections.

Central Landfill Palmer, Alaska	
MONITORING WELL MW-22 CONSTRUCTION DETAIL	
January 2008	32-1-17153-001
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants	Fig. A-2

MATERIAL DESCRIPTION	Depth, Ft.	Symbol	Samples	Ground Water	Depth, Ft.	Penetration Resistance (340 lb. weight, 30" drop) ▲ Blows per foot
Gray COBBLES; moist to dry						
Boulder at 62 feet						
			S1			
Gray, slightly sandy GRAVEL; moist	80.0		S2, S3			
Gray, slightly silty, sandy GRAVEL; moist to wet	98.0		S4	11/28/07, 12/18/07		
Gray SILT; moist to wet	105.0					
Bottom of Boring Boring Completed 11/28/07	107.5					



LEGEND

- Sample Not Recovered
- Grab Sample
- Surface Seal
- Solid Casing and Annular Seal
- Well Casing and Filter Sand
- Cuttings Backfill
- ▽ Ground Water Level At Time Of Drilling
- ▼ Static Water Level

● Reading (ppm)

Plastic Limit ├──●──┤ Liquid Limit

Natural Water Content

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. USC letter symbol based on visual classification.

Central Landfill
Palmer, Alaska

LOG OF BORING MW-22

January 2008 32-1-17153-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Fig. A-1

ENVIRONMENTAL LOG 17153-1 MW22.GPJ S&W GEO1.GDT 1/4/08

Appendix B
Visual Monitoring Report Form

APPENDIX B
VISUAL MONITORING REPORT FORM

Central Landfill
Visual Monitoring Report Form

Inspector: ____
Date: ____
Weather: **wind:** dir______mph______. **Precipitation:** Yes No
Amount in inches. **Rain**______. **Snow**_______. **Temp:** _________

1. **Signs of damage to any and all facilities. YES NO**
   - **Explain:**

2. **Signs of damage to groundwater monitoring devices. YES NO**
   - **Explain:**

3. **Signs of settlement or ponding. YES NO**
   - **Explain:**

   ____
   ____

4. **Signs of leachate escape or unauthorized waste disposal. YES NO**
   - **Explain:**

5. **Signs of liner defects or erosion. YES NO**
   - **Explain:**

   ____
   ____

6. **Signs of fire or combustion problems. YES NO**
   - **Explain:**

   ____
   ____

7. **Signs of stress to wildlife or vegetation. YES NO**

   - **Explain:**

   ____
   ____

8. **Ground water monitoring system. YES NO**
   - **Explain:**

   ____
   ____

9. **Perimeter clean & safe.**
   - **Explain:**

Appendix C
Landfill Methane Gas
Monitoring Report Form

SHANNON & WILSON, INC.

CENTRAL LANDFILL GAS MONITORING LOG

Date: ____________ Instrument: ________________ Calibration Date: ______________

Sampling Personnel: _________________________

Location	*Date*	*Time*	*Methane (%)*	*Carbon Dioxide (%)*	*Oxygen (%)*	*Pressure (inches Hg)*
Scalehouse						
Ambient Air						
Crawlspace 1						
Crawlspace 2						
Crawlspace 3						
Animal Shelter						
Ambient Air						
Crawlspace 1						
Crawlspace 2						
Crawlspace 3						
Ambient air at ground water monitoring well locations						
MW-1						
MW-8						
MW-9						
MW-10						
MW-11						
MW-13						
MW-14						
MW-15						
MW-16						
MW-17						
MW-19						
MW-20						
MW-21						
MW-22						

Shannon & Wilson, Inc.

WATER SAMPLING LOG

Job No: ____________________ Owner/Location: ____________________

Well No.: ____________________ Weather: ____________________

ELEVATION DATA

Measuring Point (MP): Top of PVC Casing / Top of Steel Protective Casing / Other: ____________________

MP Elevation: __________ DTW Below MP: __________ Water Level Elevation: __________

Time of Depth Measurement: __________ Date of Depth Measurement: __________ Diameter of Casing: __________

PURGING DATA

Total Depth of Well Below MP: ____________________

Depth-to-Water (DTW) Below MP: ____________________

Water Column in Well: ____________________ (Total Depth of Well Below MP - DTW Below MP)

Gallons per foot: ____________________

Gallons in Well: ____________________ (Water Column in Well x Gallons per foot)

Three Well Volumes: ____________________ (Gallons in Well x 3)

Gallons Purged: ____________________

Date Purged: __________ Time Started: __________ Time Completed: __________

SAMPLING DATA

Sample Time: ________ Sample Date: ________ Odor: ________ Color: ________ Instrument: ________

Temp:	°C	Sp. Cond.:	mS/cm	pH:	S.U.	ORP:	mV
______		______		______		______	
______		______		______		______	
______		______		______		______	
______		______		______		______	
______		______		______		______	
______		______		______		______	

Duplicate Sample Designation: ____________________ Time / Date: ____________________

Triplicate Sample Designation: ____________________ Time / Date: ____________________

Evacuation Method: Disposable Bailer / Whale Pump / Dedicated Bladder Pump / Grundfos / Other: __________

Sampling Method: Disposable Bailer / Whale Pump / Dedicated Bladder Pump / Grundfos / Other: __________

Remarks: ____

____

Sampling Personnel: ____

WELL CASING VOLUMES (GAL/FT): 2" = 0.16 2.5" = 0.25 3" = 0.37 4" = 0.65 6" = 1.46

Appendix E
Chain-of-Custody Form

Shannon & Wilson, Inc.
5430 Fairbanks Street, Suite 3
Anchorage, Alaska 99518
(907) 561-2120
Fax (907) 561-4483

				ADEC Selected Table J Parameters					Appendix I Parameters		Appendix II Parameters					Previously Detected Appendix II Parameters			
				Total Dissolved Solids	Chloride, pH	Diesel Range Organics	Gasoline Range Organics	Total Mercury	40 CRF 258 Appendix I VOCs (8260), dichlorodifluromethane, and MTBE	Appendix I Total Metals: Ag, As, Ba, Be, Cd, Co, Cr, Cu, Ni, Pb, Sb, Se, Tl, V, Zn	40 CFR 258 Appendix II VOCs & MTBE	Appendix II SVOCs, OCPs, OCHs, & PCBs	Cyanide	Sulfide	Appendix II Total Metals: Ag, As, Ba, Be, Cd, Co, Cr, Cu, Hg, Ni, Pb, Sb, Se, Sn, Tl, V, Zn	SVOC: acetophenone, di-n-butyl phthalate, bis(2-ethylhexyl)phthalate, phenol, and p&m cresols	Cyanide	Sulfide	Total Metal: tin only
Date	**Time**	**Sample ID**	**Total Containers**	HDPE No Pres	Nalgene No Pres	Amber HCl	VOA Vials HCl	HDPE HNO_3	VOA Vials HCl	HDPE HNO_3	VOA Vials HCl	Amber No Pres	Nalgene NaOH	HDPE NaOH & Zn Acetate	HDPE HNO_3	Amber No Pres	Nalgene NaOH	HDPE NaOH & Zn Acetate	HDPE HNO_3

Relinquished By:		**Project Information**	
Signature:	Date:	Project Number:	Contact:
Print Name:	Time:	Project Name: Central Landfill	Sampler:
Company:		Special Instructions:	
Received By:		**Sample Receipt**	
Signature:	Date:	Temp Blank:	Sample Matrix: Water
Print Name:	Time:	Cooler Temperature Upon Arrival:	
Company:		**Standard TAT. Excel EDD Required**	

Central Landfill Cell 2A Final Cover Plan

Prepared for

Matanuska-Susitna Borough

Palmer, Alaska

August 27, 2001

CH2MHILL
301 West Northern Lights Boulevard, Suite 601
Anchorage, Alaska 99503-2662
(907) 278-2551

Contents

Attachments

1 Technical Papers

Experience with Geosynthetic Clay Liners for Landfill Closure at the Tomoka Farms Road Landfill, Dayton Beach, Florida. September 1996 SWANA Conference.

Cost Effective Alternative To An Unreinforced GCL For Landfill Final Cover Systems, Geosynthetics Conference 2001.

Geosynthetic Clay Liners Used in Municipal Solid Waste Landfills, EPA530-F-97-002, July 1997.

2 HELP Model Output Results

3 Draft Technical Specifications

TECHNICAL MEMORANDUM

CH2MHILL

Central Landfill Cell 2A Final Cover Plan

PREPARED FOR: Greg Goodale/Mat-Su Borough

PREPARED BY: Henry Friedman/CH2M HILL
Kelly Merrill/CH2M HILL

DATE: August 17, 2001

Introduction

The Central Landfill, located in the Matanuska-Susitna Borough, is the third largest landfill in Alaska. It is located off the Palmer-Wasilla highway within a designated landfill reserve consisting of 620 acres. Only about 10 to 15 acres of the reserve is actively developed for landfill use at any one time. As portions of the landfill reach their final design elevation, they are closed and new expansion areas are developed.

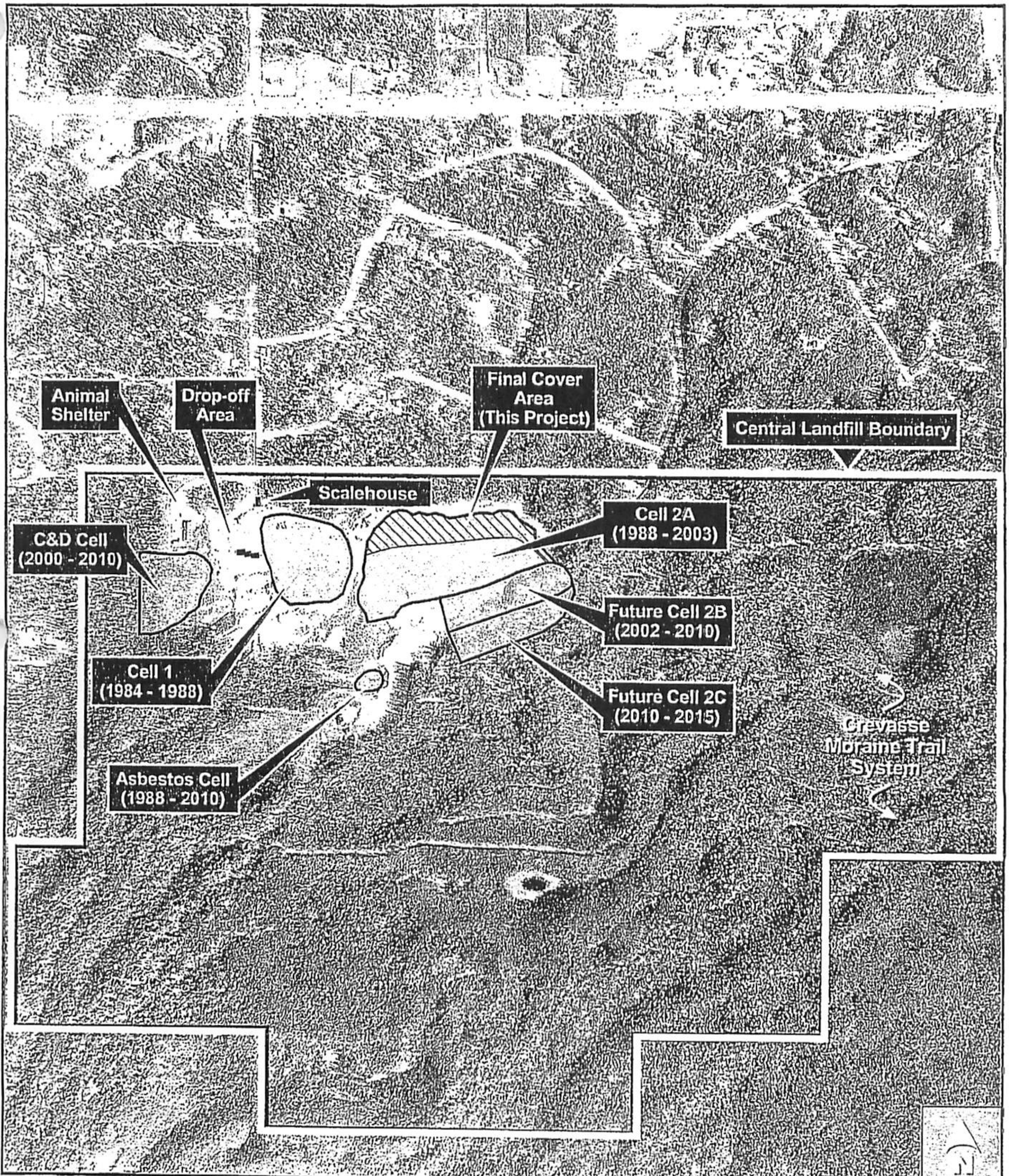
The first landfill cell (Cell 1) was closed in 1988. The currently active cell is Cell 2A, which was developed in the same year that Cell 1 was closed. Cell 2A is an unlined cell, as was permitted at the time it was developed. The northern side slopes of this cell will reach their final design elevation by 2002. The next cell in the phased development plan for Central Landfill will be a lined cell called Cell 2B. Cell 2B has been designed and is planned for construction in 2002. The location of various landfill facilities can be seen in Figure 1.

The geologic setting of the Central Landfill area is described in detail in the Central Landfill Operating Plan (CH2M HILL, February 1994). Near-surface geologic units include both glacial drift and glacial outwash deposits. Soils within these units consist primarily of relatively clean sand and gravel with frequent cobbles and boulders. The material is typically in a dense condition. A deep stratum of lacustrine silt and clay underlies the landfill site (greater than 40 feet below the existing ground surface). Measured groundwater depths in monitoring wells at the landfill have ranged from approximately 30 to 130 feet below the ground surface.

Final Cover Area

Description of Closure Area

The portion of Cell 2A that will be ready for final cover in the summer of 2002 can be seen in Figure 2. This area consists primarily of the northern side slope of Cell 2A. The total area designated for final cover in 2002 is 4 acres in size.



15705O.CL.CC ExistFuture2.fh8 07/13/01 and/a

Aerial Photograph Taken May 9, 1995
Reproduced by permission
© AeroMap U.S., Inc.

500 0 1000
SCALE IN FEET

CH2MHILL

Figure 1

Existing and Future Facilities Central Landfill
Matanuska-Susitna Borough

Phased Facility Closure

Cell 2A and Cell 2B will be closed in a series of phases. The capping of the northern slope of Cell 2A is the first of three phases. The height of Cell 2A will remain near elevation 300 with a temporary cover until Cell 2B is constructed. Once Cell 2B is filled to the height of Cell 2A, additional waste will be placed over both cells until a final elevation of about 340 feet is reached. An additional cell (Cell 2C) is currently proposed for construction just south of Cell 2B. Cell 2C will also be brought up to the elevation of the previous cells. Other future cells are anticipated for construction south and west of Cell 2C.

The second phase of closure will include remaining side slopes that have been brought up to design grade. This second phase of closure will likely include several separate construction projects. Each closure project will cover a specific side-slope area that has reached final design grades. The closure projects will be scheduled such that the areas to be covered are large enough for practical and cost-effective construction.

The third phase of the closure will be the final cover over the top of Cells 2A, 2B, 2C, and possibly other future cells once the final design elevation is reached. A conceptual north-to-south cross-section through the cells indicating the closure phases is shown in Figure 3.

Schedule

The northern side slopes of Cell 2A are scheduled for closure construction in the summer of 2002. The closure will be performed concurrently with the construction of Cell 2B under the same contract. This scheduling will reduce costs because mob/demob expenses can be shared between the two construction tasks. Also, additional cost savings are anticipated because of economies of scale resulting from use of similar materials where appropriate in the Cell 2B bottom lining system and the Cell 2A final cover.

Closure Requirements

Regulatory Requirements

The prescriptive final cover as defined in Title 18, Chapter 60.3959(a) of the *Alaska Administrative Code* (AAC) for an unlined municipal landfill consists of an infiltration layer at least 18 inches thick with a permeability no greater than 1×10^{-5} centimeters per second, and an erosion layer at least 6 inches thick of earthen material capable of sustaining native plant growth.

For a lined landfill, the final cover must have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils.

Regulation 18 AAC 60.395(b) allows the department to approve an alternative final cover design that will protect public health and the environment if it includes the following:

- An infiltration layer that achieves an equivalent reduction in infiltration as the prescriptive infiltration layer, and
- An erosion layer that provides equivalent protection from wind and water erosion as the prescriptive erosion layer.

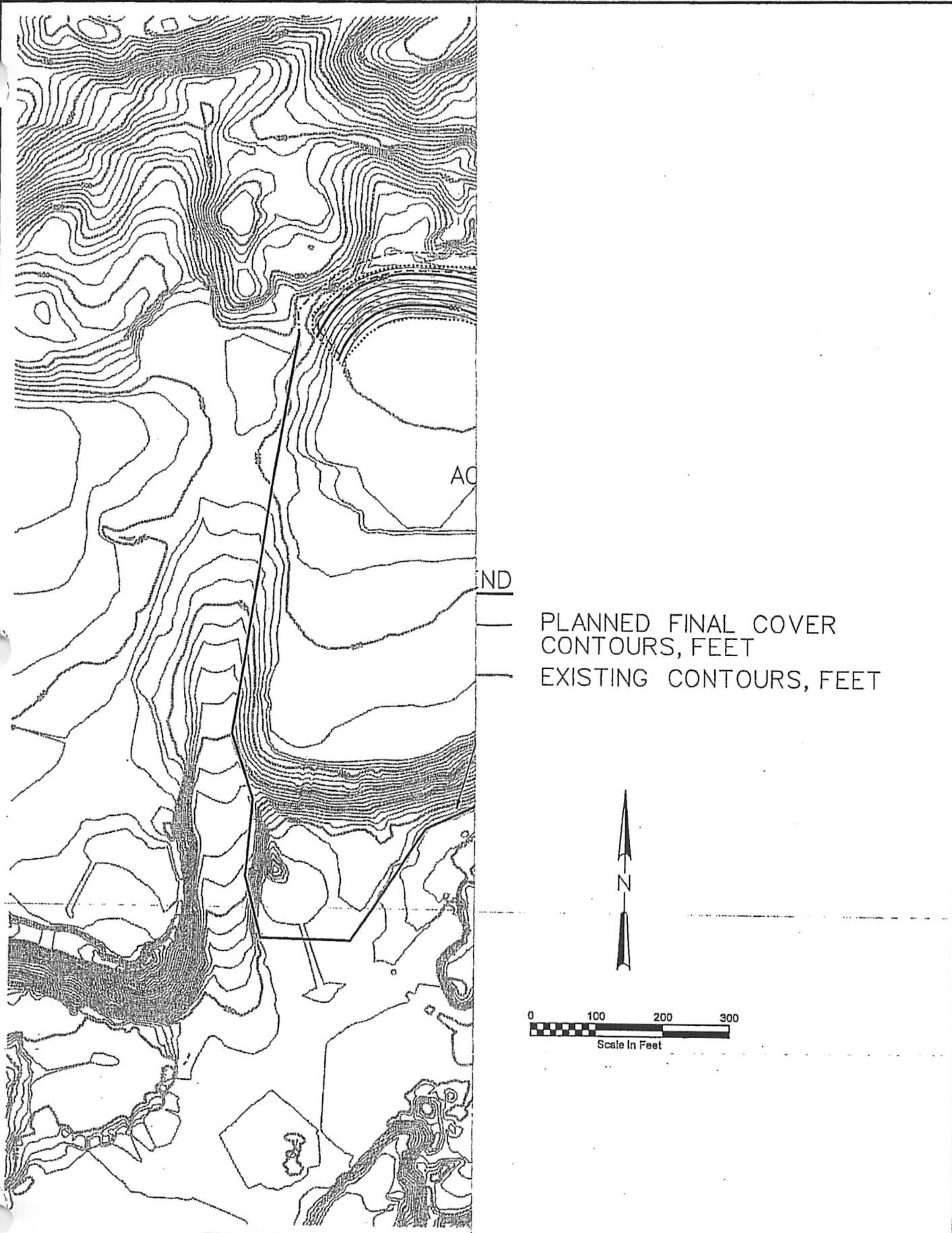


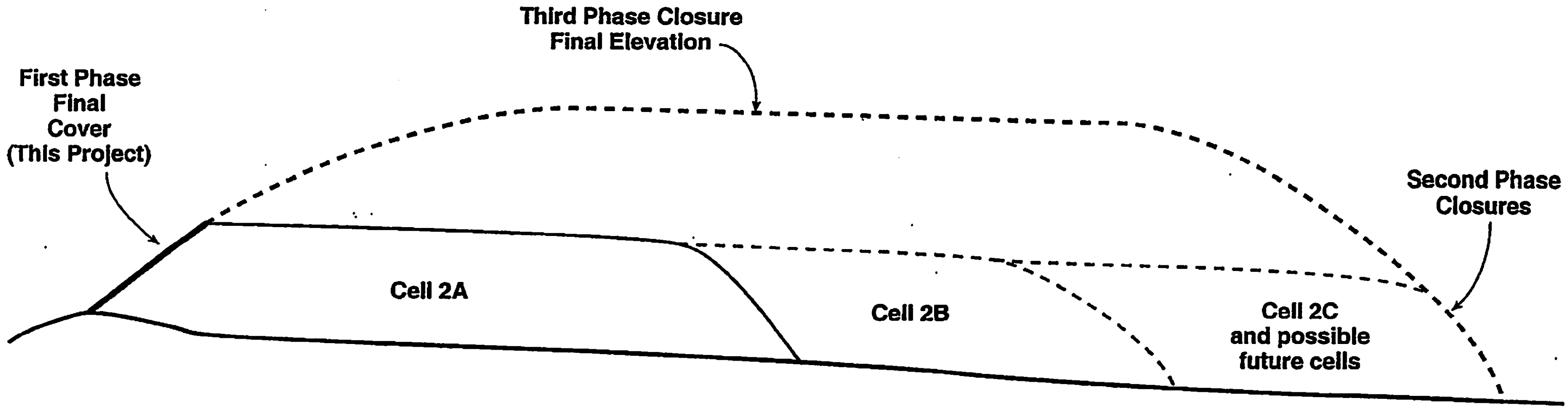
FIGURE 2
PLANNED CELL 2A FINAL COVER AREA

DSGN	
DR	K. BAILEY
CHK	K. MERRILL
APVD	

NO.	DATE

SHEET	x
DWG NO.	x
DATE	JULY 2001
PROJ NO.	157050.CL.CC

Figure2 Cell2A Cover.dgn 11-JUL-2001 13:42:15



Section A (from Figure 2)

Not to Scale

157050.CI.CC CoverPhase.fh8 07/13/01 anc/ra

CH2MHILL

Figure 3

Final Cover Phases
Central Landfill
Matanuska-Susitna Borough

Types of Final Covers

There are two basic types of final covers including the resistive barrier and the monolith capacitance barrier. These two final cover concepts minimize infiltration through different mechanisms.

The resistive barrier consists of a very low permeable soil or synthetic membrane layer that impedes the flow of water. This type of cap is designed so that water will run off if the precipitation rate is higher than the infiltration rate. Some moisture will also evaporate from upper soil layers, reducing the amount of moisture infiltrating through the barrier layer. The prescriptive final cover is a resistive barrier cap. This type of final cover is best suited to areas of high precipitation. The major disadvantage with this type of cover is that the infiltration rate can dramatically increase once the barrier layer is breached due to cracking or a tear in the synthetic membrane liner.

A monolith capacitance barrier consists of a fine-grained soil layer thick enough to absorb and retain the seasonal accumulation of water within the final cover. Water is held in the upper layers of soil by water tension, which is a stronger force in some soils than gravitational forces; therefore, the water does not drain from these soils. Moisture held near the surface will either evaporate or be lost through evapotranspiration. This type of cap sometimes includes a capillary barrier below the absorption soil layer to minimize infiltration of water into lower layers. The monolithic capacitance barrier is best in semiarid areas with low storm intensity. The major disadvantage with this type of cover is that the infiltration rate can dramatically increase once the field capacity of the adsorption layers are exceeded.

Previously Proposed Cell 2A Final Cover

The Mat-Su Borough originally proposed the prescriptive final cover for Cell 2A using locally available silt (CH2M HILL, December 2000). The average permeability of the silt was slightly greater than 10^{-5} centimeters per second; however, leakage evaluations using the Hydrologic Evaluation of Landfill Performance (HELP) model indicated that it would perform as well as the prescriptive cover.

After reviewing the design plan, the Alaska Department of Environmental Conservation (ADEC) requested that a test plot lysimeter be constructed to verify the HELP model results and to demonstrate the final cover's effectiveness. The Borough decided against the test plot because of the costs associated with the design, construction, and operation of a test plot area on the landfill; and because the majority of the landfill will probably require a different type of final cover as future expansion areas will be constructed with a bottom liner system.

Currently Proposed Cell 2A Final Cover

The currently proposed Cell 2A final cover being presented for ADEC review and approval consists of a low-permeability resistive barrier covered with a minimum of 2 feet of local soils. The barrier layer will consist of a geosynthetic clay liner (GCL) with an average permeability of about 10^{-9} centimeters per second. The GCL will consist of a layer of bentonite clay sandwiched between two nonwoven geotextiles. The GCL will be reinforced by needlepunching through the geotextiles to provide enhanced shear strength for stability reasons.

The operational cover over the waste will be prepared to form an even surface, and if necessary, a 6-inch-thick leveling course will be placed over the operational cover to provide a smooth surface before the GCL is set in place. An 18-inch layer of onsite sand and gravel will be placed over the GCL to protect the GCL and to provide a drainage medium over the barrier layer of GCL. The leveling course, if needed, and the 18-inch drainage layer above the GCL will be specified with a maximum particle size of 1 inch to provide protection to the GCL from oversize gravels and cobbles. The grain-size distribution of the 18-inch drainage layer will also be specified to serve as an effective filter to reduce migration of fines from the surficial topsoil layer into the drainage layer.

The uppermost layer will consist of 6 inches of a silt-loam organic soil capable of sustaining vegetative growth. The final cover will be hydroseeded with ground cover species demonstrated to thrive in similar soils in local weather conditions. The hydroseeding will establish an initial grass vegetative cover to minimize erosion and improve appearance. Indigenous vegetation will be allowed to eventually become established on the final cover. The final cover will be installed on slopes inclined no steeper than 4:1 (horizontal:vertical). Figure 4 shows a typical cross-section of this proposed cover.

This type of final cover has been approved and successfully implemented for both unlined and lined landfill cells in other states. Technical papers describing similar caps used in other locations are included in Attachment 1.

Stability Issues

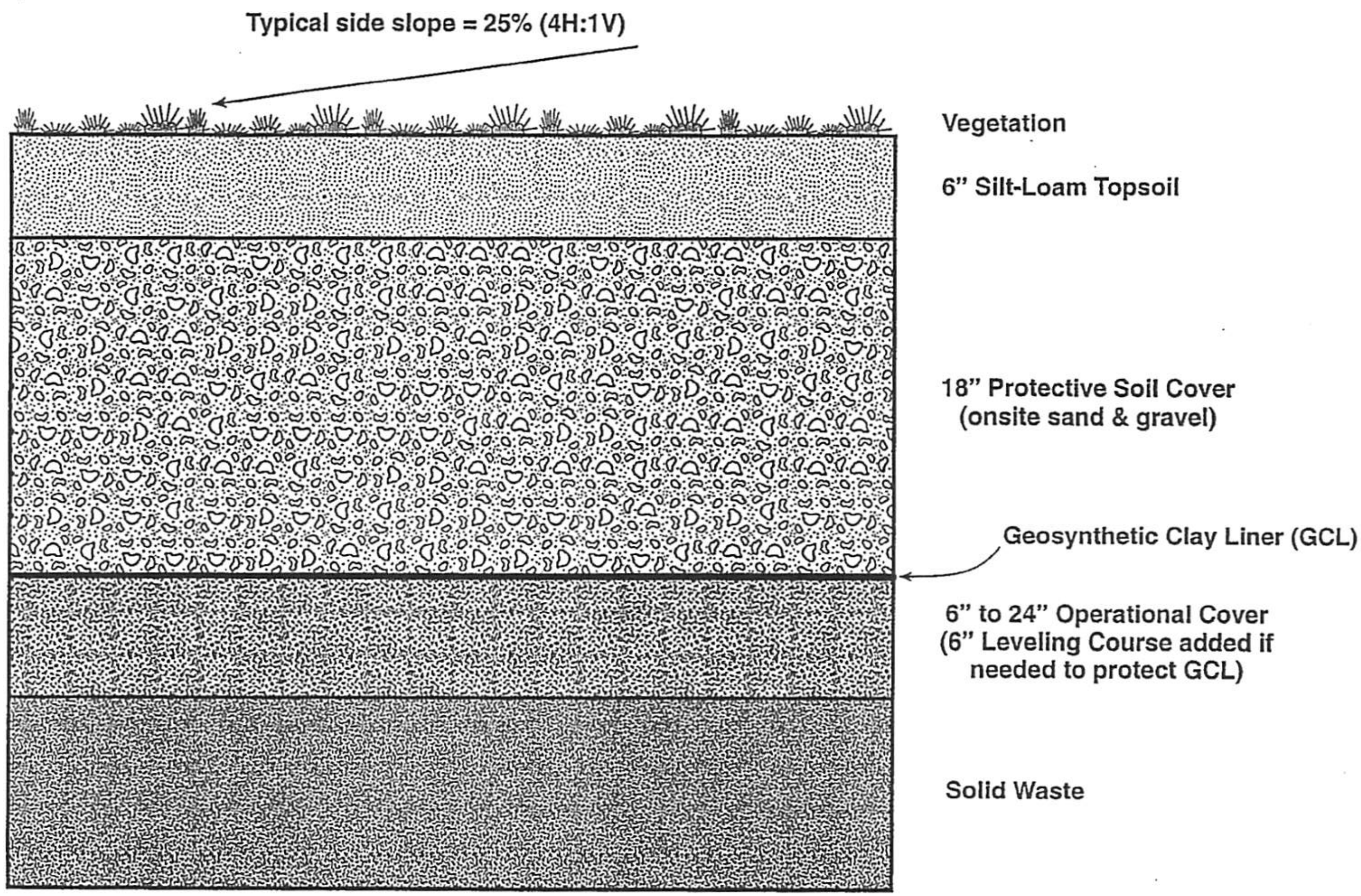
Static Stability

The internal stability of the proposed soil/GCL cover system on the Cell 2A side slopes was analyzed to confirm that a 4:1 (horizontal:vertical) slope would provide an adequate factor of safety against slope instability. The side-slope stability analyses were conducted for the following cases:

- Self-weight of cover system (dead loads)
- Dead loads plus loads from seepage forces in the drainage layer above the GCL during or after heavy rainfall events
- Dead loads plus equipment loads
- Dead loads plus equipment loads plus seepage forces

The static stability analyses were run using a slope height of 50 feet, which is approximately the maximum slope height in the planned Cell 2A cover area. The system components analyzed are as depicted in Figure 4. Material properties were determined from past test results on similar materials in our files and information in the literature. The analyses were conducted with the aid of the computer program SLOPBASE (Druschel, 1993).

The HELP model was used to determine appropriate seepage heights to use in the analyses. The design storm was taken as a 100-year, 24-hour storm event resulting in 2.2 inches of precipitation at the site. A maximum seepage height of 0.6 feet in the granular drainage layer above the GCL was used in the slope stability analysis based on the results of the HELP model.



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CH2MHILL

Figure 4

Cell 2A Final Cover Cross-Section
Central Landfill
Matanuska-Susitna Borough

Equipment loads were determined using the following weight and track width values for a Caterpillar D6 dozer:

- Total weight = 45,000 pounds (lbs)
- Total track width = 10 feet (ft)
- Distributed load = 4,400 lbs/ft

The specifications will require that the D6 dozer operate on at least 12 inches of soil over the GCL to provide adequate protection for the geosynthetic layer.

Results of the static stability analyses are summarized below in Table 1:

TABLE 1
Static Stability Results–Cell 2A Cover

Case Analyzed	Static Factor of Safety
Self-weight of cover system (dead loads)	2.02
Dead loads plus loads from seepage forces in the drainage layer above the GCL during or after heavy rainfall events	1.71
Dead loads plus equipment loads	1.84
Dead loads plus equipment loads plus seepage forces	1.58

The minimum static factor of safety resulting from the analyses was about 1.6. A minimum factor of safety of 1.3 is generally considered to be acceptable with respect to static slope stability. Accordingly, static stability is considered to be adequate for the proposed cover system.

Seismic Stability

The first step in assessing the seismic stability of the Cell 2A cover was to select appropriate earthquake design criteria. U.S. Environmental Protection Agency (EPA) Landfill Regulations–Resource Conservation and Recovery Act, Subtitle D (Chapter 40, Part 258 of the *Code of Federal Regulations*)–specify that all landfill containment structures be designed to resist the maximum expected horizontal acceleration with a 90 percent or greater probability of not being exceeded over a design period of 250 years. This criterion applies to the final landfill configuration. Peak horizontal ground accelerations with a 90 percent probability of not being exceeded over the specified 250-year design period were conservatively determined for the Central Landfill site from a site-specific seismic risk assessment carried out for the Anchorage Regional Landfill (ARL) site near Eagle River (Earth Mechanics, April 1994). The Central Landfill is approximately 25 miles north of the ARL site. Current seismic hazard maps developed by the U.S. Geological Survey (USGS, 1998) indicate a similar but slightly lower seismic hazard at the Central Landfill site as compared to the ARL site to the south. Accordingly, use of the ARL seismic hazard results is considered to be appropriate and slightly conservative for the Central Landfill site. The design peak horizontal ground acceleration determined from the ARL study is 0.54g.

The same cover system analyzed for static stability as described above was also analyzed for seismic stability using the computer program PCSTABL5M (Purdue University). Average pseudostatic seismic coefficients equal to one-half the peak horizontal acceleration value were used in the analysis (Richardson and Kavazanjian, 1995). The analysis was run only for the case of self-weight of cover combined with the seismic load. Assuming that the design seismic event would occur simultaneously with a design seepage event or when equipment is on the slope would be overly conservative.

The resulting seismic factor of safety was approximately 0.9. Seismic factors of safety of 1.0 or greater using the methodology described here indicate that permanent deformations are expected to be limited to less than 1 foot under the design seismic loading (Richardson and Kavazanjian, 1995). Maximum allowable deformations of 6 to 12 inches have typically been used in practice for design of geosynthetic liner systems (Richardson and Kavazanjian, 1995). The seismic factor of safety of 0.9 indicates that cover movements may be slightly more than 1 foot under the design earthquake load. However, because the cover system is close to the surface, any damage to the GCL or other cover components can be easily repaired if such an event occurs. The risk of adverse impacts to landfill facilities or to the environment resulting from such cover movements is very low.

Erosion and Seepage Control

The proposed final cover is highly resistant to erosion. Natural slopes in the area consisting of sandy gravel soil overlain with a loess layer are found at much steeper angles without significant erosion. The proposed uppermost 6-inch layer of silty loam is the same type of soil used on adjacent farms. This soil is excellent for the establishment of vegetative cover and is resistant to erosion when vegetated.

Provisions for drainage will be provided at the toe of the slope to allow water to drain from the sandy gravel layer over the GCL in the final cover. Drainage water will be allowed to infiltrate into adjacent lands within the landfill property boundaries but outside of areas with buried waste.

Landfill Gas Venting

Landfill gas venting will be necessary because the low-permeability GCL will not allow gas to pass through freely. Gas control will consist of passive vent pipes protruding through the GCL. Bentonite clay powder will be used to fill the seam around the pipe penetration. The vent will have a shepherd's hook or cap to prevent water from entering. The vents will be connected by perforated corrugated polyethylene pipes in the operational cover material beneath the GCL. The perforated pipes and vents will be spaced at approximately 200 feet on center to provide adequate venting.

Leakage Rate Evaluation

The leakage rate of the prescriptive and proposed final cover were estimated using the HELP model, version 3.07. Site specific climatic data were entered into the program. Both the prescriptive and proposed final cover layers were entered to compare leakage rates. The two covers differ in that the proposed cover includes a GCL between the operational cover layer and the infiltration layer. In the proposed cover, the infiltration layer was modeled as a lateral drainage layer rather than a vertical percolation layer because the underlying GCL is a barrier layer. This layer configuration more closely approximates actual conditions and is consistent with design examples presented in the HELP model user guide. The HELP model output results are included in Attachment 2.

Comparison with Prescriptive

The proposed final cover for portions of Cell 2A has many advantages over the prescriptive final cover. The proposed cover will minimize leachate production compared to the prescriptive cover and is easier to construct.

The proposed final cover was estimated by the HELP model to have a lower leakage rate than the prescriptive. The prescriptive final cover for an unlined landfill was estimated to have a leakage rate of 1.99 ± 0.060 inches per year (5-year average ± one standard deviation), whereas the proposed final cover was estimated to have a leakage rate of 0.05 ± 0.02 inches per year. The leakage rate of the proposed final cover is significantly less than the rate of the prescriptive. Also, the prescriptive leakage rate has a higher standard deviation, indicating that it is more susceptible to seasonal variations than the proposed final cover.

The proposed cover's resistance to erosion is expected to be as good as, if not better, than the prescriptive cover. The uppermost layer is exactly the same in both liner scenarios; however, the infiltration layer in the proposed cover has a higher permeability, which will allow water to seep into the cover and flow above the GCL rather than tending to saturate the topsoil and infiltration layers. Subsurface drainage is preferred over surficial saturation because there is typically less erosion potential.

The sandy gravel infiltration layer in the proposed final cover is more resistant to freeze-thaw and desiccation cracking than the silt/clay infiltration layer in the prescriptive cover. Tests have shown that GCLs are also resistant to freeze-thaw and desiccation cracking. The seasonal frost depth in this area is over 12 feet deep; therefore, the cap will be subjected to repeated freeze-thaw cycles. The silt/clay infiltration layer required in the prescriptive cover would be susceptible to cracking and increasing permeability with time under these conditions.

The proposed final cover is also more resistant to damage from differential settlement than the prescriptive. The sandy gravel infiltration layer and GCL are very flexible and resistant to cracking when flexed or stretched. The silt/clay infiltration layer of the prescriptive cover is more susceptible to cracking when stressed.

The hydraulic barrier in the proposed final cover utilizes a factory made GCL with a high level of quality control. It is very difficult to maintain the same level of quality control when constructing soil liners in the field, such as the silt/clay infiltration layer of the prescriptive cover.

The proposed cover is easier to construct than the prescriptive, while still maintaining a high level of quality control and quality assurance. The GCL is fast and easy to install in a controlled and consistent manner. The 18-inch-thick silt/clay layer required in the prescriptive cover takes longer to install than a GCL and the soil gradation and moisture content must be controlled to achieve the desired low permeability. Changes in the weather can require drying or wetting of the silt/clay soil to achieve the optimum moisture content for compaction. The prescriptive cover, therefore, is more difficult to construct with the same level of quality control than the proposed GCL liner cover.

Compliance with Regulations

The proposed final cover complies with regulation 18 AAC 60.395(b) because it has a lower permeability than the prescriptive cover and it is more resistant to erosion than the prescriptive. Overall, the proposed final cover is estimated to perform better than the prescriptive cover.

Construction QA/QC

The effectiveness of the final cover will depend on how well it is constructed; therefore, quality assurance/quality control (QA/QC) procedures will be included in the construction specifications. In addition to these requirements imposed on the construction contractor, an onsite Borough representative will provide construction oversight to ensure that QA/QC procedures are followed. Quality control checks will include, but not be limited, to the following:

- GCL subgrade preparation
- GCL storage, handling, and placement
- Quality of GCL seam construction
- Cover material quality tests
- Depth and grading of cover layers
- Proper installation of gas venting structures
- Establishment of vegetation on uppermost layer

Construction Specifications

Draft technical specifications have been prepared for the construction of the final cover and are included as Attachment 3. As the Cell 2A final cover construction will be combined with Cell 2B construction, specifications relevant to both Cell 2A and 2B are included in Attachment 3.

Post-Closure Maintenance

Vegetation

The construction contract will require the contractor to water the final cover area, as needed, until the planted area is established within the first growing season. Bare spots will be re-seeded, fertilized, and watered to reestablish a vegetated cover. Some landscaping with other types of indigenous plants may be performed in the future.

Erosion and Settlement Repair

Areas of significant erosion, if present, will be regraded and vegetation will be established as described in the previous section.

Settlement areas, if present, will be filled to prevent ponding on the surface of the landfill.

Integration with Closure of Adjacent Cells in the Future

An as-built record drawing of the final cover will be prepared by the construction contractor and the drawings will be maintained with the landfill records. In addition, markers will be placed along the perimeter of the final cover so that the edge can be found when the next phase of the final cover is constructed or maintenance work is needed along the toe of the landfill.

When the next phase of the closure is implemented, the edge of the GCL in the previously closed portion of the landfill will be exposed and tied into the final cover of the adjacent section. The GCL or other type of barrier layer used in the final cover will overlap the previously closed area by at least 3 feet. Detailed design plans and specifications will be prepared before the final closure phase is constructed.

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Attachment 1
Technical Papers

EXPERIENCE WITH GEOSYNTHETIC CLAY LINERS FOR LANDFILL CLOSURE AT THE TOMOKA FARMS ROAD LANDFILL, DAYTONA BEACH, FLORIDA

by

Lee A. Powell, P.E., SCS Engineers, and James L. Griffin, Director of Solid Waste Services, Volusia County.

Technical Reviews by David Poe, P.E. and Robert Gardner, P.E.

Sept 1996 SWANA Conference

PURPOSE

The purpose of this paper is to describe the experience Volusia County has had with the use of geosynthetic clay liners for closure of the Tomoka Farms Road Landfill.

Tomoka Farms Road Landfill is located on 3500 acres in Daytona Beach, Florida. The site is owned and operated by Volusia County (County) and takes in an average of 1300 tons of waste per day. The 120-acre landfill is designed as a high-rise landfill, rising approximately 100 feet above surrounding grade. The landfill has 6H:1V side slopes on three sides and 5H:1V side slopes on the western slope. There are terraces after every 20 feet of vertical rise. Built in the late 1970's, the bottom of the landfill has a polyvinyl chloride (PVC) geomembrane liner placed on top of a natural clay layer.

The operating permit for the landfill, issued by the Florida Department of Environmental Protection (FDEP), required the County to construct the final cover on the exterior surfaces as an on-going operation. The final cover was to consist of six to twelve inches of daily soil cover, eight inches of compacted clay liner (CCL), twelve inches of protective soil cover, and six inches of topsoil, as shown on Figure 1. Florida now requires compacted clay liners to be at least 18 inches thick, constructed in 6-inch thick lifts.

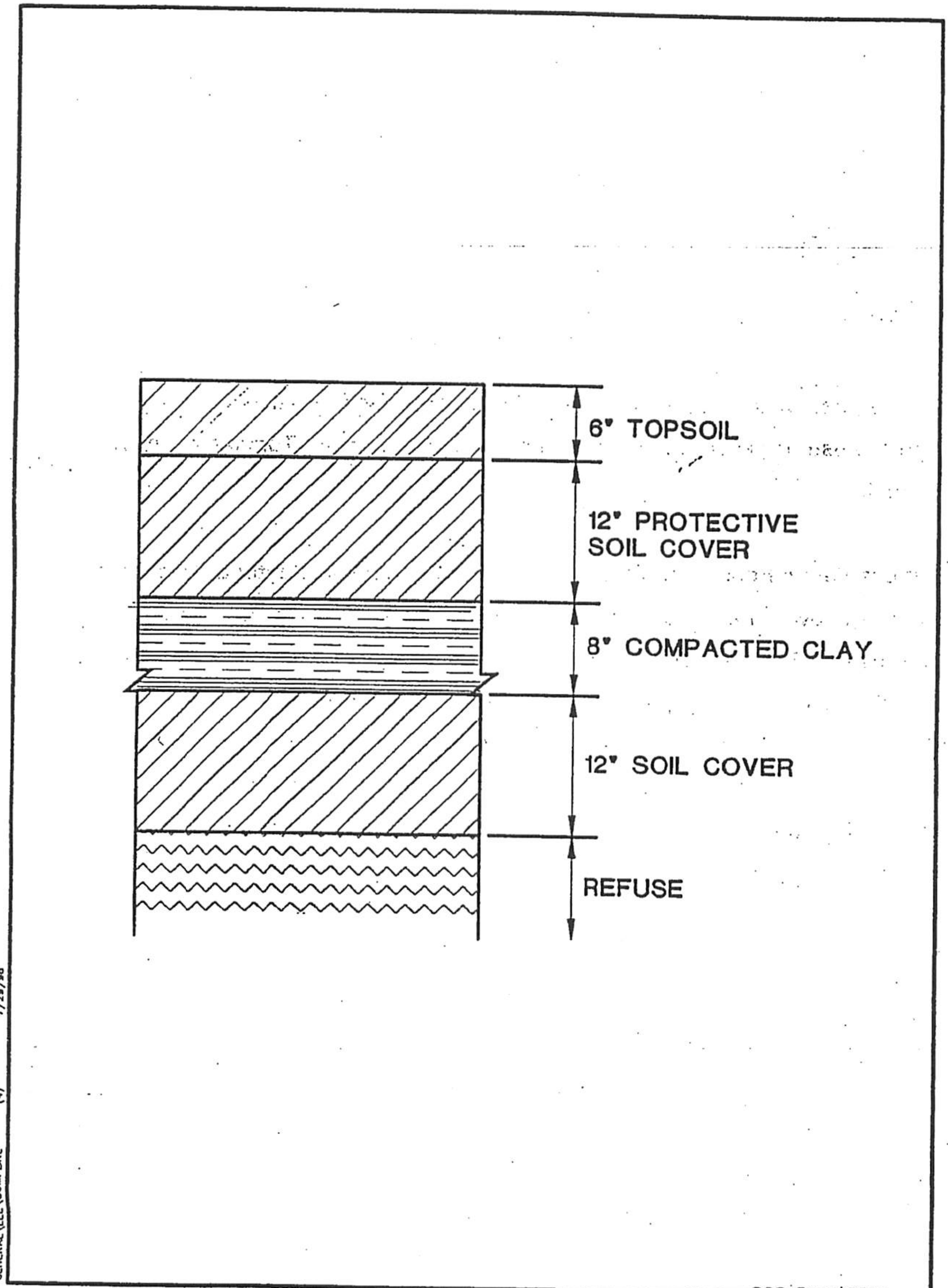

Figure 1. Compacted Clay Liner.

The County was in the process of constructing a CCL from the base to the first terrace on the closed-out portion of the landfill when problems arose. Intermittent rainfall, with its consequent erosion and over wetting of the clay, made closure more time-consuming and costly than anticipated. To reduce the cost of the ongoing closure construction project, the County began considering alternative cover systems.

COVER SYSTEMS

The purpose of a landfill liner system is to isolate the buried solid waste from the environment. The final landfill cover or cap is an important element of the complete liner system. Final landfill cover systems typically are made up of one or more protective soil layers and a low permeability barrier layer. Compacted clay liners (CCL) and geomembranes commonly are used for the low permeability barrier layer. However, both CCLs and geomembranes possess inherent disadvantages when installed over closed landfills.

Description of Common Barrier Layer Materials

Compacted Clay Liners (CCLs)--

CCLs typically are constructed in multiple lifts of six to eight inches in thickness. A 12-inch thick clay layer would normally be constructed in two six-inch lifts. An 18-inch thick layer, such as is required in Florida, would be constructed in three six-inch thick lifts. Each lift must be compacted sufficiently to achieve the project hydraulic conductivity requirements.

The relationship among compaction, moisture content, and hydraulic conductivity is unique for a specific clay and for specific types of field equipment. This relationship is usually tested in the field by construction of a "test strip" at the beginning of the project. Periodic testing of the clay source for grain size and Atterburg limits typically is required to confirm that the clay being used is the same as the clay that was tested within the test strip. Even within a single clay borrow pit, the characteristics of the clay may vary from one part of the pit to another, or from one layer of the pit to another.

Typically, project specifications require the clay to be compacted to 95 or 97 percent of the maximum dry density by either ASTM D1447 (Modified Proctor) or ASTM D698 (Standard Proctor) corresponding to the optimum moisture content. Since the surface of a closed landfill is not homogeneous, differing degrees of compaction may be achieved at different locations on the site. Typically, project specifications require that the subgrade be compacted to 90 to 95 percent of the maximum dry density. The required degree of compaction is not easily achieved over areas of compressible wastes. Controlling the moisture content of the clay is paramount. For best results, the moisture content of the clay prior to compaction should be 0 to 5 percent wet of the optimum moisture content. One rainfall can shut down a project for days while erosion is repaired and the clay dries out to proper moisture levels. However, too much sunny weather can dry out the clay, making it necessary to add moisture.

CCLs are also dependent upon field testing for quality assurance. A typical construction quality assurance plan might include four depth measurements, three field density tests, three moisture content tests, and one or two hydraulic conductivity tests per acre for each lift of installed barrier layer. Hydraulic conductivity tests can take several weeks to run, and a failing test can require excavation and reworking of the barrier layer. When only a few tests are conducted per acre, questions remain about the quality of the CCL in the areas between test sites.

Geomembrane Liners--

Geomembrane liners, such as polyvinyl chloride (PVC) and polyethylene (low and high density), are manufactured under factory quality control, thereby reducing the reliance on field quality assurance as required for CCLs. However, geomembranes do require field seaming and installation by experienced personnel. Unlike CCLs, geomembrane liners are not self-seaming, so every linear foot of seam must be tested for leakage. Additionally, pinholes, punctures or tears that occur during placement of cover soil are not easily detected and are difficult to repair.

Description of Geosynthetic Clay Liners

Geosynthetic clay liners (GCLs), previously called bentonite mats or blankets, are factory manufactured dry bentonite clay liners sandwiched between geotextiles. Most GCLs have the two geotextiles fastened together by needle punching or by stitching to increase resistence to shear. GCLs have been used in various applications for more than a decade, but they have not been widely used for landfill closures. GCLs however have many features that make them attractive for use as barrier layers at closed landfill sites:

- They are manufactured under factory quality control.
- The bentonite portion of the GCL has a very low hydraulic conductivity ($1X10^{-9}$ cm/sec or less typical).
- The bentonite used in GCLs can swell up to 10 times its initial volume when wetted. This swelling allows the GCL to be "self healing," that is, the liner seals punctures, penetrations, and other protrusions that would otherwise cause a leak in a geomembrane liner.
- The bentonite extrudes through the geotextile layers when the GCL is hydrated. This allows the GCL to be "self sealing." Consequently, no

field seaming is required other than placing the panels with a six-inch overlap between adjacent panels.

- The geotextile component of the GCL adds tensile strength to the GCL. This helps the GCL to resist the differential settlement that occurs in old landfills as the buried organic material continues to decay.
- GCLs do not depend on extensive compaction to achieve low permeability. They can easily be installed with landfill equipment, without the extensive compaction required by CCLs. This minimizes the risk of damage to underlying layers, as well as significantly reducing the time of construction. The risks associated with weather delays and damage are also significantly reduced.

PROJECT DESCRIPTION

Volusia County wanted a cover system that could be installed by County forces as an on-going part of landfill operation. Contracting out for geomembrane installation did not appear to meet that requirement. GCLs could easily be installed by County personnel and equipment, and appeared to be an attractive alternative. The County sought and obtained approval from the FDEP to test the use of GCLs for landfill closure. The cover system proposed by the County, shown in Figure 2, replaced the eight inches of clay originally permitted with GCL, covered with 18-inches of protective soil and six inches of topsoil.

Nine rolls of Claymax® GCL, produced by the James Clem Corporation, and two rolls of Bentomat® GCL, manufactured by Colloid Environmental Technologies Company (CETCO), were delivered to the Tomoka Farms Road site. The County constructed a two-foot deep anchor trench along the first terrace in the area where the GCL was to be installed. When the side slope was adequately prepared, one roll of GCL was carried to the terrace by a front end loader equipped with a special bar attachment which held the GCL roll. The GCL was hoisted over

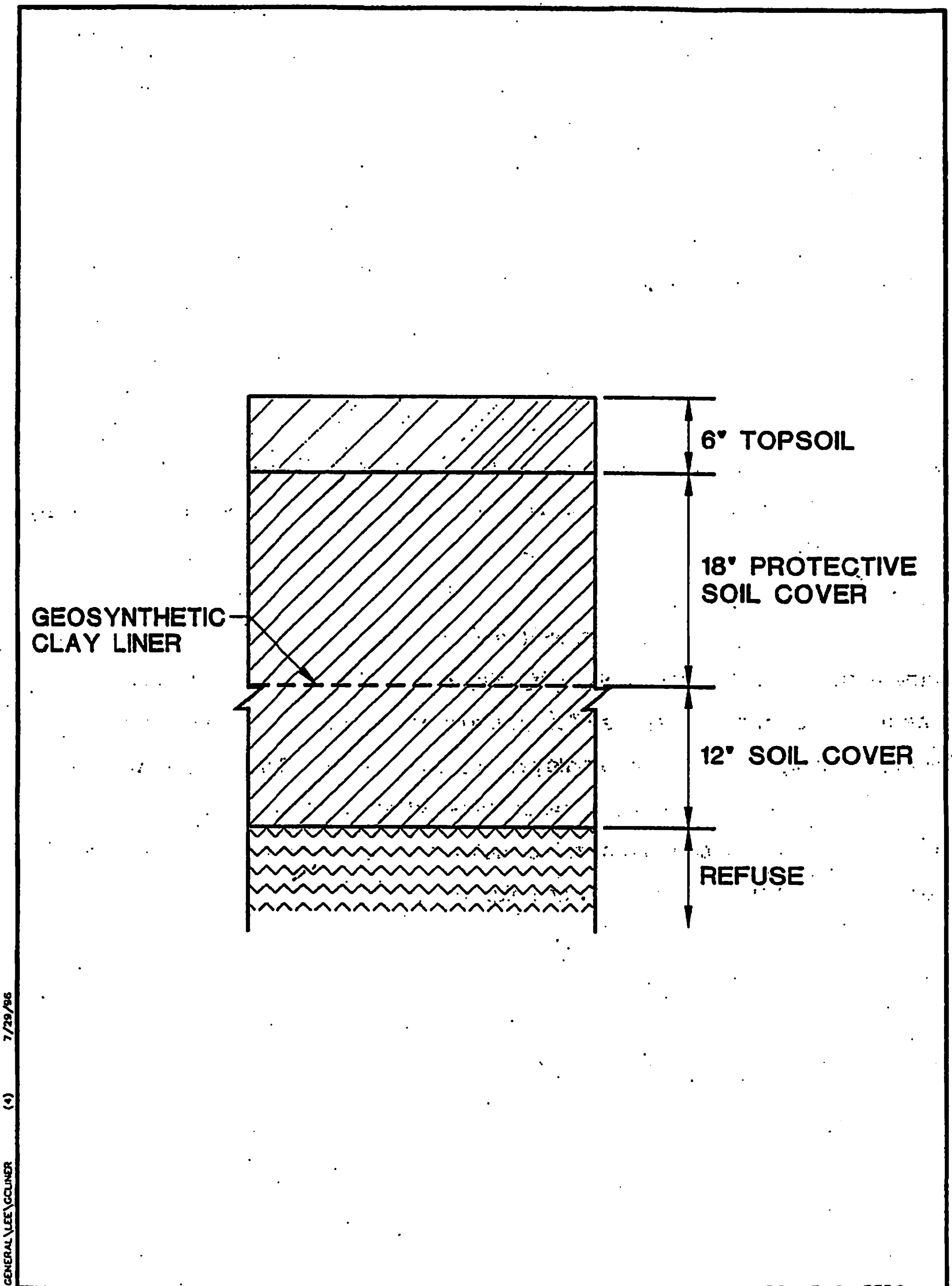

Figure 2. Geosynthetic Clay Liner.

the anchor trench and laborers walked the liner down the slope. The upper end of the GCL was placed in the anchor trench and covered with soil to hold the panel in place. The remaining panels were similarly placed, each overlapping the previous panel by six inches, and covered with two feet of soil. To ensure that the panels were properly overlapped, and to speed the installation process, the GCL manufacturers had printed overlap marks on each GCL panel six inches from the edge.

The day after the panels were installed, the County uncovered a small portion of each GCL in order to evaluate short term moisture changes. In the 24 hours subsequent to installation, the Claymax had fully hydrated and the Bentomat product was in the process of hydrating. Hydration was attributed to the relatively moist soils that were used to cover the GCL.

Based on the successful field testing, the FDEP approved the substitution of GCL as the barrier layer for closing the remaining portions of the landfill. The Construction Quality Assurance (CQA) Plan approved by the FDEP permitted the County to designate a County employee to provide on-site Construction Quality Assurance, operating under the general oversight of the County's consulting engineer. The approved CQA plan includes requirements for inspection of the subgrade, the liner, and the cover soil placed on top of the liner.

Description of GCL Installation

The areas where the GCL was to be installed were first brought to design grade, and a minimum 12-inch thick compacted soil cover was installed. Field density tests were taken by the County at a frequency of one test per acre. In place density of the compacted cover soil prior to placement of the GCL was found to vary between 95.2 and 100 percent of maximum dry density (Modified Proctor method). All subgrade was inspected and approved by the County's CQA

Inspector prior to placement of the GCL.

During the four-month period between March and June 1995, the County installed more than 48,000 square yards of GCL. All panels were inspected by the County's CQA Inspector, who also kept a daily log of all construction activity. From the anchor trench in the upper terrace, the 150-foot long panels were unrolled down the side slope to the lower terrace using a modified small back-hoe. Working only on days when no rain was expected, the County was able to install an average of 12 to 15 panels of GCL per day, in addition to completing the normal landfill operation activities. At the end of each day's installation, the exposed edge of the last panel was covered with polyethylene sheeting. When work resumed, this sheeting was peeled back and the next panel was placed with the required six-inch overlap.

Cover soil was placed on top of the GCL panels the same day as panel installation. The bulldozers spread and compacted the cover soil to a depth of 24 inches. The soil was pushed across the face of the side slope, from the upper panel to the lower panel to prevent damage to the seam overlaps. The cover soil specified was eighteen inches of a freely draining sandy soil, overlain by six inches of topsoil. Test holes were used to verify the depth of soil actually placed.

DESIGN CONSIDERATIONS RELATED TO THE USE OF GCLS FOR COVER SYSTEMS

The following design considerations and field observations were made concerning the use of GCLs at the Tomoka Farms Road Landfill:

Dehydration

With an average annual precipitation of 50 inches, dehydration is not as much of a concern at the Tomoka Farms Road Landfill as it might be at arid sites. The

Tomoka Farms Road Landfill uses the accumulated water in the stormwater ponds to irrigate the side slopes, further reducing the potential for the GCL to dehydrate. Test holes have shown that the GCL has stayed fully hydrated.

Landfill Gas

There was initial concern that landfill gas underneath the GCL could dehydrate the GCL and escape to the atmosphere, especially since the Tomoka Farms Road Landfill did not have a landfill gas management system in place at the time the GCL was installed. The County subsequently has checked for landfill gas in the areas where the GCL has been installed. To date, the County has not observed any adverse effects to the GCL from landfill. Additionally, the vegetative cover over the GCL has not been stressed as a result of fugitive landfill gas emmissions. Brown spots have occurred in several places near the base of the slope where CCL previously was installed, suggesting that the CCL has dehydrated, allowing gas to escape through the cover system. Clearly, no barrier material is a substitute for a gas management system.

Chemical Degradation

The bentonite layer in the GCL is thin, and therefore any chemical damage potentially could significantly impact the performance of the GCL. In a landfill cover system, leachate seeping out the side slopes could come in contact with the GCL. Leachate with high levels of dissolved salts, acids, alkalis, or organic contaminants such as aromatic or aliphatic compounds could impair the performance of the bentonite. However, leachate seeps are not common at the Tomoka Farms Road Landfill, and none have been observed in the areas covered by GCL. Consequently, chemical degradation of the bentonite was not considered a major concern.

Slope Stability

Hydrated bentonite has very little shear resistance, which would tend to make the

GCL unstable when installed on steep slopes. Slope stability was evaluated prior to reccommending the GCL for field testing.

In considering slope stability for the proposed GCL layer, the following were evaluated:

- Shear failure within the soil cover over the GCL.
- Shear failure at the interface between the cover soil and the GCL.
- Shear failure within the midplane of the GCL.
- Shear failure at the interface between the bottom of the GCL and the underlying soil.

The strength of each interface was calculated by the following equation:

$$S = W \cos B \tan P + C \qquad \text{(Spangler, page 294)}$$

where S = interface strength per unit slope length (lb/sf)
W = loading of cover soil (lb/sf)
B = slope angle (degrees)
P = friction angle in degrees
C = long term cohesion or adhesion

The slope angle on the western side slope at the Tomoka Farms Road Landfill was 5H:1V, or 11.3 degrees. For the analysis we assumed that the two feet of cover soil exerts a loading of 220 pounds per square feet (lb/sf). The GCL that was used at Tomoka was the Claymax "SP-500®" product, which has the two outer geotextile sheets sewn together. Although the friction angle for hydrated bentonite is very low, approaching zero degrees, the stitch bonding of the two geotextiles gives the Claymax SP-500 GCL an internal shear strength or "C" value of 500 lb/sf, as reported by the manufacturer. Of the four interfaces, the surface between the cover soil and the top of the GCL was found to be the critical or weakest interface. The shear strength per unit length or "S" for this interface was calculated to be 130 lb/sf.

The safety factor for this critical interface was calculated by the following equation:

SF = S / W sinB (Spangler, page 294)

= (130lb/sf) /(220lb/sf) (sin 11.3)

= 3.0

This was considered an adequate margin of safety. At the Tomoka Farms Road Landfill, the steepest slopes were only 5H:1V, so slope failure was not as critical a concern as it would be if the slopes were steeper. The GCL at the Tomoka Farms Road Landfill has been in place for two years with no sign of slope movement or displacement of the cover soils.

FINAL OBSERVATIONS

The use of GCLs in lieu of CCL at the Tomoka Farms Road Landfill has been successful. The County intends to continue using GCLs in the final cover system construction.

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COST EFFECTIVE ALTERNATIVE TO AN UNREINFORCED GCL FOR LANDFILL FINAL COVER SYSTEMS

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ABSTRACT

A geosynthetic clay liner (GCL) may be installed at a fraction of the cost of a California prescriptive standard compacted clay liner (CCL) when low-permeability material is not available on-site and soils must be either amended or imported. The engineered alternative selected for the final cover system at the 32 ha (79 acre) Hanford Landfill located in Kings County, California incorporates a new GCL product that offers a cost-effective alternative to both unreinforced GCLs and the State's prescriptive standard CCL, while exceeding applicable performance standards. Economic analyses comparing three design alternatives demonstrated a 41 to 63 percent cost savings over a prescriptive CCL cover system. This paper discusses the first use of a new, lightweight, woven/nonwoven, needle-punched GCL product in a landfill final cover application and presents results from conformance testing and construction quality assurance monitoring. Bentonite migration has been reported in unreinforced GCLs; however, at the Hanford Landfill, field observations of GCL panels exhumed approximately five weeks after initial placement indicated significant hydration, but no discernable bentonite migration.

INTRODUCTION

This paper utilizes a case study to present results of the first use of a new, lightweight, woven/nonwoven needle-punched geosynthetic clay liner (GCL) product in a landfill final cover application. The scope of work for the case study consists of the final closure of the Hanford Landfill, an unlined municipal solid waste (MSW) disposal facility located in the Central Valley of California (Figure 1). Average annual precipitation at the site is approximately 211 mm (8.29 in) and occurs as rain, 90 percent of which falls during the months of November through April. Subgrade excavation and refuse filling throughout the operating life has resulted in a nearly square, 32 ha (79 acre) footprint rising a maximum of 6.4 m (21 ft) above the surrounding flat terrain with refuse ranging from 7.6 to 12 m (25 to 40 feet) in thickness. The top of the landfill has been graded at 3 percent to form a series of alternating ridges and swales designed to drain the interior. The extreme northern and southern ridges steepen to approximately 10 percent away from the center and constitute a minor portion (4 percent) of the total landfill surface requiring closure. A 1.8 to 3.0 m (6 to 10 ft) high operational soil berm forms 3H:1V perimeter side-slopes.

Figure 1. Oblique aerial view of the Hanford Landfill taken during GCL and cover soil placement.

The combined absence of a local source for low-permeability material, low seismic activity, and the gently sloping surface of the landfill requiring placement of the final cover system provided an opportunity to explore possible benefits offered by the use of an unreinforced GCL. In this paper we present results of an economic analysis comparing various final cover system designs which led to the selection of a preferred GCL alternative, and discuss conformance testing and construction quality assurance monitoring during construction.

FINAL CLOSURE DESIGN

Final closure of MSW landfills in California is subject to requirements promulgated under California Code of Regulations (CCR) Title 27. The prescriptive standard for unlined waste management unit final cover systems in California consists of the following in ascending order:

- foundation layer consisting of 61 cm (24 in) of engineered fill, typically compacted to at least 90 percent relative density (modified proctor),

- compacted clay liner (CCL) consisting of 30 cm (12 in) of fine-grained material compacted to attain a saturated hydraulic conductivity no greater than 1×10^{-6} cm/sec, and

- an erosion resistant layer, typically in the form of a vegetative layer consisting of 30 cm (12 in) of soil capable of sustaining native, shallow-rooting plant growth and resisting foreseeable erosion.

Several geotechnical investigations were conducted at the Hanford Landfill to determine the suitability of on-site borrow soils for use in construction of the low-permeability clay layer and other components of the final cover system. Early investigations identified a silty-clay horizon located approximately 3 to 5 m (10 to 15 ft) below the ground surface. In addition to the onerous task of excavating this material, results of laboratory testing of undisturbed samples indicated a hydraulic conductivity that only marginally met requirements for the low-permeability layer. Hence, the on-site silty-clay material was eliminated as a potential source for low-permeability clay material. Subsequent testing of silty-clayey material exposed at the ground surface was performed to determine possible bentonite admix ratios which would allow more accessible on-site material to meet hydraulic conductivity requirements. Based on results of laboratory testing, a 3 percent bentonite admix ratio was required and was subsequently increased to 6 percent to account for variability in material and degree of mixing achieved during construction.

California allows the consideration and approval of engineered alternatives to the prescriptive standard when the prescriptive standard is not feasible and if there is a specific engineered alternative that is consistent with the performance goals addressed by the prescriptive standard, and which affords equivalent protection against water quality impairment. To establish that compliance with the prescriptive standard is not feasible, it must be demonstrated that the prescriptive standard is either unreasonably and unnecessarily burdensome and will cost substantially more than alternatives which meet the State's criteria, or is impractical and will not promote attainment of applicable performance standards.

Because the majority of slopes on the landfill surface do not exceed 3 percent, we also investigated the use of an unreinforced GCL product. We performed an economic analysis comparing three final cover system designs to assist in selection of the preferred alternative. The alternatives evaluated in the analysis included the following:

1) a prescriptive standard cover system utilizing 100 percent clay imported from the nearest commercial source,

2) a prescriptive standard cap utilizing on-site material with a 6 percent bentonite admix, and

3) an engineered alternative incorporating an unreinforced GCL.

As anticipated, the estimated cost for Alternative 1 was significantly higher than the other alternatives, with clay acquisition and transportation expenditures accounting for the cost differential. Costs, normalized to Alternative 1, are shown in Figure 2. Amending on-site soils with imported bentonite (Alternative 2) provided an estimated cost savings of 37 percent over that of Alternative 1. Alternative 3 provided a cost savings of 63 percent with respect to Alternative 1 and 41 percent with respect to Alternative 2, and was selected as the preferred engineered alternative.

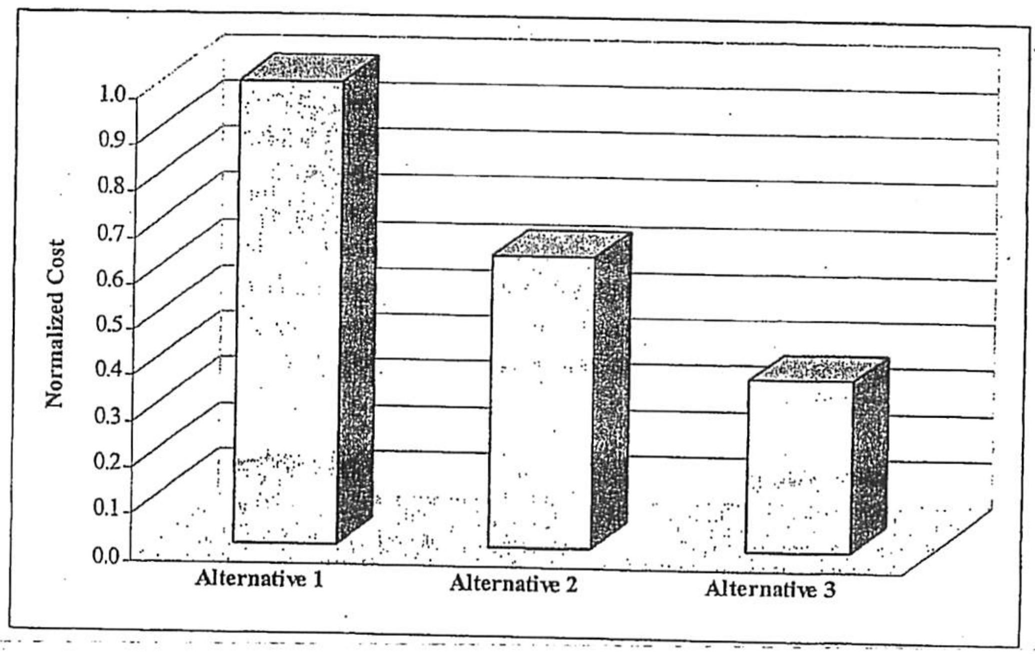

Figure 2. Relative costs for final closure alternatives described in this paper, normalized to Alternative 1.

Specifications for the engineered alternative cover on slopes less than 10 percent at the Hanford Landfill consisted of the following components in ascending order:

- a 30 cm (12 in) foundation layer placed over the existing intermediate cover and compacted to at least 90 percent relative compaction (modified proctor),

- An unreinforced GCL consisting of an approximately 3.7 kg/m^2 (0.75 lbs/ ft^2) dry weight sodium bentonite layer sandwiched between and continuously adhered to two lightweight (95 g/m^2, nominal [2.8 oz/yd^2]) woven geotextiles, and

- A 46 cm (18 in) vegetative soil layer track-walked to approximately 85 percent relative compaction (modified proctor).

Various manufacturers of GCLs have reported swelling of their products when installed in final cover systems applications in conjunction with the minimum 30 cm (12 in) vegetative layer required by the prescriptive standard. Therefore, the thickness of the vegetative layer was increased to 46 cm (18 in) to provide additional normal stress and prevent swelling of the GCL during hydration. The additional thickness also provides greater protection of the GCL against equipment damage following installation. The prescriptive standard requires a foundation layer of 61 cm (24 in) for the purpose of providing a firm and unyielding subgrade for compaction of the low permeability clay layer. However, for the GCL alternative, the main purpose of the foundation layer is to provide a smooth subgrade free of protrusions and deleterious objects which could damage the GCL. Therefore, the foundation layer thickness was reduced to 30 cm (12 in).

We petitioned the regulatory agencies and were successful in gaining approval of the preferred GCL engineered alternative. Project specifications were written to require the unreinforced GCL described above. However, the selected geosynthetics supplier proposed the use of a new, lightly needle-punched, woven/nonwoven GCL product designed specifically for the project which not only exceeded the project specifications, but also was bid at a cost savings of 4 percent to that of other bids submitted for an unreinforced GCL. The new product consists of sodium bentonite at the approximate dry weight of 3.7 kg/m^2 (0.75 lbs/ft^2) carried between a woven geotextile with a nominal weight of 95 g/m^2 (2.8 oz/ yd^2) and a nonwoven geotextile with a nominal weight of 100g/m^2 (3.0 oz/yd^2) that are lightly needle-punched together. For slopes exceeding ten percent, a standard double nonwoven needled punched (NWNP) reinforced GCL overlain by a geonet composite drainage layer was specified. Depending on the application, the authors commonly specify a minimum peel strength of 110 to 130 N (25 to 30 lbs) performed on a 10 cm (4 in) wide sample using the modified ASTM D 4632 test method. However, due to the shallow 10 percent slopes at the Hanford Landfill, the minimum acceptable peel strength was reduced to 67 N (15 lbs) using ASTM D 4632 (modified).

CQA AND INSTALLATION

Manufacturers present geosynthetic physical properties in terms of a minimum average roll value (MARV) in a particular manufacturing lot. The MARV is the value which is exceeded by 97.5 percent of the test data and is derived statistically as the average value minus two standard deviations (Koerner, 1997). Unfortunately, it can be difficult to define a manufacturing lot which can be the compilation of many tests over months or years. The average of all testing on any roll was required to be greater than the value listed in the project specifications shown in Table 1.

Table 1. GCL Specifications

Test	Method	Value	MQC[1] Testing Frequency
Base Bentonite			
Moisture Content	ASTM D 2216	25 percent (max.)	1 per 50 tons
Swell	ASTM D 5890	24 ml/2 g (min.)	1 per 50 tons
Fluid Loss	ASTM D 5891	18 ml (max.)	1 per 50 tons
Geotextiles[2]			
Mass per Unit Area	ASTM D 5261	95 g/m^2	1 per 50,000 ft^2
GCL[2]			
Grab Strength[3]	ASTM D 4632	330 N	1 per 200,000 ft^2
Bentonite Mass Per Unit Area	ASTM D 5993	3.66 kg./m^2 (oven-dried)	1 per 50,000 ft^2
Index Flux	ASTM D 5887	5 x 10^{-9} cm/sec.	1 per production-week

[1] Manufacturing Quality Control.
[2] Values for geotextiles and GCL are Minimum Average Roll Values (MARV) and the average of all measurements on any roll shall not be less than the MARV specified.
[3] Tested in machine direction.

The manufacturer of the lightly-needled GCL reports a nominal internal shear strength of 2.4 kPa (50 lbs/ft^2) and a minimum peel strength of 22 N (5.0 lbs) for the lightly-needled GCL. Peel strengths of the lightly-needled GCL for the Hanford project ranged from 24 N to 93.0 N (5.5 lbs to 20.9 lbs) with a typical value of 44 N (10 lbs). These values exceed the internal shear strength reported for unreinforced GCL.

Lightly-needled GCL rolls were delivered to the site in standard widths of 4.72 m (15.5 ft) and lengths of either 45.7 m (150 ft) or 67.1 m (220 ft). Sample coupons of GCL delivered to the site were collected for Construction Quality Assurance (CQA) testing to verify that the product met the project specifications. A compilation of CQA test results and Manufacturing Quality Control (MQC) test results for the lightly-needled GCL are presented in Table 2.

Table 2. Combined Results of CQA Testing and MQC Testing

Material	Base Bentonite			Geotextile (MARV)[1]		GCL (MARV)[1]		
Test[2]	Moisture Content	Swell	Fluid Loss	Upper Mass	Lower Mass	Grab Strength	Bentonite Mass (dry)	Index Flux
Project Specification	25% (max)	24 ml/2 g (min)	18 ml (max)	95 g/m^2 (min)	95 g/m^2 (min)	330 N (min)	3,662g/m^2 (min)	5.0x10^{-9} cm/sec (max)
Min.	7.3	24.0	10.4	122.0	103.0	333.6	3662	1.1x10^{-9}
Max.	11.0	30.0	16.4	259.0	347.0	631.6	5714	5.0x10^{-9}
Avg.	9.2	25.5	12.5	151.3	118.9	375.0	4088	4.9x10^{-9}
s.d.	0.9	1.4	1.3	33.6	30.4	70.3	309	6.2x10^{-10}

[1] The average of all measurements on any roll shall not be less than the MARV specified.
[2] A total of 164 MQC tests and 31 CQA tests were conducted for this project.

GCL rolls were deployed using a forklift boom and steel bar inserted through the core tube (Figure 3). Panels were oriented parallel to the slope and placed with adjacent GCL panels overlapped a minimum of 30 cm (12 in) along the length and 2 feet along the width (butt-seams). For slopes greater than 10 percent, a standard reinforced GCL overlain by a geocomposite drainage layer was installed prior to vegetative layer placement (Figure 4). Because non-woven geotextiles inhibit the extrusion of internal bentonite, seams were required to be augmented with powdered bentonite at a minimum rate of 0.37 kg/m (0.25 lb/ft) in a continuous bead within 15 cm (6 in) of the edge of the lower GCL panel (Figure 5). GCL rolls held up well to the handling associated with field installation activities.

Project specifications also required that all GCL panels be covered with soil by the end of each day. Scrapers delivered borrow material to the leading edge of the vegetative layer where the soil was pushed by small bulldozers over installed GCL panels in a single 46 cm (18 in) lift. Kamatsu Model D65 bulldozers equipped with 106-cm (42-in) wide, low ground pressure tracks were used to place the soil (Figure 6). Scrapers were limited to those areas where the full 46 cm (18 in) lift had been placed. The rate of GCL installation was limited to approximately 0.93 ha/day (2.3 acres/day), the maximum amount of vegetative layer material that equipment was capable of placing in one day.

A manufacturing deficiency was identified in the lightly-needled GCL by quality assurance monitors during field installation. The deficiency was characterized by a 2.5 to 7.6 cm (1.0 to

3.0 in) wide bentonite void running longitudinally along affected GCL rolls and was determined to be related to over-tensioning of the lower woven geotextile during manufacturing, requiring a minor modification of manufacturing operational procedures. Effected rolls were rejected and replaced with approved material.

FIELD PERFORMANCE

Bentonite creep has been reported in unreinforced GCLs under low normal confining loads (LaGatta et al., 1997). LaGatta et al. (1997) concluded that unreinforced GCL suffered bentonite migration, which was influenced in part by the lack of confinement from needle-punched fibers. Field observations of lightly-needled GCL panels exhumed approximately five weeks after initial placement at the Hanford Landfill indicated significant hydration, but no discernable bentonite migration. The presence of needle-punched fibers may be helping to inhibit bentonite migration, providing potentially better performance than unreinforced GCL.

Due to a construction-sequencing problem caused by a staking error, a number of lightly-needled GCL panels were required to be exhumed and replaced. Approximately five weeks after placement, the panels were exhumed with a backhoe and examined. Consistent with the observations of Daniel et al. (1998) and Bonaparte et al. (1997), the GCL had undergone significant hydration by absorbing moisture from the surrounding soils. The GCL was carefully examined for installation damage, and bentonite migration. Other than damage caused by the backhoe teeth during exhumation, the GCL panels were intact and in good condition. Although the panels appeared fully hydrated, no signs of tensile strain, swelling, or lateral shearing were observed. It should be noted that only a visual inspection was conducted and no mass per unit area or moisture content measurements were performed on the exhumed GCL. These observations suggest that the 18-inch thick soil cover provided sufficient normal stress to prevent swelling of bentonite during hydration and prevent differential normal loads which can result from heavy vehicle wheel loads over the final cover (Richardson and Marr, 1999; and Richardson, 1996).

CONCLUSION

Based on the authors' experience with cover system designs prepared for other landfill closures, a prescriptive final cover system incorporating a CCL is typically more economical than a GCL engineered alternative when suitable low-permeability clay material is available on-site.. For this case study, construction of the prescriptive standard would have required import of clay or amendment of on-site soils. The cost savings incurred through substitution of a GCL for a CCL was the primary basis for selection of a geosynthetic alternative for the Hanford Landfill. A new, lightly-needled GCL product was developed for this project that provided a higher internal shear strength; a lower potential for bentonite migration; and high installation survivability at a slightly lower-cost than an unreinforced GCL product.

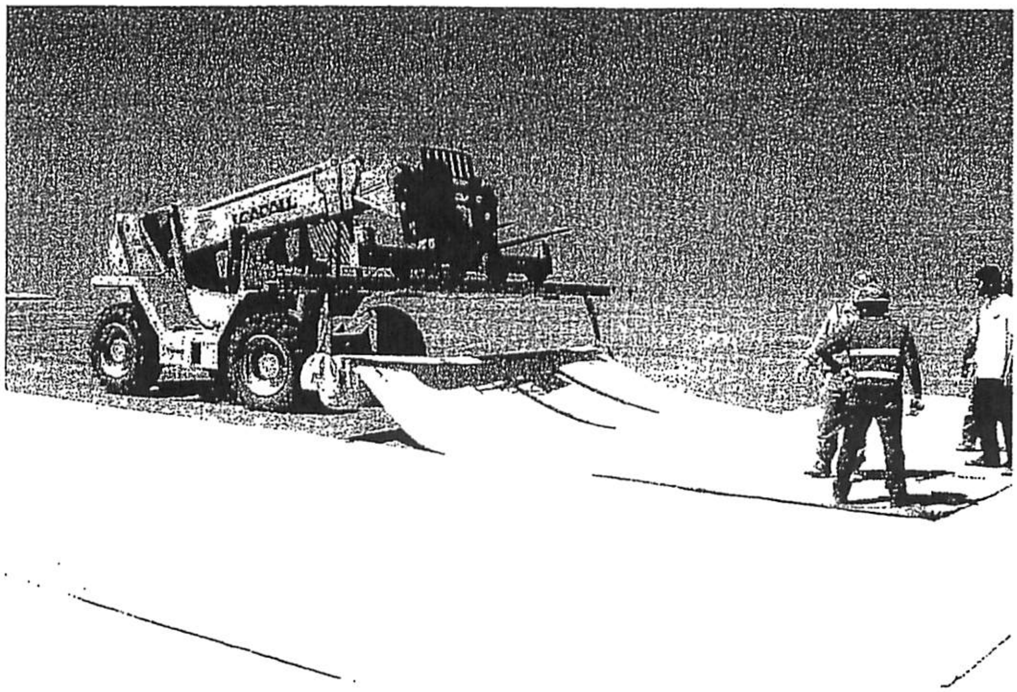

Figure 3. GCL installation over prepared subgrade.

Figure 4. Placement of standard double NWNP reinforced GCL and overlying geonet composite drainage layer on 10 percent refuse slope.

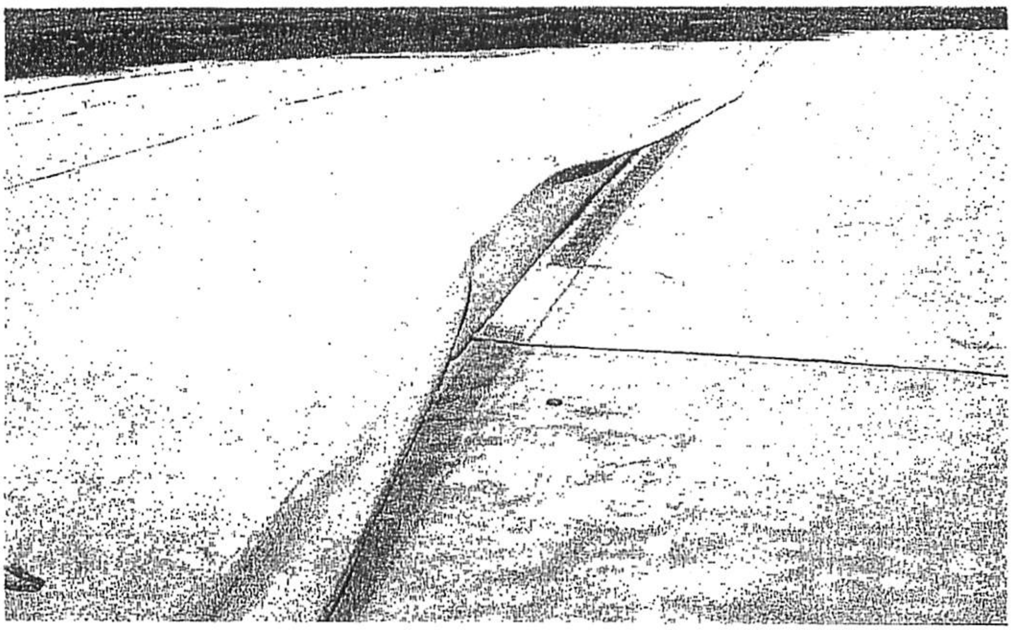

Figure 5. Bentonite powder augmenting GCL seams. Photo taken prior to hand application of bentonite at butt-seam. Note lens cap for scale.

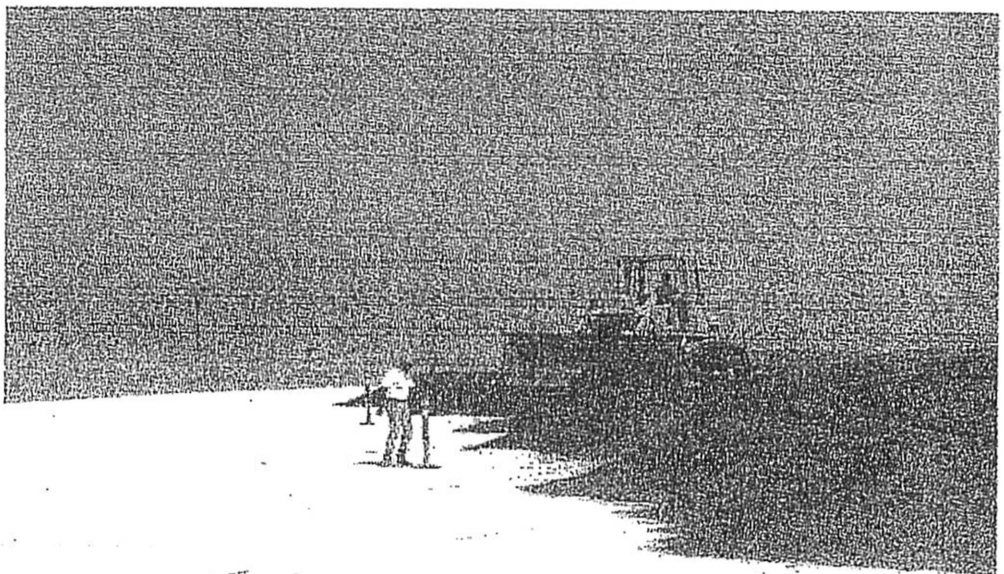

Figure 6. Vegetative Soil layer placement over GCL on 3 percent refuse slope.

A manufacturing deficiency identified during placement of GCL panels further emphasizes the importance of a rigorous quality assurance program during the installation of new geosynthetic products.

ACKNOWLEDGMENTS

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Geosynthetic Clay Liners Used in Municipal Solid Waste Landfills

This fact sheet describes new and innovative technologies and products that meet the performance standards of the Criteria for Municipal Solid Waste Landfills (40 CFR Part 258).

Geosynthetic clay liners (GCLs) represent a relatively new technology (developed in 1986) currently gaining acceptance as a barrier system in municipal solid waste landfill applications. Federal and some state regulations specify design standards for bottom liners and final covers. Alternative technologies are allowed, however, if they meet federal performance standards. GCL technology is an alternative that performs at or above standard federal performance levels.

GCL technology offers some unique advantages over conventional bottom liners and covers. GCLs, for example, are fast and easy to install, have low hydraulic conductivity (i.e., low permeability), and have the ability to self-repair any rips or holes caused by the swelling properties of the bentonite from which they are made. GCLs are cost-effective in regions where clay is not readily available. A GCL liner system is not as thick as a liner system involving the use of compacted clay, enabling engineers to construct landfills that maximize capacity while protecting area ground water.

Before using a GCL in a landfill barrier system, remember there currently are no standard methods for comparing GCL products or installation systems. In addition, GCL performance properties, including the ability of GCL liner systems to effectively prevent landfill leaching, have not yet been firmly established.

This emerging technology is currently in use at a number of sites across the nation. This fact sheet provides information on this technology and presents case studies of successful applications.

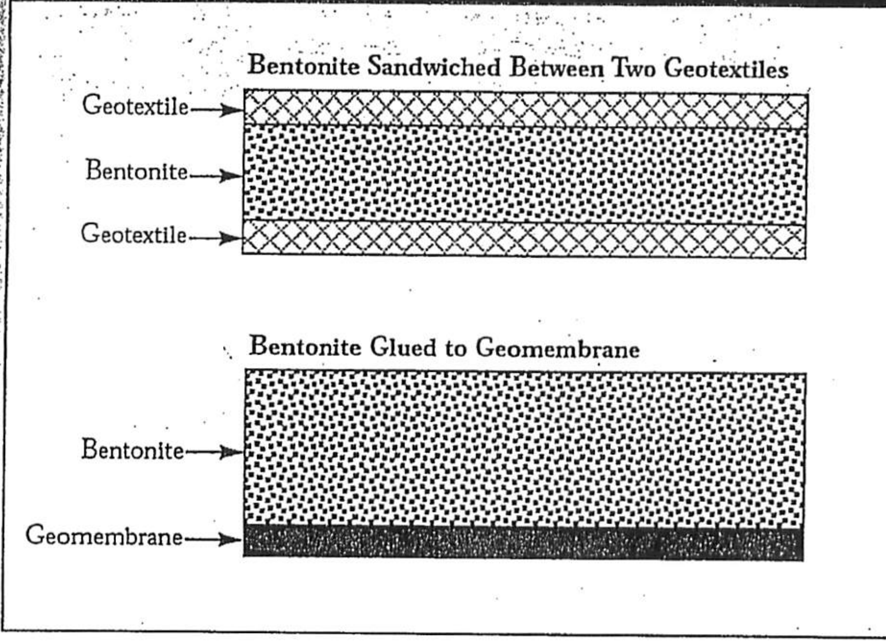
GCL Technology

Materials

A GCL is a relatively thin layer of processed clay (typically bentonite) either bonded to a geomembrane or fixed between two sheets of geotextile. A geomembrane is a polymeric sheet material that is impervious to liquid as long as it maintains its integrity. A geotextile is a woven or nonwoven sheet material less impervious to liquid than a geomembrane, but more resistant to penetration damage. Both types of GCLs are illustrated in Figure 1. Although the overall configuration of the GCL affects its performance characteristics, the primary performance factors are clay quality, amount of clay used per unit area, and uniformity.

Bentonite is an extremely absorbent, granular clay formed from volcanic ash. Bentonite attracts positively charged water particles; thus, it rapidly hydrates when exposed to liquid, such as water or leachate. As the clay hydrates it swells, giving it the ability to "self-heal" holes in the GCL. In laboratory tests on bentonite, researchers demonstrated that a hole up to 75 millimeters in diameter will seal itself, allowing the GCL to retain the properties that make it an effective barrier system.

Figure 1. General Configurations of GCLs



Bentonite is affixed to synthetic materials in a number of ways to form the GCL system. In configurations using a geomembrane, the clay is affixed using an adhesive. In geotextile configurations, however, adhesives, stitchbonding, needlepunching, or a combination of the three, are used. Although stitchbonding and needlepunching create small holes in the geotextile, these holes are sealed when the installed GCL's clay layer hydrates. Figure 2 shows cross-section views of the three separate approaches to affixing bentonite to a geotextile.

Properties and Characteristics

An important criterion for selecting an effective landfill barrier system is hydraulic conductivity. Before choosing a barrier system, the landfill operator should test the technology under consideration to ensure that its hydraulic conductivity, as well as other characteristics, are appropriate for the particular landfill site.

Hydraulic Conductivity

GCL technology can provide barrier systems with low hydraulic conductivity (i.e., low permeability), which is the rate at which a liquid passes through a material. Laboratory tests demonstrate that the hydraulic conductivity of dry, unconfined bentonite is approximately 1×10^{-8} cm/sec. When saturated, however, the hydraulic conductivity of bentonite typically drops to less than 1×10^{-9} cm/sec.

The quality of the clay used affects a GCL's hydraulic characteristics. Sodium bentonite, a naturally occurring compound in a silicate clay formed from volcanic ash, gives bentonite its distinct properties. Additives are used to enhance the hydraulic properties of clay containing low amounts of sodium bentonite.

Hydraulic performance also relates to the amount of bentonite per unit area and its uniformity. The more bentonite used per unit area, the lower the system's hydraulic conductivity. Although the amount of bentonite per unit area varies with the particular GCL, manufacturers typically use 1 pound per square foot. As a result, the hydraulic conductivity of most GCL products ranges from about 1×10^{-5} cm/sec to less than 1×10^{-12} cm/sec. That is, the permeability of finished GCL products depends on a combination of factors, including the type and amount of bentonite, the amount of additives, the type of geosynthetic material, and the product configuration (i.e., the method of affixing the geosynthetic to the clay).

Shear Strength and Other Characteristics

Depending on the particular configuration of the barrier system, GCL technology can provide considerable shear strength (i.e., the maximum stress a material can withstand without losing structural integrity). In particular, a geotextile-backed GCL, with bentonite affixed via stitchbonding, provides additional internal resistance to shear in the clay layer. Needlepunching yields an even stronger, more rigid barrier. In addition, needlepunching requires the use of a nonwoven geotextile on at least one side. These GCL configurations provide enhanced interface friction resistance to the adjoining layer, an important consideration for landfill slopes.

Both needlepunching and stitchbonding, however, tend to increase the cost of the GCL product. Needlepunching, in particular, adds to a GCL's cost, because nonwoven geotextiles are generally more expensive than woven geotextiles.

Before selecting a final barrier system, landfill operators should consider other important performance characteristics, such as free and confined swelling (i.e., whether the clay will provide a uniform barrier) and rate of creep, which measures the resistance to barrier deformation.

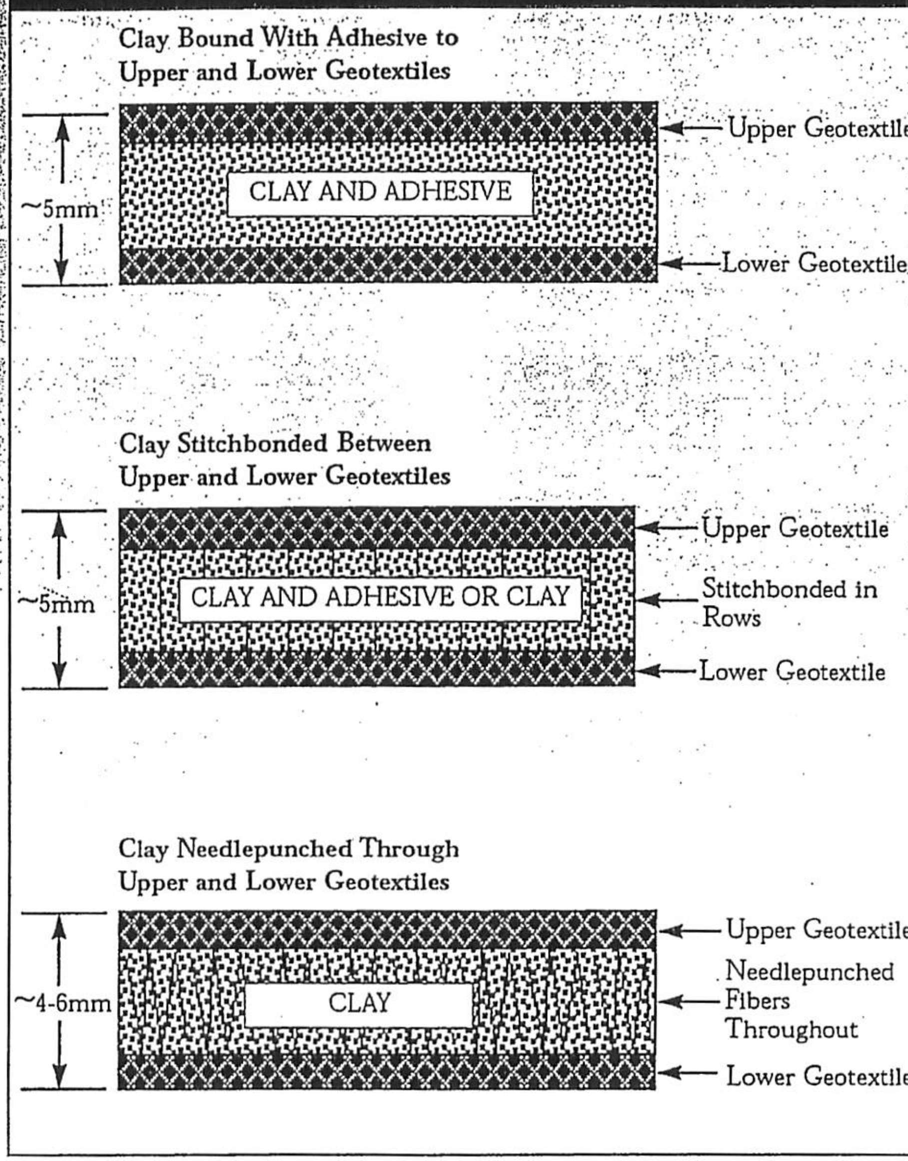
Testing

GCL configurations for barrier systems are based on the design specifications of each specific project. The American Society for Testing and Materials (ASTM) developed standardized laboratory tests for assessing mass per unit area (ASTM D-3776), hydraulic conductivity (ASTM D-5084), and direct shear (ASTM D-5321).

Researchers at the Geosynthetic Research Institute at Drexel University (in Philadelphia, Pennsylvania) and the Geotechnical Engineering Department at the University of Texas (in Austin) developed tests to measure shear strength, as well as confined swelling, rate of creep, and seam overlap permeability. These test methods have been adopted by ASTM. Additionally, the bentonite industry developed a test to measure free swell (USP-NF-XVII).

Test values for hydraulic conductivity depend on the degree of effective overburden stress around the GCL during testing. The higher the effective overburden stress, the lower the hydraulic conductivity. When comparing two different bentonite products, both must be subjected to the same degree of effective overburden stress.

Figure 2. Affixing Bentonite to Geotextiles



Available GCL Products

Product Types

The following types of GCL products are currently available:

- Geotextile type:
  - — Bentofix® (activated sodium bentonite as primary ingredient and affixed by needlepunching to a woven or nonwoven upper geotextile and a nonwoven lower geotextile).
  - — Bentomat® (sodium bentonite as primary ingredient and affixed by needlepunching to a woven or nonwoven upper geotextile and a nonwoven lower geotextile).
  - — Claymax® (sodium bentonite as primary ingredient mixed with water-soluble adhesive and bonded or stitchbonded to a woven upper and lower geotextile).
- Geomembrane type:
  - — Gundseal® (sodium bentonite as the primary ingredient mixed with an adhesive and bonded to a blend of high density polyethylene and very low density polyethylene).

Table 1 lists information on variations of these product types by manufacturer, and Figure 3 presents cross-section views of these product configurations.

In general, manufacturers ship GCL products in rolled sheets ranging from 13 to 18 feet wide and from 100 to 200 feet long. GCLs range in thickness from 0.2 to 0.3 inches.

Table 1. Principal GCL Products Available in the United States				
Manufacturer & Product Name	Upper Geosynthetic[a]	Lower Geosynthetic[a]	Bonding Method	Standard Roll Width x Length (feet)
Fluid Systems, Inc. (FSI) (Germany)				
Bentofix NS	woven	nonwoven	needlepunched	(15.2 x 100)
Bentofix WP	woven	nonwoven	needlepunched	(15.2 x 100)
Bentofix NW	nonwoven[b]	nonwoven	needlepunched	(15.2 x 100)
Colloid Environmental Technologies Company (CETCO) (United States)				
Claymax 200R	woven	woven	adhered	(13.83 x 150)
Claymax 500SP	woven	woven	adhered and stitchbonded	(13.83 x 150)
Claymax 506SP	woven	woven	adhered and stitchbonded	(13.83 x 150)
Bentomat "ST"	woven	nonwoven	needlepunched	(15.3 x 125)
Bentomat "N"	nonwoven	nonwoven	needlepunched	(15.3 x 125)
GSE Environmental (United States)[c]				
Gundseal HD 20	none[d]	HDPE[e]	adhered	(17.5 x 200)
Gundseal HD 30	none[d]	HDPE	adhered	(17.5 x 200)
Gundseal HD 30	none[d]	HDPE/VLDPE[f]	adhered	(17.5 x 200)
Gundseal HD 60	none[d]	HDPE/VLDPE	adhered	(17.5 x 170)
Gundseal HD 80	none[d]	HDPE/VLDPE	adhered	(17.5 x 150)
Gundseal HD 40	none[d]	textured HDPE	adhered	(17.5 x 200)
Gundseal HD 60	none[d]	textured HDPE	adhered	(17.5 x 200)
Gundseal HD 80	none[d]	textured HDPE	adhered	(17.5 x 200)

[a] These properties vary by product and application.

[b] Nonwoven layer is scrim (a woven, open-mesh reinforcing fabric made from continuous-filament yarn) reinforced.

[c] All Gundseal products can be manufactured in 8-foot widths and with leachate-resistant bentonite. Products with backings that are 40 mils or greater can be manufactured with VLDPE as the lower geosynthetic material.

[d] Can be manufactured with a nonwoven, 0.75-ounce-per-square-yard geotextile as the upper geosynthetic material.

[e] High density polyethylene.

[f] Very low density polyethylene.

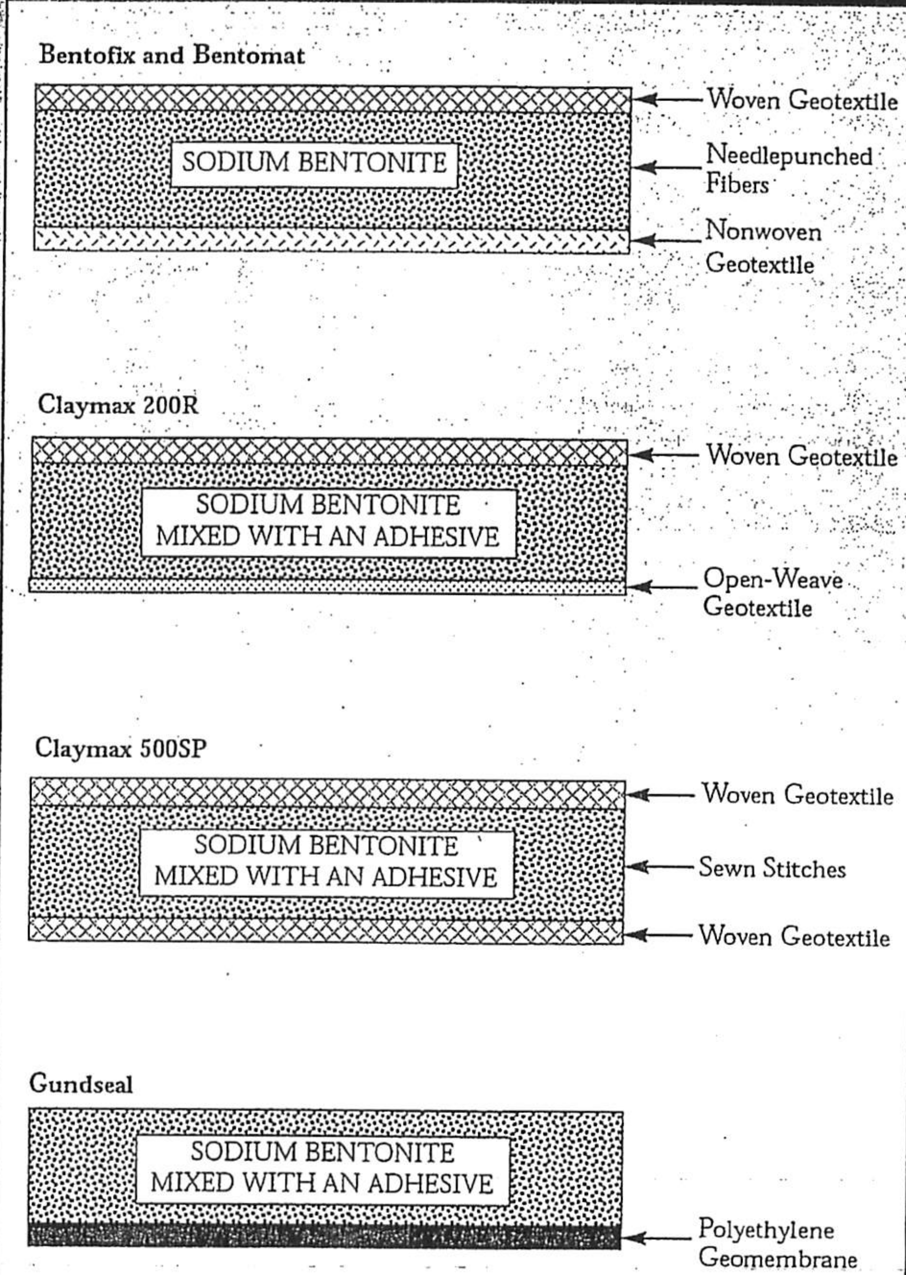
Installation

Landfill operators can install all available GCL products much faster and more easily than compacted clay liners. Unlike compacted clay liners, however, GCLs are more susceptible to damage during transport and installation. Care should be taken during and after installation to avoid hydration. Hydration results in unconfined swelling of the bentonite and causes the geotextile layers to pull apart, undermining the integrity of the GCL configuration.

Manufacturers usually specify individual GCL installation procedures. Basic procedures, however, call for rolling out the large GCL sheets onto the site subgrade, which should be smooth (e.g., free of stones and grade stakes), well compacted, and dry. Once installers cover the GCL with soil, the GCL hydrates by drawing moisture from the soil. As a result, when laying out the GCL, installers must allow enough seam overlap at adjoining sheets to guard against the potential opening of the barrier system. Currently, the recommended amount of seam overlap and other seaming considerations vary with the particular GCL product. Thus, installers should follow the manufacturer's instructions for the particular product.

GCL manufacturers, and some private engineering firms, provide training for GCL installers. Among other considerations, instructions typically emphasize techniques for minimizing potential damage to the GCL during installation. The National Institute for Certification of Engineering Technologists in Alexandria, Virginia, offers a certification program in quality assurance and quality control inspection of GCL installations.

Figure 3. Available GCL Products



Costs

As of 1994, the cost of an installed GCL ranged from $0.42 to $0.60 per square foot. Factors affecting the cost of a GCL include:

- Shipping distance
- Size of the job
- Market demand
- Time of the year

In general, GCL barrier systems are especially cost-effective in areas where clay is not readily available for use as a liner material.

Issues To Be Addressed

This emerging technology requires additional field and laboratory testing to further assess its effectiveness as a landfill barrier system in terms of the key performance factors discussed below. Improved product design and installation standards must also be established.

Performance Factors

Further research is needed into the following key performance factors of GCLs:

Hydraulic Conductivity

Available data on the hydraulic conductivity of various GCL configurations are gathered exclusively under laboratory conditions. Data from field tests should be collected to establish product design values.

Bearing Capacity

A study by the Geosynthetic Research Institute provides the basis for allaying some concerns about the bearing capacity of hydrated GCLs, but more research is needed. The study demonstrated that an adequate layer of cover soil (according to the product manufacturers' recommendations), placed on GCLs during installation, prevents a decrease in liner thickness with the application of a load. Without a sufficient soil layer, GCLs become compressed, raising their hydraulic conductivity (i.e., making them more permeable) and reducing their effectiveness as a barrier.

Slope Stability

Research is ongoing on the slope stability of GCLs used in landfill sidewall applications to determine whether this use of GCLs provides sufficient resistance to internal shear and physical displacement. Additional data are needed to support the preliminary results of a U.S. Environmental Protection Agency field study indicating good stability of GCL technology following capping operations. This study mimicked the construction stresses all four GCL products (see Figure 3) are subjected to during capping. Constructed in November 1994, the study site used five plots of GCL placed at a 3 to 1 slope and eight plots placed at a 2 to 1 slope. All plots had a 3-foot-thick soil cap. Researchers collected information on the soil and clay moisture of the GCL using internal probes, and they measured the GCL for physical displacement. Results to date indicate good slope stability for all plots.

Long-Term Reliability

The geotextile or geomembrane in GCL products remains durable for long periods of time.

Freeze and Thaw Cycles

Freeze and thaw cycles do not affect GCLs used in landfill bottom liner applications because these systems are installed below the frost line. Limited laboratory data indicate that the hydraulic conductivity of GCLs is not affected by freeze and thaw cycles. Laboratory tests performed on a bentonitic blanket indicate that hydraulic conductivity before freezing of 2×10^{-11} cm/sec was unaltered after five freeze and thaw cycles. Full-scale field tests still must be conducted, however, to corroborate the laboratory data, especially for GCL technology used as an infiltration barrier in landfill caps.

Design and Installation Standards

The following issues must be addressed to encourage the further development of GCL technology as a landfill barrier system:

Material Properties and Additional Testing Methods

To allow design engineers to develop more precise site specifications, a list of important performance properties for materials used in GCL products, as well as minimum performance values, must be established. Additional testing procedures must be developed, and all methods should be standardized to facilitate the realistic comparison of different GCL products.

Construction and Installation Procedures

Standardized practices must be developed to address GCLs' vulnerability to the following:

- System stress from inclement weather after installation.
- Potential for lack of hydration of bentonite clay in arid regions.
- Punctures in the barrier system (reducing the barrier potential of both the clay and the geosynthetics).
- System decay caused by biological intruders, such as burrowing animals and tree roots (potentially affecting both the clay and the geosynthetics).

Additionally, a standardized quality assurance and quality control program must be developed.

Case Studies

The following case studies illustrate some of the uses of GCL technology as a barrier system in landfills. Currently available information from these sites relates to installation only; long-term performance is still being assessed. Only one of the studies concerns the use of GCL technology in bottom liner applications, because this use is relatively new. The other two studies focus on cap system applications, which represent a slightly more established use of the technology. The case studies represent sites in three different geographic regions and involve three different GCL products.

GCL Landfill Liner: Broad Acre Landfill Pueblo, Colorado

Broad Acre Landfill installed a liner system in 1991 that included:

- A 60-mil Gundseal GCL
- 1 foot of compacted clay

According to landfill operators, the Gundseal was easy to work with. They installed 200,000 square feet in 1 week. Workers installed the liner with the bentonite side down (i.e., the geomembrane side up). As of February 1996, landfill officials reported that the liner was functioning effectively. No releases of leachate have been detected by the ground-water monitoring system.

GCL Landfill Cap: Whyco Chromium Landfill Thomaston, Connecticut

During July 1989, Whyco Chromium Landfill installed a Claymax 200R GCL in a cap system that included the following (from top to bottom):

- 6 inches of topsoil
- 24 inches of earthen material
- Geogrid (for tensile strength)
- Geotextile
- Polyvinyl chloride geomembrane (30-mil thickness)
- Claymax
- Geotextile

The landfill site occupies 41,000 square feet, and workers installed the Claymax product in 1 day. Thus far, the cap is functioning well.

GCL Landfill Cap: Enoree Landfill Greenville, South Carolina

In August 1994, the first phase of closure at the Enoree Landfill involved installing the following cap system:

- 6 to 12 inches of new and native soil
- 18 inches of compacted clay
- Bentofix GCL

Enoree staff capped approximately 26 acres of the landfill in 6 weeks. Landfill officials report that the cap is functioning effectively.

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EPA

United States
Environmental Protection Agency
(5306W)
Washington, DC 20460

Official Business
Penalty for Private Use
$300

Attachment 2
HELP Model Output Results

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**              HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                  **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**              USAE WATERWAYS EXPERIMENT STATION                           **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\data\help3\MATSU4.D4
TEMPERATURE DATA FILE:        C:\DATA\HELP3\MATSU7.D7
SOLAR RADIATION DATA FILE:    C:\DATA\HELP3\MATSU13.D13
EVAPOTRANSPIRATION DATA:      C:\data\help3\MATSU11.D11
SOIL AND DESIGN DATA FILE:    C:\DATA\HELP3\matsu23.D10
OUTPUT DATA FILE:             C:\DATA\HELP3\matsu23.OUT

TIME:    8:49     DATE:  11/14/2000

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     TITLE:  Central Landfill Cell 2a Prescriptive Final Cover

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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
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                     TYPE 1 - VERTICAL PERCOLATION LAYER
                     EROSION LAYER - TOPSOIL
                     MATERIAL TEXTURE NUMBER   8
          THICKNESS                   =      6.00   INCHES
          POROSITY                    =      0.4630 VOL/VOL
          FIELD CAPACITY              =      0.2320 VOL/VOL
          WILTING POINT               =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.2141 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.369999994000E-03 CM/SEC


                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                     INFILTRATION LAYER - PRESCRIPTIVE
                     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  =      0.3592 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.900000032000E-05 CM/SEC
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LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
OPERATIONAL COVER - GRAVEL
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	6.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0448	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER	=	91.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.591	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.310	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.132	INCHES
INITIAL SNOW WATER	=	1.383	INCHES
INITIAL WATER IN LAYER MATERIALS	=	8.019	INCHES
TOTAL INITIAL WATER	=	9.402	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Central Landfill Alaska

STATION LATITUDE	=	61.50	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	145	
END OF GROWING SEASON (JULIAN DATE)	=	259	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	5.00	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	69.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	59.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR FLAGSTAFF ARIZONA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.86	0.69	0.52	0.51	0.71	1.45
2.28	2.65	2.49	1.57	1.01	0.97

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BETHEL ALASKA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
13.00	18.20	25.30	36.60	47.00	55.00
57.70	55.50	47.60	34.90	21.00	13.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BETHEL ALASKA
AND STATION LATITUDE = 61.50 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.83	50202.902	100.00
RUNOFF	1.178	4274.850	8.52
EVAPOTRANSPIRATION	10.763	39071.199	77.83
PERC./LEAKAGE THROUGH LAYER 3	1.888526	6855.349	13.66
CHANGE IN WATER STORAGE	0.000	1.489	0.00
SOIL WATER AT START OF YEAR	8.019	29109.656	
SOIL WATER AT END OF YEAR	8.020	29111.145	
SNOW WATER AT START OF YEAR	1.383	5020.605	10.00
SNOW WATER AT END OF YEAR	1.383	5020.605	10.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.72	78843.594	100.00
RUNOFF	5.044	18308.488	23.22
EVAPOTRANSPIRATION	13.605	49386.602	62.64
PERC./LEAKAGE THROUGH LAYER 3	3.008100	10919.402	13.85
CHANGE IN WATER STORAGE	0.063	229.121	0.29
SOIL WATER AT START OF YEAR	8.020	29111.145	
SOIL WATER AT END OF YEAR	8.329	30234.607	
SNOW WATER AT START OF YEAR	1.383	5020.605	6.37
SNOW WATER AT END OF YEAR	1.137	4126.263	5.23
ANNUAL WATER BUDGET BALANCE	0.0000	-0.016	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.72	53433.605	100.00
RUNOFF	3.101	11257.097	21.07
EVAPOTRANSPIRATION	11.984	43502.625	81.41
PERC./LEAKAGE THROUGH LAYER 3	1.758300	6382.629	11.94
CHANGE IN WATER STORAGE	-2.124	-7708.746	-14.43
SOIL WATER AT START OF YEAR	8.329	30234.607	
SOIL WATER AT END OF YEAR	7.293	26473.406	
SNOW WATER AT START OF YEAR	1.137	4126.263	7.72
SNOW WATER AT END OF YEAR	0.049	178.719	0.33
ANNUAL WATER BUDGET BALANCE	0.0000	0.001	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.75	57172.516	100.00
RUNOFF	2.168	7868.554	13.76
EVAPOTRANSPIRATION	10.607	38505.184	67.35
PERC./LEAKAGE THROUGH LAYER 3	1.402120	5089.697	8.90
CHANGE IN WATER STORAGE	1.573	5709.061	9.99
SOIL WATER AT START OF YEAR	7.293	26473.406	
SOIL WATER AT END OF YEAR	8.254	29962.174	
SNOW WATER AT START OF YEAR	0.049	178.719	0.31
SNOW WATER AT END OF YEAR	0.661	2399.010	4.20
ANNUAL WATER BUDGET BALANCE	0.0000	0.019	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.17	58697.113	100.00
RUNOFF	2.472	8972.500	15.29
EVAPOTRANSPIRATION	11.611	42148.906	71.81
PERC./LEAKAGE THROUGH LAYER 3	1.909488	6931.441	11.81
CHANGE IN WATER STORAGE	0.177	644.251	1.10
SOIL WATER AT START OF YEAR	8.254	29962.174	
SOIL WATER AT END OF YEAR	8.884	32249.086	
SNOW WATER AT START OF YEAR	0.661	2399.010	4.09
SNOW WATER AT END OF YEAR	0.208	756.350	1.29
ANNUAL WATER BUDGET BALANCE	0.0000	0.016	0.00

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.73	0.71	0.81	0.53	0.46	2.66
	1.96	3.28	2.17	1.63	0.80	0.69
STD. DEVIATIONS	0.68	0.47	0.40	0.30	0.51	1.64
	0.74	1.18	1.14	0.98	0.43	0.66
RUNOFF						
TOTALS	0.000	0.001	0.689	0.573	0.139	0.538
	0.041	0.135	0.361	0.214	0.081	0.020
STD. DEVIATIONS	0.000	0.003	0.694	0.544	0.189	0.721
	0.076	0.158	0.470	0.285	0.144	0.045
EVAPOTRANSPIRATION						
TOTALS	0.335	0.384	0.319	0.195	1.435	2.026
	2.126	2.161	1.532	0.704	0.283	0.214
STD. DEVIATIONS	0.034	0.083	0.041	0.210	0.485	1.017
	1.160	0.724	0.224	0.061	0.163	0.051
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0166	0.0091	0.0071	0.0053	0.2564	0.3179
	0.1462	0.0465	0.3685	0.4795	0.2903	0.0500
STD. DEVIATIONS	0.0062	0.0023	0.0015	0.0009	0.3392	0.2415
	0.2482	0.0485	0.4381	0.2326	0.2418	0.0602

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.44 (3.090)	59669.9	100.00
RUNOFF	2.792 (1.4374)	10136.30	16.987
EVAPOTRANSPIRATION	11.714 (1.2029)	42522.90	71.264
PERCOLATION/LEAKAGE THROUGH LAYER 3	1.99331 (0.60261)	7235.704	12.12621
CHANGE IN WATER STORAGE	-0.062 (1.3228)	-224.97	-0.377

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.16	7840.800
RUNOFF	1.074	3898.3765
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.132484	480.91678
SNOW WATER	2.54	9223.4766

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4087
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2189

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	2.2259	0.3710
2	6.4156	0.3564
3	0.2426	0.0404
SNOW WATER	0.208	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                DEVELOPED BY ENVIRONMENTAL LABORATORY                     **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**            FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\data\help3\MATSU4.D4
TEMPERATURE DATA FILE:        C:\DATA\HELP3\MATSU7.D7
SOLAR RADIATION DATA FILE:    C:\DATA\HELP3\MATSU13.D13
EVAPOTRANSPIRATION DATA:      C:\data\help3\MATSU11.D11
SOIL AND DESIGN DATA FILE:    C:\DATA\HELP3\matsulat.D10
OUTPUT DATA FILE:             C:\DATA\HELP3\Matsulat.OUT


TIME:   9:16     DATE:   7/ 5/2001

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     TITLE:  Central Landfill GCL Cover With Lateral Drainage Layer

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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
                    EROSION LAYER - TOPSOIL
                    MATERIAL TEXTURE NUMBER   8
          THICKNESS                  =      6.00    INCHES
          POROSITY                   =      0.4630 VOL/VOL
          FIELD CAPACITY             =      0.2320 VOL/VOL
          WILTING POINT              =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2147 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.369999994000E-03 CM/SEC


                                  LAYER  2
                                  --------

                      TYPE 2 - LATERAL DRAINAGE LAYER
                      INFILTRATION LAYER - ON-SITE SANDY GRAVEL
                      MATERIAL TEXTURE NUMBER   2
          THICKNESS                  =     18.00    INCHES
          POROSITY                   =      0.4370 VOL/VOL
          FIELD CAPACITY             =      0.0620 VOL/VOL
          WILTING POINT              =      0.0240 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.1004 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.579999993000E-02 CM/SEC
          SLOPE                      =     25.00    PERCENT
          DRAINAGE LENGTH            =    150.0     FEET
```

LAYER 3

TYPE 3 - BARRIER SOIL LINER
GEOSYNTHETIC CLAY LINER (GCL)
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
OPERATIONAL COVER - GRAVEL
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	6.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0376	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 150. FEET.

SCS RUNOFF CURVE NUMBER	=	81.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.723	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.022	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.984	INCHES
INITIAL SNOW WATER	=	1.383	INCHES
INITIAL WATER IN LAYER MATERIALS	=	3.501	INCHES
TOTAL INITIAL WATER	=	4.884	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Central Landfill Alaska

STATION LATITUDE	=	61.50 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	145
END OF GROWING SEASON (JULIAN DATE)	=	259
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	5.00 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	69.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	59.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	74.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR FLAGSTAFF ARIZONA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.86	0.69	0.52	0.51	0.71	1.45
2.28	2.65	2.49	1.57	1.01	0.97

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BETHEL ALASKA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
13.00	18.20	25.30	36.60	47.00	55.00
57.70	55.50	47.60	34.90	21.00	13.90

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BETHEL ALASKA
AND STATION LATITUDE = 61.50 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.83	50202.902	100.00
RUNOFF	0.789	2865.766	5.71
EVAPOTRANSPIRATION	10.145	36825.727	73.35
DRAINAGE COLLECTED FROM LAYER 2	2.8478	10337.624	20.59
PERC./LEAKAGE THROUGH LAYER 3	0.046833	170.004	0.34
AVG. HEAD ON TOP OF LAYER 3	0.1501		
PERC./LEAKAGE THROUGH LAYER 4	0.037241	135.185	0.27
CHANGE IN WATER STORAGE	0.011	38.592	0.08
SOIL WATER AT START OF YEAR	3.501	12708.422	
SOIL WATER AT END OF YEAR	3.512	12747.014	
SNOW WATER AT START OF YEAR	1.383	5020.605	10.00
SNOW WATER AT END OF YEAR	1.383	5020.605	10.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.011	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	21.72	78843.594	100.00
RUNOFF	2.306	8369.238	10.61
EVAPOTRANSPIRATION	13.255	48116.320	61.03
DRAINAGE COLLECTED FROM LAYER 2	6.0826	22079.914	28.00
PERC./LEAKAGE THROUGH LAYER 3	0.072653	263.731	0.33
AVG. HEAD ON TOP OF LAYER 3	0.3229		
PERC./LEAKAGE THROUGH LAYER 4	0.070507	255.940	0.32
CHANGE IN WATER STORAGE	0.006	22.171	0.03
SOIL WATER AT START OF YEAR	3.512	12747.014	
SOIL WATER AT END OF YEAR	3.764	13663.527	
SNOW WATER AT START OF YEAR	1.383	5020.605	6.37
SNOW WATER AT END OF YEAR	1.137	4126.263	5.23
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.72	53433.605	100.00
RUNOFF	1.680	6098.671	11.41
EVAPOTRANSPIRATION	11.566	41984.777	78.57
DRAINAGE COLLECTED FROM LAYER 2	3.5299	12813.409	23.98
PERC./LEAKAGE THROUGH LAYER 3	0.049038	178.010	0.33
AVG. HEAD ON TOP OF LAYER 3	0.1852		
PERC./LEAKAGE THROUGH LAYER 4	0.063022	228.770	0.43
CHANGE IN WATER STORAGE	-2.119	-7692.026	-14.40
SOIL WATER AT START OF YEAR	3.764	13663.527	
SOIL WATER AT END OF YEAR	2.733	9919.045	
SNOW WATER AT START OF YEAR	1.137	4126.263	7.72
SNOW WATER AT END OF YEAR	0.049	178.719	0.33
ANNUAL WATER BUDGET BALANCE	0.0000	0.003	0.00

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.75	57172.516	100.00
RUNOFF	1.287	4672.295	8.17
EVAPOTRANSPIRATION	10.232	37141.043	64.96
DRAINAGE COLLECTED FROM LAYER 2	2.5955	9421.648	16.48
PERC./LEAKAGE THROUGH LAYER 3	0.042522	154.353	0.27
AVG. HEAD ON TOP OF LAYER 3	0.1382		
PERC./LEAKAGE THROUGH LAYER 4	0.037025	134.399	0.24
CHANGE IN WATER STORAGE	1.599	5803.102	10.15
SOIL WATER AT START OF YEAR	2.733	9919.045	
SOIL WATER AT END OF YEAR	3.720	13501.856	
SNOW WATER AT START OF YEAR	0.049	178.719	0.31
SNOW WATER AT END OF YEAR	0.661	2399.010	4.20
ANNUAL WATER BUDGET BALANCE	0.0000	0.026	0.00

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	16.17	58697.113	100.00
RUNOFF	2.002	7267.340	12.38
EVAPOTRANSPIRATION	11.498	41736.281	71.10
DRAINAGE COLLECTED FROM LAYER 2	2.4787	8997.705	15.33
PERC./LEAKAGE THROUGH LAYER 3	0.039866	144.712	0.25
AVG. HEAD ON TOP OF LAYER 3	0.1311		
PERC./LEAKAGE THROUGH LAYER 4	0.043322	157.259	0.27
CHANGE IN WATER STORAGE	0.148	538.523	0.92
SOIL WATER AT START OF YEAR	3.720	13501.856	
SOIL WATER AT END OF YEAR	4.320	15683.039	
SNOW WATER AT START OF YEAR	0.661	2399.010	4.09
SNOW WATER AT END OF YEAR	0.208	756.350	1.29
ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

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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	0.73	0.71	0.81	0.53	0.46	2.66
	1.96	3.28	2.17	1.63	0.80	0.69
STD. DEVIATIONS	0.68	0.47	0.40	0.30	0.51	1.64
	0.74	1.18	1.14	0.98	0.43	0.66
RUNOFF						
TOTALS	0.000	0.001	0.646	0.533	0.122	0.123
	0.000	0.002	0.078	0.025	0.064	0.018
STD. DEVIATIONS	0.000	0.002	0.657	0.519	0.181	0.184
	0.000	0.005	0.115	0.052	0.125	0.040
EVAPOTRANSPIRATION						
TOTALS	0.335	0.384	0.319	0.195	1.350	1.866
	2.097	2.130	1.473	0.694	0.283	0.214
STD. DEVIATIONS	0.034	0.083	0.041	0.210	0.438	0.935
	1.021	0.640	0.228	0.070	0.163	0.051

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	0.0000	0.0000	0.0000	0.0000	0.4911	0.5378
	0.5237	0.1359	0.7986	0.7800	0.2275	0.0124
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.3520	0.2771
	0.7167	0.0798	0.9448	0.4720	0.2045	0.0244

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0055	0.0075
	0.0075	0.0043	0.0096	0.0096	0.0048	0.0013
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0034	0.0023
	0.0059	0.0007	0.0078	0.0039	0.0018	0.0014

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0073	0.0051	0.0045	0.0036	0.0018	0.0001
	0.0016	0.0035	0.0028	0.0038	0.0073	0.0087
STD. DEVIATIONS	0.0016	0.0008	0.0007	0.0005	0.0006	0.0002
	0.0011	0.0030	0.0018	0.0030	0.0039	0.0021

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.3071	0.3476
	0.3275	0.0850	0.5161	0.4878	0.1470	0.0078
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.2201	0.1791
	0.4482	0.0499	0.6106	0.2952	0.1321	0.0153

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

	INCHES		CU. FEET	PERCENT
PRECIPITATION	16.44	(3.090)	59669.9	100.00
RUNOFF	1.613	(0.5958)	5854.66	9.812
EVAPOTRANSPIRATION	11.339	(1.2650)	41160.83	68.981
LATERAL DRAINAGE COLLECTED FROM LAYER 2	3.50690	(1.49642)	12730.060	21.33412
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.05018	(0.01306)	182.162	0.30528
AVERAGE HEAD ON TOP OF LAYER 3	0.185	(0.080)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.05022	(0.01554)	182.311	0.30553
CHANGE IN WATER STORAGE	-0.071	(1.3269)	-257.93	-0.432

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.16	7840.800
RUNOFF	0.800	2904.5100
DRAINAGE COLLECTED FROM LAYER 2	0.19162	695.56714
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.001682	6.10436
AVERAGE HEAD ON TOP OF LAYER 3	3.715	
MAXIMUM HEAD ON TOP OF LAYER 3	7.045	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000493	1.78970
SNOW WATER	2.54	9223.4766

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2757
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0553

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	2.2754	0.3792
2	1.6397	0.0911
3	0.1800	0.7500
4	0.2252	0.0375
SNOW WATER	0.208	

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Attachment 3
Draft Technical Specifications

SECTION 02200
SITE PREPARATION

PART 1 GENERAL

1.1 DEFINITIONS

A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2 inches in diameter to a depth of 6 inches below subgrade.

D. Stripping: Removal of topsoil remaining after applicable clearing and grubbing is completed.

E. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.2 QUALITY ASSURANCE

A. Obtain ENGINEER's approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

1.3 SCHEDULING AND SEQUENCING

A. Prepare site only after adequate erosion and sediment controls are in place. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls to maximum of 2 acres.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 GENERAL

A. Clear, grub, and strip areas actually needed for excavation, staging and stockpiling operations, or site improvements within limits shown or specified.

B. Do not injure or deface vegetation that is not designated for removal.

3.2 LIMITS

A. As follows, but not to extend beyond Project limits.

1. Excavation: 5 feet beyond top of cut slopes.
2. Fill:
   a. Clearing and Grubbing: 5 feet beyond toe of permanent fill.
   b. Stripping: 2 feet beyond toe of permanent fill.
3. Roadways: Clearing, grubbing, and stripping 30 feet from centerline.
4. Overhead Utilities:
   a. Clearing and Grubbing: Entire width of easements and rights-of-way.
   b. Scalping and Stripping: Wherever grading is required.
5. Other Areas: As shown.

B. Remove rubbish, trash, and junk from entire area within Project limits. Dispose of these materials in the Central Landfill, active Cell 2A, as approved by the OWNER.

3.3 CLEARING

A. Clear areas within limits shown or specified.

B. Fell trees so that they fall away from facilities and vegetation not designated for removal.

C. Cut stumps not designated for grubbing flush with ground surface.

D. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

E. All trees to be placed in the C&D Cell shall be hydroaxed.

3.4 GRUBBING

A. Grub areas within limits shown or specified.

3.5 STRIPPING

A. Strip areas within limits to minimum depths shown or specified. Do not remove subsoil with topsoil.

3.6 TREE REMOVAL OUTSIDE CLEARING LIMITS

A. Remove Within Project Limits:

1. Dead, dying, leaning, or otherwise unsound trees that may strike and damage Project facilities in falling.
2. Trees designated by OWNER.

B. Cut stumps off flush with ground, remove debris, and if disturbed, restore surrounding area to its original condition.

3.7 SALVAGE

A. Saleable log timber may be sold to CONTRACTOR's benefit. Promptly remove from Project site.

3.8 DISPOSAL

A. Clearing, Grubbing, and Stripping Spoils:

1. Place spoils at the Central Landfill C&D Cell in uniform lift thickness in locations as approved by OWNER.

END OF SECTION

SECTION 02315
FILL AND BACKFILL

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society for Testing and Materials (ASTM):
   a. C117, Standard Test Method for Materials Finer Than 75-Micrometers (No. 200) Sieve in Mineral Aggregates by Washing.
   b. C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. D75, Standard Practice for Sampling Aggregates.
   d. D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
   e. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
   f. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
   g. D2922, Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
   h. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   i. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

1.2 DEFINITIONS

A. Relative Compaction:

1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D1557.
2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by ENGINEER.

B. Optimum Moisture Content:

1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.
2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

C. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.

D. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

E. Completed Course: A course or layer that is ready for next layer or next phase of Work.

F. Lift: Loose (uncompacted) layer of material.

G. Geosynthetics: Geotextiles, geogrids, or geomembranes.

H. Well-Graded:

1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

I. Influence Area: Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:

1. 1-foot outside outermost edge at base of foundations or slabs.
2. 1-foot outside outermost edge at surface of roadways or shoulder.
3. 0.5-foot outside exterior at spring line of pipes or culverts.

J. Borrow Material: Material from required excavations or from designated borrow areas on or near site.

K. Selected Backfill Material: Materials available onsite that ENGINEER determines to be suitable for specific use.

L. Imported Material: Materials obtained from sources offsite, suitable for specified use.

M. Structural Fill: Fill materials as required under structures, pavements, and other facilities.

N. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.

O. Processed Materials: Materials processed onsite for specified use. Materials specified for use on Project may be either processed from onsite materials or imported. However, the CONTRACTOR shall be solely responsible for determining the suitability of onsite soils to meet these specifications after processing. Any onsite processing operations shall be subject to review and approval by the ENGINEER prior to commencing operations.

1.3 SUBMITTALS

A. Quality Control Submittals:

1. Catalog and manufacturer's data sheets for compaction equipment.
2. Certified test results from independent testing agency.
3. Work plan for any onsite materials processing operations, including crushing, screening, washing, and other processing operations. Include site plan, equipment locations, haul routes, processing methods, water source and disposal methods, and other information as requested by the ENGINEER.

1.4 QUALITY ASSURANCE

A. Notify ENGINEER when:

1. Areas are ready for fill placement, and whenever filling operations are resumed after a period of inactivity.
2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
3. Fill material appears to be deviating from Specifications.

1.5 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in 02200, SITE PREPARATION; 02316, EXCAVATION; and 02319, SUBGRADE PREPARATION, prior to placing fill or backfill.

PART 2 PRODUCTS

2.1 SOURCE QUALITY CONTROL

A. Gradation Tests:

1. As necessary to verify compliance with these specifications. All tests shall be the CONTRACTOR's responsibility, including obtaining samples and retaining a qualified independent testing laboratory to conduct the tests.
2. Test representative samples of the following materials taken from each 1,500 tons of materials or as otherwise determined by the ENGINEER. Provide test results to ENGINEER within 48 hours after sampling unless otherwise approved by the ENGINEER.
   a. Earthfill.

b. Select Earthfill.
c. Sand Leveling Course.
d. Granular Drainage Material.
e. Leachate Collection Gravel.
f. Base Course
g. Cover Material.

B. Provide other test results as required to demonstrate that materials meet these Specifications, as approved by the ENGINEER.

C. Samples: Collect all samples in accordance with ASTM D75. Clearly mark to show source of material and intended use.

2.2 EARTHFILL

A. Well-graded granular material free from rocks larger than 8 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials. Material shall contain no more than 10 percent by weight passing a No. 200 sieve. Material shall be sufficiently well-graded such that placed material can be compacted to form a firm, unyielding surface.

2.3 SELECT EARTHFILL

A. Same as Earthfill, except that maximum particle size shall be 3 inches.

2.4 SAND LEVELING COURSE

A. Granular material free from dirt, clay balls, organic material, trash, ash, snow, ice, and other deleterious materials. Sand Leveling Course shall conform to the aggregate quality requirements of Section 703-2.03 of the ADOT&PF Standard Specifications for Highway Construction (1988 Edition), Aggregate D-1 for Untreated Base.

B. Clean and well-graded from coarse to fine (ASTM D422) within the limitations of the following table:

Sand Leveling Course Gradations	
U.S. Standard Sieve	**Percent Passing**
½-inch	100
No. 4	80 to 100
No. 10	60 to 100
No. 40	40 to 90
No. 100	0 to 30
No. 200	0 to 10

C. Sand Leveling Course shall be sufficiently well-graded within the specified limits that material placed on a 4:1 (horizontal:vertical) slope can be compacted to form a firm, unyielding surface.

2.5 GRANULAR DRAINAGE MATERIAL

A. Granular material free from dirt, clay balls, trash, ash, organic material, and other deleterious material. Material shall be washed and screened as required to provide a free-draining material. The material shall have a minimum permeability of 1×10^{-1} cm/sec, as determined by ASTM D2438. A minimum of two permeability tests shall be run on representative samples of the material prior to ENGINEER approval.

B. Granular Drainage Material shall conform to the aggregate quality requirements of Section 703-2.03 of the ADOT&PF Standard Specifications for Highway Construction (1988 Edition), Aggregate D-1 for Untreated Base.

C. Material shall consist of clean coarse sand or fine gravel, graded within the limitations of the following table (ASTM D422). Material must meet both the permeability specification and the gradation specification.

Granular Drainage Material Gradations	
U.S. Standard Sieve	**Percent Passing**
3/8-inch	100
No. 4	45 to 90
No. 8	25 to 55
No. 16	5 to 35
No. 30	0 to 15
No. 50	0 to 8
No. 100	0 to 4
No. 200	0 to 2

2.6 LEACHATE COLLECTION GRAVEL

A. Gravel free from dirt, clay balls, trash, ash, organic material, and other deleterious materials. Material shall be washed and screened, as required to provide a free-draining material meeting the specified gradation.

B. Leachate Collection Gravel shall conform to the aggregate quality requirements of Section 703-2.03 of the ADOT&PF Standard Specifications for Highway Construction (1988 Edition), Aggregate D-1 for Untreated Base.

C. Material shall consist of fractured, angular, clean gravel, well-graded within the following limitations (ASTM D422):

Leachate Collection Gravel Gradations	
U.S. Standard Sieve	**Percent Passing**
1-inch	100
¾-inch	80 to 100
3/8-inch	10 to 40
No. 4	0 to 4
No. 200	0 to 2

2.7 BASE COURSE

A. Granular material consisting of clean, hard, durable crushed rock or crushed gravel, free from dirt, clay balls, trash, ash, organic material, and other deleterious materials.

B. Base Course shall conform to all requirements of Section 703-2.03 of the ADOT&PF Standard Specifications for Highway Construction (1988 Edition), Aggregate D-1 for Untreated Base.

C. Gradation as required for D-1 aggregate, as follows:

Base Course Gradation	
U.S. Standard Sieve	**Percent Passing**
1-inch	100
¾-inch	70 to 100
3/8-inch	50 to 80
No. 4	35 to 65
No. 8	20 to 50
No. 40	8 to 30
No. 200	0 to 6

2.8 COVER MATERIAL

A. Cover Material shall consist of clean, well-graded, durable sand and gravel, free from dirt, clay balls, organic material, trash, ash, snow, ice, and other deleterious materials. Material shall have a maximum particle diameter of 1 inch, with no more than 5 percent by weight passing a No. 200 sieve. Cover Material shall conform to the aggregate quality requirements of Section 703-2.03 of the ADOT&PF Standard Specifications for Highway Construction (1988 Edition), Aggregate D-1 for Untreated Base.

2.9 TOPSOIL

A. Topsoil shall consist of a natural, friable, sandy, silty loam, capable of sustaining vegetative growth. Topsoil shall be obtained from well-drained areas, free from objects larger than 2 inches maximum dimension, and free of subsoil, roots, grass, other foreign matter, hazardous or toxic substances, and deleterious material that may be harmful to plant growth or may hinder grading, planting, or maintenance.

2.10 SOIL/BENTONITE MIXTURE

A. Soil:

1. Imported material or material processed from onsite excavation free from roots, organic matter, frozen material, debris, rocks or slag larger than 1 inch, and other deleterious material.
2. Low plasticity or nonplastic silty or sandy soil.
3. Gradation: Material having 90 percent or more by weight passing U.S. No. 4 sieve and between 5 and 50 percent by weight passing U.S. No. 200 sieve in accordance with ASTM D422.

B. Bentonite

1. Free-flowing, semigranular, high swelling, sodium montmorillonite clay (bentonite) free of additives.
2. Manufacturers and Products:
   a. American Colloid Co.; Volclay.
   b. Federal Ore and Chemicals, Co.; Federal Bentonite.
   c. International Mineral and Chemical Co.; Imclay Bentonite.
   d. NL Baroid Co.; National Bentonite.
   e. Wyo-Ben Co.; Envirogel.

2.11 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

PART 3 EXECUTION

3.1 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and other buried facilities even.

D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:

1. Fill or backfill to an elevation 2 feet above top of item to be laid.
2. Excavate trench for installation of item.
3. Install bedding, if applicable.
4. Install item.
5. Backfill envelope zone and remaining trench; before resuming filling or backfilling specified in this section.

F. Tolerances:

1. Final Lines and Grades: Within a tolerance of 0.1-foot unless dimensions or grades are shown or specified otherwise.
2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

G. Settlement: Correct and repair any subsequent damage to adjacent facilities, caused by settlement of fill or backfill material.

3.2 ACCESS RAMP

A. Fill with select earthfill as shown on the drawings. Place select earthfill in lifts of 12-inch maximum thickness and compact each lift with minimum three passes of suitable compaction equipment as approved by the ENGINEER.

3.3 BASE COURSE

A. Under Facilities: Within Influence Area beneath structures, slabs, conduits, duct banks, travel areas, other facilities, and as shown on the Drawings, backfill with Base Course, unless otherwise shown. Place Base Course in Lifts of 6-inch maximum thickness and compact each Lift to minimum of 95 percent Relative Compaction.

3.4 EARTHFILL AND SELECT EARTHFILL

A. Outside Influence Areas Beneath Structures, Slabs, Piping, and Other Facilities: Unless otherwise shown, place Earthfill as follows:

1. Maximum 12-inch-thick Lifts.
2. Place and compact fill across full width of embankment.
3. Compact to minimum 90 percent Relative Compaction as determined in accordance with ASTM D1557.
4. Dress completed embankment with allowance for topsoil, crest surfacing, and slope protection, where applicable.

B. For all other areas not identified above, place Select Earthfill to lines and grades shown on Drawings. Compact in maximum 8-inch-thick horizontal lifts to 95 percent relative compaction unless otherwise shown.

3.5 PLACING SAND LEVELING COURSE OR COVER MATERIAL BELOW GEOSYNTHETICS

A. Place Sand Leveling Course or Cover Material on subgrade prepared in accordance with Section SUBGRADE PREPARATION and approved by the ENGINEER.

B. Place Sand Leveling Course or Cover Material to the lines and grades shown in the Drawings in one uniform and continuous lift unless otherwise approved by the ENGINEER.

C. The Sand Leveling Course or Cover Material shall provide a smooth, firm, unyielding surface on which to place the geosynthetics.

D. The CONTRACTOR shall provide and maintain a means of continually observing the depth of the Sand Leveling Course or Cover Material, such as survey markers, spaced at no more than 50 feet on center each way, until placement is complete. Sharpened stakes or other materials that may damage the geosynthetics will not be allowed. All markers shall be removed after final grading is complete.

E. The Sand Leveling Course or Cover Material shall be compacted to at least 95 percent relative compaction unless otherwise approved by the ENGINEER. Blading and rolling shall continue until the surface is smooth and free of irregularities. The Sand Leveling Course or Cover Material shall be maintained in the specified condition until the overlying geosynthetics are in place.

3.6 PLACING GRANULAR DRAINAGE MATERIAL OR COVER MATERIAL OVER GEOSYNTHETICS

A. General:

1. All underlying geosynthetics shall be inspected and approved by the ENGINEER before placement of the Granular Drainage Material or Cover Material.
2. Place Granular Drainage Material over Geosynthetics with sufficient care to avoid damage to the Geosynthetics.
3. Place only by back dumping and spreading.
4. Dump only on previously placed material.
5. While operating equipment, avoid sharp turns, sudden starts or stops that could damage Geosynthetics.
6. Anchor trenches for geosynthetics shall be completely backfilled and compacted before placement of Granular Drainage Material or Cover Material on side slopes.

B. Hauling: Operate hauling equipment or other heavy construction equipment on minimum of 3 feet of Granular Drainage Material or Cover Material over geosynthetics or pipes.

C. Spreading over Geosynthetics:

1. Spreading equipment shall be track mounted, low ground pressure, D-6 bulldozer or lighter (operating weight to total track width ratio of 4,400 pounds per foot or less).
2. Operate spreading equipment on minimum of 12 inches of fill over Geosynthetics.
3. Limit distance material falls onto the Geosynthetics to maximum of 2 feet.
4. Flatten small wrinkles of Geosynthetics in the same direction as that of the spreading operation. Wrinkles greater in height than 2 inches or spaced so close together that when combined will be greater in height than 2 inches shall be corrected in a manner approved by the ENGINEER.
5. Maintain proper overlap of unseamed Geosynthetics.
6. Avoid overstressing Geosynthetics and seams.
7. Spreading equipment shall not be used on sideslope areas during or just after heavy rainfall.

D. Compaction: Compact Granular Drainage Material or Cover Material only after uniformly spread to full thickness shown. Compact with two complete passes over the entire surface by the tracks of the bulldozer, or approved equivalent method.

E. Geosynthetic Damage:

1. Mark punctures, tears, or other damage to Geosynthetics, so repairs may be made.
2. Clear overlying fill as necessary to repair damage.
3. Repairs to Geosynthetics shall be made by respective installers as specified in respective specification section for each geosynthetic.
4. CONTRACTOR shall be responsible for making repairs to any geosynthetics damaged during placement of the Granular Drainage Material or Cover Material at no cost to the OWNER.

3.7 PLACE LEACHATE COLLECTION GRAVEL

A. Geosynthetics and Granular Drainage Material underlying the Leachate Collection Gravel shall be inspected and approved by the ENGINEER before placement of the Leachate Collection Gravel.

B. Leachate Collection Gravel shall be placed around leachate collection pipe as shown on the Drawings. No Leachate Collection Gravel shall be placed directly on the primary bottom liner. Special care shall be taken to place and compact Leachate Collection Gravel under the pipe haunches and adjacent to the pipe wall so as to provide complete, uniform lateral support of the pipe.

C. If any portion of Leachate Collection Gravel materials does not meet the specified requirements, the CONTRACTOR shall remove such material and replace with material that meets the Specifications at the CONTRACTOR's sole expense.

D. Method of placing and spreading materials shall be approved by the ENGINEER and shall ensure uniform distribution of the material and prevent damage to the underlying geosynthetics. Approval does not absolve the CONTRACTOR of responsibility for damage to underlying components. Construction traffic for placement of the Leachate Collection Gravel will not be permitted to travel on exposed geosynthetics.

E. Compaction of Leachate Collection Gravel shall be accomplished by tamping with blunt pieces of wood during dumping or other methods approved by the ENGINEER.

3.8 OTHER AREAS

A. Unless otherwise shown, place earthfill as follows:

1. Maximum 12-inch thick lifts.
2. Place and compact fill across full width of embankment.
3. Compact each lift with minimum 3 passes of suitable compaction equipment as approved by the ENGINEER.

3.9 SITE TESTING

A. Gradation:

1. One sample from each 1,500 tons of finished product or more often as determined by ENGINEER, if variation in gradation is occurring, or if material appears to depart from Specifications.
2. If test results indicate material does not meet Specification requirements, terminate material placement until corrective measures are taken.
3. Remove material placed in Work that does not meet Specification requirements.

3.10 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by ENGINEER as follows:

1. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
2. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
   a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Earthfill.
   b. Steep Slopes (Steeper than 3:1):
      1) Correct overexcavation by transitioning between overcut areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.
      2) Backfilling overexcavated areas is prohibited unless, in ENGINEER's opinion, backfill will remain stable, and overexcavated material is replaced as compacted earth fill.

B. CONTRACTOR shall repair unauthorized overexcavated areas at his sole expense.

3.11 MIXING AND PLACING SOIL/BENTONITE

A. Combine bentonite with specified soil material in a 50/50 ratio (1 part bentonite to 1 part soil by volume). Add sufficient water and mix to achieve a homogeneous mix free of lumps or clods, as approved by the ENGINEER.

B. Place approved soil/bentonite mix at locations and to thicknesses shown on the Drawings.

C. Compact exposed surface of soil/bentonite with light hand compaction equipment to protect soil/bentonite from moisture changes.

3.12 TIRE HAULING AND PLACEMENT

A. The work under this section consists of providing all operations necessary for hauling used tires from a stockpile on the landfill site and placing the tires in a single layer in the Cell 2B solid waste disposal area as directed by the Engineer.

B. Used tires will be stockpiled on the landfill site by the OWNER through summer 2001. Tires will range in size from those used on small passenger vehicles to those tires used for large earthmoving equipment. Tires will be delivered to the stockpile by the OWNER by dumping and not stacking. There will be no attempt to segregate the tires in the stockpile by type or size by the OWNER. Tires with rims shall remain in the stockpile location and shall not be placed in Cell 2B.

C. Place tires in a single layer in the Cell 2B solid waste disposal area after installation of the Granular Drainage Material and Leachate Collection Gravel is completed and approved. The tires shall be placed on the base of the cell beginning at the toe of the west containment berm and working to the east. Tire placement shall continue in this manner, as approved by the ENGINEER, until the tire stockpile is depleted. No tires shall be placed on the cell side slopes. Each tire shall be in contact with adjacent tires at a minimum of four points.

D. Operate tire hauling equipment or other heavy construction equipment on minimum of 3 feet of Granular Drainage Material over the liner or pipes. CONTRACTOR shall be responsible for any damage to the lining system or pipes occurring during the tire haul and placement.

3.13 TOPSOIL PLACEMENT

A. Topsoil shall only be placed on the Cell 2A final cover area and on other disturbed areas where shown on the Drawings.

B. Do not place topsoil when subsoil or topsoil is frozen, excessively wet, or otherwise detrimental to the Work.

C. Spread topsoil evenly on the designated areas to a depth that, after settlement and compaction, is a nominal 6 inches.

D. Uniformly distribute to within 1/2 inch of final grades. Fine grade topsoil eliminating rough or low areas and maintaining levels, profiles, and contours of subgrade.

E. Remove stones exceeding 2 inches, roots, sticks, debris, and foreign matter during and after topsoil placement.

F. Remove surplus subsoil and topsoil from site.

END OF SECTION

SECTION 02316
EXCAVATION

PART 1 GENERAL

1.1 DEFINITIONS

A. Common Excavation: Removal of material not classified as rock excavation.

1.2 SUBMITTALS

A. Shop Drawings:

1. Excavation Plan, Detailing:
   a. Methods and sequencing of excavation.
   b. Proposed locations of stockpiled excavated material.
   c. Proposed onsite and offsite spoil disposal sites.
   d. Traffic/haul plan addressing interface with landfill operations and other contractors.

1.3 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation. No reimbursement will be made for unauthorized overexcavation quantities.

1.4 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.5 SEQUENCING AND SCHEDULING

A. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 02200, SITE PREPARATION, prior to excavating.

B: The CONTRACTOR shall perform whatever work is necessary to prevent flow and accumulation of surface water, groundwater, snow, or ice in all excavations. Avoid settlement or damage to adjacent property. Dispose of water in a manner that will not damage adjacent property. When dewatering open excavations, dewater from outside the structural limits and from a point below the bottom of excavation. Design dewatering system to prevent removal of fines from existing ground. All work associated with snow and ice removal, pumping, or dewatering shall not be paid for directly, but shall be considered as an incidental obligation of the CONTRACTOR.

C. Excavation Support: Install and maintain shoring, sheeting, bracing, or sloping, as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work. Install and maintain shoring, sheeting, bracing, and sloping, as required by OSHA and other applicable governmental regulations and agencies. The CONTRACTOR shall be solely responsible for making all excavations in a safe manner.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1-foot except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable.

B. Do not overexcavate without written authorization of ENGINEER. Unauthorized overexcavation quantities will not be reimbursed.

C. Remove or protect obstructions as shown and as specified in Section 01500, CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS, Article PROTECTION OF WORK AND PROPERTY.

3.2 UNCLASSIFIED EXCAVATION

A. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered. If waste is encountered within Cell 2B excavation limits, CONTRACTOR shall move waste into Cell 2A as directed by the ENGINEER.

3.3 EMBANKMENT AND CUT SLOPES

A. Shape, trim, and finish cut slopes to conform with lines, grades, and cross-sections shown, with proper allowance for topsoil or slope protection, where shown.

B. Remove stones and rock that exceed 3-inch diameter and that are loose and may roll down slope. Remove exposed roots from cut slopes.

C. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.

3.4 STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material at onsite locations approved by the OWNER.

B. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.

C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

D. Do not stockpile excavated material adjacent to trenches and other excavations unless excavation sideslopes and excavation support systems are designed, constructed, and maintained for stockpile loads.

E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could induce excessive settlement.

3.5 DISPOSAL OF SPOIL

A. Place spoils from clearing, grubbing, and stripping operations in C&D Cell in uniform lift thickness in locations as approved by the OWNER.

END OF SECTION

SECTION 02319
SUBGRADE PREPARATION

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society for Testing and Materials (ASTM):
   a. D698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
   b. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

1.2 DEFINITIONS

A. Optimum Moisture Content: As defined in Section 02315, FILL AND BACKFILL.

B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.

C. Relative Compaction: As defined in Section 02315, FILL AND BACKFILL.

D. Relative Density: As defined in Section 02315, FILL AND BACKFILL.

E. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.

F. Proof-Rolling: Testing of subgrade by compactive effort to identify areas that will not support the future loading without excessive settlement.

1.3 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Sections 02200, SITE PREPARATION, and 02316, EXCAVATION, prior to subgrade preparation.

1.4 QUALITY ASSURANCE

A. Notify ENGINEER when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Prepare subgrade when unfrozen and free of ice and snow.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 GENERAL

A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.

B. Bring subgrade to proper grade and cross-section and uniformly compact surface.

C. Do not use sections of prepared ground surface as haul roads. Protect prepared subgrade from traffic.

D. Maintain prepared ground surface in finished condition until next course is placed.

3.2 COMPACTION

A. All subgrade areas: Three passes with three-wheeled power vibratory roller weighing approximately 10 tons, or other suitable compaction equipment as approved by the ENGINEER.

3.3 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.4 TESTING

A. Proof-roll subgrade with equipment specified in Article COMPACTION to detect soft or loose subgrade or unsuitable material, as determined by ENGINEER.

3.5 CORRECTION

A. Soft or Loose Subgrade:

1. Adjust moisture content and recompact, or

2. Over excavate as specified in Section 02316, EXCAVATION, and replace with suitable material from the excavation, as specified in Section 02315, FILL AND BACKFILL.

B. Unsuitable Material: Over excavate as specified in Section 02316, EXCAVATION, and replace with suitable material from the excavation, as specified in Section 02315, FILL AND BACKFILL.

END OF SECTION

SECTION 02340
SOIL STABILIZATION

PART 1 GENERAL

1.1 DEFINITIONS

A. Maintenance Period: Begin maintenance immediately after each area is planted and continue for a period of 4 weeks after all planting under this section is completed.

B. Satisfactory Stand: Grass or section of grass that has:

1. No bare spots larger than 3 square feet.
2. Not more than 10 percent of total area with bare spots larger than 1 square foot.
3. Not more than 15 percent of total area with bare spots larger than 6 square inches.

1.2 SUBMITTALS

A. Quality Control Submittals:

1. Manufacturer's Product Data and Installation Instructions: Commercial products.
2. Seed certifications.
3. Copies of delivery invoices or other proof of quantities of mulch and fertilizer.

1.3 DELIVERY, STORAGE, AND PROTECTION

A. Seed:

1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
2. Keep dry during storage.

B. Hydroseeding Mulch: Mark package of cellulose fiber mulch to show air dry weight.

1.4 SEQUENCING AND SCHEDULING

A. ENGINEER's acceptance of Construction Period Stormwater Pollution Prevention Plan required prior to starting earth disturbing activities.

B. Prepare topsoil as specified in Section 02315, FILL AND BACKFILL, before starting Work of this section.

C. Complete soil preparation, seeding, fertilizing, and mulching within 10 days after final grades have been reached.

D. Notify ENGINEER at least 3 days in advance of:

1. Materials delivery.
2. Start of planting activity.

E. Seeding: Perform between May 15 and August 15.

1.5 MAINTENANCE

A. Operations:

1. CONTRACTOR tasks during maintenance period shall include:
   a. Watering: Keep seeded surface moist.
   b. Washouts: Repair by filling with topsoil, fertilizing, seeding, and mulching.
   c. Mulch: Replace wherever and whenever washed or blown away.
   d. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.
   e. Reseed during next planting season if scheduled end of maintenance period falls after September 15.
   f. Reseed entire area if satisfactory stand does not develop by July 1 of the following year.
2. Inspect, repair, and replace as necessary all erosion control measures during the time period from start of construction to completion of construction.

2 PART 2 PRODUCTS

2.1 FERTILIZER

A. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose.

B. Fertilizer shall have the following minimum percentage of plant food by weight and be applied at a rate of 450 lbs./acre:

1. Summer Hydroseed Mix:
   a. Nitrogen: 20 percent.
   b. Phosphoric Acid: 20 percent.
   c. Potash: 10 percent.

2.2 SEED

A. Fresh, clean new-crop seed of the following composition applied at the rate of 1 lb./1,000 square feet:

		Proportion by Weight (percent)
1.	Arctared Red Fescue	60
2.	Norcoast Bering Hair Grass	30
3.	Annual Rye Grass	10

2.3 MULCH

A. Cellulose Fiber Mulch:

1. Specially processed wood or paper fiber containing no growth or germination inhibiting factors.
2. Dyed a suitable color to facilitate inspection of material placement.
3. Manufactured such that after addition and agitation in slurry tanks with water, the material fibers will become uniformly suspended to form a homogenous slurry.
4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.
5. Apply at 1,500 lbs./acre or as otherwise recommended by the manufacturer.

2.4 TACKIFIER

A. Derived from natural organic plant sources containing no growth or germination-inhibiting materials.

B. Capable of hydrating in water, and to readily blend with other slurry materials.

C. Cellulose Fiber: Add as tracer, at rate of 150 pounds per acre.

D. Manufacturers and Products:

1. Chevron Asphalt Co.; CSS-1.
2. Terra; Tack AR.
3. J-Tack; Reclamare.
4. Or as otherwise approved by the ENGINEER.

2.5 STRAW BALES

A. Machine baled clean salt hay or straw of oats, wheat, barley, or rye, free from seed of noxious weeds, using standard baling wire or string.

2.6 POSTS FOR STRAW BALES

A. 2 inch by 2 inch untreated wood or commercially manufactured metal posts.

PART 3 EXECUTION

3.1 SOIL PREPARATION

A. Before start of hydroseeding, and after surface has been shaped and graded, and lightly compacted to uniform grade, scarify soil surface to minimum depth of 1 inch.

3.2 SEEDING

A. Prepare 1-inch depth seed bed; obtain ENGINEER's acceptance prior to proceeding.

B. Apply by hydroseeding method on moist soil, but only after free surface water has drained away. Prevent drift and displacement of mixture into other areas.

C. Apply at rates specified in Part 2, PRODUCTS, of this specification.

3.3 MULCHING

A. Apply uniformly on disturbed areas that will remain undisturbed for 7 days or more, as requested by ENGINEER, and on seeded areas.

B. Application: Sufficiently loose to permit penetration of sunlight and air circulation, and sufficiently dense to shade ground, reduce evaporation rate, and prevent or materially reduce erosion of underlying soil.

1. Cellulose Fiber: 1,500 pounds per acre or as otherwise recommended by the manufacturer.

3.4 TACKIFIER

A. Apply on areas mulched.

B. Spray on after mulch is in place, or combine in hydroseed mix with all other slurry constituents.

C. Apply in quantities sufficient to equal retention properties of a CSS-1 asphalt emulsion being applied at rate of 400 gallons per acre.

3.5 STRAW BALES

A. If required by Stormwater Pollution Prevention Plan, embed minimum of 4 inches in flat-bottomed trench.

B. Place with ends tightly abutting or overlapped. Corner abutment is not acceptable.

C. Install so that bale bindings are oriented around the sides and not over the top and bottom of the bale.

D. Use two posts for each bale. Drive posts through the bale until top of post is flush with top of bale.

E. Wedge loose straws in any gaps between bales.

3.6 FIELD QUALITY CONTROL

A. Upon completion of maintenance period and on written notice from CONTRACTOR, ENGINEER will, within 15 days of receipt, determine if a satisfactory stand has been established.

B. If a satisfactory stand has not been established, ENGINEER will make another determination upon written notice from CONTRACTOR following the next growing season.

END OF SECTION

SECTION 02667
GEOSYNTHETIC CLAY LINER (GCL)

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society for Testing and Materials (ASTM):
   a. ASTM D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
   b. ASTM D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   c. ASTM D4643, Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
   d. ASTM D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
   e. ASTM D5084, Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.
   f. ASTM D5199, Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.
   g. ASTM D5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
   h. ASTM D5321, Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
   i. ASTM D5890, Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners.
   j. ASTM D5891, Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners.
   k. ASTM D5993, Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners.

1.2 DEFINITIONS

A. Geosynthetic Clay Lining (GCL): Flexible panel made of layer of domestic, natural, high swelling sodium bentonite clay (montmorillonite) encapsulated between two geotextiles.

B. Geotextile: Nonwoven permeable manmade textile used with geotechnical engineering related materials.

C. Minimum Average Roll Value (MinARV): Minimum of a series of average roll values representative of product furnished.

D. Maximum Average Roll Value (MaxARV): Maximum of a series of average roll values representative of product furnished.

E. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

1.3 SUBMITTALS

A. Shop Drawings (submit at least 4 weeks prior to shipment of materials to site):

1. Product Data:
   a. Montmorillonite content by weight, typical moisture content, and swell index values.
   b. Recommended sealing compound.
   c. Repair adhesive.
2. Factory test results demonstrating conformance with all the requirements of this section.
3. Layout and installation drawings.
4. Panel joining methods.
5. Handling and storage instructions.

B. Samples:

1. At least 8 weeks prior to shipment of GCL, provide a sample of GCL (3 feet by roll width) to be used by ENGINEER for shear strength testing that will be done at ENGINEER's discretion. The GCL sample shall be from a typical GCL roll planned for use on the project and for which factory test results and material certifications have been provided to the ENGINEER. Identification numbers, such as the roll number, shall be included with the sample provided.
2. On request from ENGINEER, 2 square yards of material from each shipment.

C. Quality Control Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01300, SUBMITTALS.
2. Factory test results on actual materials to be used on the project, certified by manufacturer demonstrating conformance with the requirements of this specification.

D. Contract Closeout Submittals:

1. Record documents: Include scaled layout and installation drawings with lot and roll numbers, identity and location of each repair, location of samples taken for testing, and other data as may be requested by the ENGINEER.
2. All quality control test results.

3. Special guarantee.

1.4 QUALITY ASSURANCE

A. Prior to packaging finished product, manufacturer shall inspect surface of each roll by using strong light source on one side of panel and observing other side for zones of inadequate bentonite distribution or by using other reliable methods, such as physical measurements or sampling, to detect deficiencies in uniformity of bentonite distribution. Deficient rolls shall be rejected.

B. Each roll shall be labeled with length, width, and weight, along with lot number and date of manufacture.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store GCL in dry, protected facility or in protected area on pallets off ground and covered with heavy, waterproof membrane that allows free flow of air between membrane and materials. Protect GCL materials from water and freezing. Replace GCL materials that are damaged or contaminated with dust, dirt, or excess moisture at the CONTRACTOR's own expense.

1.6 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with OWNER named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of OWNER, removal and replacement of Work specified here that is found defective during period defined below, commencing on the date of Substantial Completion.

1. Manufacturing Defects: 20 years on a pro rata basis.
2. Installation Defects: 5 years.

PART 2 PRODUCTS

2.1 MANUFACTURERS AND PRODUCTS

A. Needle-punched GCL products; double nonwoven geotextiles:

1. Colloid Environmental Technologies Co. (CETCO), Arlington Heights, IL; Bentomat DN.
2. Approved equivalent.
3. Use of manufacturers and products listed here does not release the manufacturer or CONTRACTOR from full compliance with the provisions of this section.

2.2 GEOSYNTHETIC CLAY LINING

A. Panels of bentonite and encapsulating geotextiles manufactured shall perform as continuous lining. Panels shall contain at least 0.8 pounds per square foot of high-swelling sodium bentonite clay at 0 percent moisture content, or equivalent weight at other moisture content using ASTM D5993.

B. Bentonite shall contain:

1. High quality natural sodium bentonite without chemical resistance enhancers or polymers.
2. 90 percent typical montmorillonite content by weight.
3. Minimum Bentonite Swell Index of 24 mL/2g when tested pursuant to ASTM D5890.
4. Maximum fluid loss of 18 mL when based on ASTM D5891 test standard.

C. GCL shall be manufactured so that bentonite shall be continuously contained throughout GCL and to support geotextile so that no displacement of bentonite occurs when material is unrolled, moved, cut, torn, or punctured. To contain granular bentonite, GCL materials shall be stabilized by process of needle-punching through top and bottom layers of geotextile and bentonite.

D. Encapsulating geotextile materials shall be nonwoven fabrics.

E. Manufactured GCL products shall meet the following material properties:

Property	Requirement	Test Method
Bentonite Content, Mass/Unit Area, lb/sq ft at 0% moisture content, MinARV	0.8	ASTM D5993
Bentonite Moisture Content, %, max.	12	ASTM D4643
Bentonite Swell Index, mL/2g, MinARV	24	ASTM D5890
Bentonite Fluid Loss, mL, MaxARV	18	ASTM D5891
Nonwoven Cover Geotextile Weight oz/sq yd, MinARV	6.0	ASTM D5261
Peel Strength, lbs., MinARV	35	ASTM D4632—modified
Grab Strength, lbs, Tested Dry, MinARV	150	ASTM D4632
Grab Elongation, %, Tested Dry, MaxARV	100	ASTM D4632
Index Flux, m^3/m^2/sec, max. at 5 psi	$1x10^{-8}$	ASTM D5887

Property	Requirement	Test Method
Permeability with Water, under 400 lb/sq ft Normal Load, cm/sec, MaxARV	5×10^{-9}	ASTM D5084
Finished GCL Roll Width, Feet, MinARV	14	Linear Measurement
Finished GCL Roll Length, Feet, MinARV	See Par. 2.2.F of this section	Linear Measurement

F. Each roll shall be labeled with the length, width, and weight, along with the lot number and date of manufacturer. Minimum GCL roll length shall be 220 feet for all side slope areas where the slope length is equal to or greater than 205 feet. Shorter roll lengths may be used for sideslopes where the slope length is less than 205 feet, although roll lengths must be sufficient to avoid horizontal seams on the sideslopes for such cases and to provide for necessary top of slope anchorage and toe of slope overlap as shown and specified without horizontal seams.

2.3 BENTONITE SEALING COMPOUND

A. Bentonite sealing compound in powder or granular form shall be same product used in manufacture of GCL materials.

B. Sealing compound shall be applied to seal overlaps, around penetrations and structures shown on Drawings and under repair patches. Manufacturer shall recommend minimum amount of sealing compound to use in each instance in order to effect adequate seal.

C. The sealing compound shall be furnished by the manufacturer of the GCL product furnished for this Project.

2.4 REPAIR ADHESIVE

A. Repair adhesive for securing GCL patches shall be nontoxic adhesive as recommended by GCL manufacturer.

PART 3 EXECUTION

3.1 GENERAL

A. Inspect GCL materials delivered to project site for damage. Inventory by quantity, lot number, roll number, panel size, and weight. Provide updated copy of inventory to ENGINEER when each shipment is delivered to the Project site prior to placement of any material from that shipment.

B. Remove only quantity of material from storage that is to be installed during current work day.

3.2 SUBGRADE PREPARATION

A. Surface on which GCL is to be installed shall be prepared in accordance with Section 02319, SUBGRADE PREPARATION and as indicated on Drawings.

B. Surface on which GCL is to be placed shall be maintained in firm, clean, dry, and smooth condition during GCL installation.

3.3 PLACEMENT OF GEOSYNTHETIC CLAY LINING

A. Only those GCL panels that can be anchored and covered in the same day by the geomembrane shall be unwrapped and placed in position.

B. Place GCL surface on underlying soil with surface of GCL in contact with soil as recommended by manufacturer.

C. GCL panels shall not be dragged over surface, except for slight adjustments as may be necessary for obtaining correct overlap of panels. Rolled-up panels shall not be allowed to unroll unrestrained down slope.

D. Anchor trench for area to receive GCL shall be prepared as shown on Drawings before installation of GCL begins.

E. Panels shall be placed to provide minimum overlap of 6 to 9 inches on longitudinal seams and 24 inches on transverse seams or as shown on the Drawings or as specified. On the Cell 2B sideslopes, a maximum of one transverse seam per GCL panel will be allowed. No transverse seams will be allowed on the Cell 2A cover sideslopes. Sideslope transverse seams will be allowed only where the slope length is equal to or exceeds 205 feet. Provide a minimum overlap of 5 feet for all transverse seams on the sideslopes. Transverse seams shall be placed as close to the toe of slope as possible given the minimum specified roll length for long slopes. Seam overlap on slopes shall be shingled so that the direction of flow is from the top panel onto the bottom panel. On all sideslopes, the panels shall be placed with the long dimension (roll length) running perpendicular to the contours from the anchor trench at the slope crest to the slope toe, unless otherwise approved by the ENGINEER.

F. GCL panels shall not be installed in standing water, while it is raining or when rain may begin before panels can be covered with geomembrane and protected. GCL shall be "dry" when installed and "dry" when geomembrane is installed over it. If the GCL is hydrated partially or in full during installation by natural or man-made causes, the hydrated portion of GCL shall be replaced at the CONTRACTOR's sole expense. The need for GCL replacement due to hydration will be determined at the ENGINEER's sole discretion.

G. GCL shall be laid smooth without creases or wrinkles and without stretching material to fit area. GCL shall be free of tension or stress upon completion of installation.

H. GCL shall be covered with required geomembrane cover as it is installed without getting more than two panel widths or 24 feet beyond cover system over GCL material. GCL is to be completely covered and protected at end of each shift or workday.

I. Leading edge and panels of GCL left uncovered shall be protected with heavy, waterproof membrane or tarp that is adequately secured and protected with sandbags or other ballast.

3.4 SEAMING GCL PANELS

A. Mark overlaps 6 and 9 inches from panel edge longitudinally on GCL to assist in obtaining proper overlap.

B. Prior to lapping, remove dirt, gravel, or other debris from overlap area. Apply 1/4 pound of sealing compound per lineal foot of seam or as otherwise recommended by manufacturer, whichever, represents greatest amount of bentonite. Where soil and sand encroaches lap areas after initial application of bentonite sealant, additional bentonite sealant in amount of 1/4 pound per lineal foot evenly shall be spread across longitudinal seam area.

C. Seam overlap on all slopes shall be shingled so that direction of flow is from top panel onto bottom panel.

D. Hot Weather Installation:

1. Provide compensation for shrinkage when ambient temperatures are greater than 85 degrees F. At minimum, longitudinal overlap should be increased to 12 inches and transverse overlap should be increased to 36 inches.
2. Dimensions to use for overlapping during temperatures greater than 85 degrees F shall be approved by ENGINEER.

3.5 PATCHING AND REPAIRS

A. Irregular shapes, cuts, or tears in GCL shall be overlapped with additional layer of GCL material minimum of 12 inches in all directions from defect.

B. Patch seams parallel to slope and secure with repair adhesive recommended by manufacturer.

C. Patches and repairs shall not be allowed on slopes greater than 7H:1V.

D. Complete panels shall be removed and replaced with undamaged panels when damage is extensive as determined by ENGINEER.

3.6 PLACEMENT OF OVERLYING MATERIALS

A. Equipment shall not operate directly on GCL, except to minimum extent necessary to deploy specified geosynthetic materials on GCL, as approved by ENGINEER. Deploy geosynthetic materials with equipment and by methods approved by ENGINEER.

B. The GCL shall be covered as it is installed, as the GCL installation is accepted for cover by the installation superintendent and the ENGINEER. The intent of the Specification is to cover the GCL as it is installed without getting more than two panel widths or 24 feet beyond the cover system over the GCL material. In any event, the GCL is to be completely covered and protected at the end of each shift or workday. The CONTRACTOR shall be fully responsible to protect the GCL from damage, shrinkage, or prehydration and shall replace all affected materials at the CONTRACTOR's sole expense.

C. To prevent premature hydration or shrinkage in hot weather, only the amount of GCL that can be anchored, inspected, repaired, and covered in the same day shall be installed.

D. The CONTRACTOR shall ensure that moisture and surface water runoff collected on completed sections of the liner or cover systems or draining from other areas does not drain or seep into the liner or cover system and expose the GCL to moisture at any time. Any GCL exposed to moisture, as determined by the ENGINEER, either covered with HDPE or not, shall be removed and replaced at the CONTRACTOR's expense.

E. Any leading edge or panels of GCL left uncovered shall be protected with a heavy, waterproof membrane or tarp which is adequately secured and protected with sandbags or other ballast.

F. Equipment used to installed the cover materials shall not operate directly on the GCL.

3.7 FIELD QUALITY CONTROL

A. Conformance Testing:

1. Conformance testing shall be the sole responsibility of the CONTRACTOR and shall be performed on samples taken from GCL rolls delivered to the site. The conformance sampling and testing shall occur at a frequency of one per 50,000 square feet. The following tests shall be performed by a qualified third party Geosynthetic Quality Control laboratory retained by the CONTRACTOR to determine GCL characteristics. Additional tests may be performed by the ENGINEER

to verify material conformance with specifications at the discretion of the ENGINEER.

a. Bentonite Content: Mass/Unit Area; ASTM D5993.
b. Grab Tensile and Elongation: ASTM D4632.
c. Peel Strength: ASTM D4632.

2. Where optional procedures are noted in the test method, the requirements of these specifications shall prevail.
3. Sampling Procedures:
   a. Sample across the entire width of the roll excluding the first 3 feet.
   b. Cut sample 3 feet long by width of roll unless otherwise specified.
   c. Mark longitudinal direction of roll on the samples with an arrow.
4. For each sample taken, provide a corresponding sample to the ENGINEER. Provide lot number, roll number, and location for each sample.
5. Provide test results to the ENGINEER prior to installation and as required in Article SUBMITTALS.

END OF SECTION

Lori Davidson

From: Tammy Clayton
Sent: Thursday, August 14, 2014 9:39 AM
To: Lori Davidson
Subject: RE: DEC Landfill Inspection

We will not be completing it until September as we get ready for our audit. I will forward it to you once complete then.

From: Lori Davidson
Sent: Wednesday, August 13, 2014 11:40 AM
To: Tammy Clayton
Subject: DEC Landfill Inspection

Good Morning Tammy,

It has come to my attention that we are scheduled for our Landfill inspection by ADEC on Tuesday August 19th. I was asked to see if you would be able to provide us with the required **LOCAL GOVERNMENT FINANCIAL ASSURANCE FORM** as required in our landfill permit I am not sure if this take a lot of your time but I would appreciate it if we could get a copy of this hopefully by the end of the week?

Thank you for your time,

Lori Davidson
Central Landfill
907 861-7603

FYI -
New form to
be inserted in
September

Local Government Financial Assurance Form

I, Tammy Clayton, the Chief Financial Officer for the Matanuska-Susitna Borough certify that the local government has complied with the provisions of 18 AAC 60.398 for financial assurance by complying with the following sections of 40 CFR 258.74(f)[Local Government Financial Test] for fiscal year 2013.

Please initial those sections that were done to demonstrate compliance. (All five must be initialed to be in compliance.)

jel A. The current cost estimate for:

1) Closure and post-closure of the landfill is $18,227,073.
2) Corrective action for the landfill is $________________________.[1]

jel B. The cost for closure, post-closure and corrective action is not greater than: (circle one)

1) 43 percent of the local government's total annual revenue, if the local government does not assure other environmental obligations through a financial test, **or**
2) 43 percent of the local government's total annual revenue for the total of all environmental obligations assured through a financial test.[2]

jel C. Currently the Local Government has: (circle one)

1) Outstanding general obligation bonds rated no lower than Baa for Moody's or BBB for Standard and Poor, **or**
2) The following financial ratios:
   i) cash plus marketable securities to total expenditures greater than or equal to 0.05, and
   ii) annual debt service to total expenditures less than or equal to 0.20.

jel D. The local government's comprehensive annual financial report was:

1) Prepared in conformity with Generally Accepted Accounting Principles for governments.
2) Audited by an independent, certified public accountant, and
3) The auditor issued an unqualified opinion for the report.

jel E. The local government:

1) Is not currently in default on any outstanding general obligation bonds.
2) Has no outstanding general obligation bonds rated lower than Baa as issued by Moody's or BBB as issued by Standard and Poor's; and
3) Has not operated at a deficit equal to five percent or more of total revenue in each of the past two fiscal years.

Tammy E. Clayton — 9/30/13

Signature of Local government's Chief Financial Officer — Date

[1] Corrective action costs are only required if a long-term remediation project for the landfill is currently required.

[2] The total of all environmental obligations including landfill closure must be considered when addressing the 43% limit. This would include such things as UIC facilities under 40 CFR 144.62, petroleum underground storage facilities under 40 CFR 280, PCB storage facilities under 40 CFR 761, and hazardous waste treatment, storage, and disposal facilities under 40 CFR 264 and 265.

Local Government Financial Assurance Form

I, Tammy Clayton, the Chief Financial Officer for the Matanuska-Susitna Borough certify that the local government has complied with the provisions of 18 AAC 60.398 for financial assurance by complying with the following sections of 40 CFR 258.74(f)[Local Government Financial Test] for fiscal year 2010.

Please initial those sections that were done to demonstrate compliance. (All five must be initialed to be in compliance.)

_____ A. The current cost estimate for:
1) Closure and post-closure of the landfill is $16,680,353.
2) Corrective action for the landfill is $ __________.[1]

_____ B. The cost for closure, post-closure and corrective action is not greater than: (circle one)
1) 43 percent of the local government's total annual revenue, if the local government does not assure other environmental obligations through a financial test. **or**
2) 43 percent of the local government's total annual revenue for the total of all environmental obligations assured through a financial test.[2]

_____ C. Currently the Local Government has: (circle one)
1) Outstanding general obligation bonds rated no lower than Baa for Moody's or BBB for Standard and Poor. **or**
2) The following financial ratios:
   i) cash plus marketable securities to total expenditures greater than or equal to 0.05, and
   ii) annual debt service to total expenditures less than or equal to 0.20.

_____ D. The local government's comprehensive annual financial report was:
1) Prepared in conformity with Generally Accepted Accounting Principles for governments.
2) Audited by an independent, certified public accountant, and
3) The auditor issued an unqualified opinion for the report.

_____ E. The local government:
1) Is not currently in default on any outstanding general obligation bonds.
2) Has no outstanding general obligation bonds rated lower than Baa as issued by Moody's or BBB as issued by Standard and Poor's; and
3) Has not operated at a deficit equal to five percent or more of total revenue in each of the past two fiscal years.

______________________________ 9-30-10
Signature of Local government's Chief Financial Officer Date

Central Landfill 2010 Permit Application
Attachment Q

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[1] Corrective action costs are only required if a long-term remediation project for the landfill is currently required.
[2] The total of all environmental obligations including landfill closure must be considered when addressing the 43% limit. This would include such things as UIC facilities under 40 CFR 144.62, petroleum underground storage facilities under 40 CFR 280, PCB storage facilities under 40 CFR 761, and hazardous waste treatment, storage, and disposal facilities under 40 CFR 264 and 265.

Memorandum on Slope Stability Analyses (Draft), Pages 9 -11

Maximum allowable deformations of 6 to 12 inches have typically been used in practice for design of geosynthetic liner systems (Richardson and Kavazanjian, 1995).

Seismic Deformation Analysis

The pseudostatic analysis described above provides a general indication of slope behavior under seismic loading. To further assess slope behavior, permanent deformations under earthquake loading were evaluated using an approach suggested in the literature (Seed and Makdisi, August 1977; and Newmark, 1965).

Deformation analyses were performed on Cell 2B, Section 1. Resulting estimated permanent deformations for Section 1 are shown in Table 6 for both strength cases. For Case 1 (residual strengths), estimated deformations are expected to be 12 inches or less. For Case 2 (peak strengths), estimated deformations are expected to be very small or negligible at less than 1 inch.

These results indicate the proposed waste configuration in Cell 2B is acceptable based on seismic stability considerations. As noted above, maximum allowable deformations of 6 to 12 inches have typically been used in practice for design of geosynthetic liner systems (Richardson and Kavazanjian, 1995). Accordingly, the expected 12 inches or less of permanent seismic deformation estimated for Cell 2B even using the conservative residual strength case confirms adequate seismic stability for the proposed configuration.

It should be noted that a larger earthquake of greater magnitude and/or higher peak ground accelerations could occur at any time and could cause greater seismic deformations with subsequent increased risk of damage to the lining system. However, the design earthquake used in these analyses is a very large earthquake with a low probability of occurrence over the relatively short period of time during which the temporary Cell 2B configuration will exist as analyzed. Accordingly, the design is considered to be a reasonable approach to the objective of achieving adequate slope stability.

Summary and Conclusions

Based on the static and seismic analyses described above, the following conclusions concerning Cell 2B stability are provided:

- A GCL/HDPE composite lining system will be stable on the 3:1 side slopes of Cell 2B. The GCL will need to be reinforced by needle-punching or equivalent means, and should have nonwoven geotextiles on both sides of the fabric. The HDPE must be textured on both sides.

- It is critical that the granular drainage layer above the HDPE meet specifications regarding fines content and permeability to maintain the required stability of the side-slope lining system.

- Confirmation laboratory shear strength tests should be run prior to final approval and installation of the actual materials proposed for use on the project. Laboratory tests should be run to determine peak and residual shear strength for the following:
  - GCL/HDPE interface
  - GCL internal
  - HDPE/granular drainage material interface

- The waste in Cell 2B can safely be placed to a maximum height of Elevation 330 or 350 prior to being buttressed by waste placed in adjacent Cell 2C.

- Under static loading conditions, factors of safety against mass waste instability were approximately 1.5 and 2.0 for residual and peak strength cases, respectively.

- Under the design seismic loading, a minimum factor of safety of about 1.0 was determined for the Cell 2B waste for the residual strength case. A factor of safety of approximately 1.4 was estimated for the peak strength case. These results indicate that only limited levels of permanent deformation is expected to occur under the design seismic loading.

- Permanent seismic deformations of 12 inches or less are estimated for the sliding waste mass in Cell 2B under the design earthquake. Deformations limited to these levels are typically considered tolerable for geosynthetic lining systems in current practice.

Recommendations For Waste Placement Operations

The stability analyses described in this memorandum were conducted to determine a stable lining system and waste fill configuration for Cell 2B. The stability analyses were based on various assumptions concerning waste placement operations in Cell 2B. Guidelines for waste placement operations and practical construction/maintenance considerations are summarized below:

- The open face of interior waste slopes should be no steeper than 3 to 1.

- Cell 2B should be filled in horizontal 10-foot thick lifts across the entire base of the fill area.

- Exterior waste slopes should be inclined at no steeper than 4 to 1.

- When operating equipment or placing waste on the granular drainage layer above the lining system, care should be taken to avoid damaging the liner. Special care will be necessary for equipment operation on the side slopes. Equipment should always operate on a minimum of 12 inches of granular drainage material over the lining system.

- Only Caterpillar D4H dozers or lighter should be used for construction and maintenance on the side slopes. Dozers or other equipment should not be operated on the slope during or soon after periods of heavy rainfall.

- The granular drainage material on the side slopes of Cell 2B will be installed during construction. Portions of the granular drainage material will be exposed for up to several years in some areas prior to waste placement. The granular drainage layer on the side slopes should be monitored for excessive erosion or localized sloughing.

- Repair any damage to the granular drainage layer by regrading or other necessary means in a timely manner. Any repairs on the side slopes should be accomplished using a lightweight dozer (Caterpillar D4H or lighter). The dozer should not make any sharp turns or sudden braking maneuvers on the slope.

- Any soil stockpiles placed on the waste should be set back a minimum of 100 feet from the top of slope. Such soil stockpiles should not be placed any higher than the recommended maximum waste elevation.

CENTRAL LANDFILL OPERATING PERMIT SW1A007-15

ISSUED BY: STATE OF ALASKA – DEC

(Date Issued: February 21, 2014 – Date Expires: November 19, 2015)

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