CONSTRUCTION QUALITY ASSURANCE
FINAL REPORT
ON-SITE DISPOSAL FACILITY, PHASE I AND LEACHATE CONVEYANCE SYSTEM

REVISION 0
JANUARY 1998
VOLUME I

United States Department of Energy
Fernald Environmental Management Project
Fernald, Ohio

prepared by

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under

Fluor Daniel Fernald
Subcontract 95PS005028

Department of Energy

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JAN 29 1998

DOE-0384-98

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U.S. Environmental Protection Agency
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Mr. Tom Schneider, Project Manager
Ohio Environmental Protection Agency
401 East 5th Street
Dayton, Ohio 45402-2911

Dear Mr. Saric and Mr. Schneider:

CONSTRUCTION QUALITY ASSURANCE FINAL REPORT, PHASE I ON-SITE DISPOSAL FACILITY

This letter transmits the On-Site Disposal Facility (OSDF) Phase I Construction Quality Assurance Final Report. This report summarizes the construction quality control and quality assurance activities performed by GeoSyntec Consultants during the construction of the Leachate Conveyance System and Phase I of the OSDF. The activities performed by GeoSyntec included monitoring of the following:

- soils construction;
- geosynthetics installation;
- leachate collection system and leak detection system construction; and,
- leachate conveyance system construction.

The construction quality assurance and quality control activities were performed to confirm that the construction materials and procedures were in compliance with the construction drawings, technical specifications, OSDF Construction Quality Assurance Plan, and approved changes.

Recycled and Recyclable

If there are any questions, please contact Jay Jalovec at (513) 648-3122.

Sincerely,

Johnny Reising

FEMP:Jalvoec

Johnny W. Reising
Fernald Remedial Action
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Enclosure: As Stated

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1. INTRODUCTION

1.1 Background

The Fernald Environmental Management Project (FEMP), located near Fernald, Ohio, is a Department of Energy (DOE) site undergoing remediation pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Remediation at the FEMP is being addressed as five interrelated sets of activities, with each set identified as an "operable unit" (OU).

As described in the 1995 *Final Record of Decision* (ROD) *for Remedial Actions at Operable Unit 2* (OU2), the selected remedy for OU2 involves construction of an on-site disposal facility (OSDF) for permanent disposal of impacted material, including soil, flyash, lime sludge, and solid waste excavated as part of the OU2 remedial action. The conceptual design of the OSDF was developed as an alternative in the 1995 *Final Feasibility Study* (FS) *Report for Operable Unit 2* and identified as the selected remedial alternative in the OU2 ROD.

On-site disposal of impacted material is also the preferred alternative for Operable Unit 3 and Operable Unit 5 at the FEMP. The final Records of Decision for these operable units are dated August 1996 and January 1996, respectively. In addition, the material sent to the OSDF by OU3 may include contributions from OU1 and OU4. All material destined for OSDF disposal must meet the OSDF waste acceptance criteria (WAC). The OU2 ROD has established an initial WAC for the OSDF for 346 picoCuries/gram (pCi/g) of uranium-238 (U-238) or 1030 parts per million (ppm) total uranium. The OU3 and OU5 RODs established additional WAC.

DOE intends to build only one OSDF. Therefore, the OSDF is designed to accommodate all or any portion of the total volume of impacted material meeting the WAC that results from remediation of the operable units. The total volume of material from all operable units is estimated to be 2.5 million bank/unbulked (i.e., in-place prior to excavation) cubic yards (1.9 million bank/unbulked cubic meters). The OSDF will be constructed over a period of time to be determined, depending on availability of funding. The first year of construction included two projects referred to as Phase I of the OSDF and the Leachate Conveyance System.

Phase I of the OSDF refers to construction of the double composite liner system and other engineering controls for Cell 1 of the OSDF. Ancillary construction also included a sedimentation basin for storm water runoff, an access corridor, a decontamination facility, excavation in the area of future Cell 2 construction, and final grading and grassing of areas external to Cell 1.

The Leachate Conveyance System project included permanent manholes for Cells 1 through 3, a gravity HDPE piping system, a permanent lift station, and a force main designed to convey leachate to the BioSurge Lagoon.

The interface between Phase I of the OSDF and the Leachate Conveyance System was at the stub-out of the manholes for Cell 1 leachate collection and leak detection systems.

1.2 Report Overview

This final report summarizes the Construction Quality Control (CQC) and Construction Quality Assurance (CQA) activities performed by GeoSyntec Consultants (GeoSyntec), Atlanta, Georgia during the construction of two interrelated projects; Phase I of the OSDF and the Leachate Conveyance System at the FEMP. CQC and CQA activities performed by GeoSyntec will be collectively referred to as CQA activities in this report. The CQA activities performed by GeoSyntec included monitoring of: (i) soils construction; (ii) geosynthetics installation; (iii) leachate collection and leak detection systems construction; and (iv) leachate conveyance system construction. The CQA activities were performed to confirm that the construction materials and procedures which were monitored were in compliance with the certified-for-construction drawings, technical specifications, CQA Plan and approved changes.

This report was prepared for Fluor Daniel Fernald (FDF) by Mr. Kenneth Cargill, P.E., Mr. David Phillips, P.E., and Mr. Michael Monteleone, P.E. and it was reviewed by Dr. John Beech, P.E., all of GeoSyntec. The CQA services described in this report were provided in accordance with the terms of Fluor Daniel Fernald (FDF) Subcontract 95PS005028, awarded to GeoSyntec on 11 August 1995.

1.3 Report Organization

This final report is organized as described below.

- A description of the project is provided in Section 2.
- A description of the CQA program, including a summary description of specific tasks performed under the program, and a listing of project personnel, are presented in Section 3.
- A description of the CQA monitoring and testing activities performed during the earthwork portion of the project is provided in Section 4.
- A description of the CQA monitoring and testing activities performed during the geosynthetics installation is provided in Section 5.
- A description of the CQA monitoring and testing activities performed during construction of the leachate conveyance system is provided in Section 6.
- A summary of the observations resulting from the CQA monitoring and testing activities performed by GeoSyntec; and a certification statement verifying that the projects were constructed in accordance with the Technical Specifications and Construction Drawings are presented in Section 7.

Documentation and record drawings presenting the results of the CQA monitoring and testing activities performed by GeoSyntec are contained in the appendices to this report. Weekly reports prepared by the CQA Site Manager and Resident Engineer are also included in the appendices. Daily reports prepared by the CQA monitors are not included in appendices; however, these daily reports can be made available on request.

2. PROJECT DESCRIPTION

The OSDF is a low-level radioactive waste disposal facility dedicated to the FEMP that will, upon completion, cover approximately 90 acres (36 hectares) of landfill footprint. The landfill is owned by DOE and is being constructed, filled, and operated by FDF as part of FEMP remediation activities. The landfill is being developed in several phases. Phase I was the first phase constructed and is the primary subject of this report. This report also covers the leachate conveyance system.

The landfill design incorporates a double-composite liner system and other engineering controls that meet the applicable or relevant and appropriate requirements (ARARs), DOE functional requirements, and general design criteria as described in the Design Criteria Package (DCP) developed and approved for the project during the design phase. The double-composite liner system forming the base of the landfill area consists of the following components, from top to bottom:

- 7 oz/ yd^2 (240 g/m^2) needlepunched nonwoven geotextile filter;
- 1.0-ft (0.3-m) thick granular leachate collection system (LCS) drainage layer;
- 10 oz/yd^2 (340 g/m^2) needlepunched nonwoven geotextile cushion;
- 80-mil (2.0 mm) thick high density polyethylene (HDPE) geomembrane (textured) component of a composite primary liner, hereafter referred to as geomembrane primary liner;
- a geosynthetic clay liner (GCL);
- 1.0-ft (0.3-m) thick granular leak detection system (LDS) drainage layer;
- 10 oz/yd^2 (340 g/m^2) needlepunched nonwoven geotextile cushion;
- 80-mil (2.0 mm) thick HDPE geomembrane (textured) component of a composite secondary liner, hereafter referred to as geomembrane secondary liner;
- a geosynthetic clay liner (GCL);

- 36 in. (.9-m) thick low-permeability compacted clay liner; and
- varying thickness of prepared subgrade or compacted fill hereafter referred to as subgrade.

The Cell 1 foot print, which is the landfill area primarily addressed in this CQA report, has a rectangular configuration and is located at the northern end of the OSDF. The Cell 1 floor is approximately 400 ft (122 m) long and 700 ft (213-m) wide and is bounded by an intercell berm on the south. Phase I construction also includes a temporary end to the liner system in the Cell 2 footprint.

The leachate conveyance system is a linear system of manholes and HDPE piping, a permanent lift station, and a force main designed and constructed to convey leachate from each of the OSDF cells to the advanced waste water treatment facility. The portion of the leachate conveyance system covered by this report includes permanent manholes for Cells 1 through 3 and a permanent lift station.

The Certified-For-Construction Drawings and Technical Specifications (dated October 1996) for the landfill and leachate conveyance system were prepared by GeoSyntec in accordance with the terms of FDF Subcontract 95PS005028, GeoSyntec Project Number GE3900. The prime contractor for construction of the Leachate Conveyance System project was Village Building Services, Inc., with assistance from Wise Construction Company, both of Cincinnati, Ohio. The prime contractor for construction of OSDF Phase I project was Petro Environmental Technologies, Inc. (PETRO) of Cincinnati, Ohio. Installation of the geosynthetic components of the double-liner system was performed by Ground Safe Incorporated (GSI) and Environmental Design and Construction Incorporated (EDCI) as subcontractors to PETRO. The surveyor retained by FDF for the Leachate Conveyance System project was B. L. Payne. The surveyor retained by PETRO for the OSDF Phase I project was Hirsch and Associates. As required by the specifications, Hirsch and Associates surveyed the required layers of the liner system (i.e., subgrade, top of compacted clay, layout of secondary and primary geomembrane liners, top of drainage layers, the invert of primary and secondary collection pipes, and the top of the protective layer) and furnished data for the record drawings. CQA monitoring, testing, and documentation was provided by GeoSyntec. A list of primary personnel involved in construction is included in Section 3.2 of this report.

Primary construction activities monitored by GeoSyntec's CQA personnel for the OSDF Phase I project included the following:

- rough grading of the cell floor (i.e., cut and fill operations);
- final preparation of the subgrade in excavation areas;
- placement of compacted fill material in fill areas;
- construction of the perimeter and intercell berms;
- construction of the compacted clay liner;
- installation of the GCL;
- installation of the geomembrane secondary liner and primary liner;
- installation of geotextile cushion and separator;
- installation of the LDS;
- installation of the LCS; and
- placement of protective layer.

Construction activities monitored by GeoSyntec's CQA personnel for the Leachate Conveyance System project included the following:

- trenching and excavation for the leachate conveyance system, including piping, manholes, and permanent lift station;
- placement and compaction of embedment fill for pipes and manholes;
- installation and welding of HDPE piping systems, manholes, permanent lift station;
- hydrostatic and/or pneumatic testing of the leachate conveyance system, including HDPE piping, manholes and permanent lift station;

- placement and compaction of granular material over and around piping systems, manholes, and permanent lift station; and
- backfilling and grading of the construction area.

The approval process for construction materials used during the OSDF Phase I and Leachate Conveyance System projects required the contractor to submit manufacturer's data, quality control certifications, and shop drawings to the Construction Manager for review and approval. The Construction Manager and Resident Engineer reviewed, commented (as needed), and approved construction materials for use during construction for each of the projects. The submittal details and approvals are summarized in the Resident Engineer's weekly reports presented in Appendix C.

A storm water management system, an access corridor, an impacted material haul road, a decontamination facility, and a sedimentation basin were included as a part of the OSDF Phase I project. The access corridor and decontamination facility are scheduled for completion in the Spring of 1998. These, and other items to be completed, are listed in Section 3.1.3 of this report. Construction activities related to the construction of these facilities were monitored by GeoSyntec's on-site personnel. The documentation of these activities are included in the field reports presented in Appendix C.

Earthwork construction associated with the Leachate Conveyance System project began on 28 April 1997 and earthwork construction associated with OSDF Phase I project began on 27 May 1997. GSI began installation of the secondary geomembrane liner on 21 October 1997 and continued work through 19 November 1997. EDCI began completion of the secondary geomembrane liner on 12 November 1997 and completed installation of the primary geomembrane liner on 18 December 1997. The construction of the OSDF Phase I project and the Leachate Conveyance System project was substantially completed 22 December 1997 prior to beginning of placement of the protective layer on 23 December 1997. Protective layer placement was completed on 31 December 1997.

3. CONSTRUCTION QUALITY ASSURANCE PROGRAM

3.1 Scope of Services

3.1.1 Overview

The scope of CQA services performed by GeoSyntec during the OSDF Phase I project construction and the Leachate Conveyance System project construction included:

- review of documents;
- monitoring, testing, and documentation of field operations; and
- preparation of final report and record drawings.

These services are described in the following subsections of this report.

3.1.2 Review of Documents

As previously noted, this final report summarizes the CQA activities performed by GeoSyntec during construction of the OSDF Phase I and Leachate Conveyance System projects. The CQA activities conducted by GeoSyntec were intended to satisfy the requirements of the following documents:

- "Technical Specification, OSDF Phase I," Revision 0, October 1996;
- "Technical Specifications, Leachate Conveyance System, OSDF," Revision 0, October 1996;
- "Construction Quality Assurance Plan, OSDF," Revision 0, May 1997;
- "OSDF Phase I," Construction Drawings, Revision 0, October 1996;
- "Leachate Conveyance System," Construction Drawings, Revision 0, August 1996; and

- "Impacted Material Placement Plan," Revision I, October 1997.

During construction, design change notices (DCNs) were prepared which modified these documents. Documents containing the details of these DCNs are referenced in the appropriate sections of this report, and are included in Appendix T. Also included in Appendices S and U are requests for clarification of information (RCIs) and nonconformance reports (NCRs).

The above documents (including the DCNs and RCIs) will be collectively referred to as the project documents in this final report. Prior to the commencement of on-site CQA activities, the project documents were reviewed by GeoSyntec Field Services personnel for familiarity.

3.1.3 CQA Field Operations

The following activities were performed as part of GeoSyntec's on-site CQA services:

Earthwork:

- collecting conformance test samples of soils considered for use as compacted fill, compacted clay liner, and granular components of the leachate conveyance system and/or Phase I liner system for testing in either the on-site or off-site geotechnical laboratories;
- performing geotechnical conformance testing in field soils laboratory;
- reviewing and evaluating geotechnical laboratory conformance test results to ensure compliance with the requirements of the project documents;
- monitoring proofrolling and subgrade preparation;
- monitoring trenching operations for installation of the leachate conveyance system;

- monitoring placement and compaction of pipe and manhole embedment fill and backfill;
- monitoring of grading operations (i.e., cutting and filling) on the cell floor;
- monitoring final preparation on the cell floor subgrade;
- monitoring perimeter berm construction;
- testing of the in-place moisture/density of the compacted fill and compacted clay liner;
- monitoring placement of the leachate collection and leak detection systems;
- verifying (by means of reviewing the surveyor's data, or observing the surveyor's survey stakes) that the elevations and the thicknesses of the soil layers are consistent with the project documents;
- monitoring placement of backfill in the perimeter anchor trench;
- monitoring protective layer placement; and
- monitoring placement of compacted clay layers above anchor trench.

Geosynthetics:

- tracking the inventory of geosynthetic materials (i.e., HDPE pipes, manholes, liner penetration boxes, GCL, geomembrane, and geotextile rolls) delivered to site;
- monitoring geosynthetic materials delivered to site to observe whether the materials had been damaged during transportation or handling, and if so, marking damage for replacement or repair;
- collecting and reviewing geosynthetic manufacturers' certification documents to verify compliance with the requirements of the project documents;

- collecting geosynthetic conformance samples and forwarding samples to the off-site geosynthetics testing laboratory;
- reviewing and evaluating geosynthetic laboratory conformance test results to verify compliance with the requirements of the project documents;
- monitoring trial welds and production welding of HDPE pipes;
- monitoring deployment and installation of geosynthetic materials and marking damage for replacement or repair;
- monitoring overlapping of adjacent GCL panels during installation;
- monitoring geomembrane trial seaming operations and field testing;
- monitoring geomembrane production seaming operations;
- monitoring nondestructive testing of the geomembrane seams;
- selecting geomembrane destructive seam sample locations, monitoring sample collection and field testing using a calibrated tensiometer, distributing destructive samples to the geosynthetics laboratory, and reviewing laboratory test results to ensure compliance with the requirements of the project documents;
- monitoring the joining of adjacent geotextile panels;
- monitoring repairs to portions of the geosynthetics that were observed to have defects, or that failed destructive or nondestructive testing; and
- monitoring the placement of the geosynthetics and the backfilling and compacting of compacted clay material in the anchor trench.

Leachate Collection and Leak Detection Systems (LCS and LDS):

- monitoring installation and field air pressure testing of liner penetration boxes;
- monitoring installation of leachate sideslope penetrations;

- testing of the in-place moisture/density of compacted pipe embedment material, forcemain backfill, and compacted fill for the conveyance pipe;
- reviewing source qualification test results on samples of aggregate used in the LCS and LDS layer systems;
- monitoring deployment of the geotextile cushions;
- monitoring placement of the LCS and LDS layer aggregate;
- monitoring installation of the LCS collection pipe, LCS redundant pipe, LDS collection pipe, and LCS and LDS drainage corridor aggregate;
- monitoring installation of manholes, pipes, permanent lift station and cleanouts;
- monitoring of the placement of concrete, the quality control sampling of concrete specimens, and shipment of concrete specimens to an off-site laboratory for testing; and
- visual monitoring of hydrostatic and pneumatic pressure testing of the LCS piping, LDS piping, and the leachate conveyance system piping, manholes, and permanent lift station.

During construction activities involving monitoring and/or testing, the observations made, and test results obtained, by GeoSyntec CQA personnel were compared to the project documents. FDF and/or the appropriate contractor were notified of deficiencies in construction practices and/or materials so the contractor could take the appropriate corrective actions. The corrective actions were monitored and/or tested by CQA personnel to ensure compliance with the project documents.

Upon substantial completion of construction and testing of the OSDF Phase I and the Leachate Conveyance System projects, an interim construction certification letter was prepared and submitted to FDF. A copy of the letter is included in Appendix B. This final certification report includes all construction required by the project documents except those items listed below. These items will be completed as weather permits. Monitoring and testing documentation for these items will be included in

either an addendum to this report or in the initial final certification report for OSDF Phase II construction. Items not complete at the time of this report include:

- decontamination facility;
- access corridor;
- final cell access ramp;
- compacted clay layer and sacrificial layer over anchor trench;
- pressure testing of LCS and LDS stub-outs at manholes for Cells 2 and 3;
- miscellaneous punch-list items; and
- final grading and grassing.

3.1.4 Final Report and Record Drawings

Record drawings and this final CQA report were prepared as the final task of the CQA program. This final report summarizes the CQA monitoring, testing, and documentation activities performed by GeoSyntec.

During construction, documentation of on-site CQA activities was maintained by CQA personnel. Daily documentation consisted of daily field reports and testing and monitoring logs. These documents were used to prepare weekly field summaries. CQA personnel also documented the results of on-site geotechnical laboratory testing and reviewed results of off-site geotechnical laboratory testing conducted as part of the CQA program. In addition, manufacturer quality control (QC) certificates and quality control test results for the geosynthetic materials were provided to GeoSyntec for review; these documents are included in Appendix H of this final report. Surveyor's data were provided to GeoSyntec for review and production of record drawings. The recording drawings are included in Appendix P of this final report. Geosynthetics CQA conformance test results are also presented in Appendix I to this final report. Descriptions of the construction activities and the CQA documentation are presented in the narrative sections of this report.

Volume I of this CQA report contains the narrative sections of the report and Appendices A and B. Volume II of this report contains Appendices C through D; Volume III contains Appendices D (continued) through F; Volume IV contains Appendices F (continued) through G; Volume V contains Appendices G (continued)

through H; Volume VI contains Appendices H (continued) through I; Volume VII contains Appendices I (continued) through J; Volume VIII contains Appendices K through Q; Volume IX contains Appendices Q (continued) through T; and Volume X contains Appendices T (continued) through U. A summary of the documentation included in the appendices to the final report is provided below:

- Appendix A: Photographic Documentation
- Appendix B: Interim Construction Certification Letter
- Appendix C: Field Reports
- Appendix D: Minutes of Meetings
- Appendix E: Personnel Logs
- Appendix F: Phase I - Geotechnical Laboratory Test Results
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  - Secondary
  - Primary

- Appendix O: Geomembrane Repair Summary Logs
  - Secondary
  - Primary

- Appendix P: Geomembrane Seam and Panel Repair Location Logs
  - Secondary
  - Primary

- Appendix Q: Leachate Conveyance System Test Logs
  - Compacted Fill
    - Geotechnical Laboratory Test Results
    - Field Moisture/Density Test Results
  - Embedment Fill
  - Aggregate Base
  - Concrete Test Results
  - Hydrostatic Pressure Test Results

- Appendix R: Record Drawings
  - Subgrade
  - Top of Compacted Clay Liner
  - Top of Leak Detection Layer
  - Top of Leachate Collection Layer
  - Top of Protective Layer

Geomembrane Panel Layout
Secondary
Primary

- Appendix S: Requests for Clarification of Information (RCI)
  Leachate Conveyance System
  OSDF Phase I

- Appendix T: Design Change Notices (DCN)
  Leachate Conveyance System
  OSDF Phase I

- Appendix U: Nonconformance Reports (NCR)
  Leachate Conveyance System
  OSDF Phase I

3.2 Personnel

3.2.1 Project Personnel

Senior personnel or representatives for the firms involved in the project are as follows:

Fluor Daniel Fernald (Owner's Representative)

- John J. Berretz, Engineer/Geologist
- Charles D. Brown, Safety & Health
- Robert D. Crowley, Radiological Field Support
- Jeffrey R. Ellis, Engineering
- Maureen M. Richard, Engineering
- Donald A. Fleming, Industrial Hygiene
- Michael W. Godber, QA/QC Team Leader
- Donald B. Goetz, Construction Engineer, OSDF
- Kevin Harbin, Construction
- Richard E. Heath, Engineering
- Michael J. Hickey, Project Coach
- Richard A. Holbrook, Acquisition and Finance Team Leader

- James C. Jenkins, Engineering
- Gregg K. Johnson, Safety & Health Team Leader
- Uday A. Kumthekar, Engineering Team Coach
- Richard L. McGuire, Construction Team Leader - LCS
- Christine M. Messerly, Environmental Compliance
- Jeffrey A. Middaugh, Safety & Health
- Gregory R. Peters, Construction Coordinator - Haul/NE Roads
- P. Gary Pope, Construction Coordinator - LCS
- Daniel H. Stempfley, Radiological Engineering
- Robert M. Turnbull, Construction Coordinator - OSDF
- James T. Turner, Quality Assurance
- Muriel K. Vigus, Quality Assurance
- Louis R. Wehlitz, Construction Team Leader - OSDF
- William A. Zebick, Construction Team Coach

GeoSyntec Consultants (CQA Consultant)

- R. Bonaparte, Ph.D., P.E., Program Manager
- R. Bachus, Ph.D., Technical Evaluation Team Leader
- J. Beech, Ph.D., P.E., Principal-in-Charge
- Tom Sargent, Sr., P.E., DEE, Program Administrator
- K. Cargill, P.E., Construction Team Leader and CQA Managing Engineer
- D. Phillips, P.E., Project Administrator and Construction Coordinator
- D. Bodine, P.E., Resident Engineer
- J. McMichen, Site Manager

GeoSyntec's Geomechanical and Environmental Laboratory (GEL)(off-site geotechnical laboratory)

- N. Rad, Ph.D., P.E., Laboratory Manager
- B. Sigmon, Program Manager/Quality Control Manager
- J. Stalcup, Operations Manager

GeoSyntec's Soil-Geosynthetic Interaction Testing Laboratory (SGI)(off-site soil-geosynthetic interaction testing)

- R. Swan, Jr., Laboratory Manager
- Z. Yuan, Jr., Quality Control Manager

GeoSyntec's Materials Testing Laboratory (MTL)(off-site geosynthetics testing laboratory)

- D. Schauer, Laboratory Manager
- B. Tindell, Program Manager
- D. Carlson, Quality Control Manager

B. L. Payne (Surveyor, Leachate Conveyance System)

- B. L. Payne, Survey Chief

Hirsch and Associates (Surveyor, OSDF Phase I)

- Lynn Hirsch, Survey Chief

Petro Environmental Technologies, Inc. (Contractor, senior personnel only)

- Mark Mather, President
- Bob Elkin, Field QC
- Pete Bolig, Safety & Health Officer
- Steve Brandstetter, Project Manager
- Jeff Browning, Labor Steward
- Jill Hibbard, Project Administrator
- Lee Oliver, Labor Foreman
- Rick Schairbaum, QC Manager
- John Stacey, Field Superintendent
- Dave Williams, General Superintendent

Village Building Services, Inc. (Contractor, senior personnel only)

- Marvin Brooks, Superintendent
- Mary Jo Cleveland, Project Manager
- Mayur Kadakia, Chief Estimator
- Howard Milliron, Quality/Field Engineer

- Steve Porter, Safety Representative
- Oscar Willingham, President
- Yahava Willingham, Construction Engineer

Ground Safe, Inc. (Geosynthetic Installer)

- Kevin Allen, Superintendent
- John Allen, Master Seamer

Environmental Design and Construction, Inc. (Geosynthetic Installer)

- Mike Harris, Superintendent
- Jerry Istere, Master Seamer
- Daryl Brinkman, Master Seamer

3.2.2 GeoSyntec's On-Site Personnel Schedules

GeoSyntec project personnel were present on site according to the following schedules:

• J. P. Giroud, Ph.D., P.E., Management Assessment Group (member)	7 November 1997
• Rudy Bonaparte, Ph.D., Program Manager	Periodically, As Required
• J. Beech, Ph.D., P.E., Principal-in-Charge	Periodically, As Required
• K. Cargill, P.E., CQA Managing Engineer	Periodically, As Required
• Dennis Vander Linde, P.E.	Periodically, As Required
• Marcia Ruland, Health & Safety Coordinator	Periodically, As Required
• Sherry Hall, Corporate Health & Safety	Periodically, As Required
• Dan Bodine, P.E., Resident Engineer	18 February 1997 - December 1997
• Jeph McMichen, Site Manager	3 March 1997 - December 1997
• H. E. Meekins, Senior Engineering Technician	19 March 1997 - December 1997
• Brian Erisman, Engineering Technician	15 April 1997 - December 1997
• Randy Livingston, Engineering Technician	18 June 1997 - 2 October 1997
• Kirk Wills, Engineering Technician	21 June 1997 - 30 October 1997
• Pete Prommer, Engineering Technician	17 September 1997 - 24 October 1997
• Rob Peddicord, Engineering Technician	29 May 1997 - December 1997
• Paul Odurah, Engineering Technician	1 June 1997 - 1 August 1997

• Scott Quammon, Engineering Technician	23 June 1997 - December 1997
• Jeff Williams, Engineering Technician	13 June 1997 - 29 August 1997
• Bill Nagel, Engineering Technician	8 August 1997 - December 1997
• Brian Nichols, Engineering Technician	1 September 1997 - 28 September 1997
• Alan Zargaran, Engineering Technician	2 October 1997 - 29 October 1997
• Jennifer Lepkowski, Engineering Technician	14 September 1997 - 29 October 1997; 29 November 1997 - 19 December 1997

4. CONSTRUCTION QUALITY ASSURANCE - PHASE I EARTHWORK

4.1 General

GeoSyntec monitored the construction of the earthwork components associated with the OSDF Phase I project. The OSDF Phase I project consisted of Cell 1, stormwater management facilities, impacted material haul road adjacent to the OSDF, access corridor, decontamination facility, and the sedimentation basin. Different earthwork materials were used to construct the various components of the Phase I project. These materials included existing subgrade material, compacted fill, compacted clay liner, granular drainage material for the LDS and LCS layers, embedment fill, and aggregate base material. The earthwork construction activities using these materials are generally described below.

- The cell was initially rough graded. The surface was proofrolled by using a loaded tandem dump truck, loaded articulated dump truck or a loaded pan and visually monitored by CQA personnel. Soft or loose materials were either dried and compacted or undercut and replaced with fill material which was compacted as described below.

- The cell floor was graded to achieve the required subgrade elevations. The subgrade in areas of the cell floor that required filling were proofrolled prior to fill placement to detect excessively soft or loose zones. Soft or loose zones were excavated prior to placement of fill. The fill material consisted of compacted fill which was obtained from cut areas in the cell or other on-site borrow sources within the Phase I construction area. The compacted fill was placed in approximately 7 in. to 9 in. (180 mm to 230 mm) thick (maximum) loose lifts and compacted to a minimum relative density of 95 percent of the maximum dry unit weight, as determined by the standard Proctor compaction test (i.e., American Society for Testing and Materials (ASTM) D 698). The fill was compacted at a moisture content between 3 percent dry and 3 percent wet of the optimum moisture content measured in the standard Proctor compaction test.

- The perimeter berms were also constructed using compacted fill. The fill was placed in approximately 8 in. (200 mm) thick (maximum) loose lifts and compacted as described above.

- The 36 in. (0.9-m) thick compacted clay liner was constructed using a 8 in. (200 mm) thick (maximum) loose lifts; with exception of the first lift which was placed as a 12 in. (0.3-m) loose lift. This initial 12-inch loose lift resulted in a compacted lift of about six inches (measured to the bottom of the pad foot indentation) and about three inches of material between compactor foot indentations (material which was included in the second lift). The compacted clay material was obtained from the area contained within the Cell 1 and future Cell 2 footprints. Each lift was compacted to a minimum relative compaction of 95 percent of the maximum dry unit weight, as determined by the standard Proctor compaction test (i.e., ASTM D 698). The compacted clay liner was compacted at a moisture content between zero and 3 percent wet of the optimum moisture content measured in the standard Proctor compaction test. The field moisture content and dry unit weight were also required to fall within the acceptable permeability zone (APZ) as established by the test pad program and defined in the Technical Specifications. These three criteria were used to assure a hydraulic conductivity of less than 1×10^{-7} cm/s. Clay materials used in the compacted clay liner were approved through conformance testing which included hydraulic conductivity testing of remolded compacted clay samples in the off-site geotechnical laboratory.

- The granular components of the liner system, which included a 12 in. (0.3-m) thick LDS layer and a 12 in. (0.3-m) thick LCS layer were constructed using material obtained from off-site borrow sources. Each material was placed in one loose lift.

CQA personnel observed these earthwork construction activities and tested the soil materials to confirm that the material properties conformed to the project documents, that the specific lift thicknesses were not exceeded, and that the materials were compacted in accordance with the project documents. Geotechnical soil tests were performed and documented by CQA personnel. The testing was carried out either: (i)

in-place; (ii) on-site, in the geotechnical laboratory; or (iii) off-site, at GeoSyntec's GEL in Alpharetta, Georgia.

4.2 Changes in Earthwork Specifications

Requests for clarification of information (RCI) and design change notices (DCN) of the earthwork drawings and specifications were processed and approved according to procedures described in FEMP document number ED-12-5002 entitled "Engineering Design Change Process." RCIs and DCNs were approved, as appropriate by the design organization. Copies of the RCIs and DCNs for Phase I are presented in Appendices S and T, respectively.

Approved RCIs and DCNs have been transmitted to the designer for consideration in Phase II construction drawings and specifications.

4.3 Conformance Activities

Soil samples were obtained from proposed sources, generally prior to construction, to verify conformance with the project specifications for each material type. Also during construction, soil samples were obtained from the delivered material as required by the project documents. CQA personnel obtained representative samples of compacted fill, compacted clay liner material, and granular drainage materials to be used in the LDS and LCS drainage layers from the appropriate source depending on the material type.

Compacted fill material used in the OSDF Phase I construction was obtained from on-site borrow areas within active construction areas. Compacted clay liner material was obtained from on-site borrow areas within the Cell 1 and Cell 2 footprint. The granular drainage material was obtained from an off-site source. The LCS and LDS drainage layer (No. 78 stone) was obtained from a site known as Highland Stone in Hillsboro, OH. The LCS and LDS drainage corridor material (No. 57 stone) was obtained from Martin Marietta, in Fairfield, OH.

In accordance with the project documents, a series of geotechnical tests were performed on the soil samples to confirm that the following requirements were met.

- Compacted fill material used in construction classified as GC, SC, SM, ML or CL according to the Unified Soil Classification Systems (USCS) when evaluated in accordance with ASTM D 2487 and the maximum particle size was 5.0 in. (130 mm).

- Compacted clay liner material used in construction classified as CL or CH according to the USCS when evaluated in accordance with ASTM D 2487; a maximum particle size of 2.0 in. (50 mm); a plasticity index (PI) between 10 and 40 when tested in accordance with ASTM D 4318; and hydraulic conductivity (i.e., permeability) of 1.0×10^{-7} cm/s or less, when evaluated in accordance with ASTM D 5084.

- The granular drainage material used in construction of the LCS and LDS layers classified as GP according to the USCS when evaluated in accordance with ASTM D 2487; had 100 percent passing a 0.75 in. (19 mm) opening sieve when tested in accordance with ASTM C-136; met gradation requirements for No. 78 stone; the carbonate content was less than or equal to 5 percent in accordance with ASTM D 3042 at a pH of 4; the hydraulic conductivity (i.e., permeability) requirement was 1.0×10^{-1} cm/s or greater when evaluated in accordance with ASTM D 2434.

- The granular drainage material used in construction of the LCS and LDS corridors classified as GW or GP according to the USCS when evaluated in accordance with ASTM D 2487; had 100 percent passing a 1.5 in. (38 mm) opening sieve when tested in accordance with ASTM C-136; met gradation requirements for No. 57 stone; the carbonate content was less than or equal to 5 percent in accordance with ASTM D 3042 at a pH of 4; the hydraulic conductivity (i.e., permeability) requirement was 10.0 cm/s or greater when The perimeter berm anchor trench backfill had the same requirements as the compacted clay liner material.

A description of the geotechnical tests and results are described in Section 4.5 of this report. Construction of the perimeter berm anchor trench is described in Section 4.6.2 of this report.

4.4 Field Monitoring Activities

4.4.1 General

GeoSyntec's CQA personnel monitored the placement of soil as previously described. At times, several earthwork construction operations were conducted simultaneously for the Phase I project. When this occurred, the on-site personnel monitored those operations considered most critical to the performance of the liner system. Potentially nonconforming or questionable practices observed by CQA personnel were brought to the attention of the Construction Manager for review and correction.

4.4.2 Excavation

CQA personnel monitored excavation operations within Phase I work areas. Topsoil, organic matter (i.e., stumps, roots, or vegetation), and any other deleterious material unsuitable for foundation material was excavated prior to construction of the liner system and stockpiled on-site.

4.4.3 Compacted Fill

CQA personnel monitored the placement of the compacted fill for the cell floor, perimeter berms, and other areas requiring fill material. Areas receiving fill and areas which were cut to subgrade elevations were proofrolled by the contractor to detect soft or loose zones. Proofrolling was performed using a loaded tandem dump truck, loaded articulated dump truck or a loaded pan making passes in two perpendicular directions. In large areas where soft or loose materials were detected, the areas were undercut and compacted fill was placed. In cut areas and during proofrolling, the surface was monitored by CQA personnel to confirm that potential deleterious materials were removed. In areas where the fill was extended from previous construction, the previously compacted fill was cut back, in order to establish a key-in, prior to the construction of the extension.

The compacted fill material was placed in controlled lifts (as described previously) using articulated dump trucks and scraper pans and using a Caterpillar D-6R bulldozer to spread the material. The horizontal lifts were then compacted using a Caterpillar 815 sheepfoot compactor. When there was inclement weather which impacted the exposed lift of compacted fill, prior to further placement of subsequent lifts, the surface of the top lift was scarified using the tracks of a bulldozer.

4.4.4 Compacted Clay Liner

After completing the compacted fill grading operations, CQA personnel observed the placement of the compacted clay liner material. Construction of the compacted clay liner was in accordance with the project documents and patterned after the Test Pad Program. Two compacted clay liner test pads were constructed prior to the construction of the compacted clay liner. The results of the test pad program were used to develop the specifications for compacted clay liner materials and construction. The test pad program is described in a report entitled "Test Pad Program Final Report, Revision 0, dated June 1997."

The construction sequence of the compacted clay liner is described below:

- after stripping the topsoil at the source, the clay was processed on-site using a bar screening plant and stockpiled in preparation for transportation to the cell construction site;
- a water bar attachment on the screening plant added water to the material in an effort to increase the moisture content, as needed;
- the cell floor surface and the top surface of each lift of compacted clay was scarified using a soil stabilizer; the sideslopes of the cell and top surface of each lift of compacted clay on the sideslopes was scarified with the tracks of a Caterpillar D-6R bulldozer;
- the compacted clay material was hauled from the stockpile by articulated dumps or pan scrapers and placed in the cell;

- the compacted clay was spread in approximately 7 in. to 9 in. (180 mm to 230 mm) thick (loose) lifts using a D-6R bulldozer;
- after spreading, a soil stabilizer (RACO 250) was used to break up clods of compacted clay; if necessary, water was added to increase the compacted clay's moisture content as required;
- each lift of compacted clay was compacted using a Caterpillar 815 sheepsfoot compactor making a minimum of six passes;
- lift thickness was controlled for the first lift by grade stakes placed by the contractor at an approximate spacing of 50 ft (15 m); CQA personnel visually monitored the placement and compaction of the compacted clay relative to these stakes to provide a check of lift thickness; the stakes were removed immediately before the material adjacent to the stakes was compacted; subsequent lifts were visually monitored by the contractor using traffic cones for grade control;
- a D-6R bulldozer was used to grade the compacted clay material;
- the final grade was rolled with a vibratory smooth drum roller to seal the top surface of the compacted clay; and
- after final grading of the compacted clay surface, the surveyor confirmed final grade elevations;

The contractor periodically added water during or after compacted clay placement to limit drying or desiccation cracking of the compacted clay surface. Prior to deployment of the GCL, the compacted clay liner was visually observed by the installer and CQA personnel for surface cracks. If drying or cracking of the compacted clay surface was observed, the contractor was instructed to moisture condition and rework the affected area.

4.4.5 Leak Detection System Layer

CQA personnel monitored the placement of the LDS layer for the Phase I area. The 12 in. (0.3-m) thick LDS layer was constructed using granular drainage material obtained from Highland Stone. The method of placement and the CQA procedures during construction of the LDS layer were similar to the methods and procedures used during construction of the LCS layer, discussed below.

It is noted that the same material was used in the LDS drainage layer as the LCS layer, which is discussed below. In addition, a leachate collection pipe was installed in the LDS layer. The pipe was surrounded by LDS drainage corridor aggregate.

4.4.6 Leachate Collection System Layer

CQA personnel monitored the placement of the LCS drainage layer and corridor material for the Phase I area. The 12 in. (0.3-m) thick LCS layer was constructed using granular drainage material obtained from Highland Stone. The granular drainage material was stockpiled in an area south of the construction area. The LCS drainage corridor material was constructed using granular drainage material obtained from Martin Marietta. The granular drainage material was stockpiled in an area south of the construction area.

The construction sequence of the LCS layer was as follows:

- Caterpillar D25 or Volvo articulated dump trucks hauled the granular drainage material from the stockpile to the cell area using a haul road constructed of LCS material to a minimum 3-foot thickness;
- the granular drainage material was spread in approximately one 12 in. (250 mm) thick (loose) lift using a Caterpillar D-6R LGP wide-track bulldozer; and
- a contractor's laborer was utilized during the fill-spreading operation to control and prevent wrinkle formation in the underlying geosynthetics.

During placement of the LCS layer, CQA personnel monitored the contractor's activities to assure that geomembrane wrinkling and the risk of damage to the underlying geomembrane was minimized. CQA personnel also confirmed that the contractor operated bulldozers in areas where at least a 1-ft (0.3-m) thick layer of granular drainage material was maintained over the geomembrane, and that a 3-ft (0.9-m) thick layer of granular drainage material was maintained over the geomembrane in heavily trafficked areas.

In addition, a leachate collection pipe was installed in the LCS layer. The pipe was surrounded by LCS drainage corridor aggregate.

4.4.7 Protective Layer

CQA personnel monitored the placement operations for the protective layer. The protective layer was constructed using impacted material obtained from the East Impacted Material Stockpile. The protective layer was placed in a 12 to 15 in (300 to 380 mm) thick loose lift and was tracked with a medium sized bulldozer.

4.4.8 Miscellaneous Facilities

CQA personnel performed monitoring and testing activities for construction of stormwater management ditches, an impacted material haul road adjacent to the OSDF, and a sedimentation basin, as a part of the OSDF Phase I construction. An access corridor and a decontamination facility will be constructed, weather permitting, in the early months of 1998. These construction activities will be monitored and tested by CQA personnel.

4.4.9 Special Conditions

During construction of the OSDF compacted clay liner, the contractor encountered large quantities of oversized rock particles (i.e., greater than 2-inch (50 mm) in the largest dimension). During the first week of compacted clay liner construction (i.e., 18-24 August 1997), oversized rock particles were removed from the clay liner by hand. Hand removal alone was not adequate to meet contractor's construction demands. A

screening operation using a Finlay 390C Powerscreen was implemented during the second week of placement. Removal activities continued to be supplemented by hand removal after the screening plant was set up. Additional screeners were mobilized to the site (i.e., a total of 3 screeners) to fully implement machine screening. After 2 September 1997 only screened material was used for compacted clay liner construction. Visual removal of oversized particles continued, as a supplement to mechanical screening, throughout construction.

4.5 Field Testing Activities

4.5.1 General

As part of CQA activities, geotechnical testing was performed on each of the soil components of the Cell 1 double-composite liner system. Depending on the specific test, testing was performed in-place or at either the on-site or off-site geotechnical laboratory. The following geotechnical tests were performed.

- In-place nuclear moisture/density tests were performed on compacted lifts of compacted fill and compacted clay liner material. The tests were performed in general accordance with ASTM D 2922 and ASTM D 3017.

- Standard Proctor compaction tests were conducted on the soils used for compacted fill and compacted clay liner material. The tests were performed in general accordance with ASTM D 698.

- Moisture content tests were performed on samples of compacted fill and compacted clay liner material. The tests were performed in general accordance with ASTM D 2216.

- Grain-size distribution tests were conducted on the soils used for compacted fill and compacted clay liner material. The tests were performed in general accordance with ASTM D 422. Atterberg limits tests were conducted on the soils used for compacted clay liner material. The tests were performed in general accordance with ASTM D 4318. Based on the test results, the Unified

Soil Classification System (USCS) was used to classify the material in accordance with ASTM D 2487.

- Carbonate content tests and hydraulic conductivity tests were conducted on the LCS and LDS drainage layers and LCS and LDS corridor material. The tests were performed in general accordance with ASTM D 3042 and ASTM D 2434, respectively.

- Hydraulic conductivity tests were performed on the compacted clay liner material. The hydraulic conductivity tests on compacted clay liner material were conducted in accordance with ASTM D 5084.

A summary of the results of the geotechnical laboratory tests are presented in Appendix F. The results of the in-place nuclear moisture/density tests are presented in Appendix G. GeoSyntec supplied two nuclear gauges (i.e., Troxler model 3440) for the Phase I construction, which were used to perform the moisture/density tests for Phase I construction. The results of the nuclear moisture/density tests were verified periodically, by comparing the tests with results observed using the sand cone method conducted in accordance with ASTM D 155 and with oven moisture content tests. A moisture correction factor was developed for compacted clay liner material based on oven moisture content tests. The data are presented in Appendix G to support the field density test data.

A grid layout of the site was used to visually locate the in-place tests and sample locations. Since only visual positioning of test locations was used, the locations and elevations of the tests and samples given in the appendices are approximate.

4.5.2 Compacted Fill

Compacted fill was compacted to a minimum relative density of 95 percent of the maximum dry unit weight, as determined by the standard Proctor compaction test. CQA personnel conducted in-place nuclear moisture/density tests at a minimum frequency of 2 tests per acre per lift of soil. A total of 367 field moisture/density tests were performed in the Phase I area. Of these, 35 tests failed to meet the minimum relative compaction requirement. In each case of a failing test, the contractor reworked

and recompacted the area surrounding the failure and then the area was retested by CQA personnel. This procedure was repeated until satisfactory moisture/density test results were obtained in each location. The results of the field moisture/density tests are presented in Appendix G.

In addition to the in-place testing, 19 representative samples were obtained for laboratory testing during construction. A summary of the testing requirements is presented in Table 4-1. Geotechnical test results are presented in Appendix F.

4.5.3 Compacted Clay Liner

CQA personnel performed in-place nuclear moisture/density tests at a minimum frequency of 5 tests per acre per lift of the compacted clay liner. A total of 969 field moisture/ density tests were performed. A total of 370 tests failed to meet the minimum relative density requirement of 95 percent of the maximum dry unit weight at less than 3 percent over optimum moisture content, as determined by the standard Proctor compaction test and within the acceptable permeability zone (APZ). In all but two cases (Test No. 515 and 625) of a failing test, the contractor reworked and recompacted the area surrounding the failure and then the area was retested by CQA personnel. This procedure was repeated until satisfactory moisture/density test results were obtained in each location. The two points not within the criteria have been since reviewed. One point is a marginal failure (not within the APZ) which falls within 1/2 percent of the 90 percent saturation line. This marginal failure and the second point are considered insignificant to the performance of the compacted clay liner. The results of the field moisture/density tests are presented in Appendix G. A summary of compacted clay liner properties is presented in Table 4-2.

Off-site geotechnical laboratory hydraulic conductivity tests were performed on remolded samples of the compacted clay liner. Samples were obtained during cell construction on a minimum frequency of one per 1,500 cubic yards (1,150m^2) of clay liner material. A total of 4 samples failed to meet the hydraulic conductivity criterion of 1×10^{-7} cm/s or less. As required by the CQA Plan, failing material was rejected and removed or additional samples were taken in the area of the failing samples and retested. Two additional remolded samples were obtained from the immediate vicinity

of each of the failed sample location. All of the retested samples exhibited acceptable hydraulic conductivity results. The laboratory test results are presented in Appendix F.

As part of the CQA activities for the compacted clay liner, CQA personnel periodically checked the clay's moisture content at the stockpile. The adequacy of the lift thickness and the bonding between lifts were checked by hand augering test holes at random locations. These test holes, as well as the holes left at the moisture/density tests, were filled with bentonite powder and compacted clay material. The mixture was manually compacted in the holes using a steel rod.

In addition to the geotechnical testing described above, index tests were performed on the clay material as required by the project documents. Index tests were performed at a minimum frequency of one set per 1,500 cubic yards (1,150 m^2) of stockpiled material. A total of 79 grain-size distribution tests and 73 Atterberg limit tests were performed on the compacted clay liner material to verify that the consistency of the material corresponded to the requirements of the Technical Specification. The tests indicated a variation in the plasticity index between 10 and 40. The tests indicated a minimum clay content of 15 percent. The grain-size distribution tests all resulted in a classification of CL or CH for this material, according to the USCS. The results of these tests are presented in Appendix F.

Following confirmation of the test results and prior to deployment of the GCL and geomembrane liner, the surface of the compacted clay liner was visually observed by the installer and CQA personnel for surface cracks. If drying or cracking of the surface was observed, the contractor was instructed to moisture condition and rework the affected area.

TABLE 4-1

PHASE I COMPACTED FILL MATERIAL PROPERTIES SUMMARY

DESCRIPTION	TEST STANDARD	PROJECT(1) SPECIFICATIONS	TEST FREQUENCY (yd^3)	APPROXIMATE NUMBER OF TESTS REQUIRED(2)	NUMBER OF TEST PERFORMED (FAILURES)
LABORATORY TEST					
Particle Size: Sieve	ASTM D 422	100% Finer than 5 inch (See DCN No. 1702-019)	1 per 1,500	10	19
Compaction	ASTM D 698	---	1 per 1,500/ as required	10	19
Moisture	ASTM D 2216 ASTM D 4643	---	1 per 1,500/ as required	10	18 15
Soil Classification	ASTM D 2487	GC, SC, SM, ML or CL	1 per 1,500	10	19 (1)
Atterberg Limits	ASTM D 4318	---	1 per 1,500	10	19
FIELD TEST					
Sand Cone: Soil density Soil moisture	 ASTM D 1556 ASTM D 2216	 --- ---	1 per 25 passing density tests	15	
Nuclear Gauge: Soil density Soil moisture	 ASTM D 2922 ASTM D 3017	 ▾95% ▾ 3% O.M.C.	2/acre/lift	62	367 (35)

NOTES: (1) Reference Section 02200 of the Specification and Section 6 of the CQA Plan for further details.

(2) The approximate number of tests required is based on a total volume of 50,000 yd^3 for the Phase I construction.

TABLE 4-2

PHASE I COMPACTED CLAY LINER PROPERTIES SUMMARY

DESCRIPTION	TEST STANDARD	PROJECT(1) SPECIFICATIONS	TEST FREQUENCY (yd^3)	APPROXIMATE NUMBER OF TESTS REQUIRED(2)	NUMBER OF TEST PERFORMED (FAILURES)
LABORATORY TEST					
Particle Size:	ASTM D 422		1 per 1,500	63	
Sieve					
Percent Finer than 2.0 in.		100%			79
Percent Finer than .075 in.		▾90%			(5)
Hydrometer					
Percent Finer than #200	ASTM D 1140	▾50%			71
Percent Finer than .002 mm		▾15%			(5)
Compaction	ASTM D 698	---	1 per 1,500/ as required	63	70
Moisture	ASTM D 2216 ASTM D 4643	---	1 per 1,500/ as required	63	241 197
Soil Classification	ASTM D 2487	CL or CH	1 per 1,500	63	69
Atterberg Limits	ASTM D 4318	10 ▾PI ▾ 40	1 per 1,500	63	73 (3)
Hydraulic Conductivity:	ASTM D 5084		1 per 1,500	63	73
Source					(4)
Remold		▾ 1 x 10^{-7} cm/sec			
FIELD TEST					
Sand Cone:		---	1 per 25 passing density tests	10	21
Soil density	ASTM D 1556				
Soil moisture	ASTM D 2216				
Nuclear Gauge:		Within APZ and ▾95% M.C. ▾ + 3% O.M.C.	5/acre/lift	240	980
Soil density	ASTM D 2922				(370)
Soil moisture	ASTM D 3017				
Depth Verification Survey	---	---	---	---	---

NOTES: (1) Reference Section 02225 of the Specification and Section 6 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a stockpile volume of 93,700 yd^3 for the Phase I construction.

4.5.4 Leak Detection System Layer

The 1.0-ft (0.3-m) thick leak detection system (LDS) layer was constructed using granular drainage material. The material was spread on top of the geotextile cushion and geomembrane secondary liner. This layer of the liner system had the same CQA requirements as the LCS layer, discussed below.

GeoSyntec personnel performed on-site laboratory and off-site laboratory geotechnical testing on the granular drainage material used for the LDS layer as part of the CQA activities during the Phase I construction. These tests were identical to those for the LCS layer, as described in the next section.

Grain-size distribution tests were performed on representative samples obtained from the on-site stockpiles. GeoSyntec also performed off-site laboratory permeability tests and carbonate tests on representative samples of the granular drainage material. A summary of the testing requirements for granular drainage material for the drainage layer is presented in Table 4-3. A summary of the testing requirements for granular drainage material for the drainage corridor is presented in Table 4-4. Geotechnical laboratory test results are presented in Appendix F.

4.5.5 Leachate Collection System Layer

The 1.0-ft (0.3-m) thick leachate collection system (LCS) layer on the geomembrane primary liner of the cell was constructed using granular drainage material. The material was spread on top of the geotextile cushion and the geomembrane primary liner as previously described in Section 4.4.6. It is noted that this material was used in both the LCS and LDS layer which was discussed above.

GeoSyntec performed on-site laboratory and off-site laboratory geotechnical testing on the granular drainage material used for the LCS and LDS layers as part of the CQA activities during Phase I construction. On-site and off-site laboratory grain-size distribution tests were performed on 12 samples obtained from the on-site stockpile. The LCS and LDS drainage layer material was classified as a GW or GP, based on the USCS. The laboratory grain-size distribution test results are presented in Appendix F.

GeoSyntec also performed off-site laboratory hydraulic conductivity tests and carbonate tests on representative samples of the granular drainage material. A summary of the testing requirements for granular drainage material for the drainage layer is presented in Table 4-3. A summary of the testing requirements for granular drainage material for the drainage corridor is presented in Table 4-4. Geotechnical laboratory test results are presented in Appendix F.

4.5.6 Protective Layer

The 12 in. (0.3-m) thick protective cover was constructed using impacted material as described in the Impacted Material Placement Plan (IMPP). The material was spread on top of the geotextile filter and LCS granular drainage material.

To protect the underlying liner system from construction damage, the protective layer was not compacted with conventional compaction equipment but was tracked with a medium-sized bulldozer.

CQA personnel monitored transport, placement and tracking of the protective layer to verify conformance with the IMPP and the CQA Plan. CQA personnel signed the manifest to verify placement was in accordance with the IMPP and CQA Plan.

4.6 Soil Anchorage of Geosynthetics

4.6.1 General

GeoSyntec's CQA personnel monitored the placement of material for anchorage for the geosynthetic material around the perimeter of the cell. Compacted clay liner material was used to provide the permanent anchorage of the double-liner system. Details of the anchoring are presented in the two subsections which follow.

TABLE 4-3

PHASE I GRANULAR DRAINAGE MATERIAL (LCS AND LDS DRAINAGE LAYER) NO. 78 STONE

DESCRIPTION	TEST STANDARD	PROJECT(1) SPECIFICATIONS	TEST FREQUENCY (yd^3)	APPROXIMATE NUMBER OF TESTS REQUIRED(2)	NUMBER OF TEST PERFORMED (FAILURES)
LABORATORY TEST					
Particle Size: Sieve	ASTM C 136	3/4 in. 100 1/2 in. 85-100 3/8 in. 40-75 No. 4 5-25 No. 8 0-10 No. 16 0-5 No. 200 0-2 (See DCN No. 1702-015)	1 per 3,000	5	12 (5)
Soil Classification	ASTM D 2487	GP	1 per 3,000	5	12
Carbonate Content	ASTM D 3042	▾ 5%	1 per 5,000	3	5
Hydraulic Conductivity: Granular	ASTM D 2434	▾1 x 10^{-1} cm/sec	1 per 3,000	5	7
FIELD TEST					
Depth Verification: Survey	visual	12 in. thick			

NOTES: (1) Reference Section 02710 of the Specification and Section 6 of the CQA Plan for further details.

(2) The approximate number of tests required is based on a total volume of 15,000 yd^3 for the Phase I construction.

TABLE 4-4

PHASE I GRANULAR DRAINAGE MATERIAL (LCS AND LDS DRAINAGE CORRIDOR) NO. 57 STONE

DESCRIPTION	TEST STANDARD	PROJECT(1) SPECIFICATIONS	TEST FREQUENCY (yd^3)	APPROXIMATE NUMBER OF TESTS REQUIRED(2)	NUMBER OF TEST PERFORMED (FAILURES)
LABORATORY TEST					
Particle Size: Sieve	ASTM C 136	1 1/2 in. 100 1in. 95-100 1/2 in. 25-60 No. 4 0-10 No. 8 0-5 No. 200 0-2	1 per 3,000	2	6 (3)
Soil Classification	ASTM D 2487	GP	1 per 3,000	2	6
Carbonate Content	ASTM D 3042	▾ 5%	1 per 5,000	2	4
Hydraulic Conductivity: Granular	ASTM D 2434	▾10 cm/sec	1 per 3,000	2	3
FIELD TEST					
Depth Verification: Survey	Visual	As shown on drawings	---	---	---

NOTES: (1) Reference Section 02710 of the Specification and Section 6 of the CQA Plan for further details.

(2) The approximate number of tests required is based on a total volume of 100 yd^3 for the Phase I construction.

4.6.2 Perimeter Anchor Trench

As required by the project documents, an anchor trench was constructed around the perimeter of the Cell 1 construction area. The construction sequence of the perimeter anchor trench was as follows:

- a 6-ft wide by 2-ft deep (1.8-m wide by 0.6-m deep) anchor trench was excavated along the Cell 1 perimeter berm, 3 ft (0.9-m) from the crest of the slope;
- the geomembrane secondary liner system (i.e., GCL, geomembrane, and geotextile) was subsequently placed in the anchor trench; lifts of compacted clay material were placed over these material and compacted; and
- the geomembrane primary system (i.e., GCL, geomembrane, and geotextile) was placed in the anchor trench behind the secondary geosynthetics, and lifts of compacted clay material were placed into the anchor trench and compacted.

The general construction procedure for placing and compacting the compacted clay material in the perimeter anchor trench was as follows:

- backfill material was obtained from the processed stockpile and placed in the trench using backhoes;
- backfill material was placed in the anchor trench for the first lift in 10- to 12 in. (250- to300 mm) thick (loose) lifts and in subsequent lifts in approximately 6 in. (150 mm) thick loose lifts; and
- the backfill material was compacted using a walk behind articulated pad roller.

Anchor trench backfill was compacted to the specifications as previously described for compacted clay liner material. Nuclear moisture/density tests were performed on the compacted clay material in the anchor trench. A summary of the results of the compaction tests and the field moisture/density tests are included in Appendix G.

5. CONSTRUCTION QUALITY ASSURANCE - PHASE I GEOSYNTHETICS

5.1 General

GeoSyntec monitored the installation of the geosynthetic components of the double-composite liner system. Principal field activities are described in Section 3.1.3. At times, several liner system installation operations were conducted simultaneously during the Phase I construction. When this occurred, the on-site CQA personnel monitored those operations which were considered most critical to the performance of the liner system. Non-conforming or questionable practices observed by GeoSyntec were brought to the attention of the Construction Manager for review and correction.

The total quantity of geomembrane installed during the Phase I construction, as measured by CQA personnel, was 811,650 ft^2 (74,672 m^2), which consists of geomembrane primary liner and geomembrane secondary liner. The primary and secondary geomembrane panel layout drawings are presented in Appendix R.

5.2 Changes in Geosynthetic Specifications

Requests for clarification of information (RCI) and design change notices (DCN) of the geosynthetic drawings and specifications were processed and approved according to procedures described in FEMP document number ED-12-5002 entitled "Engineering Design Change Process." These RCIs and DCNs were approved, as appropriate, by the design organization. Copies of the RCIs and DCNs issued for Phase I are presented in Appendices S and T, respectively.

Approved RCIs and DCNs have been transmitted to the designer for consideration in Phase II construction drawings and specifications.

5.3 CQA of Geosynthetic Clay Liner

5.3.1 Conformance Testing and Documentation

A geosynthetic clay liner (GCL) was used in construction of the double-composite liner system. The GCL, Bentofix, was supplied by National Seal Company and was manufactured by Bentofix Technologies, Inc. in Barrie, Ontario. CQA personnel obtained 29 conformance samples (including two samples to isolate a failing roll of GCL from Lot Number 97101002) from the 24 GCL lots delivered to the site. A representative from FDF and a representative from GeoSyntec visited Bentofix Technologies, Inc. to observe production, review procedures, and sample material on two separate occasions (10 October 1997 and 23-24 October 1997). Eight of the 29 conformance samples were obtained at the factory prior to shipment of materials. The sampling frequency exceeds the minimum acceptable sample frequency of one per 100,000 ft^2 (9,300 m^2) required by the project documents. Conformance samples were forwarded to GeoSyntec's GEL for hydraulic conductivity testing and to GeoSyntec's SGI for direct shear testing. Based on conformance testing results, including supplier's testing, a total of 16 lots were approved for construction, two are pending approval for use in OSDF Phase II construction, and six lots were rejected. Of the six rejected lots, three failed conformance testing and three were rejected based on lot size and supplier testing. One roll (lot number 97101002) was rejected based on hydraulic conductivity results; however, isolation rolls (i.e., rolls manufactured prior to and following the failing roll) passed hydraulic conductivity testing and the lot was accepted. The conformance test results and the manufacturer's quality control (QC) certificates were reviewed by design personnel and, as appropriate, slope stability calculations were performed, using the interface and internal shear strength conformance data, to verify compliance with the design factors of safety. A summary table for GCL approval is presented in Table 5-1. The GCL conformance computation packages are presented in Appendix I. The manufacturer's QC documentation is presented in Appendix H. GeoSyntec's conformance test results are presented in Appendix I. A summary of the physical properties of the GCL and the conformance test frequency is presented in Table 5-2.

TABLE 5-1

GEOSYNTHETIC CLAY LINER (GCL) CONFORMANCE TESTING APPROVAL SUMMARY

LOT No.	QA ID No.	PET ID No.	QA Testing	QC Testing	Approved for Constr.	Date Approved	No. Rolls[6]	Lot Square Footage[6]
97082302	07	NA	Pass	NA	Yes	10 Oct 97	18	41,610
97081402	01	NA	Pass	NA	Yes	10 Oct 97	27	62,775
97090302	13	NA	Pass	NA	Yes	10 Oct 97	21	45,904
97090402	14	NA	Pass	NA	Yes	10 Oct 97	18	41,850
97082802	12	NA	Pass	NA	Yes	15 Oct 97	16	37,200
97090512	17	07	Pass	Pass	Yes	15 Oct 97	14	31,166
97082702	09	04	Pass	Fail [1]	Yes	17 Oct 97	29	67,037
97090702	19	NA	Pass	NA	Yes	21 Oct 97	13	30,138
97080802	21	NA	Pass	NA	Yes	30 Oct 97	8	18,600
97082102	05	NA	Pass	NA	Yes	30 Oct 97	6	13,950
97101002	22	08	Pass	Fail [1]	Yes	10 Nov 97	--	--
97101002	23	09	Pass[3]	Fail [1]	Yes	10 Nov 97	66	153,450
97062902	03	01	Pass	Pass	Yes	10 Nov 97	1	1,937
97082012	04	02	Pass	Fail [1]	Yes	07 Nov 97	28	65,100
97102302	24	NA	Pass	NA	Yes	14 Nov 97	--	--
97102302	25	NA	Pass	NA	Yes	14 Nov 97	61	132,925
97102402	26	NA	Pass	NA	Yes	14 Nov 97	--	--
97102402	27	NA	Pass	NA	Yes	14 Nov 97	25	56,896
97090612	18	NA	Pass	NA	Yes	18 Nov 97	4	8,958
97090102	11	NA	Pending[2]	NA	Pending	Pending	38	88,350
97082602	08	05	Pending[2]	Fail	Pending	Pending	13	30,225
97082812	10	NA	Fail	NA	No	Rejected	34	78,662
97090202	15	06	NA	Fail	No	Rejected[5]	9	20,925
97081302	20	NA	NA	NA	No	Rejected[4]	1	2,325
97090502	16	NA	NA	NA	No	Rejected[4]	3	6,975
97081502	02	NA	Fail	NA	No	Rejected	6	13,950
97082502	06	03	Fail	Fail	No	Rejected	16	37,200

Notes:
1. Factor of Safety, using QA & QC data, in slope stability analysis yields passing results.
2. Pending approval for use in Phase II.
3. Failed Hydraulic Conductivity. Isolation rolls pass hydraulic conductivity testing. Roll No. 40698 rejected.
4. Not tested due to small lot size.
5. Not tested by QA lab due to failing results from QC testing.
6. Quantity received as of 5 December 1997.

TABLE 5-2

GEOSYNTHETIC CLAY LINER PHYSICAL PROPERTIES SUMMARY

DESCRIPTION	TEST STANDARD	MANUFACTURER SPECIFICATIONS	PROJECT[1] SPECIFICATIONS	TEST FREQUENCY[5] (ft^2)	
				Manf. QC	Conformance QA
Bentonite Content (lb/ft^2)	ASTM D 5261	0.90 (dry)	≥1.0	40,000	NA
Bentonite Moisture Content (%)	ASTM D 4643		≤25	40,000	NA
Direct Shear[4]	ASTM D 5321		LD Shear - 12° LD Shear - 7° LD Shear - 6.5° Peak Shear - 17°	100,000	100,000 or per lot
Grab Strength (lb)	ASTM D 4632	135 lb.		40,000	NA
Hydraulic Conductivity (cm/s) (σ' = 5 psi)	GRI-GCL2	$<5x10^{-9}$	$<5x10^{-9}$	100,000	100,000
Bentonite Free Swell (ml/2g)	ASTM D 5890	24	≥24	40,000	NA

Total Number of Rolls Delivered to Site: Total Number of Conformance Samples:

Notes:
(1) Reference Section 02772 of the Specifications and Section 8 of the CQA Plan for further details.
(2) Ambient placement temperatures are between 40°F and 104°F. The GCL rolls are overlapped a minimum of 6 in. along edges, with a 12 in. end overlap. No horizontal seams are allowed on the slopes (≥5H:1V). Patches extend 12 in. beyond a defect on ≤5% slope areas and 24 in. on ≥5% slope areas.
(3) Bentofix is the GCL supplier. Roll dimensions are 15.5 ft by 125 ft.
(4) Peak Shear Strength and Large-Displacement (LD) shear strength at normal stress of 5, 20, 45 psi, reported as Secant Angle in degrees.
(5) Testing shall be performed at a frequency of one per lot or at listed frequency, whichever is greater. A lot is defined by ASTM D4354.
MD - Machine Direction; XD - Cross Direction; NA - Not Applicable; σ' = Effective Confining Stress.

5.3.2 Field Monitoring Activities

5.3.2.1 Delivery and On-Site Storage

Upon delivery, GCL rolls were unloaded in a laydown area located to the northeast of the Phase I construction area and covered with a tarpaulin. The GCL rolls had a plastic wrapping to protect against water and premature hydration. The rolls were transported by an all-terrain lift truck or a front-end loader. The rolls were deployed or were temporarily stored adjacent to the construction area prior to deployment. CQA personnel periodically monitored the installer's delivery, unloading, and storage procedures. Potentially nonconforming or questionable practices observed by CQA personnel were brought to the attention of the Construction Manager for review and correction. The CQA personnel observed that the material was stored and handled in an appropriate manner or corrective action was taken, where appropriate.

5.3.2.2 Deployment

CQA personnel monitored the deployment of the GCL rolls. During deployment, the CQA personnel checked for the following:

- manufacturing defects;
- evidence of premature hydration of the bentonite;
- damage that may have occurred during shipment, storage, and handling; and/or
- damage resulting from installation activities.

If materials were observed to be damaged, the installer was notified and the damaged materials were either discarded or repaired. CQA personnel observed repair locations, during and after the repair was complete.

CQA personnel monitored the deployment of the GCL, as well as its condition after installation, to ensure that the installer followed the following procedures:

- prior to deployment, the installer signed a Certificate of Acceptance of subgrade (presented in Appendix J);
- the GCL was unrolled and placed in a manner which kept the roll of GCL in sufficient tension to avoid excessive wrinkling using low ground-pressure rubber-tracked equipment;
- the rolls were deployed with the geotextile printed with the manufacturer's name facing upwards (i.e., woven geotextile up and nonwoven geotextile in contact with the underlying soil component);
- measures were taken to avoid entrapment of stones or other objects in the GCL panels;
- measures were taken to avoid damage to the underlying clay surface during deployment of the rolls;
- measures were taken to keep the GCL free of contamination and protected from premature hydration; and
- geomembrane installation immediately followed installation of the GCL.

After deployment of the GCL, CQA personnel observed that the following procedures were used by the installer to join adjacent rolls of GCL:

- adjacent GCL panels were overlapped a minimum of 6 in. (150 mm) along the length of the panels and a minimum of 12 in. (300 mm) along the width of the panels; and
- dry bentonite powder was applied, at a minimum rate of one pound per linear foot, around liner penetration boxes.

Observed holes or tears in the GCL were repaired by the installer by placing a patch of the same material over or under the hole or tear and at a distance of at least 2 ft (0.6 m) beyond the edges of the hole on slopes greater than 5 percent or 1 ft (0.3 m) beyond

the edges of the hole or tear on slopes less than 5 percent. In areas where premature hydration of the GCL was detected, the GCL was removed and replaced with new approved material.

5.4 CQA of Geomembrane

5.4.1 Conformance Testing and Documentation

The 80-mil (2.0mm) thick textured HDPE geomembrane was supplied by National Seal Company of Galesburg, Illinois. Prior to and during Phase I construction, geomembrane conformance samples were taken randomly from the 80-mil (2.0 mm) thick HDPE textured geomembrane rolls used to construct the lining system. A total of 18 conformance samples were obtained by CQA personnel from on-site stockpiles during the Phase I construction. These samples represented 15 lots of geomembrane which comprised 79 geomembrane rolls. The total number of conformance samples exceeds the minimum acceptable sample frequency of one per 100,000 ft^2 (9,300 m^2) or one per lot as required by the project documents.

The conformance samples were forwarded to GeoSyntec's MTL for testing. The conformance test results and the manufacturer's QC certificates, for each roll, were reviewed by CQA personnel and were found to be in compliance with the project documents. The geomembrane manufacturer's QC documentation included resin and geomembrane certifications and are presented in Appendix H. The geomembrane manufacturer's roll numbers, GeoSyntec's conformance sample logs, and GeoSyntec's conformance test results are presented in Appendix I. A summary of the physical properties of the geomembrane and the conformance test results are presented in Tables 5-3.

In addition to geomembrane conformance testing, the project documents specified a manufacturer's certification letter of conformance for the extrudate rod. CQA personnel obtained one letter of certification for the extrudate rod during construction of Phase I. The certification letter is presented in Appendix H.

5.4.2 Field Monitoring Activities

5.4.2.1 Delivery and On-Site Storage

Upon delivery to the site, geomembrane rolls were stored in an area located to the northeast of the Phase I construction area. The rolls of geomembrane had nylon straps which were used to lift the rolls. The rolls were transported by a front end loader. Occasionally, the rolls were temporarily stored adjacent to the construction area prior to deployment. CQA personnel periodically monitored the delivery, unloading, and storage procedures. The CQA personnel compared the roll numbers to the geomembrane rolls that were sampled at the manufacturer's plant and also to the bill of lading. The CQA personnel observed that procedures were used that minimized the potential for damage to the rolls.

5.4.2.2 Deployment

The geomembrane rolls were lifted using a spreader bar attached to a front end loader. An all-terrain vehicle was used in the deployment of geomembrane panels over the previously installed GCL panels using procedures approved by the Construction manager to assure no damage to the GCL. The installer generally deployed the geomembrane panels from the top of the north berm downward and across the cell floor and in accordance with the approved panel layout drawing. The installer used laborers to manually position the panels.

CQA personnel monitored the deployment of each geomembrane panel or roll. During deployment, the CQA personnel checked for the following:

- manufacturing defects;
- damage that may have occurred during shipment, storage, or handling; and/for
- damage resulting from installation activities, including damage as a consequence of panel placement, seaming operations, or weather.

If the materials were observed to be damaged or deficient, the installer was notified and the damaged materials were either discarded or repaired. CQA personnel observed repair locations, either during or after the repair was complete.

Details of the geomembrane panel placement were recorded by CQA personnel on the panel placement monitoring logs which are presented in Appendix K.

5.4.2.3 Trial Seams

Prior to production seaming, the installer prepared geomembrane trial seams daily for each piece of seaming equipment and each technician using a specific piece of seaming equipment. The trial seaming operations were observed by CQA personnel. The following procedure was used to evaluate the trial seams:

- trial seam samples varying in length from 3 ft to 15 ft (0.9 m to 4.5 m) and having a width of approximately 12 in. (0.3 m) wide were welded under similar conditions as for production seaming;
- test strips were cut across the trial seam at random locations using a manual dye press; each test strip was approximately 1 in. (25 mm) wide by 8 in. (200 mm) long;
- two test strips were tested in peel and two were tested in shear using a field tensiometer;
- the passing criteria for the tests were as follows:

  Fusion

  - *Peel test* - a minimum bonded seam strength of 104 lb/in. (15 kN/m) and the observation of a Film Tearing Bond (FTB); and
  - *Shear test* - a minimum bonded seam strength of 160 lb/in. (23 kN/m); and the observation of a FTB;

Extrusion

- *Peel test* - a minimum bonded seam strength of 90 lb/in. (13 kN/m); and the observation of a FTB; and
- *Shear test* - a minimum bonded seam strength of 144 lb/in. (21 kN/m); and the observation of a FTB;
- if any of the strips failed, corrective actions to the welding procedure were implemented, a new trial seam was fabricated, and the test procedure repeated; passing tests in both peel and shear were achieved prior to acceptance of the trial seam; if this retest strips failed the welder and/or the equipment were rejected until the problem was corrected and two consecutive passing trial seams were completed; and
- once a trial seam passed both tests, the technician was authorized to proceed with production seaming following the procedures and controls used to prepare the accepted trial seams; occasionally, the installer's foreman authorized the technician to proceed with the field seaming operations prior to testing of the strips and if the test failed, the seamed area was capped in its entirety and the welding equipment was not used again until two passing trial seams were obtained.

A total of 320 trial seams were observed by CQA personnel during the Phase I construction. A total of 148 trial seams were made using double-track fusion (i.e., hot wedge) welders and 172 were made using extrusion welders. A total of 24 trial seams failed (13 fusion seams and 11 extrusion seams). In the case of a failing test, the retesting protocol described above was followed.

Trial seam samples were not archived. The trial seam test results are presented in Appendix L.

5.4.2.4 Production Seams

Geomembrane production seaming operations were monitored by CQA personnel. The majority of the geomembrane production seams were fabricated using double-track fusion (i.e., hot wedge) welders. Geomembrane seam repairs were made using hand-held extrusion welders. During or after fabrication, the geomembrane seams were visually examined for workmanship and continuity. Geomembrane seaming logs are presented in Appendix M.

Cold weather seaming (i.e., below temperatures of 40°F (5°C)) was performed by the installer in accordance with the Construction Manager's authorization which required the destructive seam testing frequency to be increased to one sample for every 250 linear feet of production seam fabricated during cold weather seaming conditions and no geomembrane seaming activities were conducted below ambient temperatures of 15°F (-10°C). Production seaming activities were not performed below 27°F (-3°C) during the Phase I project.

5.4.3 Nondestructive Seam Testing

5.4.3.1 Scope

Nondestructive testing of geomembrane seams was periodically monitored by CQA personnel. Geomembrane seams were nondestructively tested by the installer for continuity using the air pressure or the vacuum-box test procedures. Double-track fusion seams were tested using air pressure test methods. The vacuum-box test method was used for seams made with extrusion welders. Failed air pressure test seams were capped and retested using vacuum-box test methods after minimizing the failed seam length. Leaks identified using the vacuum-box method were repaired and retested, as described in Section 5.4.5 of this report.

5.4.3.2 Air Pressure Testing

Accessible double-track fusion seams were nondestructively tested using the air pressure test. The procedure used by the installer for air pressure testing was as follows:

- CQA personnel visually observed the integrity of the annulus of the section of seam being tested;
- a test section was isolated by sealing the ends of the annulus using heat and pressure;
- the needle of a pressure test apparatus was inserted into the annulus at one end of the seam;
- the annulus was inflated to a gauge pressure of approximately 25 to 30 psi (170 to 200 kPa) with an air pump;
- the gauge pressure was maintained for at least five minutes;
- if the pressure loss exceeded 3 psi (23 kPa), or if the pressure did not stabilize, the faulty area was repaired in accordance with Section 5.4.5 of this report;
- the location of the test was recorded along with the beginning time, the ending time and the testing pressures; and
- upon completion of the test, air flow through the entire annulus was confirmed by releasing the air from the seam at the opposite end from where the needle was inserted.

Geomembrane air pressure test logs are presented in Appendix P.

5.4.3.3 Vacuum-Box Testing

The vacuum-box was used by the installer to nondestructively test extrusion seams and repairs. The procedure used by the installer for vacuum testing was as follows:

- vacuum-box assembly was connected to the vacuum pump;
- a strip of seam was wet with a soapy solution (during freezing temperatures, a small amount of glycol was added to the soapy solution);

- the vacuum-box assembly was placed over the wetted area;
- the bleed valve was closed and the vacuum valve was opened, if necessary;
- the box was forced onto the sheet until a vacuum was established as evidenced by a negative box pressure of approximately 5 psi (34 kPa);
- the seam was examined through the viewing window for a period of approximately 20 seconds for the occurrence of air bubbles;
- the location of any leaks were recorded;
- the vacuum valve was closed and the bleed valve was opened, if necessary; and
- the assembly was removed and the process was continued.

On the fusion-welded seams (i.e., tie-in seams, butt seams) that were not air pressure tested, the installer trimmed the overlap and vacuum box tested the seam. When nondestructive testing indicated repairs were necessary, repairs were made in accordance with procedures presented in Section 5.4.5 of this report and the vacuum testing repeated. Vacuum test logs are presented in Appendix P.

5.4.4 Destructive Seam Sample Testing

5.4.4.1 Scope

In accordance with the CQA Plan, CQA personnel identified and collected geomembrane seam samples for destructive testing. The samples were forwarded to GeoSyntec's MTL.

A total of 140 geomembrane seam sample locations were identified during Phase I construction; 48 passing and 23 failing tests on the geomembrane secondary liner and 65 passing and 4 failing tests on the geomembrane primary liner. Approximately 49,000 linear ft (14,900 linear meter) of seams were constructed. This corresponds to an approximate sample frequency of one per 450 linear feet (135 linear meter) of seam. This frequency meets the minimum acceptable sample frequency of one per 500 linear

feet (150 linear meter) required by the CQA Plan. During cold weather seaming operations, the minimum acceptable sample frequency of one per 250 linear feet (75 linear meter) was required by the Construction Manager's authorization. Approximately, 12 additional samples were required to be obtained because of cold weather seaming production. Prior to the removal of the full seam sample, two geomembrane test strips were taken by the installer from either end of the destructive sample. Each strip was tested in the field in peel. If the peel samples exhibited a FTB failure mode and minimum strength, the adjacent destructive seam sample was shipped to the laboratory for testing.

For a destructive seam sample to be considered as passing, the following seam strength criteria had to be met on four out of the five tests performed on each of the destructive seam specimens obtained from each of the destructive seam samples. In addition, a non-FTB was considered to exhibit more than 10 percent seam separation.

Fusion

- *Peel test* - a minimum bonded seam strength of 104 lb/in. (15 kN/m) and the observation of a FTB; and
- *Shear test* - a minimum bonded seam strength of 160 lb/in. (23 kN/m); and the observation of a FTB;

Extrusion

- *Peel test* - a minimum bonded seam strength of 90 lb/in. (13 kN/m); and the observation of a FTB; and
- *Shear test* - a minimum bonded seam strength of 144 lb/in. (21 kN/m); and the observation of a FTB;

In addition, if more than one non-FTB failure (i.e., greater than or equal to 10 percent seam separation) was observed, the destructive seam sample would fail.

5.4.4.2 Sampling Procedures

At each destructive seam sample location, a test sample which measured approximately 12 in. (300 mm) across the seam and 42 in. (1.1 m) along the seam was obtained. The sample was divided and distributed as follows:

- 12 in. (300 mm) wide by 12 in. (300 mm) long for owner's archives;
- 12 in. (300 mm) wide by 12 in. (300 mm) long for the installer; and
- 18 in. (500 mm) wide by 12 in. (300 mm) long for CQA laboratory testing.

5.4.4.3 Test Results

Off-site laboratory testing of geomembrane seam test samples was performed in accordance with the CQA Plan at the MTL. In the laboratory, 1 in. (25 mm) wide test specimens were removed from the destructive seam sample using a die press. On a gauged tensiometer, five test specimens were tested in peel for adhesion. For fusion seams, tests were performed on both the inside track and on the outside track. Additionally five specimens were tested for shear strength. The seam-strength criteria and the acceptance/rejection described this Section were used.

For Phase I, 27 failures were recorded on the initial destructive samples; 25 failures occurred in the field test strips and 2 failures occurred in the laboratory destructive samples. In each case, the failed area was isolated by selecting additional test-strip locations at a minimum distance of 10 ft (3 m) on either side of the failure. If the additional test strips had passing results, a full destructive seam sample was taken. These destructive seam samples were tested in accordance with procedures previously described in this section. Thirty-two additional seam samples were obtained to isolate failures and on reconstructed seams; 7 on the geomembrane primary liner and 25 on the geomembrane secondary liner. Seams having failing destructive samples were repaired using procedures presented in Section 5.4.5. The destructive seam test sample locations were also repaired using the procedure presented in Section 5.4.5. The destructive seam

test results and a summary of the number of samples obtained are presented in Appendix N.

5.4.5 Geomembrane Repairs

The procedures presented in this subsection were used by the installer during the following repair operations:

- patching holes and tears;
- capping failed seams;
- spot-extruding impact damage or other minor scratches; and
- grinding and extrusion welding small sections of failed fusion seams (if the exposed edge was accessible).

The repair procedure for fusion seams, agreed upon between the installer and Construction Manager, was to either thermally heat seal the overlap and extrusion weld the exposed seam or cap strip the failed seam. The first technique was used primarily for seams with insufficient overlap. The second technique was used for failing destructive tests.

In the cases where patches or caps were used to repair the damaged geomembrane (i.e., small holes, tears, or on seams which failed nondestructive or destructive tests), an approximately 12 in. (300 mm) wide capping strip was used. All panel tie-in seams (i.e., T-seams) were extrusion welded/repaired. During the repair or panel tie-in operations, the following provisions were implemented:

- technicians and seaming equipment used during repair operations had trial seams approved prior to use;
- geomembrane surfaces to be repaired were clean and dry at the time they were welded;

- patches or caps extended at least 6 in. (0.15 m) beyond the edge of the defect, and all corners were rounded;
- fusion annuli were ground down to the surface of the bottom geomembrane at the ends of the seams; and
- repairs were vacuum tested where accessible, and visually observed for continuity.

Seam and panel repair locations are presented in Appendix P. Complete panel layout drawing indicating the location of seam and panel repairs are shown on the record drawings.

5.5 CQA of Geotextile

5.5.1 Conformance Testing and Documentation

Three types of geotextiles were used in construction of Phase I:

- a needlepunched nonwoven geotextile having a nominal weight per unit area of 7 oz/yd^2 (240 g/m^2) was used for filtration and separation applications (i.e., geotextile filter). This geotextile was manufactured by TNS Advanced Technologies of Greer, South Carolina;
- a needlepunched nonwoven geotextile having a nominal/minimum weight per unit area of 10 oz/yd^2 (340 g/m^2) was used for cushioning applications (i.e., cushion geotextile). This geotextile was manufactured by TNS Advanced Technologies of Greer, South Carolina; and
- a needlepunched nonwoven geotextile having a nominal weight per unit area of 16 oz/yd^2 (540 g/m^2) was used for cushioning applications (i.e., supplemental cushion geotextile). This geotextile was manufactured by TNS Advanced Technologies of Greer, South Carolina.

CQA personnel obtained 17 conformance samples from the 149 geotextile rolls delivered to the site. Eight conformance samples were obtained from 42 rolls of filter and separator geotextile, 9 conformance samples were obtained from 95 rolls of geotextile cushion, and 1 conformance sample was obtained from 12 rolls of supplemental geotextile cushion. These sampling frequencies exceed the minimum acceptable frequency of one per 100,000 ft^2 (9,300 m^2) required by the project documents. The conformance samples were forwarded to GeoSyntec's MTL for testing. The conformance test results and the manufacturer's QC certificates were reviewed by CQA personnel and were found to be in compliance with the project documents. The manufacturer's QC documentation is presented in Appendix H. GeoSyntec's conformance test results are presented in Appendix I . A summary of the properties of the geotextile material and the conformance test results is presented in Tables 5-5, 5-6, and 5-7.

5.5.2 Field Monitoring Activities

5.5.2.1 Delivery and On-Site Storage

Upon delivery to site, geotextile rolls were stored in an area located northeast of the Phase I construction area. The geotextile rolls had a plastic wrapping to protect against ultraviolet radiation, dust, and dirt. The geotextile rolls were transported by a front-end loader. The rolls were deployed or temporarily stored adjacent to the construction area prior to deployment. CQA personnel periodically monitored the delivery, unloading, and storage procedures. The CQA personnel observed that the material was handled in an appropriate manner.

5.5.2.2 Deployment

CQA personnel monitored the deployment of the geotextile rolls for the following:

- manufacturing defects;
- damage that may have occurred during shipment, storage, and handling; and
- damage resulting from installation activities.

If any materials were observed to be damaged, the installer was notified and the damaged materials were either discarded or repaired. CQA personnel observed repair locations, either during or after the repair was complete.

CQA personnel periodically monitored the deployment of the geotextile as well as its condition after installation, to ensure that the installer:

- unrolled the geotextile down the slope in a manner which kept the geotextile panel in sufficient tension to avoid excessive wrinkling and folding; and
- took measures to avoid the entrapment of dust, stones, and other objects in the geotextile.

After deployment of the geotextile, CQA personnel observed that the following procedures were used by the installer to join adjacent rolls of geotextile:

- geotextile panels were overlapped a minimum of 6 in. (0.15 m); and
- geotextile panels were continuously sewn.

The installer used a 2200 Union Special sewing machine. The seams were sewn with a single-thread chainstitch. Using a nylon bonded thread, supplied by National Seal Company, Galesburg, Illinois.

The installer repaired holes or tears in the geotextile by placing a patch of the same material over the hole or tear with at least a 2 ft (0.6 m) beyond the edges of the hole or tear. Thermal bonding of geotextile seams was requested to be used by the Contractor and approved for use by the Construction Manager and Resident Engineer. The technique was used with limited success, therefore the Contractor discontinued this seaming practice.

5.6 CQA of Liner Penetration Boxes

GeoSyntec made one field visit to the manufacturer's facility, Plastik Werks, Gainesville, GA to review shop drawings and fabrication procedures prior to production. Liner penetration boxes were air pressure tested in the factory and in the

field, as required, filled with bentonite, and sealed. Pressure test logs for the liner penetration boxes are presented in Appendix Q. Geomembrane connections to the liner penetration boxes were nondestructively tested using vacuum-box testing as outlined in Section 5.4.3.3. CQA personnel monitored installation and testing activities.

5.7 CQA of HDPE Piping

CQA personnel monitored the installation of the various HDPE piping components of the leachate collection and leak detection systems. Installation activities that were monitored by GeoSyntec's CQA personnel included the following:

- 6 in. (150-m) diameter HDPE SDR-11 perforated-wall gravity line located within the LDS and LCS drainage corridor;
- leak detection system (LDS) gravity pipeline, consisting of a 6 in. (150 mm) diameter HDPE SDR-11 solid-wall gravity line inside a 10 in. (250 mm) diameter HDPE SDR-11 solid-wall containment pipe, which transitions within an LDS manhole to a 3 in. (75 mm) diameter HDPE SDR-11 solid-wall gravity line inside a 8 in. (200 mm) diameter HDPE SDR-11 solid-wall containment pipe and ultimately connects within a leachate conveyance system (LCS) manhole to a main LCS pipe;
- redundant leachate collection system (LCS) gravity pipeline, consisting of a 6 in. (150 mm) diameter HDPE SDR-11 solid-wall gravity line inside a 10 in. (250 mm) diameter HDPE SDR-11 solid-wall containment pipe, and ultimately connects within an LCS manhole to a main LCS pipe;
- leachate collection system (LCS) gravity pipeline, consisting of a 6 in. (150 mm) diameter HDPE SDR-11 solid-wall gravity line inside a 10 in. (250-m) diameter HDPE SDR-11 solid-wall containment pipe, and ultimately connects within an LCS manhole to a main LCS pipe consisting of a 6 in. (150 mm) diameter HDPE SDR-11 solid-wall gravity line inside a 10 in.(250 mm) diameter HDPE SDR-11 solid-wall containment pipe.

5.7.1 Pipe Conformance Testing and Documentation

The pipe for the leachate collection system was delivered to site during Phase I construction. The pipe was supplied by Phillips Driscopipe of Wellford, S.C.. The pipe manufacturer provided the QC certifications for each lot of pipe supplied. CQA personnel reviewed this documentation and verified that the pipe's property data were in compliance with the requirements of the project documents. CQA personnel also verified the proper size and spacing of the perforations by visual observation of the pipe while in the stockpile or during installation. No conformance testing of the pipe was required by the CQA Plan.

5.7.2 Field Monitoring Activities

5.7.2.1 Delivery and Placement

The pipe was shipped from the manufacturer on wooden pallets. Upon delivery to the site, pipe was stockpiled in an area located northeast of the Phase I construction area. The pipe was transported from the stockpile to the construction area by a track hoe or a front-end loader using nylon straps. The pipe was deployed or temporarily stored adjacent to the construction area.

The 40 ft (12-m) long sections were joined using butt-fusion welding techniques and electrofusion couplings. The CQA activities associated with each of the pipe joining techniques are described below.

CQA personnel monitored the HDPE pipe butt-fusion welding procedures to ensure the following:

- the ends of the pipes to be joined were cleaned and the pipe sections were aligned;
- the welder tightly secured the pipe section in the welding unit clamps to allow the ends of the pipes to be trimmed with the facing tool immediately prior to the application of the heat disk;

- the ends of the pipe sections were heated for approximately one minute using a 450 to 500°F (232 to 260°C) heating disk;
- the welder quickly removed the heating disk and joined the pipes with pressure to create a roll-back bead; and
- after the butt-fusion weld was allowed to cool, the joined pipes were released from the welding unit.

CQA personnel monitored the electrofusion welding procedures to ensure the following:

- the ends of the pipes were cut square and even;
- the ends of the pipes to be joined were cleaned and surface prepared inside and out;
- the leads from the electrofusion coupling were secured to the processing unit supplied by the manufacturer;
- the processing unit was activated to produce a voltage range across the electrofusion coupling which induced melting; and then performed a unit test to evaluate the coupled joint; and
- the electrofusion weld was allowed to cool in accordance with manufacturer's recommendations.

Within the Cell 1 area, the piping system was constructed to allow drainage toward the liner penetration, located at the west end of the cell. During installation, perforated pipes were installed as part of the LDS and LCS leachate conveyance system. The pipe had 3 rows of 5/8 in. (16 mm) diameter holes on 6 in. (150 mm) centers along the length. Each row was staggered 2 in. (50 mm). LDS and LCS drainage corridor material (i.e., No. 78 and No. 57 stone, respectively) was placed around the pipe. Both the pipe and aggregate were installed over a supplemental 16 oz/yd^2 (540 g/m^2) nonwoven geotextile.

The following approximate lengths of pipe were installed in the Phase I area:

- 350-ft (310-m) of 6-in (150 mm) diameter HDPE LDS pipe; and
- 350-ft (310-m) of 6-in (150 mm) diameter HDPE LCS pipe.

The HDPE piping within Cell 1 was connected to the liner penetration boxes described in Section 5.6. The liner penetration boxes were the only point of penetration through the geomembrane liners. The leachate will be discharged through the liner penetration boxes within Cell 1 via gravity pipeline to the leachate conveyance system. The leachate conveyance system is comprised of an LDS and LCS manhole and transmission pipe which convey leachate to the permanent lift station. The permanent lift station will pump leachate via a forcemain within containment pipe to the BioSurge Lagoon. The leachate conveyance system is described in Section 6.0.

TABLE 5-3

80-MIL THICK HDPE GEOMEMBRANE (TEXTURED) PROPERTIES SUMMARY

DESCRIPTION	TEST STANDARD	MANUFACTURER[3] SPECIFICATIONS (MARV)[8]	PROJECT[1] SPECIFICATIONS	TEST FREQUENCY (ft^2)		NUMBER OF TESTS[2]				RANGE OF QA TEST RESULTS	
						REQUIRED		PASSING			
				Manf. QC	Conf. QA[4]	Manf. QC	Conf. QA	Manf. QC	Conf. QA	MAXIMUM	MINIMUM
Yield Strength (lb/in.)	ASTM D 638[5]	176	≥160[6]	40,000	100,000	19	8	42	18	246	208
Elongation at Yield (%)	ASTM D 638[5]	13	≥12	40,000	100,000	19	8	42	18	21	17
Break Strength (lb/in.)	ASTM D 638[5]	184	≥100[6]	40,000	100,000	19	8	42	18	378	194
Elongation at Break (%)	ASTM D 638[5]	200	≥200	40,000	100,000	19	8	42	18	1285	608
Thickness (mil)	ASTM D 5199 or GRI-GM8	80	Ave. 80 Min. 76	40,000	100,000	19	8	43	18	84	80
Density (g/cm^3)	ASTM D 792 or ASTM D 1505	0.94	≥0.935 (resin) ≥0.94 (sheet)	40,000[4]	100,000	19	8	43	18	.951	.946
Tear Resistance (lb)	ASTM D 1004 Die C Puncture	60	≥52	40,000	NA	19	NA	41	NA	NA	NA
Melt Flow Index (g/10 min)	ASTM D 1238 Condition E	≤1.0	≤1.0	NA	NA	19	NA	15	NA	NA	NA
Carbon Black Content (%)	ASTM D 1603	2.0	2-3	40,000	100,000	19	8	52	18	2.9	2.2
Carbon Black Dispersion	ASTM D 5596	Category 1 or 2	Category 1 or 2	40,000	100,000	19	8	41	18	CAT. 1	CAT. 1
Low Temperature Brittleness (°C)	ASTM D 746B	-75	-60 max.	400,000	NA	2	NA	2	NA	NA	NA
Dimensional Stability (%) (@ 212°F, 1 min.)	ASTM D 1204	±2 max.	±2 max.	400,000	NA	2	NA	16	NA	NA	NA
ESCR (hr)[7]	ASTM D 5397	500	≥500	400,000	NA	2	NA	2	NA	NA	NA

Total Number of Rolls Delivered to Site: 79 (811,650 ft^2)

Total Number of Conformance Samples: 18

Notes:
(1) Reference Section 02770 of the Specifications and Section 7 of the CQA Plan for further details.
(2) The approximate number of tests required is based on total of 811,650 ft^2 for the Cell 1 installation.
(3) National Seal Corp., Gailsburg, Illinois is the geomembrane supplier. Roll dimensions are 15 ft by 666 ft. (ave. length)
(4) Tests performed at a frequency of one per lot or at listed frequency, whichever is greater. A lot is as defined by ASTM 4354. Minimum test frequency of resin is 1 test per railcar.
(5) ASTM D 638 is modified by NSF-54 Annex A.
(6) Adjusted value, see Amendment No. 2.
(7) Time-to-failure at a tensile stress of 30% of the tensile yield strength (changed by DCN-215 Amendment No. 4).
(8) MARV = (minimum average roll value), 95 percent lower confidence limit.

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TABLE 5-4

80-Mil Thick HDPE Geomembrane (Primary/Secondary) (Textured)
SEAM PROPERTIES SUMMARY

DESCRIPTION	TEST STANDARD	PROJECT[1] SPECIFICATIONS		REQUIREMENTS	APPROXIMATE NUMBER OF TESTS REQUIRED
		Fusion	Extrusion		
Panel Deployment	-	-	-	Ambient placement temperature are between 40° and 104°F.	Assumption used for destructive seam testing is that eac roll is approximately 15 ft by 666 ft (ave.)
Trial Seams: (peel)	ASTM D 4437	FTB 104 ppi	FTB 90 ppi	Prior to seaming period every 5 hours, or if seaming apparatus is turned off.	Minimum of: 2 no. peel per trial seam 2 no. shear per trial seam
(shear)	ASTM D 4437	FTB 160 ppi	FTB 144 ppi		

Notes: (1) One failure requires two consecutive successful trial seams.

DESCRIPTION	TEST STANDARD	PROJECT[1][2][3] SPECS		TEST FREQUENCY[4]:	APPROXIMATE NUMBER OF TESTS REQUIRED	ORIGINAL NO. OF SAMPLES	NUMBER OF FAILURES		ADDITIONAL NUMBER OF SAMPLES TO ISOLATE FAILURES	TOTAL NUMBER OF SAMPLES
		Fusion	Extrusion				FIELD	LAB		
Seam Strength[1]: Production Welds and Reconstructed Seams	ASTM D 4437	FTB 104 ppi	FTB 90 ppi	500 lin. ft (250 lin. ft)	secondary min. of 46	secondary min. of 46	secondary 21	secondary 2	secondary 25	secondary 71
	ASTM D 4437	FTB 160 ppi	FTB 144 ppi		primary min. of 46	primary min. of 62	primary 4	primary 0	primary 7	primary 69

Note: (1) Reference Section 02770 of the Specifications and Section 7 of the CQA Plan for further details.
(2) 1 in. wide test strips are tested at a strain rate of 2 in. per minute. One non-FTB per five specimens is acceptable provided that the strength requirements are met.
(3) FTB = Film Tear Bond (maximum 10 percent seam separation)
(4) Test frequency increased for cold weather seaming production, in accordance with FDF Construction Manager's requirements.

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TABLE 5-5

NONWOVEN GEOTEXTILE (7 oz/yd^2) FILTER PROPERTIES SUMMARY

DESCRIPTION	TEST STANDARD	MANUFACTURER SPECIFICATIONS (MARV) (4)	PROJECT(1) SPECIFICATIONS	TEST FREQUENCY		NUMBER OF TESTS(2)				RANGE OF QA TEST RESULTS	
						REQUIRED		PASSING			
				Manf. QC	Conf. QA	Manf. QC	Conf. QA	Manf. QC	Conf. QA	MAXIMUM	MINIMUM
Mass Per Unit Area (oz/yd^2)	ASTM D 5261	7	≥7	50,000	100,000	4	2	16	8	8.2	7.2
Mullen Burst Strength (psi)	ASTM D 3786	400	≥350	50,000	100,000	4	2	16	8	408	351
Grab Strength (lb)	ASTM D 4632	200	≥180	50,000	100,000	4	2	16	8	251	187
Trapezoidal Tear Strength Tear (lb)	ASTM D 4533	75	≥75	50,000	100,000	4	2	16	8	136	81
Puncture Strength Resistance (lb)	ASTM D 4833	115	≥75	50,000	100,000	4	2	16	8	152	124
Apparent Opening Size (mm) (A.O.S.) (Sieve Size)	ASTM D 4751	80 sieve	≤0.21	100,000	100,000	2	2	16	8	.20	.078
Permittivity (sec^{-1})	ASTM D 4491	1.41	≥0.5	100,000	100,000	2	2	16	8	1.62	1.39
Ultraviolet Resistance (%)	ASTM D 4355	70	≥70	Cert. Ltr.	NA	NA	NA	NA	NA	NA	NA
Nonwoven Needlepunched Polymer Composition (%)	—	100% polypropylene	95 polypropylene or polyester by weight	Cert. Ltr.	NA	NA	NA	NA	NA	NA	NA

Total Number of Rolls Delivered to Site: 42 Total Number of Conformance Samples: 8

Notes:
(1) Reference Section 02714 of the Specifications and Section 9 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total of 491,200 ft^2 for the Cell 1 installation.
(3) Roll dimensions are 15 ft by 780 ft for 7 oz/yd^3 geotextile manufactured by TNS Advanced Technologies, Greer, South Carolina.
(4) MARV = (minimum average roll value), 95 percent lower confidence limit.

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TABLE 5-6

NONWOVEN GEOTEXTILE (10 oz/yd^2) LINER SYSTEM CUSHION PROPERTIES SUMMARY

DESCRIPTION	TEST STANDARD	MANUFACTURER SPECIFICATIONS (MARV)(4)	PROJECT(1) SPECIFICATIONS	TEST FREQUENCY		NUMBER OF TESTS(2)				RANGE OF TEST RESULTS	
						REQUIRED		PASSING			
				Manf. QC	Conf. QA	Manf. QC	Conf. QA	Manf. QC	Conf. QA	MAXIMUM	MINIMUM
Mass Per Unit Area (oz/yd^2)	ASTM D 5261	10	≥10	50,000	100,000	16	9	95	9	11.5	10.2
Mullen Burst Strength (psi)	ASTM D 3786	560	≥450	50,000	100,000	16	9	95	9	574	494
Grab Strength (lb)	ASTM D 4632	270	≥225	50,000	100,000	16	9	95	9	372	324
Trapezoidal Tear Strength Tear (lb)	ASTM D 4833	100	≥90	50,000	100,000	16	9	95	9	199	127
Puncture Strength Resistance (lb)	ASTM D 4833	165	≥120	50,000	100,000	16	9	95	9	207	176
Ultraviolet Resistance (%)	ASTM D 4355	70	≥70	Cert. Ltr.	NA	NA	NA	NA	NA	NA	NA
Nonwoven Needlepunched Polymer Composition (%)	—	100% polypropylene	95 polypropylene or polyester by weight	Cert. Ltr.	NA	NA	NA	NA	NA	NA	NA

Total Number of Rolls Delivered to Site: 95

Total Number of Conformance Samples: 9

Notes:
(1) Reference Section 02714 of the Specifications and Section 9 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total of 812,250 ft^2 for the Cell 1 installation.
(3) Roll dimensions are 15 ft by 570 ft for 10 oz/yd^3 geotextile manufactured by TNS Advanced Technologies, Greer, South Carolina.
(4) MARV = (minimum average roll value), 95 percent lower confidence limit.

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TABLE 5-7

NONWOVEN GEOTEXTILE (16 oz/yd^2) SUPPLEMENTAL CUSHION PROPERTIES SUMMARY

DESCRIPTION	TEST STANDARD	MANUFACTURER SPECIFICATIONS (MARV) (4)	PROJECT(1) SPECIFICATIONS	TEST FREQUENCY		NUMBER OF TESTS(2) REQUIRED		NUMBER OF TESTS(2) PASSING		RANGE OF TEST RESULTS	
				Manf. QC	Conf. QA	Manf. QC	Conf. QA	Manf. QC	Conf. QA	MAXIMUM	MINIMUM
Mass Per Unit Area (oz/yd^2)	ASTM D 5261	16	≥16	50,000	100,000	2	1	12	1	17.9	17.9
Mullen Burst Strength (psi)	ASTM D 3786	800	≥700	50,000	100,000	2	1	12	1	860	860
Grab Strength (lb)	ASTM D 4632	425	≥350	50,000	100,000	2	1	12	1	590	561
Trapezoidal Tear Strength Tear (lb)	ASTM D 4533	150	≥120	50,000	100,000	2	1	12	1	335	222
Puncture Strength Resistance (lb)	ASTM D 4833	240	≥180	50,000	100,000	2	1	12	1	319	319
Ultraviolet Resistance (%)	ASTM D 4355	70	≥70	Cert. Ltr.	NA	NA	NA	NA	NA	NA	NA
Nonwoven Needlepunched Polymer Composition (%)	NA	100% polypropylene	95 polypropylene or polyester by weight	Cert. Ltr.	NA	NA	NA	NA	NA	NA	NA

Total Number of Rolls Delivered to Site: 12

Total Number of Conformance Samples: 1

Notes:
(1) Reference Section 02714 of the Specifications and Section 9 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total of 64,800 ft^2 for the Cell 1 installation.
(3) Roll dimensions are 15 ft by 360 ft for 16 oz/yd^3 geotextile manufactured by TNS Advanced Technologies, Greer, South Carolina.
(4) MARV = (minimum average roll value), 95 percent lower confidence limit.

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6. CONSTRUCTION QUALITY ASSURANCE - LEACHATE CONVEYANCE SYSTEM

6.1 General

CQA personnel monitored the installation of the various components of the leachate conveyance system. The leachate conveyance system includes the leachate transmission system (LTS), manholes, a permanent lift station (PLS) and leachate force main. Installation of these systems was performed out by either Village Building Services or Wise Construction Company, both of Cincinnati, Ohio. Concrete construction was completed by Dias Construction, also of Cincinnati. Installation activities that were monitored by GeoSyntec's CQA personnel from the Phase I interface at Cell 1, to the PLS and continuing to the BioSurge Lagoon (BSL) included the following:

- main LTS pipe consisting of a 6 in. (150 mm) diameter HDPE SDR-26 solid-wall gravity line inside a 10 in. (250 mm) diameter HDPE SDR-26 solid-wall containment pipe;
- installation of LDS and LCS 84 in. (2.1-m) diameter HDPE Class 100 and 54-inch (1.4-m) clean out manhole, HDPE SDR-26 solid-wall manholes, fittings, valves and controls;
- main LTS from the PLS to the BSL consisting of a 4-inch (102 mm) diameter HDPE SDR-17 solid-wall pressure line inside a 8-inch (203 mm) diameter HDPE SDR-26 solid-wall containment pipe; and
- LTS trench backfilling which included compacted fill, embedment fill and aggregate base.

6.2 Changes in Drawings and Specifications

RCIs and DCNs were processed and approved according to procedures described in FEMP document ED-12-5002 entitled "Engineering Design Change Process." Copies of the RCIs and DCNs are presented in Appendices R and S, respectively. Among the approved DCNs are minor alignment changes to the leachate conveyance system to avoid interferences with underground utilities, monitoring wells, and existing structures. These alignment modifications will be shown on as-built drawings maintained by FDF.

6.3 Pipe Conformance Testing and Documentation

The pipe and manholes for the leachate collection system were delivered to site during Phase I construction. The pipe and manholes were supplied by Phillips Driscopipe of Wellford, SC. The manufacturers provided the QC certifications for each lot of pipe supplied and for each manhole supplied. The manufacturer's QC certificates are presented in Appendix H. CQA personnel reviewed this documentation and verified that the pipe and manhole property data were in compliance with the requirements of the CQA Documents. CQA personnel also verified the proper size and spacing of manhole stubs and penetrations by visual observation and measurements of the manhole while in the laydown area.

6.4 Field Monitoring Activities

6.4.1 Delivery and Placement

Upon delivery to the site, pipe and manholes were placed in laydown areas approved by FDF. The pipe was transported from the laydown area to the construction area by a track hoe or a front-end fork lift using nylon straps. The pipe was deployed or temporarily stored adjacent to the construction area.

Prior to installation, approximately 200 to 400 ft (61 to 122 m) long sections were constructed adjacent to the pipe trench. The pipe sections or manhole penetration connections were joined using butt-fusion or electrofusion welding techniques and

mechanical flange connections. The CQA activities associated with each of the pipe joining techniques are described below.

CQA personnel periodically monitored the HDPE pipe butt-fusion welding procedures to ensure the following:

- trial butt fusion joints were made to verify conditions were adequate at the beginning of each day for each fusion apparatus used that day; trial joining was made under the same conditions as the actual joining;
- the ends of the pipes to be joined were cleaned and the pipe sections were placed in a portable welding unit;
- the welder tightly secured the pipe section in the welding unit clamps to allow the ends of the pipes to be trimmed with the facing tool immediately prior to the application of the heat disk;
- the ends of the pipe sections were heated for approximately one minute using a 450 to 500°F (232 to 260°C) heating disk;
- the welder quickly removed the heating disk and joined the pipes with pressure to create a roll back bead;
- the butt-fusion weld was allowed to cool prior to the joined pipes being released from the welding unit; and
- all of the above performed in general accordance with pipe and welding unit manufacturers procedures.

CQA personnel periodically monitored the electrofusion welding procedures to ensure the following:

- the ends of the pipes were cut square and even;

- the ends of the pipes to be joined were cleaned and surface prepared inside and out;
- the leads from the electrofusion coupling were secured to the processing unit supplied by the manufacturer;
- the processing unit was activated to produce a voltage range across the electrofusion coupling which induced melting; and then performed a unit test to evaluate the coupled joint; and
- the electrofusion weld was allowed to cool in accordance with manufacturer's recommendations.

CQA personnel periodically monitored the mechanical flanged connection procedures to ensure that the 316 stainless steel flange bolts, nuts and washers were installed and tightened.

The trench varied from approximately 3 ft (0.9-m) to 8 ft (2.4-m) in depth and from 3 ft (0.9-m) to 13 ft (4.0-m) in width, depending on how many additional pipes shared the common excavation. Embedment fill was placed in nominal 7-in (175 mm) thick loose lifts up to one lift over the pipe. Compacted fill (cohesive material) was then used as backfill to final grade. The backfill was placed in approximately 8 in. (200 mm) thick loose lifts. Hand-operated compaction equipment was used to achieve compaction of the embedment and fill materials. Details of the testing are discussed in the following section.

6.4.2 Testing Activities

As part of the CQA activities, tests were performed on the different components of the leachate conveyance system. The following tests were conducted or monitored by CQA personnel for the compacted fill, embedment fill, aggregate base materials, or piping systems:

- In-place nuclear moisture/density tests were conducted on the compacted fill used in the LCS gravity and forcemain trenches.
- Grain-size distribution tests were performed on samples of compacted fill, embedment fill and aggregate base materials according to ASTM D 422 or ASTM C 136.
- Pressure tests were conducted by the contractor on the carrier and containment pipes of the LCS gravity pipeline, forcemain, and manholes. These tests were monitored by GeoSyntec's CQA personnel.

In addition to the above-mentioned tests, CQA personnel performed on-site slump tests on the concrete loads delivered to the site for the manhole bases and cover slabs. Concrete test cylinders were prepared and tested by an off-site laboratory (Fuller, Mossbarger, Scott and May Engineers, Inc.). The concrete cylinder test results were reviewed by the CQA personnel to ensure conformance to the project documents.

CQA personnel conducted a total of 367 nuclear moisture/density tests on the compacted fill within the LCS gravity and forcemain trenches. All but 11 of the test results all met the minimum degree of compaction of 95 percent of the maximum dry unit weight, as determined by the standard Proctor compaction test. In the case of the failing tests, the contractor reworked and recompacted the area surrounding the failure, and then the area was retested by CQA personnel. This procedure was repeated until a satisfactory moisture/density test result was obtained. The nuclear moisture/density test results are given in Appendix Q.

CQA personnel obtained representative samples of embedment fill material. Nine record grain-size distribution tests were performed. The materials are classified as SP based on the USCS. A summary of the testing requirements is presented in Table 6-2. Geotechnical laboratory test results are presented in Appendix Q.

CQA personnel monitored placement and compaction of embedment fill material. Material was compacted using four passes of vibratory plate compactor or by flooding method and density test.

CQA personnel also monitored the pressure testing performed by the Leachate Conveyance System contractor. For these tests, the contractor tested the carrier pipe with water to a minimum of 50 psi (345 kPa) for the carrier pipe and 15 psi (103 kPa) for the containment pipe. The pressure was monitored by CQA personnel for a minimum period of 1 hour during which time the pressure in the pipe was recorded.

Results were reviewed by the Resident Engineer and summarized in the Resident Engineer's weekly reports presented in Appendix C.

The test results and CQA documentation from the leachate conveyance system are presented in Appendix Q.

TABLE 6-1

LEACHATE CONVEYANCE SYSTEM
COMPACTED FILL MATERIAL PROPERTIES SUMMARY

DESCRIPTION	TEST STANDARD	PROJECT(1) SPECIFICATIONS	TEST FREQUENCY (yd^3)	APPROXIMATE NUMBER OF TESTS REQUIRED(2)	NUMBER OF TEST PERFORMED (FAILURES)
LABORATORY TEST					
Particle Size: Sieve	ASTM D 422	100% Finer than 3.0 inch	1 per 1,500	8	15
Compaction	ASTM D 698	---	1 per 1,500/ as required	8	15
Moisture	ASTM D 2216 ASTM D 4643	---	1 per 1,500/ as required	8	13 12
Soil Classification	ASTM D 2487	GC, SC, SM, ML or CL	1 per 1,500	8	15 (1)
Atterberg Limits	ASTM D 4318	---	1 per 1,500	8	15
FIELD TEST					
Sand Cone: Soil density Soil moisture	 ASTM D 1556 ASTM D 2216	 --- ---	1 per 25 passing Nuclear tests	15	
Nuclear Gauge: Soil density Soil moisture	 ASTM D 2922 ASTM D 3017	 ▾95% ▾ 3% O.M.C.	1/250 L.F./lift	17	367 (11)

NOTES: (1) Reference Section 02200 of the Specification and Section 6 of the CQA Plan for further details.

(2) The approximate number of tests required is based on a total volume of 11,000 yd^3 for the Phase I construction.

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TABLE 6-2

LEACHATE CONVEYANCE SYSTEM EMBEDMENT FILL

DESCRIPTION	TEST STANDARD	PROJECT(1) SPECIFICATIONS	TEST FREQUENCY (yd^3)	APPROXIMATE NUMBER OF TESTS REQUIRED(2)	NUMBER OF TEST PERFORMED (FAILURES)
LABORATORY TEST					
Particle Size: Sieve	ASTM C 136	Section 703.06 Ohio DOT	1 per 1,000	3	6 (3)
Soil Classification	ASTM D 2487	GW, GP, SW or SP	1 per 1,000	3	6
FIELD TEST					
Depth Verification: Survey	Visual	6 in. thick (compacted)(3)	---	---	---

NOTES: (1) Reference Section 02215 of the Specification and Section 6 of the CQA Plan for further details.
(2) The approximate number of tests required is based on a total volume of 3,000 yd^3 for the Phase I construction.
(3) Compacted using four passes with vibratory plate compaction.

TABLE 6-3

LEACHATE CONVEYANCE SYSTEM AGGREGATE BASE

DESCRIPTION	TEST STANDARD	PROJECT(1) SPECIFICATIONS	TEST FREQUENCY (yd^3)	APPROXIMATE NUMBER OF TESTS REQUIRED(2)	NUMBER OF TEST PERFORMED (FAILURES)
LABORATORY TEST					
Particle Size: Sieve	ASTM C 136	Item 304 Ohio DOT	1 per 1,000	2	2
Soil Classification	ASTM D 2487	---	---	---	2
FIELD TEST					
Depth Verification: Survey	Visual	6 in. thick (compacted)	---	---	---

NOTES: (1) Reference Section 02230 of the Specification and Section 6 of the CQA Plan for further details.

(2) The approximate number of tests required is based on a total volume of 40 yd^3 for the Phase I construction.

7. SUMMARY AND CONCLUSIONS

Construction of the OSDF Phase I project and Leachate Conveyance System project for the FEMP was carried out during the period from 28 April 1997 to the present time. During this time, GeoSyntec provided from one to ten on-site CQA personnel to monitor the construction of the OSDF Phase I and Leachate Conveyance System projects. As part of their CQA activities, CQA personnel monitored the construction and installation of the following components:

- earthwork (subgrade preparation, perimeter and intercell berm construction, compacted clay liner, LDS and LCS drainage layer construction, and protective layer);
- geosynthetics (installation of GCL, geomembrane primary and secondary liners, and geotextile layers);
- stormwater management facilities; access route; impacted material haul road adjacent to the OSDF; decontamination facility; and sedimentation basin construction; and
- leachate conveyance system (installation of LDS and LCS collection pipe, LDS and LCS gravity pipeline and forcemain pipe, manholes, and liner penetration boxes).

During construction of the above components, CQA personnel verified that conformance and CQA testing were performed on the construction materials at the frequencies required in the project documents, and that materials meeting the project document requirements were used. CQA personnel also verified that conditions or materials identified as not conforming to the project documents were replaced, repaired, and/or retested, or that clarifications to the project documents were approved by the designer to allow the conditions or materials to be used, as described in this report.

The results of the CQA activities undertaken by GeoSyntec as described in this report indicate that Phase I and the Leachate Conveyance System of FEMP OSDF were constructed in accordance with the Specifications and Construction Drawings, which were prepared by GeoSyntec Consultants, Atlanta, Georgia, as approved by FDF, DOE, OEPA and USEPA.

STATE OF OHIO
KENNETH
W. CARGILL
#E-60938
REGISTERED
PROFESSIONAL ENGINEER

Kenneth W. Cargill, P.E.
CQA Managing Engineer
Ohio P.E. No. 60938

APPENDIX A:

PHOTOGRAPHIC DOCUMENTATION

1. Trial weld for 8-inch leachate conveyance containment pipe.

2. Production welding of dual containment pipe, Leachate Conveyance System.

3. Compaction of pipe embedment fill, Leachate Conveyance System.

4. Tent structure for welding dual containment pipe during inclement weather.

5. Cutting geomembrane for conformance sample.

6. Geomembrane conformance sample being trimmed for shipment to MTL.

7. Foreground: Stabilizing Subgrade in Cell 1, OSDF.
   Background: Excavation of Cell 2, OSDF.

8. Powerscreen, Finlay 390C. One of three screening operations to remove oversized rock particles from clay liner material.

9. Processing Clay in Cell 1 with Soil Stabilizer (RACO 250).

10. In-place density testing using sand cone method, compacted clay liner Cell 1.

11. Use of nuclear gauge for in-place moisture/density check of compacted clay liner, Cell 1.

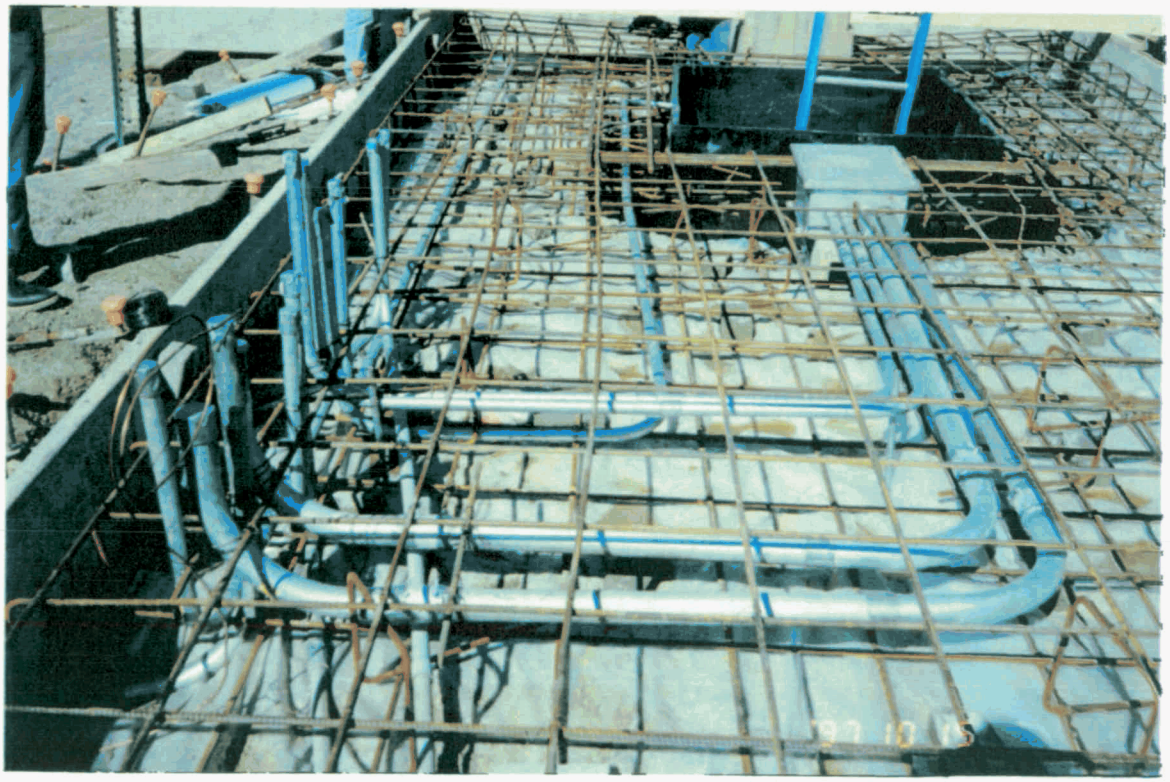
12. Installation of LDS-01 manhole (in progress).

13. Installation of 3-inch electrofusion coupling between LCS-01 and LDS-01 manholes (in progress).

14. Assembly of mitered lateral to be installed immediately north of permanent lift station.

15. Village Building Service backfilling/compacting fill for LDS/LCS pipes for Cell 1.

16. Installation of LDS pipe for Cell 1.

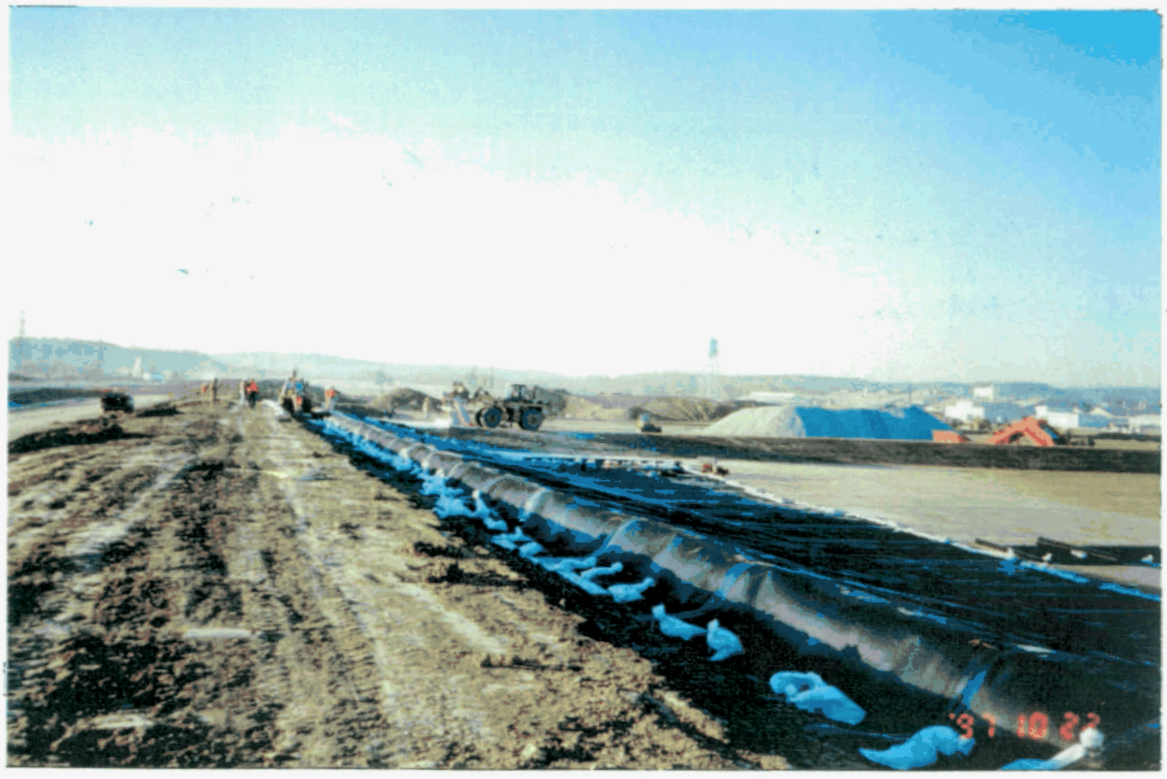


17. Conduit – layout at leachate lift station.

18. Deployment of secondary Geomembrane Line (GML) over deployed geosynthetic clay liner (GCL).

19. Secondary GML destructive sample (DS-2) location.

20. Non-destructive testing (air-pressure test) in progress for double fusion seam on secondary GML.



21. Secondary GML in-place along the east berm.

22. Deployment method for GCL on north berm over compacted clay liner.

23. Deployment of secondary GML over deployed GCL using ATV.

24. Foreground: Fusion seaming of secondary GML.
    Background: Secondary GML panel placement.

25. Installer performing non-destructive testing (vacuum box) on secondary GML extrusion repair/production seams.

26. Installer stitching seam (10-oz geotextile cushion) for secondary liner system.

27. Installer performing extrusion welding around liner penetration box on secondary GML.

28. Placement of No. 78 stone aggregate LDS drainage layer material over secondary GML/ geotextile cushion (note temporary haul road).

29. Drainage corridor stone placement.

APPENDIX B:

INTERIM CERTIFICATION LETTER

GEOSYNTEC CONSULTANTS

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17 December 1997

Mr. Michael A. Hickey
Fluor Daniel Fernald
MS: 64
P.O. Box 538704
Cincinnati, Ohio 45253-8704

Subject: Interim Construction Certification
On-Site Disposal Facility (OSDF), Phase I
and Leachate Conveyance System
Subcontract No. 95PS005028

Dear Mr. Hickey:

The purpose of this letter is to certify that the construction quality assurance and quality control (CQA and CQC) activities performed by GeoSyntec Consultants during construction of the On-Site Disposal Facility (OSDF), (Cell 1) and the Leachate Conveyance System (LCS) is substantially complete.

CQC personnel have monitored, tested, and documented placement of soil and geosynthetic components to include cell subgrade, compacted clay liner, granular leachate collection and detection layers, geosynthetic clay liner, geomembrane liners, and geotextile cushions and filters. We also monitored and documented construction and testing of the leachate collection and conveyance system. Field reports, logs, geotechnical and geosynthetic testing reports, and other associated documentation have been reviewed for accuracy and completeness. A final certification report including CQC record drawings is currently being completed. The final certification report will be submitted within 2 weeks.

Based on our observations and documentation, the OSDF Phase I construction and the LCS have been constructed in accordance with the project specifications, drawings, CQA Plan, and approved changes. The construction has been in full compliance with applicable or relevant and appropriate requirements (ARARs), functional requirements, and general design requirements described in the Design Criteria Package developed and approved during the design process. On the basis of our observations and testing, it is anticipated that Cell 1 of the OSDF will be ready to receive impacted material meeting the OSDF waste acceptance criteria (WAC) and the LCS will be ready to handle leachate from the cell on 19 December 1997.

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Boca Raton, FL
Huntington Beach, CA

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It is anticipated that this letter will satisfy Department of Energy and Environmental Protection Agency (both US and Ohio) requirements. If you have any questions, please do not hesitate to contact the undersigned.

Sincerely,

Kenneth W. Cargill, P.E.
Associate
Ohio P.E. No. E-60938

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