CEMP-C Engineer Pamphlet 415-1-261_5 Volume 5	Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	EP 415-1-261_5 Volume 5 15 July 1997
	Construction QUALITY ASSURANCE REPRESENTATIVE'S GUIDE Technologies Used at Hazardous, Toxic, and Radioactive Waste (HTRW) Sites to Contain or Clean-Up Contamination	
	Distribution Restriction Statement Approved for public release; distribution is unlimited.	

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, D.C. 20314

CEMP-C

Pamphlet
No. 415-1-261_5

15 July 1997

CONSTRUCTION
QUALITY ASSURANCE REPRESENTATIVE'S GUIDE

FOREWORD

This volume of the Quality Assurance Representative's Guide addresses technologies which are used predominantly at hazardous, toxic, and radioactive waste (HTRW) sites to contain or clean up contamination. The reason for this pamphlet's existence and continuance is to provide construction representatives, those with quality assurance/quality control responsibilities, a reliable checklist type reference for each phase of construction.

Quality Assurance/Quality Control (QA/QC) representatives will find the information useful and appropriate for their roles of assuring and controlling construction quality in accordance with the plans and specifications. The guide will, therefore, become a valuable reference when implementing project plans and specifications. Their contents will also help refresh the memory of experience, training, and good common sense. The application of sound knowledge together with a proper sense of responsibility and use of authority will result in meaningful decision making, a factor considered essential for effective quality assurance/quality control. The objective is to produce quality products for Corps' customers worldwide.

FOR THE COMMANDER:

OTIS WILLIAMS
Colonel, Corps of Engineers
Chief of Staff

SUMMARY of CHANGE

EP 415-1-261 Vol 5
Quality Assurance Representative's Guide – Technologies Used at Hazardous, Toxic, and Radioactive Waste (HTRW) Sites to Contain or Clean Up Contamination

This administrative revision, dated 28 November 2023—

- Corrects the Pamphlet number from EP 415-1-261 to EP 415-1-261_5

TABLE OF CONTENTS

CHAPTER 1
GENERAL INFORMATION FOR HTRW PROJECTS

Chapter 1 GENERAL INFORMATION FOR HTRW PROJECTS

1-1. INTRODUCTION. This document is a useful supplement to construction contract documents and provides detailed information on what a Quality Assurance (QA) Representative should be looking for during construction at Hazardous, Toxic and Radioactive Waste (HTRW) sites. The information provided is based on the Corps of Engineers guide specifications and the experience of Corps of Engineers designers and QA Representatives who have worked on HTRW sites. As a QA Representative, you must be thoroughly familiar with all the provisions of the contract documents, including amendments and submittals. These contract documents must be strictly enforced when administering the contract. If there are significant differences between the information provided in this document and the contract documents, contact your supervisor for guidance or clarification.

1-2. RESPONSIBILITY. The primary purpose of a QA Representative is to ensure that construction is carried out according to the plans and specifications. There are many unique requirements on HTRW projects which the QA Representative should be knowledgeable of, and ensure compliance with the following:

a. Federal, state, and local environmental laws and regulations which pertain to the project. Multiple submittals dealing with protection of the environment are generally required on HTRW projects;

b. Health and safety requirements for Government employees, contractors, and the public;

c. Compliance with regulatory training requirements;

d. Manifesting of contaminated materials;

e. Requirements for chemical sampling and testing;

f. Ensuring regulatory milestones are being met. Your supervisor should be notified of slips in the schedule so that the appropriate regulatory authorities can be notified in writing;

g. Management of special contracts such as cost reimbursable type contracts;

h. Monitoring of project funds due to lack of contingency funding on DERP projects and state contribution (cost sharing) for EPA lead projects;

i. Community relations plans; and

j. Procedures for site closeout.

1-3. REFERENCES.

Federal Regulations

-29 CFR 1926.65 - Hazardous Waste Operations and Emergency Response

-29 CFR 1910.120 - Hazardous Waste Operations and Emergency Response

-Federal Acquisition Regulation (FAR) 52.236-13

-Public Law 96-510, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, also known as Superfund

-Public Law 99-499, the Superfund Amendments and Reauthorization Act (SARA)

Engineering Regulations

-ER 385-1-92 - Safety and Occupational Health Document Requirements for HTRW Activities

-ER 1110-1-263 - Chemical Data Quality Management for Hazardous Waste Remedial Activities

Engineering Pamphlet

-EP 415-1-266 - Resident Engineer Management Guide

-EP 200-1-2 - Process and Procedures for RCRA Manifesting

Engineering Manuals

-EM 385-1-1 - Safety and Health Requirements Manual

-EM 200-1-1 - Validation of Analytical Chemistry Laboratories

-EM 200-1-2 - Technical Project Planning - Guidance for HTRW Data Quality Design

-EM 200-1-3 - Requirements for the Preparation of Sampling and Analysis Plans

-EM 1110-1-1804 - Geotechnical Investigations

-EM 1110-1-1906 - Soil Sampling

-EM 1110-1-4000 - Monitor Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites

-EM 1110-1-4001 - Soil Vapor Extraction and Bioventing

Corps of Engineers Guide Specifications

-CEGS 01110 - Safety, Health and Emergency Response

-CEGS 01450 - Contractor's Chemical Quality Control

Environmental Protection Agency References

-EPA/625/6-87/016 - Handbook-Ground Water

-EPA/600/R-93/182 - Quality Assurance and Quality Control for Waste Containment Facilities

-EPA/625/R-93/003a - Subsurface Characterization and Monitoring Techniques: A Desk Reference

-EPA/542/b-94/013 - Remedial Technologies Screening Matrix and Reference Guide

-EPA/530/SW-91/051 - Technical Guidance Document: Inspection Techniques for the Fabrication of Geomembrane Field Seams

American Society of Testing Materials

-ASTM D 422-63(1990) - Test Method for Particle-Size Analysis of Soils

-ASTM D 698-91 - Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))

-ASTM D 1140-92 - Test Method for Amount of Material in Soils Finer Than the No. 200 (75-um) Sieve

-ASTM D 1556-90 - Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

-ASTM D 1586-84(1992) - Test Method for Penetration Test and Split-Barrel Sampling of Soils

-ASTM D 1785-94 - Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40,80, and 120

-ASTM D 2167-94 - Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

-ASTM D 2216-90 - Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock

-ASTM D 2241-94 - Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)

-ASTM D 2488-93 - Description and Identification of Soils (Visual-Manual Procedure)

-ASTM D 2922-91 - Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depths)

-ASTM D 3017-88(1993) - Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depths)

-ASTM D 3034-94 Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings

-ASTM D 4318-93 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

-ASTM D 4643-93 - Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method

-ASTM D 5084-90 - Measurement of Hydraulic Conductivity of Saturated Porous Material Using a Flexible Wall Permeameter

-ASTM D 5088-90 - Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites

-ASTM D 5092-90 - Recommended Practice for Design and Installation of Ground-Water Monitoring Wells in Aquifers

-ASTM D 5093-90 - Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed Inner Ring

-ASTM D 5299-92 - Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities

-ASTM D 5521-94 - Guide for Development of Ground-Water Monitoring Wells is Granular Aquifers

-ASTM D 5608-94 - Practice for Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites

-ASTM D 5890-95 - Swell Index of Clay Mineral Component of Geosynthetic Clay Liners

-ASTM D 5891-95 - Fluid Loss of Clay Component of Geosynthetic Clay Liners

1-4. AUTHORITY. Make sure you know the extent and source of your authority. Failure to coordinate with the customer could jeopardize future work for the Corps of Engineers (USACE). There are several types of projects for which the USACE does HTRW construction oversight. The level of authority the QA Representative has varies depending on the type of project. The following paragraphs describe the types of projects for which the USACE has provided construction oversight.

a. Comprehensive Environmental Response, Compensation, and Liability Act. In February 1982, the USACE entered into an Interagency Agreement (IAG) with the Environmental Protection Agency (EPA) to provide assistance in executing Public Law 96-510, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, also known as Superfund. The Superfund legislation was amended in 1986 by Public Law 99-499, the Superfund Amendments and Reauthorization Act (SARA). Superfund projects are initiated by the EPA to clean up contamination which has resulted from past site activities. The level of oversight required on Superfund projects depends on the type of project and what requirements are established between the EPA and the USACE. These requirements then establish the basis for a site-specific IAG between the EPA and the USACE. All site-specific documents (IAG's, Consent Orders, etc...) should be carefully reviewed so that USACE personnel clearly understand the extent of their authority. Superfund projects are divided into Fund Lead projects and Enforcement Lead projects.

(1) Fund Lead Projects. Fund Lead projects use public funds (Superfund Trust Funds) to clean up hazardous waste sites. The USACE has been involved with the design and construction of many of these projects. During construction, the QA Representative will usually have similar authority to that exercised on standard USACE projects. Processing of payments under the Superfund program requires that special procedures be followed. Refer to EP 415-1-266 for specific details.

(2) Enforcement Lead Projects. Enforcement Lead Projects refer to projects where a Potentially Responsible Party (PRP) (private party or a Government agency) has accepted, through a consent decree, responsibility for cleaning up a hazardous waste site. The EPA has occasionally asked the USACE to do construction oversight for Enforcement or PRP Lead Projects. On this type of project, the USACE personnel usually only report construction deficiencies and safety violations to the EPA and do not have the authority to direct contractor activities. A prior agreement between USACE personnel and

the EPA Remedial Project Manager on how to handle imminent safety hazards should be in place for all Enforcement Lead Projects.

b. Defense Environmental Restoration Program (DERP). DERP was established in 1984 to evaluate and remediate contamination at Department of Defense sites. DERP is implemented subject to, and in a manner consistent with, CERCLA and SARA, however, environmental restoration under this program is not limited to those activities legally required by CERCLA. DERP projects are separated into two categories: Installation Restoration Program (IRP) and Formerly Used Defense Sites (FUDS). IRP work is done at active military bases while FUDS work is performed at sites formerly used by the military where contamination resulted from military activities. The level of authority that a QA Representative has on DERP projects will usually be similar to that exercised on standard USACE construction projects.

c. Base Realignment and Closure (BRAC) Program. The BRAC program requires closure and subsequent disposal of designated Department of Defense installations. Environmental restoration is required at many BRAC sites and the USACE is involved in many of these environmental restoration projects. The level of authority that a QA Representative has, varies from project to project and, should be defined prior to the start of construction.

d. Civil Works Projects. HTRW projects also exist on properties owned, or operated and maintained by USACE-Civil Works. The level of authority the QA Representative has varies from project to project and should be defined prior to the start of construction.

e. Environmental Support for Others (ESFO). The USACE, upon request, provides environmental restoration support for other Government agencies such as the Department of Energy, the General Services Administration, and the Federal Aviation Administration, etc. The level of authority the QA Representative has varies from project to project and should be defined prior to the start of construction.

1-5. REAL ESTATE. Land not owned by the Government is often required for support zones, decontamination facilities or other construction purposes. There are a number of methods for obtaining access to, and the use of, such lands. These methods include the use of a right-of-entry, a lease, a negotiated purchase, or a condemnation of an interest in the property, if it is either privately owned or owned by a non-Federal Governmental entity. A permit may be required if the land is controlled by another Federal agency. A Real Estate Planning Report (REPR) is typically prepared during the design phase of HTRW projects which determines how access to such lands will be obtained. The Contracting Officer's Representative (COR) should verify that access to the construction site has been obtained prior to advertisement of a construction project in accordance with the REPR or other planning documents. QA Representatives should:

a. Know the boundary of Government-owned, leased or controlled property;

b. Ensure that construction contractors do not trespass upon property located outside the boundaries of the construction site; and

c. Notify your supervisor if access to additional property is required to accomplish the construction of the project.

d. On long-term projects, be aware of the termination dates of any rights-of-entry, leases, or temporary easements and notify your supervisor in sufficient time to allow for their extension if access is required beyond such dates.

1-6. <u>CHEMICAL QUALITY CONTROL AND QUALITY ASSURANCE</u>. A unique aspect of most HTRW projects is the additional responsibilities of both the contractor and the QA Representative with respect to ensuring the quality of sampling and chemical data. ER 1110-1-263, Chemical Data Quality Management for Hazardous Waste Remedial Activities prescribes chemical data quality management responsibilities and procedures for chemical sampling, handling, and testing to assure analytical data obtained is of sufficient quality to meet the intended needs of a project. It should be noted that the latest revision of ER 1110-1-263, promotes enhanced flexibility for QA activities for chemical data quality management for HTRW projects. The project management team, including technical support staff, determines the appropriate level of compliance monitoring. This determination is made based upon the intended use of the analytical results and the degree of confidence needed in the quality of the results. The required level of compliance monitoring is established using the Data Quality Objectives (DQO) process (see EM 200-1-2) and should be summarized in the Sampling and Analysis Plan (SAP). Compliance monitoring may consist of a combination of activities including: validation of laboratories; sample shipment inspections by the QA laboratory; field and/or laboratory QC and QA sample analysis; laboratory analysis of double-blind performance evaluation samples; validation of laboratory data using USEPA regional or national functional guidelines; validation of data using project-specific guidelines; and the evaluation of laboratory data using comparisons of field sample, QC sample, and QA sample analysis results.

a. Chemical Data Quality Management (CDQM). A specification section which covers chemical data quality management (usually Section 01450) should exist in every set of plans and specifications for HTRW and UST projects where environmental, process control, or waste samples will be collected and analyzed.The document should be reviewed as part of the Biddability, Constructibilty, Operability and Environmental (BCOE) Review so that the QA Representative becomes familiar with the CDQM requirements. This specification will outline a detailed plan, and related data quality objectives, for collecting and analyzing samples from all media. The specification will address all chemistry testing, including field screening and definitive field analysis using standard and modified protocols.

b. Sampling and Analysis Plan (SAP). The contractor is required to prepare and submit a SAP for acceptance prior to commencement of sampling activities. A SAP is comprised of a Field Sampling Plan (FSP) and a Quality Assurance Project Plan (QAPP). Chemical measurements for the initial phases of the contract may be allowed by the COR through an Interim Sampling and Analysis Plan (ISAP) in accordance with CEGS 01450. The following paragraphs provide definitions of the plans referenced above.

(1) SAP - A submittal comprised of the FSP and QAPP. The SAP is used to define all aspects of the project sampling and analytical work to be done.

(2) FSP - That portion of the SAP which defines the field activities. It includes all requirements for sampling, field documentation, onsite chemical analysis, sample packaging, etc.

(3) QAPP - The portion of the SAP which defines the laboratory analytical and chemical data reporting requirements.

c. Chemical Data Quality Control Plan (CDQCP). The contractor is also required to prepare and submit a CDQCP for acceptance prior to the initiation of related site activities. The purpose of this plan, distinct from the SAP, is to propose the chemical data quality control (QC) system, staff, and qualifications that will be utilized to carry out the CDQM specification.

d. HTRW Chemistry Laboratories. Each HTRW construction project involving chemical sampling and analysis may require the utilization of a HTRW Chemistry Laboratory for QA program support. If split samples are to be generated for the project, support provided by the designated QA Laboratory would include inspection of split sample shipments, analysis of split samples, and preparation of a Chemical Quality Assurance Report.

e. Review of contractor CDQM Submittals. Assistance in review of contractor submittals related to CDQM are to be made available from the designated HTRW design district, the HTRW Chemistry Laboratory (assigned QA lab) or the HTRW CX. It is the responsibility of the HTRW design district or the HTRW Chemistry Laboratory to arrange for HTRW CX review support if necessary.

f. Contractor Reports. Contractor reports include Daily Chemical Quality Control Reports and Chemical Quality Control Summary Reports. Chemical Data Interim Reports can be utilized for long term projects in order to aid the HTRW Chemistry Laboratories in producing split sample comparative data for Chemical Quality Assurance Reports. The CDQM specification should detail requirements for the timing of interim data reports.

g. Chemical Quality Assurance Report (CQAR). As part of the data evaluation process, the designated QA laboratory may provide a single or multiple CQARs to the Technical Manager. In general, this report will provide an evaluation related to each split sample shipment with regard to the status of sample integrity (i.e., appropriate sample packaging and preservation) as well as an evaluation of internal QC for the contractor’s data set and the comparison of referee sample and primary sample data.Data discrepancies will be noted in the report which will aid the QA Representative in making judgements relative to measurement and payment or potential resampling. When required, the CQAR should be made available within a maximum of 30 days of the contractor’s data being reported to the QA Laboratory.

h. Laboratory Validation. Laboratories providing sample analyses utilizing standard environmental analytical methods should be validated by CEMRO-HX-C in accordance with EM 200-1-1. For laboratories which have never been validated for USACE HTRW projects, 12 to 16 weeks should be allowed for this process to be completed.

i. Guidance. The basic requirements for the USACE CDQM program are detailed in ER 1110-1-263, Chemical Data Quality Management for Hazardous, Toxic, and Radioactive Waste Remedial Activities. Related USACE guidance includes, EM 200-1-1, Validation of Analytical Chemistry Laboratories, EM 200-1-2, Technical Project Planning - Guidance for HTRW Data Quality Design, EM 200-1-3, Requirements for the Preparation of Sampling and Analysis Plans, and Corps of Engineers Guide Specification 01450, Chemical Data Quality Control.

1-7. HEALTH AND SAFETY REQUIREMENTS.

a. General. A specification section which covers safety, health, and emergency response (usually Section 01110 from CEGS 01110 - "Safety Health & Emergency Response (HTRW/UST)") should exist in every set of plans and specifications for HTRW and underground storage tank (UST) projects. This section should be reviewed as part of the Biddability, Constructibility, Operability, and Environmental (BCOE) Review so that the QA Representative becomes familiar with the health and safety requirements. The specification should identify minimum initial health and safety requirements (for personal protective equipment (PPE), training,decontamination, air monitoring, etc.) that the contractor must address in the Site Safety and Health Plan (SSHP).

b. Pre-Bid Site Inspections/Visits. All prospective bidders entering contaminated areas of the site, or who will handle samples, soil/core borings, etc. should develop their own abbreviated SSHP for the site inspection activities. Any site visits by prospective bidders into contaminated areas should require the following (Refer to EP 415-1-266, Section 3, for more details):

(1) Compliance with the abbreviated SSHP for the site visit;

(2) Presentation of minimum documentation of compliance with training and medical surveillance requirements of OSHA, 29 CFR 1910.120/ 29 CFR 1926.65; and

(3) Signing of a "hold-harmless"-type liability waiver statement (consult District Counsel for wording).

(4) Site visit announcements should specify if prospective bidders must provide their own appropriate PPE in accordance with their abbreviated SSHP. Disposable PPE may be the most appropriate, if an accessible means of collecting and disposing of the PPE is in place at the site. Otherwise, some form of decontamination facility is required.

c. Notice-To-Proceed. Frequently, a phased Notice-To-Proceed, (NTP),is issued where the contractor may work on submittals or perform non-intrusive site activities in the support zone or clean areas of the site pending acceptance of the SSHP and approval of the CDQCP and SAP.

d. Site Safety and Health Plan (SSHP). The contractor is required to prepare and submit a SSHP for acceptance prior to commencement of on-site activities. A SSHP is the contractor's site-specific plan to comply with OSHA Standard 29 CFR 1926.65 - "Hazardous Waste Operations and Emergency Response" (the OSHA construction standard version of 29 CFR 1910.120). Specific HTRW requirements are identified in EM 385-1-1 - "Safety and Health Requirements Manual" and ER 385-1-92 - "Safety and Occupational Health Document Requirements for HTRW Activities." CEGS 01110 and ER 385-1-92 specify that the Federal Acquisition Regulation (FAR) 52.236-13 for a separate Accident Prevention Plan (APP) shall be considered met if the contractor integrates the components of the APP, including activity hazard analyses, into the SSHP submission. ER 385-1-92 requires the field office to utilize the industrial hygiene/safety professionals in their geographic district's Safety and Occupational Health Office (SOHO) to review and recommend acceptance of the contractor's SSHP to the COR. Acceptance of the SSHP by the COR is usually given to the contractor by official letter, and is subject to satisfactory implementation by the contractor. While it is the Government's responsibility to monitor implementation of the SSHP, including activity hazard analyses, acceptance of the SSHP by signing or initialing the documents should not be performed. The SSHP is the contractor's plan, and the contractor retains the responsibility for its content and implementation at the site.

e. Site Safety and Health Plan Modifications. Once the SSHP is accepted, it becomes an enforceable contract document. The SSHP can be modified by the prime contractor's Site Safety and Health Officer (SSHO) and the certified industrial hygienist (CIH), with concurrence of the QA Representative, at any time. If there are questions on any modifications, the QA Representative should consult with the geographic district Safety and Occupational Health Office (SOHO) and/or the design district to receive recommendations for concurrence.

f. Daily Inspections. The SSHO's daily inspection logs should be attached to and submitted with the Daily Quality Control Reports.

1-8. ORDNANCE AND EXPLOSIVES (OE) REQUIREMENTS. If you encounter or suspect the presence of OE on your site, you must immediately stop the work and request assistance and advice from your district. Personnel involved in activities where OE may be present must receive training on ordnance recognition and safety. Assistance from the OE Design District and the OE Center of Expertise(CX)is mandatory to ensure safe operations. If OE is present at the site, the following questions should be asked:

a. Is there a site safety plan approved by the OE CX?

b. Are construction personnel with the proper training and qualifications on site to provide QA and oversight activities?

1-9. WORK PLANS AND OTHER SUBMITTALS. HTRW projects have many unique submittal requirements which are in addition to those required for non-HTRW projects. The following is a list of some of the HTRW specific submittal requirements:

a. Plan of Operations;

b. Remedial Action Plan;

c. Closure Plan;

d. Materials Handling Plan;

e. Chemical Sampling and Testing Plans (SAP and CDQCP);

f. Manifesting and other Regulatory Compliance Procedures;

g. Spill Prevention Control and Countermeasures Plan;

h. Dust, Vapor, and Odor Control Plan; and

i. Storm Water Pollution Prevention Plan.

The actual submittal list will be developed by the contractor and USACE on ENG Form 4288-R. Submittals may or may not have the actual titles listed above and some subjects may be combined and others separated. Some submittals may require review and approval from Federal, state or local regulators as well as several offices and laboratories within the USACE. Subsequent chapters of this document will describe submittal requirements for specific processes and technologies. The QA Representative should be aware of submittal approval requirements, i.e., whether or not submittal is required by:

(1) Other districts, divisions, or laboratories within the USACE; or

(2) Government agencies outside of the USACE.

1-10 HANDLING AND STORAGE OF MATERIALS.

a. Materials Handling Plan (MHP). A MHP describes procedures for the safe handling of contaminated liquids and solids. The plan describes off-site transportation and disposal of materials, manifesting requirements, and chain-of-custody procedures. A MHP may also discuss imported fill materials, truck routes to be used, traffic safety plans, and special road permits (if required).

b. Manifesting Requirements. USACE personnel involved with on-site management and manifesting of hazardous material must complete specialized training. USACE policy and guidance on hazardous material manifests and shipping has been issued under the following references:

(1) EP 200-1-2, "Process and Procedures for RCRA Manifesting". This document summarizes the training requirements and procedures for manifesting hazardous materials;

(2) Construction Bulletin No. 96-9, 13 Mar 96, Subject: Hazardous Waste Manifest Signature Policy and Procedures;

(3) CEMP-RT memorandum dated 30 April 93, Subject: Signatory Responsibility for Hazardous Waste Manifests and Related Documents - Policy Guidance;

(4) EP 415-1-266 Resident Engineer Management Guide for HTRW Projects; and

(5) PROSPECT Course - Hazardous Waste Management and Manifesting, Course Control Number 223 and Department of Transportation (DOT) Refresher Training and Certification, Course Control Number 429.

c. Treatment Storage and Disposal Facility (TSDF). The plans and specifications should provide criteria for selection and approval of an off-site TSDF. The facility selected may require pre-approval by the USACE and/or the EPA.

1-11. PROGRESS SCHEDULES. The following items should be considered when reviewing the progress schedule.

a. Delays are possible due to regulatory review. Verify that sufficient time for regulatory review has been incorporated into the schedule.

b. Ensure that the schedule includes sample analysis turnaround time, especially if sample results (such as background air or water monitoring) are required before a specific phase of work can begin.

c. Consider how the schedule will be affected if items such as the SAP must be submitted more than once prior to approval.

1-12. COMMUNITY RELATIONS PLAN. A community relations plan is required on all CERCLA projects. AR 200-1 Environmental Protection and Enhancement requires a community relations plan for all IRP and FUDS properties that have sites included or proposed for inclusion on the National Priorities List. Typically, QA representatives will only provide a support role to EPA and will not become the lead in community relations activities at CERCLA Sites. However, due to their full-time on-site presence, QA Representatives are often faced with being the first point of contact for concerned citizens, media representatives, etc.

a. The QA Representative should review the community relations plan.

b. The QA Representative should be familiar with those who are charged with responding to citizens and media inquiries, and should regularly consult with these people.

1-13. PERMITS. The contractor is often required by the specifications to obtain construction permits (building and electrical permits, etc.) for various on-site activities. For on-site activities under CERCLA, Federal, state, and local permits are not required. However, the Government and its contractors must comply with the substantive requirements of all Applicable or Relevant and Appropriate Requirements (ARARs) (Federal, state, and local laws) identified in the Record of Decision (ROD)/Enforcement Decision Document (EDD).

a. Do the plans and specifications identify permit requirements and who is responsible for obtaining each?

b. Has the Government and/or contractor obtained the permits for which each is responsible?

c. Are there any fees or prequalification requirements.

d. Have all installation permits (digging, electrical, etc...) been obtained.

1-14. PRECONSTRUCTION CONFERENCE.

a. Ensure appropriate USACE personnel, along with the installation, EPA (including the Potentially Responsible Party(s), if applicable), state, and local officials, are invited to the preconstruction conference.

b. In some instances representatives from the QA laboratory, the designated HTRW design district, and/or the HTRW CX should attend the conference.

c. Multiple preconstruction meetings may be required due to the complexity of some HTRW projects.

d. The QA Representative will be responsible for assisting the COR in setting the agenda and conducting preconstruction conferences.

1-15. QUALITY CONTROL DAILY REPORT. Quality Control Daily Reports are broader in scope for HTRW sites because of issues related to health and safety, regulatory requirements, and chemical sampling and analysis. The following are items commonly submitted in Quality Control Daily Reports for HTRW sites:

a. Daily health and safety report;

b. Calibration data and certification of testing equipment; and

c. Qualifications of personnel performing testing and monitoring.

If chemical sampling and analyses are included in a report, The QA Representative should submit copies to the QA laboratory.

1-16. QUALITY ASSURANCE DAILY REPORT. The primary focus of QA reports is to document the QA tasks which have been performed. QA reports are also important for supporting construction costs for contracts which contain unit price items, and for cost-reimbursable contracts such as Total Environmental Restoration Contracts (TERC). Daily reports need to be accurate to support audits and prevent double billing.

1-17. SPILL REPORTING. There are many different environmental regulations that require spill reporting and notification of regulatory agencies. Since the USACE does work for many different customers, the person or agency responsible for reporting spills may vary depending upon the project. In all cases, USACE employees must report spills as required by statute and regulation. Just notifying the customer does not relieve the USACE or contractor personnel of liability. Guidance on complying with spill reporting regulations is provided in the Headquarters Memorandum entitled “Spill Reporting Procedures for USACE Personnel Involved in HTRW Projects” dated 20 July 1995.

a. Are you familiar with the spill reporting requirements for the project?

b. It is recommended that QA Representative consult with the Office of Counsel regarding spill reporting requirements prior to undertaking management of a project.

c. Verify the contract specifications contain a section which outlines contractor responsibilities regarding spill reporting requirements.

1-18. PHOTOGRAPHS. Photographs and videos are taken to document site conditions and activities. Remotely located video cameras (including time-lapse surveillance) are often used to allow the QA Representative to inspect construction activities without putting on protective equipment and physically visiting the construction site.

a. Site conditions prior to the start of site activities should be documented with photographs or video tapes. Aerial photographs can also be valuable in documenting preconstruction site conditions. Make frequent checks of video cameras to ensure they are operable and positioned correctly.

b. Photographs or videos of existing roads used as haul routes should be taken prior to the start of construction to help document potential damage resulting from construction traffic.

c. Photographs or videos should document each phase of construction, equipment used, and construction techniques.

d. Dates and activities shown on photographs and videos should be well documented.

1-19. CLAIMS. There are many opportunities for the contractor to make claims against the Government on HTRW projects because it is often difficult to characterize the nature and extent of contamination during design.

a. Differing site conditions should be immediately documented and reported to your supervisor.

b. Time spent by contractors due to differing site conditions or regulatory changes should be carefully documented.

c. Determine if additional testing is required to verify differing site conditions.

d. Actual quantities often exceed estimated quantities on HTRW sites. Carefully document actual quantities.

1-20. CLOSEOUT REPORTS AND RECORD DRAWINGS.

a. There are additional record keeping requirements for HTRW projects. Record drawings are required for things such as monitoring well installation, geomembrane panel layout, and sampling locations. Subsequent chapters will provide more detail on requirements for record drawings.

b. Closeout reports are required for EPA projects. Closeout reports are also required by most states for UST removals.

c. States and other agencies often have requirements for submission of record drawings, analytical data, and other information.

1-21. OPERATION AND MAINTENANCE (O&M). Specific O&M requirements are covered in subsequent chapters of the document. The specifications should be reviewed to determine what permits are required for O&M of the facility.

a. Confirm the requirements for startup, O&M, and transition of the facility to the follow-on agency/operator are detailed in the contract specifications.

b. Check requirements for spare parts, replenishment of chemicals, etc. at the time of project transfer.

c. Operating permits may take considerable effort and time to obtain. Have required operating permits been obtained by the Government or contractor?

d. Have applicable project files been transferred from the construction contractor to the operation and maintenance agency/contractor.

1-22. WARRANTIES. Make sure you are clear about when warranties begin. Warranties generally begin at project acceptance and not with completion of the O&M phase. In fact, these periods are both typically one year in length so both would expire at the same time, and just as the project is being transferred. Careful BCOE review and coordination is necessary to ensure that both the O&M and warranty provisions are acceptable to the end user of the facility.

1-23. ACRONYMS. The following is a list of acronyms used in this document:

Acronym	Definition
APP	Accident Prevention Plan
ARAR	Applicable or Relevant and Appropriate Requirement
ASTM	American Society for Testing and Materials
BCOE	Biddability, Constructibility, Operability and Environmental
BRAC	Base Realignment and Closure
CDQCP	Chemical Data Quality Control Plan
CDQM	Chemical Data Quality Management
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CIH	Certified Industrial Hygienist
COR	Contracting Officer's Representative
CQAR	Chemical Quality Assurance Report
CX	Center of Expertise
DERP	Defense Environmental Restoration Program
DO	Dissolved Oxygen
DOT	Department of Transportation
DQO	Data Quality Objectives
EDD	Enforcement Decision Document
EPA	Environmental Protection Agency
ESFO	Environmental Support for Others
FAR	Federal Acquisition Register
FSP	Field Sampling Plan
FUDS	Formerly Used Defense Sites
GAC	Granular Activated Carbon
GCL	Geosynthetic Clay Liners
HDPE	High Density Polyethylene
HTRW	Hazardous, Toxic and Radioactive Waste
IAG	Interagency Agreement
IRP	Installation Restoration Program
ISAP	Interim Sampling and Analysis Plan
MHP	Materials Handling Plan
O&M	Operation and Maintenance
OE	Ordnance and Explosives
ORP	Oxidation-Reduction Potential
OSHA	Occupational, Safety and Health Administration
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride

QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
REPR	Real Estate Planning Report
ROD	Record of Decision
SAP	Sampling Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCADA	Supervision Control and Data Acquisition
SDRI	Sealed Double Ring Infiltrometer
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
VFPE	Very Flexible Polyethylene

CHAPTER 2.1
GROUND WATER EXTRACTION WELLS

CHAPTER 2.1 GROUND WATER EXTRACTION WELLS

2.1-1. GENERAL. Ground water extraction wells are often an integral part of a pump and treat system. The extraction wells remove contaminated ground water or create a hydrologic barrier to the movement of a plume of contaminated ground water. Each well extracts water at rates that can vary from a few gallons per minute up to hundreds of gallons per minute. Other fluids, such as non-aqueous phase liquids, may also be removed using extraction wells. The water from an extraction well system usually is pumped to a treatment plant where the contaminants are removed. After the water has been treated, it may be discharged back into the subsurface, to a sewer system, or to a lake or stream. Subsurface discharge can be accomplished by means of one or more recharge wells. These wells are designed to recharge ground water, to provide some measure of hydrologic control on the migration of the contaminated ground water, or to create a flushing of contaminants toward adjacent extraction wells.

a. Scope. This section describes the installation of ground water extraction and recharge wells. Monitoring wells and piezometers are also installed as part of ground water extraction systems and they are discussed to a limited extent in this section. For the purposes of this document, the term piezometer will refer to a device that is used to measure the ground water elevation of a particular hydrologic unit (geologic material that has distinct hydrologic parameters), whereas a monitoring well will be used to obtain a representative water sample in addition to water elevation data. See EM-1110-1-4000, and ASTM D 5092 for more detailed information on monitoring wells.

b. Equipment.

(1) Well Drilling Equipment.

(a) Determine that the drill rig has been inspected in accordance with the provisions of EM-385-1-1 (Chap. 16).

(b) Confirm that the contractor is maintaining records of tests and inspections on site.

(c) Confirm the rig is free of fluid leaks and has been decontaminated prior to moving onto the drilling location. ASTM Standards D 5088 and D 5608 address decontamination of field equipment.

(d) Confirm that the drill rig is capable of performing the approved drilling method. Additional guidance on drilling methods can be found in EPA/625/6-87/016.

(e) Ensure that the driller has all of the sampling equipment for the required geotechnical and chemical samples (split spoons, stainless steel split spoons, shelby tubes, etc.). Additional guidance on sampling methods can be found in EM 1110-1-1906 and EPA/625/R-93/003a.

(f) Ensure that the rig is equipped to carry out Standard Penetration Tests per ASTM D-1586.

(2) Personnel.

(a) Ensure that the driller is licensed in the State to perform the required work.

(b) Confirm that all persons working in the exclusion zone meet OSHA requirements for training and medical surveillance and that they have read and signed the SSHP. They also must be wearing appropriate protective clothing as described in the SSHP.

c. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Drilling and Well Installation Plan which describes:

the drilling method and equipment;

well installation procedures;

soil/rock logging procedures and forms;

soil sampling and sample handling procedures;

drill cuttings/fluid handling plan;

well development procedures;

well testing procedures and equipment;

well permitting information (copies of all permits must be maintained on site);

procedures to obtain digging permits/utility clearances; and

decontamination procedures.

The plan needs to outline the responsibilities and authorities for each of the above activities.

(a) Verify that the drilling subcontractor has read the well installation specifications prior to installation of the wells.

(b) Qualifications for the driller should be submitted if licenced drillers are required in that state. Verify that the qualifications meet the specifications and any state requirements. The qualifications, including education and experience, of the geologist or engineer responsible for logging the materials encountered in drilling should also be submitted for information.

(2) Submittals or catalog information on:

well screen and casing;

cement and/or bentonite well sealant;

precast well head vaults (if applicable);

piping;

pump(s) and associated equipment;

gauges and controls; and

electrical components.

(3) Gradation test results for filter pack material and pipe bedding/backfill, if required.

d. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Boring logs for extraction, injection, or monitoring wells.

(2) Proposed well locations or well screen placement may be a submittal if well construction was left to the contractor based on conditions encountered. Contact the design district if uncertainty exists about the adequacy of the proposal.

(3) Well construction diagrams for each well installed.

(4) Water yield test results for individual extraction (or recharge) wells. Water yields are determined by performing specific capacity tests and are used to verify design assumptions. Results of these tests may need to be submitted to the designer for review and approval.

(5) Chemical sampling results from the initial well sampling.

(6) Water level measurements and contour maps as required. This information may need to be submitted to the designer for review and approval.

(7) Geophysical logs such as gamma, neutron, resistivity, etc., if required.

(8) Well development records including parameter measurements and any required photos.

(9) Well testing records such as specific capacity tests.

(10) Well registration records with local/state authorities if the contractor has been assigned this responsibility.

e. Start-up Submittals. The contractor should provide start-up submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Completed Start-Up Checklist. This checklist is used to ensure that the equipment and controls will perform safely and as expected.

(2) Start-up Monitoring Plan. This plan identifies procedures for initial start-up of the system including step-by-step procedures for valve settings, circuit checks, energization, and monitoring.

2.1-2. PRODUCTS.

a. Water. Verify that the source of any water used in the drilling/development process is approved in the specifications or chemical testing has been performed to verify it is of adequate quality. Note, use of water from sources with free chlorine may result in contamination of the well with trihalomethanes. This may be a problem depending on the contaminants present in the ground water.

b. Below-Ground Equipment.

(1) Screen.

(a) Verify that well screen slot type, slot aperture, and material (composition and wall thickness) are consistent with specifications and the filter pack being used.

(b) New well screen should be used for all wells. It should be cleaned and wrapped at the factory. On-site, the screen should be stored in a clean, safe location where it will not be damaged by equipment. If the screen is not wrapped or is otherwise suspect, require the screen to be steam cleaned and protected until installation.

(2) Casing.

(a) Verify that well casing diameter, schedule, and material type meet specified requirements.

(b) Assure that joints can be made water-tight.

(c) Well casing should be new and wrapped at the factory. On-site, it should be stored in a clean, safe location where it will not be damaged by other equipment.

(3) Filter Pack.

(a) Check that the grain size of the filter pack is compatible with the formation and the slot size of the well screen is appropriate for the filter pack gradation selected. The filter pack should also meet all specifications for cleanliness, roundness etc.

(b) If no filter pack gradation is given, check that the filter pack is a uniform sand or gravel of gradation large enough to prevent entry of the pack through the screen slots. Uniform means it has a uniformity coefficient of 2.5 or less. The uniformity coefficient is the sieve aperture passing 60 percent (D60) of the material divided by the sieve aperture passing 10 percent (D10) of the material.

(c) Determine if a sieve analysis of material from the formation is required and ensure the test is carried out in accordance with the specifications.

(4) Well Seal. There is a wide variety of requirements for well seals among the various regulatory agencies. Therefore, the inspector must review the contract documents and regulations since each project will be different.

(a) Sodium-type bentonite must be used and should be provided in the form required by specifications.

(b) Pellets or granules should be used for bentonite seals.

(c) Cement must meet specified requirements for type and must be mixed with the appropriate amount of water.

(d) In the absence of a specified mix, allow use of 6-8 gallons of water to one 94-lb bag of cement.

(e) Bentonite powder may be mixed with the cement to reduce shrinkage.

(f) If not specified, allow 3-5 percent mixture of bentonite in the cement by weight.

(g) The bentonite powder should be mixed with the water before adding the cement to assure adequate mixing.

(5) Well vaults.

(a) Verify consistent diameters of vault penetrations with associated casing, piping, or utility conduits.

(b) Vault covers must be appropriate for traffic conditions if flush-mounted.

(c) Ensure the ground surface slopes away per specified requirements.

(d) Assure that adequate means of opening large vault covers are provided.

(e) Ensure proper labeling and painting of vault covers as required by the specifications.

(f) Ensure that covers and locking mechanisms perform according to specified requirements.

(g) Ensure that there is proper labeling of all valves, switches, etc.

(h) Ensure that all confined space requirements are clearly labeled, if required.

(6) Piping.

(a) Piping must meet requirements for schedule, diameter, and joints.

(b) Ensure that the piping is adequately supported.

2.1-3. EXECUTION.

a. Drilling.

(1) Confirm that the necessary notifications/drilling permits have been obtained from the State, County or appropriate agency before any drilling commences.

(2) Confirm that any required easements, leases, rights-of-way, etc. have been obtained.

(3) Confirm that the Public Affairs Office has been notified, when required, and that the contractor(s) know who to notify in case of public inquiries.

(4) Check that all utility clearances have been received for the subsurface work and that there are no overhead hazards that will

interfere with raising or lowering the drill mast.

(5) Determine that drilling locations are correct. If it is impossible to install a well in a specified location, determine the best alternate location that meets the requirements of the design. If there are any questions about a possible alternate location, contact the design district to confirm a new location.

(6) Confirm that safe drilling procedures are used and that an exclusion zone is well defined around the drill rig. Also verify that required safety equipment is present and that it is calibrated and operated in accordance with the requirements of the SSHP.

(7) If required, confirm that all drill cuttings and or liquids are screened, drummed, labeled and stored in accordance with the work plan. Ensure that any sampling of the drums is done in accordance with the sampling plan. On non-CERCLA sites, a RCRA hazardous waste determination should be made for all containerized wastes to establish whether they may be subject to accumulation time limitations and/or subject to special management requirements.

(8) Ensure that the field geologist records all well installation details on the well installation diagram, especially the volume of fluids added to the holes and the number of bags of filter sand, cement, bentonite, etc.

(9) Verify that samples are collected at the prescribed levels and that the geologist is logging the hole according to USACE guidelines. Additional guidance on logging requirements can be found in EM 1110-1-4000 and EM 1110-1-1804.

(10) Verify that the well is at the proper depth or geologic interval before allowing the screen to be installed.

(11) Determine if slot size criteria for the screen are outlined in the specifications. If not, the contractor will have to perform the appropriate grain size tests and calculations should be made to determine the appropriate screen slot size.

(12) Determine that the diameter of the hole is within the range stated in the specifications.

(13) Ensure that the well location is surveyed and documented. Wells are typically surveyed to the nearest 1 foot horizontally and .01 foot vertically.

(14) Ensure that the driller has made arrangements for emergency response and transport and that emergency numbers are posted on site.

b. Installation.

(1) Determine that all materials to be installed in the well are the correct diameter, length, size and grade as indicated in the specifications. Materials should be clearly labeled and in their original packaging or the labels should be fixed on the materials (e.g. PVC pipe).

(2) ensure that well materials are wrapped and sterile. If not, they must be decontaminated with a steam cleaner and wrapped to prevent contamination. Workers handling the unwrapped screen should wear clean (latex) gloves. The objective of not touching the screen

is to minimize the possibility of biological fouling occurring in the well.

(3) Ensure that the borehole is protected from foreign objects or surface water run in if the borehole is left open at any time.

(4) Confirm that the well is in the center of the hole and that centralizers are properly installed if required by the specifications.

(5) Determine that all of the materials to be added to the annular space are present in adequate amounts and that they meet the requirements of the specifications.

(6) All materials to be added to the annular space (filter pack sand, bentonite, grout, etc.) should be tremied in from bottom to top and at a flow rate which prevents bridging. The tremie pipe should be lowered carefully into the annulus to the bottom of the hole and the material poured or pumped down the pipe. As the space fills the tremie pipe should be gradually withdrawn from the hole.

(7) Ensure that the well casing has a temporary cover on it once it is installed to prevent foreign materials from falling into the well.

(8) Make sure that the installers frequently measure the levels of annular fill materials with a weighted tape. This ensures uniformity of placement around the circumference of the annular space and that the proper thickness of materials is maintained.

(9) After all materials are placed in the annular space, a test should be carried out to verify the plumbness and alignment of the wells. This requires the contractor to lower a ten foot long, steam-cleaned, weighted slug of inert material (often PVC filled with sand) the full length of the well to demonstrate the plumbness of the well so that pumps and other equipment can be lowered into the well.

(10) Ensure that the completed well conforms to all state/local installation requirements.

c. Predevelopment. After the filter pack is in place it is not uncommon in a mud-rotary drilled hole to pump out or circulate clean water into the hole to remove as much of the drilling mud as possible before it "sets up" in the hole. This process needs to be fully documented as to the amounts of fluids removed and/or added on the well installation diagram.

d. Development.

(1) Ensure that development does not proceed until after the prescribed waiting period (usually 48 hours after the annulus has been grouted).

(2) Ensure that all required instruments are in working order before development begins and that they have been calibrated in accordance with the requirements in the specifications. Example instruments include pH meter, thermometer, specific conductance, total dissolved solids (TDS), Eh or other meters which measure oxidation-reduction potential, dissolved oxygen (DO) and turbidimeter.

(3) Confirm that the development proceeds until the parameters

stabilize.

(4) Confirm that the requirements for turbidity are met using a calibrated turbidimeter.

(5) Check that the development method to be used conforms with the method outlined in the specifications.

(6) No additives other than water should be placed in the well unless they are specifically called for in the specifications. If additives are to be used, ensure that the chemicals are clearly labeled.

(7) Check any apparent digressions from the language of the specifications with a project geologist for concurrence and document the conversation.

e. Installation of Equipment.

(1) Ensure that the pumps that go in the hole correspond with the specifications and submittals.

(2) Verify that the pumps are installed at the designed level in the well.

f. Wells Containing Light Non-Aqueous Phase Liquids (LNAPL).

(1) Review the drawings to determine whether one or two pumps are to be installed in the hole.

(2) Ensure that the installer measures the depth to water and product in the well.

(3) Confirm that the pump(s) are installed at the depth(s) required in the specifications. This is usually referenced to depths above or below the water/product interface.

g. Manhole or Doghouse.

(1) Ensure that these structures comply with the plans and specifications.

(2) Check that all equipment and piping are properly installed and that all equipment, valves and meters are accessible and readable.

(3) Ensure that the structures have a functioning, locking mechanism and that the required keys, etc. are provided.

(4) Manholes, etc. may be classified as confined spaces and require appropriate safety measures outlined in the SSHP. If the structure is a confined space, ensure that the required confined space labeling is present.

h. Abandoning Wells. In the event that there are problems or deficiencies with installed wells, ensure that the well is abandoned by the contractor according to the specifications and state regulations. This may involve grouting the hole, removing casing or cutting it off below the ground surface, surveying (if required) and notification of the appropriate regulatory authority. ASTM D 5299 provides additional guidance on abandoning wells.

i. Ground Water Monitoring Wells. Monitoring wells follow the same general principles for installation as outlined for extraction wells. Requirements for the installation of monitoring wells are addressed in EM 1110-1-4000 and ASTM D-5092. Whereas the primary goal of an extraction well is to produce a specified pumping rate for ground water, the goal of a monitoring well is to produce a representative sample of ground water from the aquifer. Monitoring wells differ from extraction wells in three main aspects: diameter, development criteria, and surface completion.

(1) Installation.

(a) Confirm the well materials are the correct size and schedule.

(b) Generally monitoring wells are two inches in diameter. However, in some cases where free product is present, four inch diameter wells may be required.

(c) Confirm whether the surface completion is flush mounted or a nominal stickup.

(d) Confirm that flush mounted vaults meet requirements of size and strength for traffic loads.

(e) Confirm that the concrete pad meets specifications and slopes away from the well.

(f) Confirm that protective bollards are installed if required by the specifications. The bollards should not be installed in the concrete pad.

(g) If protective locking casing is installed, assure that it allows access to the monitoring well.

(2) Development. ASTM D 5521 provides additional guidance on well development.

(a) Confirm that development proceeds until the specified parameters stabilize.

(b) Confirm that requirements for turbidity are met using a calibrated turbidimeter.

(c) Ensure that the specified amount of water is removed during development. This may include an amount equivalent to that added (or lost) by drillers during drilling and installation.

(d) Check that the development method to be used conforms with the method outlined in the specifications.

CHAPTER 2.2
GROUND WATER EXTRACTION TRENCHES

CHAPTER 2.2 GROUND WATER EXTRACTION TRENCHES

2.2-1. GENERAL. This section describes the installation of ground water extraction and recharge trenches. Extraction trenches are used to remove contaminated ground water while recharge trenches are used to reintroduce treated ground water back into the subsurface.

a. Equipment.

(1) Trench Excavating Equipment.

(a) Confirm that any drill rigs used have been inspected in accordance with the provisions of EM-385-1-1 (Chap. 16).

(b) Confirm that the contractor is maintaining records of tests and inspections on site.

(c) Verify that the trencher/backhoe is free from leaks of fluids and has been decontaminated prior to moving onto the project.

(d) Confirm that the trencher/backhoe is capable of achieving the required dimensions for the excavation.

(2) Personnel.

(a) Confirm with the Site Safety and Health Officer (SSHO) that all persons working in the exclusion zone meet OSHA requirements for training and medical surveillance and that they have read and signed the SSHP. They also must be wearing appropriate protective clothing as described in the SSHP.

(b) Confirm that the contractor who installs the ground water collection or injection trenches has the required licenses (state or local) to perform the work. Note that in some states a trench for extraction or recharge of ground water is classified as a well.

(c) Confirm that personnel and equipment decontamination and collection facilities are in place and conform with the specifications.

b. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Excavation and Installation Plan which describes:

the trenching method and equipment;

screen installation procedures;

soil/rock logging procedures and forms;

soil sampling and sample handling procedures;

dewatering and water handling plan (if required);

procedures to containerize, label and store potentially hazardous soils or liquids (if required);

decontamination procedures;

where required, well permitting information (copies of all permits must be maintained on site); and

procedures to obtain digging permits/utility clearances.

(2) Verify that the trenching subcontractor has read the installation specifications prior to installation of the trenches.

(3) Qualifications for the trench installation contractor should be submitted if licences are required in that state. Note that some states consider ground water extraction and recharge trenches to be wells. Verify that the contractor's qualifications meet the specifications and any state requirements. The qualifications, including education and experience, of the geologist or engineer responsible for logging the materials encountered during drilling should also be submitted for information.

(4) Catalog information on:

pump screen or slotted pipe and casing;

cement and/or bentonite sealant;

precast well head vaults (if applicable);

piping;

pump(s) and associated equipment;

gauges and controls;

electrical components;

geosynthetic materials;

backfill materials;

slurry materials, e.g. bentonite, bioslurry; and

gradation test results for filter pack material and pipe bedding/backfill (if required).

c. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Geologic logs for extraction and/or recharge trenches.

(2) Proposed trench locations or screen placement may be a submittal if trench construction was left to the contractor based on conditions encountered. This submittal should be provided to the design district for review and approval.

(3) Construction diagrams for all trenches and associated wells and piezometers. The contractor may be required to furnish these submittals to the design district for review and approval.

(4) Water yield test results for individual extraction (or recharge) wells. These are determined by performing a specific capacity test and are used to verify design assumptions. The

contractor may be a required to furnish this submittal to the design district for review and approval.

(5) Backfill density test results, if required.

(6) Chemical sampling results from initial trench sampling. The contractor may be required to furnish this submittal to the designer for review and approval.

(7) Water level measurements and contour maps as required.

d. Start-up Submittals. The contractor should provide start-up submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Completed Start-Up Checklist. This checklist is used to ensure that the equipment and controls will perform safely and as expected.

(2) Start-Up Monitoring Plan. This plan identifies procedures for initial start-up of the system including step-by-step procedures for valve settings, circuit checks, energization, and monitoring. Plans for testing each trench individually in a multi-trench system including correct valve settings and range of acceptable flow rates in a step test should also be included. The step test consists of starting at a low flow rate (10 to 25 percent of the design flow rate) and stepping up in increments to the design and finally the maximum design flow rate. For reinjection trenches, it is critical that the test be of sufficient length to overcome the initial wetting of the soils so that the step test is carried out on saturated soils.

2.2-2. PRODUCTS.

a. Water. Verify that the source of any water used in the construction of the trench is approved in the specifications or chemical testing has been performed to verify it is of adequate quality. Note, use of water from sources with free chlorine may result in contamination of the well with trihalomethanes.

b. Below-Ground Equipment.

(1) Excavation.

(a) Confirm that the trench dimensions conform to the specifications.

(b) Verify that the trench is completed at the proper depth and/or in the appropriate geologic unit.

(c) Confirm that any material added to the bottom of the trench is not finer-grained than the adjacent materials.

(d) Confirm that the piping/screen is placed at the correct slopes.

(e) Determine that all safety procedures and egresses are in place before anyone enters trenches deeper than four (4) feet.

(2) Slotted Pipe/Screen.

(a) Verify that slot type, slot aperture, diameter, and material (composition and wall thickness) are consistent with the specifications.

(b) Verify that any backfill material in the trench under the slotted pipe is the proper gradation, thickness, slope, etc.

(c) Slotted pipe/screen should be new and stored in a clean, safe location where it will not be damaged by equipment.

(d) Ensure that all connections are consistent with specifications and can be made water tight.

(e) Verify that all joints are cleaned prior to gluing.

(f) Ensure that appropriate safety procedures are followed before any person enters sumps or other subsurface structures to connect piping.

(3) Piping.

(a) Verify that casing schedule, diameter, joints and material meet specifications.

(b) Assure that joints can be made water-tight.

(c) Casing should be new and stored in a clean, safe location where it will not be damaged by equipment.

(d) Verify that all joints are cleaned prior to gluing.

(e) Above-ground piping must be UV resistant.

(f) Ensure that materials which will be in contact with the contaminants are compatible with the contaminants.

(4) Filter Backfill.

(a) Filter backfill must meet the required gradation.

(b) If no filter backfill gradation is given, check that the backfill is a uniform sand or gravel large enough to prevent entry of the pack through the screen slots.

(c) Check the specifications to see if the backfill must be washed.

(d) Verify that geotextiles placed on top of the filter material meet specifications for material properties and placement.

(5) Valves, Gauges and Vaults.

(a) Assure compliance with specification.

(b) Verify consistent diameters of vault penetrations with associated casing, piping, or utility conduits.

(c) Vault covers must be appropriate for traffic conditions if flush-mounted.

(d) Assure that adequate means of opening large vault covers is provided.

(e) Circular vault lids are preferable to rectilinear ones because they cannot fall into the vault and damage the system.

2.2-3. EXECUTION.

a. Trenching.

(1) Ensure that the contractor has made arrangements for emergency response, transport, etc.

(2) Confirm that the necessary notifications/permits have been obtained from the State, County or appropriate agency before trenching begins.

(3) Check that all utility clearances have been received for the subsurface work.

(4) Determine that the trench location is in accordance with the specifications. If it is impossible to install the trench in a specified location, determine the best alternate location that meets the requirements of the design. If there are any questions about a possible alternate location, contact the design district to confirm a new location.

(5) Confirm that safe excavating procedures are used and that an exclusion zone is well defined around the excavator. Also determine that required safety equipment is present and that it is operated in accordance with the requirements of the SSHP. Ensure that the sides of the trenches are benched or sloped according to the provisions of EM-385-1-1.

(6) If required, confirm that all excavated materials and liquids are containerized or covered in accordance with the specifications or approved work plan.

(7) Verify that samples are collected at the prescribed levels and that the geologist is logging the trench according to USACE guidelines.

(8) Verify that the trench is at the proper depth or geologic interval before allowing installation of the gravel pack and screen.

(9) Verify that grain size tests and calculations have been made to determine the appropriate screen size. Otherwise verify that the slot size of the screen is in accordance with the specifications.

(10) Determine that the dimensions of the trench are within the range allowed in the specifications.

(11) If unexpected debris or liquids are encountered in the hole, stop construction and notify the appropriate personnel including the Site Safety Officer. At some sites, potentially hazardous waste has been encountered while excavating.

(12) Ensure that site contingency plans for spills, releases, etc. are in place and discussed.

b. Installation.

(1) Verify that all materials to be installed in the trench are the correct diameter, length, size and grade as indicated in the

specifications. Materials should be clearly labeled in their original packaging or the labels should be fixed on the materials (e.g. PVC pipe).

(2) Check that screen materials are wrapped and sterile. If not, they must be decontaminated with a steam cleaner and wrapped to prevent contamination. Workers handling the unwrapped screen should wear clean (latex) gloves.

(3) Confirm that the screen is in the center of the trench.

(4) Determine that all of the backfill materials to be added are present in adequate amounts and that they meet the requirements of the specifications. If the backfill is stored on the ground without a plastic liner, the material in direct contact with the ground should not be added as backfill.

(5) Check that the grain size of the filter pack is compatible with the slot size of the well screen and that the filter pack meets all specifications for cleanliness, roundness etc.

c. Development. Development of trenches is much more difficult than development of wells. The goal of trench development is to remove fines so that they will not damage the final pumps or cause problems in the treatment process. The process involves using a development pump temporarily hooked into the extraction system that is not as susceptible to damage by fines. Usually the specifications will state a minimum number of hours of development and a minimum pumping rate. If the water does not clear up in the prescribed time, it will be necessary to collect a sample to determine the quantity of sediment still present and its constituents (silt, sand, etc.). Once this is done, discussions with the design district can determine whether additional development will be required.

d. Installation of Equipment.

(1) Ensure that the pumps that go in the trench correspond with the specifications.

(2) Verify that the pumps are installed at the designed level.

e. Trenches Containing Light Non-Aqueous Phase Liquids (LNAPL).

(1) Determine whether one or two pumps are to be installed in the trench.

(2) Ensure that the installer measures the depth to water and product in the trench.

(3) Confirm that the pump(s) are installed at the depth(s) required in the specifications. This is usually referenced to depths above or below the water/product interface.

f. Manhole or Doghouse.

(1) Ensure that the structures comply with the plans and specifications.

(2) Check that all the equipment and piping are properly installed and that all equipment, valves and meters are accessible and readable.

CHAPTER 3.1
LANDFILL COVERS AND LINERS

CHAPTER 3.1 LANDFILL COVERS AND LINERS

3.1-1. GENERAL

a. Purpose and Function. This section describes the typical configurations used for hazardous waste landfill covers and liners. Subsequent sections describe the QA requirements during construction of the various components of covers and liners. The primary purpose of a landfill is to isolate waste materials from the environment by minimizing the infiltration of surface water, collecting leachate generated by the waste materials, preventing human and animal contact with the waste materials, and controlling landfill gases.

b. Regulatory Criteria. The components of a landfill cover and liner are dependent on functional, environmental, and regulatory factors. The Resource Conservation and Recovery Act (RCRA) provides guidance on cover and liner configurations for both municipal solid waste and hazardous waste landfills. The federal guidelines for municipal solid waste landfills are found in 40 CFR Part 258. The federal guidelines for hazardous waste landfills are found in 40 CFR Part 264. State and local Governmental agencies also have criteria for landfill systems and in some instances, these criteria are more stringent than federal guidelines.

3.1-2. RCRA HAZARDOUS WASTE LANDFILL COVERS. The components of a typical hazardous waste landfill cover are shown below. These components vary from site to site depending on regulatory criteria and availability of soils with the appropriate physical characteristics. From top to bottom, the components of a typical hazardous waste landfill cover are described in Table 3.1.

TABLE 3.1

COMPONENT	MATERIAL TYPICALLY USED
Top Soil	150 mm (6 inches) of top soil
Select Fill	450 mm (18 inches) or more of soil
Filter Layer	Geotextile
Drainage Layer	Geonet or 300 mm (12 inches) of sand or gravel
Barrier Layer	
-Geomembrane	40-60 mil polyethylene or PVC
-Clay	600 mm (24 inch) layer or geosynthetic clay liner
Gas Venting Layer	300 mm (12 inches) of sand/gravel
Foundation Layer	300 mm (12 inches) or more of soil to provide slopes for drainage
Waste Material	

3.1-3. RCRA HAZARDOUS WASTE LANDFILL LINERS. The components of a typical hazardous waste landfill liner are shown below. Again, these components vary from site to site depending on the regulatory criteria and the availability of soils with appropriate physical characteristics. From top to bottom, the components of a typical hazardous waste landfill liner are described in Table 3.2.

TABLE 3.2

COMPONENT	MATERIAL TYPICALLY USED
Filter Layer	Sand, gravel or geotextile
Leachate Collection Layer	300 mm (12 inches) of sand or gravel
Primary Liner	60-80 mil high density polyethylene (HDPE)
Leak Detection Layer	Geonet
Secondary Liner	
-Geomembrane	60-80 mil HDPE
-Clay	900 mm (36 inch) layer, Hyd. Cond. $\leq 1 \times 10^{-7}$ cm/sec
Subgrade	Existing or imported soil

3.1-4. GENERAL INSPECTION ITEMS FOR LANDFILLS. The following are general inspection items which are not unique to any single component of a landfill cover or liner.

a. Third Party Quality Assurance Inspector. A third party QA Inspector is often hired to inspect the installation of geomembranes and other geosynthetics. If this is the case, many of the inspection responsibilities listed in the following chapters will be performed by the third party QA Inspector.

(1) Verify that the third party QA Inspector has the appropriate qualifications as described in the plans and specifications.

(2) Authority. If an independent third party QA Inspector will be used, make sure the level of authority the QA Inspector has is clearly understood by everyone. They will generally be responsible for monitoring and documenting construction activities. However, they will not have the authority to direct the contractor.

b. Reports. Record keeping and reporting is a key element in the construction of a landfill cover or liner. The following are typical record keeping and reporting requirements during construction.

(1) Daily Reports. The purpose of daily reports is to provide a summary of QA activities performed by the third party QA Inspectors and to highlight matters requiring the COR’s action. The following is an outline for a typical daily report:

project name, location, and date;

weather conditions, including: temperature (daily high and low); wind direction and speed; last precipitation event; and amount of precipitation;

construction activities underway, equipment in use, and QC testing performed;

summary of QA activities;

items requiring action by the COR; and

list of any conferences with the contractor or Government personnel.

(2) Final Report. The last phase of landfill construction QA involves preparing a final report by the QA inspection team. The final report will be completed at the end of construction and typically includes the following information:

brief description of the project, including type of facility, name of site, location, name of owner, design engineer, geomembrane installer, earthwork contractor, etc.;

detailed description of the lining system, including surface area, cross section, definition of all materials, etc.;

reference to the construction QA plan;

copy of geosynthetic material specifications;

copy of, or reference to, geosynthetic manufacturer's QC documentation;

general record of activities, such as dates of performance of QA operations, number and names of QA Inspectors, number and names of geosynthetic Installer's personnel, etc.;

photographic record including photographs of the site at different phases of construction, photographs of construction details, and photographs of QA operations;

A copy of all forms and logs filled out by QA Inspectors and of all their daily reports;

copy of all field and laboratory test results;

discussion of special problems encountered and their solutions;

copy of the written acceptance of the subgrade by the geomembrane and GCL installers; and

statement that construction has been done in substantial accordance with the design (including modifications, if any, approved by the design engineer).

c. Quality Assurance Laboratory. Check to see if the specifications or QA plan require the use of an independent QA

Laboratory to test geosynthtics and/or soils.

(1) If an independent QA Laboratory is used, verify the Laboratory's qualifications statement, including resumes of key personnel involved in testing, conform to the requirements outlined in the specifications.

d. Quality Assurance Sample Collection

(1) Review the plans and specifications to determine if QA (conformance) testing is required and on which materials. Samples should be collected at locations approved by the QA Representative. A QA Representative should be present during collection of these samples to ensure they are properly packaged.

(2) If QA testing will be performed, geosynthetic samples are usually collected by cutting a 900 mm (3 foot) long sample for the entire width of the roll being tested. The outside layer of geosynthetic rolls is often removed prior to collecting QA samples. Samples must be properly identified with a unique sample number, project name, sample location and date. For geosynthtics, the manufacturer's name, product identification, lot and roll number, and machine direction should also be identified.

(3) Determine if the specifications contain any special requirements for QA sample packaging.

(a) GCL samples are usually tightly rolled onto a 75 mm (3 inch) diameter core and then covered with 2 layers of plastic sheeting. Tape should be used to hold the plastic sheeting in place.

(b) Geomembranes are generally wrapped on a cylinder and taped in place. Geonet and geotextile samples are generally placed in a box for safe shipment.

(4) Verify test results from the QA laboratory meet the requirements stated in the specifications.

e. Borrow Source Chemical Contamination Tests. All borrow soils are generally tested prior to use to verify they are not contaminated. The plans and specifications should indicate the frequency of testing and what testing should be performed to verify borrow soils are clean. Contact the designer if this information is not provided.

f. Interface Friction Testing. The interface frictional resistance of geosynthetics is often low. Since landfill covers and liners generally have steep slopes, this creates potential stability problems. To ensure a landfill cover or liner will not slip, the contractor is often required to perform direct shear tests on the geosynthetic interfaces.

(1) Verify friction test results indicate adequate interface shear strength exists at the geosynthetic interfaces. Minimum interface shear strength requirements should be outlined in the plans and specifications. Contact the designer if they are not.

(2) Check to see that all interface shear strength tests are performed using the specified normal stresses, strain rates, moisture conditions, and other test requirements outlined in the specifications.

(3) Verify the same geosynthetics and borrow sources used for interface friction testing will be used for full scale construction.

g. Geosynthetics Warranties. Designers or regulators often require warranties for geosynthetics.The length requirements for warranties vary significantly from project to project. Warranties are often required from both the geosynthetics manufacturer and the geosynthetics installer.

(1) Review the plans and specifications to determine which geosynthetics have warranty requirements. Become familiar with these warranty requirements.

(2) Discuss warranty requirements with the designer prior to the start of construction if the requirements are not clear.

(3) Review the warranty submittals to verify if they comply with the warranty requirements.

h. Anchor Trenches. Geosynthetics used to line waste facilities terminate in an anchor trench located around the perimeter of the liner system. Anchor trenches are typically U or V shaped. U shaped trenches are generally a minimum of 450 mm (18 inches) deep and 300 mm (12 inches) wide. Verify the anchor trench is constructed to the correct dimensions.

(1) Check the plans and specifications to determine the termination point of each geosynthetic layer.

(2) Double liner systems will generally have separate anchor trenches for primary and secondary liner systems. Verify the anchor trenches are correctly located.

(3) Ensure that the corners of anchor trenches are slightly rounded to avoid sharp bends in the geosynthetics.

(4) Verify loose soil is removed from the bottom of the anchor trench prior to placement of the geosynthetics.

(5) Require the anchor trench to be dewatered (pumped out) if ponded water is present in the bottom of the trench.

(6) Backfilling of the anchor trench should be accomplished with approved backfill soils placed at the required moisture content and compacted to the required density. Carefully inspect compaction work within the anchor trench because equipment used to compact the soil can easily damage the geosynthetics.

i. Access Ramps. Heavily loaded vehicles must enter landfill liners during construction activities and during placement of solid waste. Access ramps for large landfills will be up to 5.5 m (18 ft) in width and have grades of up to 12 percent. Large landfills will incorporate an access ramp into the layout of the liner. Access to small landfill liners with short side slopes will generally be accomplished by simply placing a thick layer of soil over the liner at the access point.

(1) Strictly enforce any requirements concerning vehicle speeds and number of vehicles on access ramps.

(2) Construction equipment should not be allowed to brake sharply while on the ramp.

(3) Regularly inspect the access ramp for cracks and slippage of protective soils layers.

(4) Also inspect the protective soil layers to ensure that thinning of this layer is not occurring due to traffic or erosion. Typically, these protective layers should be a minimum of 900 mm (3 feet) in thickness.

CHAPTER 3.2
WASTE GRADING AND SUBGRADE PREPARATION

CHAPTER 3.2
WASTE GRADING AND SUBGRADE PREPARATION

3.2-1. GENERAL. The purpose of the subgrade for landfill liners and covers is to provide a firm foundation and to establish slopes for drainage. When landfill covers are constructed over hazardous waste sites, waste regrading is commonly performed to flatten slopes and minimize the amount of borrow that needs to be brought on-site. When landfill liners are constructed, waste must be carefully placed so the liner system is not damaged. Regraded waste and waste placed in landfill liners usually must be compacted to minimize the amount of settlement which occurs.

a. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

A waste regrading plan which describes how waste will be regraded and procedures which will be followed if buried drums or other hazardous materials are discovered during regrading. Hazardous materials anticipated to be encountered should be addressed in the SSHP.

b. Daily Reports. Daily reports should indicate when unexpected drums or other potentially hazardous materials are encountered during construction.

c. Manifests. Manifesting and disposal records must be submitted for any hazardous materials which are disposed of off site. Engineering Pamphlet 200-1-2 - Process and Procedures for RCRA Manifesting provides guidance on the procedures and responsibilities associated with manifesting hazardous waste under RCRA and Department of Transportation regulations.

3.2-2. EXECUTION.

a. Clearing and Grubbing. Clearing of vegetation is performed on the surface of old landfills prior to placement of a landfill cover. However, grubbing is generally not performed to minimize disturbance of the waste.

(1) Limits of clearing and grubbing should be clearly established prior to construction.

(2) Ensure the specifications clearly define which materials generated from clearing, grubbing, and tree removal are contaminated and which materials are not contaminated.

(3) Ensure the contractor stockpiles contaminated cleared and grubbed material in a location which is separated from uncontaminated material.

(4) Ensure the contractor is disposing of both contaminated and non-contaminated cleared and grubbed material in accordance with the specifications.

(5) Ensure stockpiles containing contaminated material are lined and/or covered at all times in accordance with the plans and specifications. Contact the designer if the plans and specifications do not discuss requirements for stockpile liners and/or covers.

b. Waste Grading.

(1) Verify waste material is placed so that large void spaces do not exist.

(2) Do not allow large pieces of debris (greater than 300 mm (12 inches) in diameter) to be placed in the upper .6 meters (2 feet) of fill. Large debris should be well dispersed in lower portions of the waste fill.

(3) Over excavation may be required to remove large objects present at the surface of regraded waste.

(4) Ensure that regraded waste is placed in lifts and compacted with a landfill compactor as described in the specifications. Periodically check that the lift thickness used by the contractor does not exceed specified requirements.

(5) Halt construction in the area and notify the designers if unexpected hazardous materials (barrels, tanks, medical waste, UXO, etc...) are discovered during waste regrading.

(6) Ensure the contractor minimizes the amount of waste exposed during regrading operations to reduce odor problems.

(7) Air quality monitoring equipment should be closely monitored during waste regrading. Daily cover may need to be placed over areas of exposed waste at the end of each days operations if odor or volatilization of contaminants becomes a problem.

(8) Daily cover normally consists of a minimum of 6 inches of soil. However, foams and geosynthetics have been used as daily cover on some projects.

(9) When regrading waste prior to placement of a landfill cover, look for leachate seeps that present unsuitable conditions for fill placement. These seeps should be reported to the designer.

(10) Verify the final lines and grades of the regraded waste are correct.

c. Compaction of Waste. Compaction of waste is important in preventing damage to the landfill cover due to differential settlement.

(1) Waste compaction equipment typically weighs 18,000 to 32,000 kg (40,000 to 70,000 pounds). Check the specifications for equipment weight or compaction pressure requirements.

(2) Compaction of waste is usually specified by requiring several passes of a compactor over all areas of the waste instead of requiring that a specific density criteria be achieved. The number of passes required is site specific and should be addressed in the specifications. Spot-check to make sure the contractor is making the minimum required number of passes for each lift of waste placed.

(3) For landfill liners, verify the contractor’s method of

placement does not damage the liner system.

(4) Compaction equipment should be operated so that the compactor overlaps the rolled adjacent strip by not less than 0.3 meters (12 inches).

(5) Check for areas where additional fill needs to be placed due to settlement.

d. Subgrade. Subgrade is the term commonly used to describe the soils placed immediately beneath the landfill cover or liner. This layer provides a foundation layer for the landfill cover or liner and is typically a minimum of 0.3 meters (12 inches) in thickness.

(1) Determine from the contract drawings whether on-site or off-site borrow will be used for the subgrade soil.

(2) If on-site borrow will be used, is there sufficient quantity?

(3) Verify the subgrade soils meet the specified requirements for soil type and gradation.

(4) Verify subgrade soils are placed to the lines and grades shown on the drawings and compacted and tested in accordance with the specifications.

(5) Compaction criteria are often waived for the first lift of the subgrade layer when it is placed on top of compressible waste because it is difficult to get adequate compaction.

(6) Inspect for erosion in the surface of the subgrade and require the contractor to reshape and regrade damaged areas.

CHAPTER 3.3
LOW PERMEABILITY CLAY LAYER

CHAPTER 3.3 LOW PERMEABILITY CLAY LAYER

3.3-1. GENERAL. The purpose of the low permeability clay layer in a landfill cover or liner system is to inhibit the movement of water into or out of the waste. Soils used for the clay layer are selected to meet a specific hydraulic conductivity requirement (typically 1×10^{-7} cm/sec). If suitable clay materials are not found in the vicinity of the project, a common practice is to blend available soils with bentonite. The following steps are required to properly construct a low permeability clay layer:

locate and test borrow sources to ensure appropriate clay material is available;

preprocess soil liner material, if necessary, to adjust the water content, to remove oversized particles, to break down clods of soil, or to add amendments such as bentonite;

prepare the subgrade to provide a firm foundation on which to place clay;

place and compact the clay material at the appropriate moisture content and density. Clay barrier layers are normally a minimum of 600 mm (24 inches) in thickness. They are typically placed in several lifts with a compacted lift thickness of approximately 150 mm (6 inches). Heavy compactors with feet that penetrate the loose lifts of soil are ideal for compaction of clay layers. The Caterpillar 815B and 825C are examples of equipment that have been successfully used for compaction of clay layers;

freeze-thaw cycles and desiccation cracks will increase the hydraulic conductivity of a clay layer. Therefore, it is critical to protect the clay layer until the layer is completed and covered.

a. Equipment.

(1) Compaction Equipment.

(a) Verify the compaction equipment proposed for use are footed rollers. The compactors should also meet the weight requirements described in the specifications.

(b) During compaction operations, the spaces between the tamping feet should be kept clear of materials.

(c) Do not allow compaction equipment to be operated at speeds exceeding specified limits (generally 2.2 meters per second (5.0 miles per hour)).

(2) Scarification Equipment. Verify scarification equipment is capable of scarifying to the depth specified (generally 25 to 50 mm (1 to 2 inches)).

(3) A smooth steel wheeled non-vibratory roller should be used to produce a smooth compacted surface on the final lift of the clay layer if a geomembrane will be placed on top of the clay layer.

(4) Ensure hand operated tampers consist of impact type

equipment. Vibratory type equipment should not be allowed.

b. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Materials Handling Plan which describes the processing, placement, and protection of the clay layer.

(a) The contractor's plan for protecting the clay layer should address how the clay will be kept at the correct moisture content after placement (this includes evenings and weekends).

(b) Generally, construction of the cover or liner should progress in stages so the clay layer is periodically covered by other soil layers in order to provide protection from desiccation and freeze/thaw damage. Covering the clay layer with geosynthetics only may not provide adequate protection.

(2) Name and qualifications of the proposed commercial testing laboratory.

(3) Borrow Source Assessment Report. Borrow source assessment testing is sometimes done during the design phase. If this is the case, the amount of borrow source assessment testing done by the contractor will be greatly reduced.

(a) Borrow assessment tests should be performed on each type of soil proposed for use to develop compaction requirements for placement. At a minimum, one set of borrow assessment tests should be performed for each borrow source. A set of borrow source assessment tests generally consists of classification testing, moisture-density (compaction) testing, and hydraulic conductivity testing.

(b) An "Acceptable Zone" of moisture contents and densities which meet the hydraulic conductivity criteria should be developed and displayed on the compaction curve graphs.

(4) Samples of low permeability clay, if required.

c. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Borrow classification test results.

(2) Subgrade test results.

(3) In-place moisture content and density test results.

(4) In-place hydraulic conductivity test results.

3.3-2. PRODUCTS

a. Low Permeability Clay.

(1) For composite geomembrane/clay covers and liners, the maximum particle size is typically 12.5 mm (0.5 inches) in the upper lift of clay to prevent puncturing of the geomembrane.

(2) The maximum allowable particle size will typically be 25-50 mm (1-2 inches) in the rest of the clay layer.

(3) Check the properties of the clay material being submitted against the requirements listed in the specifications.

(4) At sites where multiple borrow sources are used for clay, ensure the correct compaction curve is used for each type of soil being placed.

(5) Perform daily inspections of stockpiles or borrow sources to see if there are visible changes in the properties of the borrow. Additional borrow source assessment testing may be required if it appears the properties of the borrow source are changing.

b. Bentonite. If bentonite is used to improve the characteristics of the soil, the following paragraphs describe items which the QA Representative should monitor.

(1) Ensure that the bentonite has been pulverized to the extent required by the specifications. A fine powdered bentonite will behave differently than a coarse, granular bentonite. Check grain size distribution test results and also visually monitor the bentonite for changes in grain size distribution.

(2) Free swell (ASTM D 5890-95) , fluid loss (ASTM D 5891-95) and other tests are also commonly specified to ensure a high quality bentonite is being used. Verify these results meet the specified requirements.

(3) The bentonite and soil are commonly mixed together using a pug mill. An alternative mixing technique is to spread the soil in a loose lift, distribute bentonite on the surface, and mix the bentonite and soil using a rototiller or other mixing equipment. Visually inspect the mixing process to ensure that the bentonite is uniformly mixed throughout the entire lift of soil. The specifications may also require QC and QA testing be performed to verify the uniformity of mixing.

3.3-3. EXECUTION

a. Subgrade Preparation.

(1) Verify that the subgrade is composed of satisfactory materials as defined by the specifications.

(2) Check in-place density test results against specified requirements.

(3) Verify the lines and grades of the top surface of the subgrade are correct prior to clay placement.

(4) The subgrade surface should be scarified prior to placement of the first lift of clay to minimize preferential flow paths along the interface and to eliminate the development of a potential slip plane.

b. Installation.

(1) Clay Placement.

(a) Carefully inspect placement and compaction of clay placed above geosynthetic layers. Look for slippage of the compaction equipment on slopes which can cause tension in the geosynthetics. Also look for thin areas of clay which could allow the geosynthetics to be punctured or torn.

(b) Verify loose lifts are no greater than the specified maximum thickness (generally 205 to 230 mm (8 to 9 inches)). In areas where hand operated tampers must be used, the loose lift thickness should not exceed 102 mm (4 inches). The most common way to determine the loose lift thickness is to stand near the working face and observe the lift being placed.

(c) Periodically measure the loose lift thickness by digging a pit through the loose lift of soil and into the underlying layer. A cross-beam is then used to measure the depth from the surface of the loose lift to the top of the previously compacted lift. The zone of scarification should be counted in the loose lift thickness for the new lift of soil.

(d) Verify the clay contains no large clods or other material prohibited in the specifications. This can be done by positioning yourself near the working face as the soil is being placed and visually inspecting for stones, organic matter, debris and other material which is unacceptable.

(e) If highly plastic soils are being used, pay particular attention to preprocessing of clods, breaking up of clods during compaction, and protection from desiccation. No standard method is available to determine clod size. Inspectors should observe the soil liner material and periodically determine the dimensions of clods by direct measurement.

(f) Verify clay is being placed to the lines and grades shown on the drawings.

(g) Grade stakes should be numbered and they should be accounted for at the end of each shift.

(2) Moisture Control.

(a) Verify clay is placed and compacted within the approved moisture content range.

(b) Inspect the entire lift thickness to verify the moisture content is uniform throughout the lift.

(c) A spreader bar on the back of a water truck is the recommended device for moistening the clay. A disk or rototiller is then used to mix the water into the lift of clay.

(d) If water is being added to the clay layer, cure time is required to obtain uniform moisture. Require additional moisture content tests to be run if there is a question about the uniformity of the moisture content within a lift.

(3) Compaction.

(a) Refer to Section 3.9 Cover Soil, if the first lift of clay will be placed directly on top of geosynthetic layers.

(b) Verify the clay is compacted to the density requirements in the approved Borrow Source Assessment Report.

(c) Check to see if the specifications require a minimum number of passes by the compaction equipment. Spot check the contractor daily to ensure the correct number of passes are being used to compact the clay layer.

(d) Review the specifications to determine if there are any special requirements for compaction around pipes and other penetrations.

(e) Verify that soil placed around pipes and other penetrations does not contain voids and is adequately compacted.

(f) Inspect pipes which penetrate the clay layer for damage due to the compaction process.

(4) Scarification.

(a) Verify that all areas of the upper surface of each lift are scarified prior to placement of the next lift of clay.

(b) The final lift of clay should be rolled with a smooth steel wheeled roller if a geomembrane will be placed above the clay layer. Check the specifications to determine the minimum number of passes required.

c. Tests.

(1) Borrow Tests.

(a) Check borrow test results (moisture content, sieve analysis, Atterberg limits, and compaction tests) to verify that the borrow material being excavated is uniform. As an approximate guide, a relatively homogeneous borrow soil would be considered a soil in which optimum moisture varies by no more than +/- 3 percent and maximum density varies by no more than +/- 80 kg/cubic meter (5 lbs/cubic foot).

(b) Additional borrow assessment testing should be performed if the properties of the borrow source change. The contractor and QA personnel should agree on what constitutes a significant change in the borrow source prior to the start of construction.

(c) For highly variable borrow sources, it is recommended that an inspector observe all excavation of borrow soil in the borrow pit. This is the best way to monitor for changes in soil type. A useful guide in helping you to perform field identification of soils is ASTM D-2488, “Description and Identification of Soils (Visual-Manual Procedure).” A key factor to look for during excavation of the borrow pit are changes in plasticity of the clay.

(2) In-Place Moisture Content and Density Tests.

(a) Typically, moisture content and density tests are performed in an evenly spaced grid pattern. The grid pattern should be staggered for successive lifts so that sampling points are not at the same location in each lift.

(b) Verify that moisture content and density test results fall within the "Acceptable Zone" for the material type being tested.

(c) If test results are not within the "Acceptable Zone", additional tests should be taken in the area where the failed test was made. If all of the repeat tests pass, the failed test result may be ignored. If any of the additional tests fail, repairs should be performed.

(d) The contractor should submit documentation describing the corrective measures taken in response to failed test results.

(e) Verify moisture content and density tests are performed using specified test procedures.

(f) At the beginning of a project, at least 10 measurements of moisture content and density should be made on representative samples of site-specific soil using any rapid measurement methods proposed for use. These results should be compared against test results using standard test methods to verify there is good correlation.

(g) Verify nuclear gauges are standardized daily on a reference standard in accordance with ASTM D 2922 and ASTM D 3017.

(h) Make sure the contractor uses nuclear gages in the direct transmission mode to measure density. This means the probe is inserted into a hole in the soil layer. The probe rod is then pressed against the surface of the hole closest to the detector and the density measurement is taken.

(i) Nuclear gages are used in the back-scatter mode to measure moisture content. This means the probe is not inserted into the clay layer.

(j) The most serious potential source of error in using nuclear gages is improper use by the operator. One gross error that is sometimes made is to drive the source rod into the soil rather than inserting the source rod into a hole that has been made with a drive rod. Other sources of error include the following: improper separation of the source from the side and base of the hole, an inadequate period of counting, inadequate warm-up of the device, other sources of gamma radiation, and infrequent calibrations.

(k) Rapid moisture content tests taken using either the nuclear gage (ASTM D-3017) or microwave method (ASTM D-4643) should be checked periodically (one in every ten tests is typical) using the standard method for determining moisture content (ASTM D-2216). This is especially critical when the contractor is using a nuclear gauge because they are susceptible to interference which results in the gauge overestimating moisture content.

(l) Rapid nuclear density tests (ASTM D-2922) should be checked periodically (one in every twenty tests is typical) using a standard method such as the sand cone (ASTM D-1556) or rubber balloon (ASTM D-2167).

(m) When checking the accuracy of rapid moisture content and density tests, the standard moisture and density tests should be taken at the same location as the rapid tests so that results can be easily compared.

(n) When observing the contractor performing sand cone tests, check to make sure the hole dug in the soil layer does not contain rough edges or overhangs that can produce voids in the sand filled hole. Also inspect the sand to make sure it is not contaminated with soil particles. Vibrations from equipment working nearby can also affect sand cone test results by densifying the sand.

(o) When inspecting rubber balloon tests being performed, check the excavated hole for rough edges which leave small zones that cannot be filled with the pressurized balloon.

(p) A minimum of one moisture content and density test should be performed each day that clay is placed.

(3) In-Place Hydraulic Conductivity Tests.

(a) Verify undisturbed samples are taken for hydraulic conductivity testing at the specified frequency for each lift of clay placed.

(b) Verify the samples are collected and tested using the procedures described in the specifications. Thin-walled sampling tubes should be pushed (not pounded) into the clay perpendicular to the plane of compaction.

(c) Hydraulic conductivity testing is generally performed in accordance with ASTM D-5084. The specifications should indicate the confining pressure and head to be used for testing the samples. Contact the design district if this information is not provided. Typically, a confining pressure of 35 kPa (5 psi) is recommended for both liner and cover systems.

d. Protection.

(1) Clay placement and compaction should not take place if the temperature is below 0 degrees C (32 degrees F) or if it is raining.

(2) Excess Surface Water.

(a) Puddles and excess moisture should be removed by replacing the wet soil, discing, or allowing the soil to dry prior to placement of additional clay.

(b) Look for areas of erosion after each rainfall. Require the contractor to repair areas of erosion and reestablish grades.

(c) Reworked areas should be retested for moisture content and density as described in Paragraph e. Repairs.

(3) Desiccation and Freezing.

(a) Ensure the contractor keeps the clay surface moist at all times so that desiccation cracks are minimized. The allowable size of desiccation cracks is often not addressed in the specifications. If this is the case, discuss this issue with the contractor prior to construction so that criteria acceptable to both, is agreed upon. Typically, cracks which are no greater than 6 mm wide by 51 mm deep (.25 inches wide by 2 inches deep) are not considered a problem.

(b) The clay layer should be covered as quickly as possible with other soil layers. Geosynthetics alone may not provide adequate protection.

(c) Require additional moisture content tests be performed if there are indications the clay is drying out. A decrease in the moisture content of one to two percent is not considered serious and within the general accuracy of testing. However, larger reductions in moisture content provide clear evidence that desiccation has taken place.

(d) The clay layer may be tested at multiple depths to get a better feel for variations in moisture content.

(e) If the subgrade soils are dry they may also be pulling moisture out of the clay.

(f) Inspect for cracking or other damage if the clay layer is exposed to freezing temperatures. It is difficult to determine the depth to which freezing took place by examining the surface of the clay layer. Dig into the clay layer and look for hairline cracks. Also look for areas where the soil breaks apart into chunks along cracks caused by freezing.

(g) Freeze/thaw is often accompanied by desiccation. Require the contractor to measure moisture content of the clay within and beneath the zone of suspected frost damage. Density may also be measured. However, freeze/thaw often has little effect on density.

(h) If freeze/thaw damage is suspected, samples can also be hand trimmed from the clay layer for hydraulic conductivity testing. Sampling tubes should not be pushed into a clay layer suspected of having freeze/thaw damage because this procedure will probably close the cracks caused by the freeze/thaw.

e. Repairs. If the clay layer does not conform to the specifications, the first step is to define the extent of the area requiring repair.

(1) Require the contractor repair the lift of clay out to the limits defined by passing QC or QA tests.

(2) Do not allow the contractor to guess at the extent of the area that requires repair. To define and minimize the limits of the area to be repaired, additional tests are often performed.

(3) Once the area requiring repair has been defined, the area should be thoroughly disced, reworked, and recompacted. If the depth of soil requiring repair is greater than one lift, it may be necessary to strip away and replace the clay.

(4) After repairs have been made, the repaired areas should be tested at the same frequency as required for the rest of the project.

(5) Ensure that voids in the clay created for tests, samples, and grade stakes are repaired by placing and compacting clay backfill or bentonite in the voids. The backfill material should be placed in the hole in loose lifts (typically 50 mm (2 inches) thick) and tamped several times with a steel rod prior to placing the next lift.

(6) If sand cone density tests are performed, verify the sand is removed prior to repairing the void.

CHAPTER 3.4
GEOSYNTHETIC CLAY LINER (GCL)

CHAPTER 3.4 GEOSYNTHETIC CLAY LINER (GCL)

3.4-1. GENERAL. Geosynthetic clay liners (GCLs) are factory manufactured hydraulic barriers consisting of bentonite clay materials supported by geotextiles or geomembranes. GCLs are used to augment or replace compacted clay layers or geomembranes. All of the GCL products available in North America use sodium bentonite in powder or granular form. The bentonite thickness of the products vary between 4.0 to 8.0 mm (160 to 320 mils). GCLs are available in widths of 2.2 to 5.2 m (7 to 17 ft) and lengths of 30 to 60 m (100 to 200 ft). GCLs are most often considered for use where there is a limited supply of natural clay or limited landfill space. GCLs are also less susceptible to the effects of desiccation and freeze/thaw than natural clay layers.

a. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) The manufacturer's QC manual and QC test results.

(2) GCL roll layout and penetration details.

(3) Qualifications for the manufacturer, installer, inspector (if required), and QA laboratory (if required).

(4) Mid-plane and interface friction test results.

(5) Sample of GCL (if required).

b. Delivery, Storage, and Handling.

(1) A QA Representative should be present during delivery and unloading of the GCL to inspect for damage.

(2) Verify rolls are labeled with the manufacturers name, product identification, lot number, roll number, roll dimensions, roll weight, and date manufactured.

(3) The QA Representative should record applicable roll numbers, date delivered, name of manufacturer, and product type. This data is used to verify manufacturer’s QC data sheets have been submitted for the rolls being delivered.

(4) Verify each GCL roll is wrapped around a central core and covered with an opaque, waterproof, protective covering. Require that tears in the packaging be repaired using tape and plastic sheeting to restore a waterproof protective barrier around the GCL.

(5) Do not allow rolls to be dragged, lifted by one end, or dropped to the ground.

(6) A pipe or solid bar of sufficient strength to support the full weight of the roll without significant bending should be used for all handling activities. Chains should be used to link the ends of the core pipe to the ends of a spreader bar. The spreader bar should be wide enough to prevent the chains from rubbing against the ends of the GCL rolls.

(7) Alternatively, a stinger bar protruding from the end of forklift or other equipment may be used. The stinger bar should be at least three-fourths the length of the core and also must be capable of supporting the full weight of the GCL without significant bending.

(8) If recommended by the manufacturer, a sling handling method utilizing loading straps may be used for handling.

(9) Verify rolls are stored in a flat dry area where water cannot accumulate. If rolls are elevated off the ground using blocks or pallets, make sure the entire roll bottom is supported.

(10) Do not allow rolls of GCL to be stacked more than three high.

c. Weather Limitations. GCL should not be deployed if precipitation is likely to hydrate the bentonite prior to placement of a geomembrane or cover soils.

3.4-2. PRODUCTS.

Geosynthetic Clay Liner.

(1) Cross check the roll numbers of the GCL delivered to the site against the roll numbers on the manufacturer's QC test data submittals to ensure they match. Ensure the GCL meets the property requirements outlined in the specifications for material type and physical properties (bentonite mass per unit area, free swell of bentonite, hydraulic conductivity, etc...).

(2) If a geotextile backed GCL is being used, verify the two layers of geotextile surrounding the bentonite are stitch-bonded or needle-punched together.

(3) Verify friction test results indicate adequate interface shear strength exists between the GCL and adjacent materials.

(4) GCLs must also be tested for internal shear strength. Verify internal shear strength results meet the specified requirements.

3.4-3. EXECUTION.

a. Subgrade Preparation.

(1) Inspect the subgrade daily to ensure it is smooth and free of vegetation, standing water, sharp-edged rocks, or any other material that could damage the GCL. The condition of the subgrade is generally certified in writing by the QA Representative and installer each day prior to GCL placement.

(2) Verify the final lines and grades of the subgrade are correct prior to GCL placement.

(3) Typically the subgrade surface is rolled with a smooth-drum compactor of sufficient weight to remove any protrusions, wheel ruts, footprints, or other abrupt changes in grade.

(4) Typically, specifications will require the repair of ruts

or protrusions greater than 12.5 mm (.5 inches) in depth or height.

(5) Do not allow the use of calcium rich soil, such as limestone, in the subgrade because it will reduce the effectiveness of the GCL.

b. Installation.

(1) A QA Representative should be present at all times during GCL installation.

(2) Protective plastic covering should not be removed from a roll of GCL until immediately prior to deployment.

(3) Do not allow personnel working on the GCL to smoke or wear shoes which could damage the GCL.

(4) Ensure equipment used to deploy the GCL will not damage geosynthetics located beneath the GCL.

(5) GCL rolls should be slowly unrolled. Do not allow the contractor to freely roll GCL down the slopes.

(6) Care must be taken to minimize the extent to which the GCL is dragged across the subgrade in order to minimize damage to the bottom surface of the GCL. GCL is often placed on sheets of plastic (slip sheets) so it can be moved without being damaged.

(7) Ensure the deployed GCL is smooth and free of wrinkles.

(8) Check the specifications for overlap requirements. Generally, GCL rolls should be overlapped a minimum of 150 mm (6 inches) for roll sides and 450 mm (18 inches) for roll ends.

(9) Ensure the overlap areas are free of dirt.

(10) On warm days, some GCLs tend to shrink. This reduces the overlap present along the sides and ends. Periodically check the overlaps. If significant shrinkage has occurred (25 to 50 mm (1 to 2 inches)) contact the designer to see if the GCL should be repositioned.

(11) GCL should generally be placed parallel to the line of maximum slope. For any horizontal seams on slopes, ensure overlaps are constructed with the up slope GCL shingled over the down slope GCL.

(12) Check the manufacturer’s recommendations to determine if there are any special seaming requirements for horizontal seams constructed on slopes.

(13) Granular bentonite is sometimes placed along GCL seams if the GCL is constructed using nonwoven geotextiles. Check manufacturer’s recommendations for proper seam construction procedures.

(14) GCL should not be left uncovered overnight. Require temporary plastic covers to be placed over exposed GCL.

(15) If exposed to water prior to being covered, check to see if the GCL has become hydrated. Hydrated GCL is often defined as material which has become soft as determined by squeezing the

material with finger pressure or material which has exhibited swelling. Another indication that hydration has occurred is the presence of bentonite swelling through the void spaces of the geotextile backing material. Contact the designer if it appears the GCL has become hydrated.

(16) Any area requiring repair should be clearly marked on the GCL.

c. Repairs. Patches should be constructed and secured as recommended by the manufacturer. Generally, patches for holes and tears should extend a minimum of 300 mm (12 inches) beyond the edge of the defect.

d. Penetrations. Penetration details should be constructed as recommended by the manufacturer. This will generally involve a collar of GCL wrapped around the pipe and hand placement of dry bentonite.

e. Covering. Refer to Chapter 3.9 Cover Soil Layer for additional information on cover soil placement.

CHAPTER 3.5
GEOMEMBRANE

Paragraph **Page**

CHAPTER 3.5 GEOMEMBRANE

3.5-1. GENERAL. Geomembranes are thin sheets of flexible, relatively impervious, plastic materials whose primary function is to act as a barrier to liquids and vapors. The plastic materials are manufactured into sheets and transported to the job site where placement and field seaming are performed. The most common types of geomembranes currently being used for landfill covers are polyvinyl chloride (PVC) and various forms of very flexible polyethylene (VFPE). A minimum thickness of 1.0 mm (40 mils) is often specified for cover geomembranes due to constructibility concerns. High density polyethylene (HDPE) is generally not used for landfill covers when a large amount of differential settlement is anticipated because it is less flexible than PVC or VFPE which makes it more susceptible to damage by differential settlement. HDPE does have very good resistance to chemical attack, therefore, it is commonly used for liner systems where less differential settlement is expected and resistance to chemical attack is important. A minimum thickness of 1.5 mm (60 mils) is often specified for liner geomembranes. Geomembranes can be manufactured with textured surfaces which improve their interface frictional resistance. Textured geomembranes are generally not used unless the slopes of the cover or liner are equal to or steeper than 1V on 4H. In general, textured geomembranes are more expensive, have diminished physical properties, have more manufacturing defects, and are more difficult to field seam and inspect than non-textured geomembranes.

a. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Manufacturer's QC manual and QC test results.

(2) Installers QC manual. Verify the installer has been approved by the manufacturer.

(3) Geomembrane panel layout and penetration detail drawings. For landfill liners, the panel layout should be arranged so that the number of seams in the sump bottom are minimized or eliminated.

(4) Manufacturer's, fabricator's, installer's, inspector's, and QA laboratory's qualification statements including resumes of key personnel involved in the project.

(5) Interface friction test results.

(6) Sample of geomembrane (if required).

b. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Final as-built drawings of the geomembrane installation showing sheet numbers and seam numbers. The locations of repairs, destructive seam samples, and penetrations should also be shown.

(2) Field test results for geomembrane thickness.

(3) Field seam test results for leaks, shear strength, and peel strength.

(4) QA test results for shear and peel strength.

(5) Seam samples for permanent record (if required).

c. Delivery, Storage, and Handling.

(1) A QA Representative should be present during delivery and unloading of the geomembrane to inspect for damage.

(2) Verify that rolls are labeled with the manufacturer's name, product identification, lot number, roll number, roll dimensions, and date manufactured.

(3) The QA Representative should record roll numbers, date delivered, name of manufacturer, and product type. This data is used to verify manufacturer's QC data sheets have been submitted for the rolls being delivered.

(4) Geomembrane rolls should be handled and unloaded with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly should be used.

(5) Do not allow rolls to be dragged, lifted by one end, or dropped to the ground.

(6) The geomembrane should be protected from puncture, abrasion, excessive heat and cold, or other damaging conditions during storage.

(7) Temporary storage should be in a flat dry area where standing water cannot accumulate. Verify the ground surface contains no stones or other sharp objects.

(8) Ensure that rolls of geomembrane are not stacked more than 5 high.

(9) Do not allow pallets of accordion folded geomembrane (PVC) to be stacked on top of each other.

d. Weather Limitations.

(1) Geomembrane should be deployed and field-seamed only when the geomembrane is dry.

(2) Check manufactures recommendations for allowable temperatures for deployment and seaming.

(a) On hot days, watch the geomembranes as they are unrolled or unfolded to see if they stick together to the extent where tearing or straining of the geomembrane occurs. The upper limit for sheet temperature is very specific to the type of geomembrane. Geomembrane should not be deployed if this temperature is exceeded unless it can be shown that the geomembrane is not being damaged.

(b) A sheet temperature of 0 degrees C (32 degrees F) is typically the lower limit at which geomembrane should be unrolled or unfolded unless it is shown that the geomembrane can be deployed without being damaged.

(3) In marginal weather conditions, require the contractor to make test seams to confirm that satisfactory seams can be constructed.

3.5-2. PRODUCTS.

Geomembrane.

(1) Cross check the roll numbers of the geomembrane delivered to the site against the roll numbers on the manufacturer's QC test data to ensure they match. Ensure the geomembrane meets the property requirements outlined in the specifications for material type and physical properties.

(2) Polyethylene seaming rods and pellets should be manufactured of resin which is essentially identical to that used in the geomembrane.

(3) For textured geomembranes, visually inspect the texturing as the rolls are being deployed. Make sure the texturing is uniform over the entire roll.

3.5-3. EXECUTION.

a. Subgrade Preparation

(1) The condition of the subgrade should be checked by the QA Representative and installer each day that geomembrane is placed. The condition of the subgrade is generally certified in writing by the QA Representative and installer each day prior to geomembrane placement.

(2) Verify the final lines and grades of the subgrade are correct prior to geomembrane placement.

(3) Ensure that surfaces to be lined with geomembrane provide a firm, unyielding foundation with no sharp breaks in grade.

(4) Soil subgrade should be rolled with a smooth drum compactor of sufficient weight to remove any protrusions, wheel ruts, foot prints, or other abrupt changes in grade.

(5) Inspect for rocks larger than specified requirements (typically 12.5 mm (1/2 inch) in diameter) or any other debris which could damage the geomembrane. This material should be removed from the upper lift of soil layers to be covered with geomembrane.

(6) Verify that construction equipment used to deploy geomembrane does not deform or rut the subgrade. Typically, ruts should not be greater than 25 mm (1.0 in.) in depth.

b. Geomembrane Deployment.

(1) A QA Representative should be present at all times during geomembrane installation.

(2) To avoid confusion, the installer and QA Representatives should use different colored markers that are easily visible on the geomembrane. The markers should be semi-permanent and compatible with the geomembrane.

(3) Look for damaged geomembrane during installation. Damage may include things such as permanent creases, folds, crimps, gouges, holes, scratches, and inadequate texturing. Any area requiring

repair should be clearly marked.

(4) Carefully inspect deployed geomembrane for damage if it has been displaced by wind.

(5) Do not allow personnel working on the geomembrane to smoke or wear shoes which could damage the geomembrane.

(6) Only geomembrane that can be anchored and seamed together the same day should be deployed.

(7) Ensure geomembrane panels which have been deployed are secured with acceptable ballast to prevent uplift by wind.

(8) Sand bags are typically used for ballast. A continuous line of sand bags should be placed along all exposed edges of geomembrane.

(9) Seams should be oriented parallel to the line of maximum slope.

(10) Where seams can only be oriented across the slope, verify the upper sheet is lapped over the lower sheet.

(11) If a composite liner (geomembrane/clay) is being constructed, make sure the geomembrane is placed directly on the underlying clay layer. Other geosynthetics should not be placed between the geomembrane and the clay layer. Slip sheets are sometimes used to position textured geomembranes. Verify the slip sheets are removed after the geomembrane has been correctly positioned.

(12) There should be sufficient slack in the deployed geomembrane to prevent tensile stresses from occurring when the temperature drops, causing the geomembrane to shrink.

(13) The trampoline effect occurs when a membrane shrinks and pulls away from the subgrade at corners. Inspect for the trampoline effect in the morning when temperatures are lowest. The trampoline effect often occurs along the bottom edge of liner systems.

(14) Ensure that the geomembrane does not have excessive slack to the point where folds in the geomembrane lay over during placement and covering.

(15) Inspect the surface of the deployed membrane in the morning for evidence of protrusions in the subgrade. Subgrade protrusions are more easily identified in the morning because the membrane has contracted due to the cooler night time temperatures.

(16) Verify that each deployed geomembrane panel is given a panel number which is recorded on the daily reports and as-built drawings.

c. Spotting.

When a geomembrane roll or panel is deployed it is generally required that some shifting will be necessary before field seaming begins. This is called spotting by many installers.

(1) Spotting of deployed geomembranes should be done without disturbing the subgrade soil or geosynthetic materials.

(2) Temporary tack welding (usually with a hand held hot air gun) of all types of thermoplastic geomembranes should be allowed at the installers discretion.

(3) When temporary tack welds are used, verify the welds do not interfere with the primary seaming method, or with the ability to perform subsequent destructive seam tests. Tack welds should not be strong enough to produce a film tearing bond.

d. Seams. Geomembrane seams fall into four general categories which are described below. This document will focus on extrusion and thermal fusion seams since they are the most common seam types used on projects the Corps of Engineers has been involved with. Additional information on the fabrication of geomembrane field seams can be found in EPA/530/SW-91/051.

Extrusion Welding Seams. A ribbon of molten polymer is extruded over the edge of, or in between, the two surfaces to be joined. The molten extrudate causes the surfaces of the sheets to become hot and melt, after which the entire mass cools and bonds together. This type of seam is used for polyethylene geomembranes.

Thermal Fusion. The surfaces of geomembranes are melted using an electrically heated resistance element in the shape of a wedge that travels between the two sheets to be seamed. The geomembranes are then pressed together using a set of rollers. A double wedge weld is usually used. A double wedge weld is created with a split wedge which forms two parallel seams with a uniform unbonded space between them. This space can be used to evaluate seam quality and continuity by pressurizing the unbonded space with air and monitoring for drops in pressure. This type of seam can be used for polyethylene, chlorosulfonated polyethylene, or PVC geomembranes.

Chemical Fusion. Chemical fusion seams make use of a liquid chemical applied between the two geomembrane sheets to be joined. After a few seconds (required to soften the geomembrane surfaces) pressure is applied to make complete contact and bond the sheets together. Bodied chemical fusion seams are similar to chemical fusion seams except that geomembrane resin is added to the adhesive to increase the viscosity of the liquid for use on slopes or to adjust the evaporation rate of the chemical. This type of seam can be used for PVC or CSPE geomembranes.

Adhesive seaming. Adhesives are applied to both geomembrane surfaces. After reaching the proper degree of tackiness, the two geomembrane sheets are placed on top of one another, followed by application of roller pressure. This type of seam can be used for PVC or CSPE geomembranes.

e. Trial Seams.

(1) Trial seams should be made on test strips of excess geomembrane under field conditions to verify that seaming methods are adequate. Make sure trial seams are constructed in the same weather conditions as the actual field seams.

(2) Require trial seams to be made each day prior to production seaming, whenever there is a change in seaming personnel or seaming

equipment, and at least once every four to five hours.

(3) Require additional trial seams if there is a quick change in weather conditions (temperature and/or sunlight) which causes a significant change in the temperature of the geomembrane.

(4) A QC sample should be obtained from each trial seam with the seam centered lengthwise. For some projects, a QA sample and an archive sample may also be collected from the trial seam. Ensure each trial seam sample is adequately labeled with the sample number, date, who will test the sample, ambient temperature, and any other information required by the QA plan or specifications.

(5) Typically, 6 to 10, 2.54 cm (1 inch) wide specimens (coupons) are cut from the sample for testing by the geomembrane installer. Half of the seam specimens will be tested for shear strength and half for peel adhesion using an approved tensiometer with a digital readout.

(6) Ensure field tensiometers used have an up to date calibration certificate.

(7) Require a second trial seam be made if tests from the initial trial seam fail.

(8) If the additional trial seam fails, the seaming apparatus or seamer should not be used until the deficiencies are corrected and two consecutive successful trial seams are made.

(9) While the test seams are being tested, the seaming crew may continue to work as long as the seams they make since their last acceptable test sample strip was prepared are completely traceable and identifiable.

(10) The QA Representative should ensure the following information is recorded for each trial seam: sample number, date, test results, welder number, ambient temperature, welder temperature and pressure, and rate of seaming. For chemical seams, the chemical type and mixture should be recorded.

f. Field Seams.

(1) General Requirements.

(a) The subgrade should be firm and dry prior to seaming. Due to wet subgrade conditions, the contractor may choose to place a sacrificial “rub sheet” under the seam to act as a barrier against moisture.

(b) Seam preparation is crucial to obtaining quality welds. Verify the areas to be seamed are clean and dry. Even morning dew can affect the quality of seams.

(c) Seaming should be performed when the ambient temperature is in the allowable range as described in the installer’s QC manual. The location where ambient temperature is measured needs to be agreed on prior to the start of installation. Often, the ambient temperature is defined as the temperature 150 mm (6 inches) above the geomembrane surface.

(d) All geomembranes which have been deployed should be seamed together by the end of the work day. Do not allow open seams to be left overnight.

(e) Verify geomembrane sheets are overlapped the minimum specified distance (typically, 76 mm (3 inches)) prior to seaming.

(f) Verify that seams extend to the outside edge of the sheets.

(g) Excessive waves along seams during the seaming operation should be avoided. When this occurs, due to either the upper or lower sheet having more slack than the other or because of thermal expansion and contraction, it often leads to the formation of "fishmouths". Inspect for fishmouths in completed seams. Fishmouths should be trimmed, laid flat and reseamed.

(h) Pay special attention to the construction of seams in the sumps of liner systems. This is where liquids will accumulate in the liner, therefore, it is critical that these areas are constructed properly.

(i) Seaming of geomembranes to be placed in an anchor trench can be accomplished by temporarily supporting the adjacent sheets to be seamed on a wooden support platform. This allows continuous horizontal seams to be made out to the end of the geomembrane sheets. The wooden platform is removed after the seam is complete and the geomembrane is allowed to drop into the anchor trench.

(j) Destructive and nondestructive tests can also be performed while the seamed geomembranes are temporarily supported in the horizontal position.

(k) Ensure that protection is provided if a generator is placed on top of the geomembrane. Fuel for generators must be stored away from the geomembrane. If accidently spilled on the geomembrane, it must be immediately removed.Spill areas should be inspected for damage and repaired if necessary.

(l) Seams around pipes and other appurtances are the most difficult seams in a facility. Therefore, these seams should be carefully inspected to ensure they are leak free. Ensure pipes are long enough to allow pipe boots to be attached.

(m) The QA Representative should ensure the following information is recorded for each seam: seam number, date, seaming unit used, name of seamer, and any other information called for in the specifications or QA plan.

(2) Polyethylene Geomembrane Seams.

(a) Fusion seams. Polyethylene geomembranes should be seamed by thermal fusion methods (double hot wedge welds) wherever possible. Look for the following when observing fusion welds.

> The type of geomembrane, rate of seaming, and ambient factors such as clouds, wind, and hot sun require the temperature setting of the wedge to vary. Depending upon the records to be kept, one might record a number of different temperatures. For example, the temperature of the hot wedge, the temperature of the seaming area and the ambient temperature. This is a site specific decision usually determined by the specifications and the QA plan.
>
> At least two people are required in making hot wedge

welds: one operator and one helper.

A leak-proof T-connection is necessary wherever intersecting seams are to be joined together. At such locations, the hot wedge device must be removed a short distance (approximately 150 mm (6 inches)) from the intersecting seam. For polyethylene geomembranes, this short distance must be completed by extrusion fillet seaming.

A smooth insulating plate or heat insulating fabric should be placed beneath hot welding devices while they are not in use.

(b) Extrusion Seams. Extrusion welding should only be allowed for patching and seaming around appurtenances. Look for the following when observing the construction of extrusion welded seams.

Heat tacking is often used to hold geomembranes in place so that extrusion seams can be made more easily. A hot air device is used to make tack welds.

The surfaces of all polyethylene geomembranes should be ground prior to extrusion welding using an electric rotary grinder. Number 80 to 100 grit size is typically used for grinding. All of the surface sheen in the area to be seamed should be totally removed.

Grinding marks should be oriented perpendicular to the seam direction and no marks should extend beyond the extrudate.

In general, grinding marks should not appear beyond 6 mm (.25 inches) outside of where extrudate is placed.

The depth of the grinding marks should be no greater than 10 percent of the sheet thickness.

Verify all of the material that has been ground from the geomembrane is wiped or blown away from the actual seaming zone.

Extrusion welding should begin within 10 minutes after grinding. The extrusion bead should be centered over the top of the geomembrane seam.

For HDPE geomembranes which are 1.5 mm (60 mils) or greater in thickness, the leading edge of the upper sheet should be beveled. The upper geomembrane must be lifted off the lower so the lower sheet is not damaged by the grinder.

Extrudate thickness should be approximately equal to or greater than the specified sheet thickness measured from the top of the upper sheet to the top or crown of the extrudate. Excessive squeeze-out of extrudate along the edges of the seam is acceptable as long as it is adequately joined to the geomembrane.

Visual inspection of the extrudate bead should be made for straight line alignment, height, and uniformity of surface texture. There should be no bubbles or pock marks in the extrudate. Such surface details on the extrudate indicates the presence of air, water or debris within the extrudate.

Where extrusion welds are temporarily terminated long enough to cool, they should be ground prior to applying new extrudate over the existing seam.

After temporary work stoppages, the extrusion welder should be purged of all old extrudate in the barrel. The extrudate should not be discharged onto the surface of previously placed geomembrane or the geomembrane subgrade.

A smooth insulating plate or heat insulating fabric should be placed beneath hot welding devices while they are not in use.

(3) Non-Polyethylene Geomembrane Seams.

(a) Non-polyethylene geomembranes can be seamed by thermal fusion or chemical methods.

(b) Seaming adhesives, solvents, or chemical cleaning agents should not be stored on top of the geomembrane and only spill-resistant containers should be used while working with these materials on the geomembrane.

(c) For chemical fusion and adhesive fabricated seams, testing cannot be performed until adequate curing of the seam occurs. During this curing time, make sure all production seaming is tracked and documented.

(d) Accelerated oven curing of chemical and adhesive fabricated seams is acceptable to obtain test results as soon as possible.

g. Field Sampling and Testing.

(1) Non-Destructive Leak Testing.

(a) Verify and document that field seams are tested for leaks over their full length. The QA Representative should verify the following is being recorded: date, seam number, test unit number (if applicable), name of test person, test data, and outcome of testing.

(b) Pressure testing should be used to test double hot wedge weld seams. This is done using the following procedure.

Isolate a section of seam. No limitations are generally placed on the length of seam that can be tested.

Pressurize the isolated channel using a hollow needle connected to an air pump. Typically the pressure used is 167 to 267 kPa (25 to 40 psi).

Monitor for pressure drops over a specified period of time (typically 5 minutes).

If the pressure drop is less than a specified value, the seam passes. The allowable pressure drop depends on the initial pressure in the seam. A typical allowable pressure drop is 20 kPa (3 psi).

Visual observation or listening for escaping air will often determine the location of leaks.

After the test is complete, the end of the seam which is opposite of where the air pump is located should be cut. A QA Representative should be present when the seam is cut open. Listen for escaping air to ensure the seam is continuous over the full length tested.

(c) A vacuum box is often used for extrusion welds and other seams where it is not possible to pressure test. The vacuum test procedure typically consists of the following steps.

Wet a section of seam with soapy water.

Place the vacuum box over the seam and create a vacuum.

View the seam through the transparent window in the box for approximately 10 seconds. If no bubbles are evident, then the area is considered passing.

If bubbles are evident, mark the area for repair, perform the repair, and repeat the vacuum test.

(d) Verify seam testing is performed as the seaming work progresses, not at the completion of field seaming.

(e) Ensure the location, date, test number, name of test person and results are recorded for all seam leak tests.

(2) Destructive Field Seam Testing. Destructive testing of seams is conducted to provide a direct evaluation of seam strength and bonding efficiency. Destructive testing involves two types of tests: shear and peel tests.

(a) Typically, one destructive test sample should be taken per 230 meters (750 feet) of field seam. Observe all production seam sample cutting.

(b) Do not identify sample locations to the installer prior to seaming. Ask for additional seam tests if seams appear to be of questionable quality.

(c) Samples are typically a minimum of 300 mm (12 inches) wide by 1.1 m (42 inches) long with the seam centered lengthwise.

(d) Each sample is typically cut into three equal pieces with one piece retained by the installer, one piece given to the QA laboratory, and the remaining piece retained by the Government for possible testing and permanent record. Ensure that the samples going to the QA laboratory are properly labeled and packaged as described in the paragraph entitled “Trial Seams”.

(e) Ensure each sample is numbered and cross referenced to a field log and also shown on the record drawings. The reason for taking the sample should also be indicated, e.g., routine, suspicious feature, change in sheet temperature, etc.

(f) Shear and peel tests are typically performed by both the installer and the QA laboratory to ensure the seams have adequate strength. Reference the paragraph entitled "Trial Seams" for a description of the testing procedure to be used. The QA Representative should monitor and document all destructive seam tests performed by the geomembrane installer.

(g) Compare the results of the field tests to the QA laboratory test results to make sure they agree. Require additional testing if there is a disagreement between the sets of test data.

(h) The QA Representative should ensure the following information is recorded for each seam sample tested: sample number, date, test results, welder number, ambient temperature, welder temperature and pressure, and rate of seaming. For chemical seams, the chemical type and mixture should be recorded.

(i) Ensure destructive seam sample holes are repaired and nondestructively tested for leaks the same day they are cut.

h. Defects and Repairs.

(1) Destructive Seam Test Repairs.

(a) Seams that fail destructive seam testing may be cap stripped by seaming an additional strip of material over the failed seam between any two passed destructive test locations.

(b) Alternatively, the contractor may choose to try to isolate the weak area of the seam by retracing the seaming path to a location a specified distance (typically, at least 3.1 m (10 feet)) on either side of the failed seam location using the following procedure:

> At each location, samples should be taken so the contractor can perform additional shear strength and additional peel adhesion tests;
>
> If these tests pass, then the remaining seam sample should be sent to the QA laboratory for shear strength and peel adhesion tests;
>
> If these laboratory tests pass the specified strength criteria, then the seam should be cap stripped between passing destructive tests;
>
> After cap stripping, the entire cap stripped seam should be tested for leaks; and
>
> Documentation of all failed destructive seams should be recorded on the as-built drawings.

(2) Patches.

(a) Patching and cap stripping should be used to repair large holes, tears, and locations where destructive seam samples were taken. Ensure patches have rounded corners and extend a minimum of 15.3 cm (6 inches) beyond the edge of defects.

(b) Minor localized flaws such as pin holes can be repaired by spot welding.

(c) Ensure repairs are non-destructively tested for leaks.

(d) Verify all repairs are documented in the daily reports and recorded on the as-built drawings.

i. Penetrations and Connections.

(1) Factory fabricated boots should be used wherever possible.

Boots are prefabricated connections which allow a water-tight seal to be constructed at pipe penetrations.

(2) The skirt of the pipe boot which flares away from the pipe penetration should typically have at least 300 mm (12 inches) of geomembrane on all sides of the pipe.

(3) Verify non-destructive leak testing is performed on the seams which attach the skirt to the geomembrane.

(4) A stainless steel clamp is generally used to attach the boots to pipes. A cushion of compressible material should be placed between the clamp and the boot.

j. Covering. Refer to Chapter 3.9 Cover Soil Layer for additional information on cover soil placement.

(1) Pushing the cover soil across the geomembrane surface can cause large wrinkles to develop. Require the contractor to modify the placement procedure if the wrinkles become so large that they fold over and crease the geomembrane.

(2) Periodically inspect the surface of the geomembrane for bulges which may be an indication that gas or water is collecting beneath the geomembrane. Stop construction and notify the design district if this situation occurs.

CHAPTER 3.6
DRAINAGE LAYER

CHAPTER 3.6 DRAINAGE LAYER

3.6-1. GENERAL. Drainage layers are constructed with either geonets or coarse grained granular soils. A geonet consists of a set of parallel plastic ribs positioned in layers such that liquid or gas can be transmitted within the void spaces between the ribs. Geonets are often used instead of soils for drainage layers because they have a higher flow capacity, require less space, and are easier to construct. Most geonets are manufactured using polyethylene and are typically 5.0 to 8.0 mm (0.20 to 0.30 inches) in thickness. The large voids within the geonet must be protected from clogging. Therefore, geonets always function with either geomembranes and/or geotextiles on their two planar surfaces. Whenever the geonet comes supplied with a geotextile attached to one or both of its surfaces, it is called a geocomposite. The geotextiles are bonded to the geonet by heat fusing or by use of an adhesive.

a. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Manufacturer's QC test results.

(2) If a geotextile is attached to one or both sides of the geonet, bond adhesion test results should be submitted.

(3) Interface friction test results.

(4) Geonet sample with any attached geotextiles (if required).

b. Delivery, Storage, and Handling.

(1) A QA Representative should be present during delivery and unloading of the geonet to inspect for damage.

(2) Verify that rolls are labeled with the manufacturers name, product identification, lot number, roll number, roll dimensions, and date manufactured.

(3) The QA Representative should record roll numbers, date delivered, name of manufacturer, and product type. This data is used to verify manufacturer’s QC data sheets have been submitted for the rolls being delivered.

(4) Geonet rolls should be handled and unloaded with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly should be used.

(5) Do not allow rolls to be dragged, lifted by one end, or dropped to the ground.

(6) Ensure the geonet is kept free of dirt, dust, mud, or any other foreign materials. Ideally, geonet should not be stored directly on the ground since they do not arrive at the job site with a protective plastic cover.

(7) Temporary storage at the job site should be in a flat smooth area where standing water cannot accumulate. A geomembrane or ground cloth should be placed under the geonet if they are stored on soil for longer than a month. This will prevent weeds from growing

into the lower rolls of the geonet. If weeds do grow in the geonet during storage, ensure they are removed when the geonet is deployed.

(8) Geocomposite should be stored with an opaque cover over it to protect the geotextile.

(9) Ensure rolls are not stacked so high that the cores are crushed or the geonet is damaged.

3.6-2. PRODUCTS.

Geonet.

(1) Cross check the roll numbers of the geonet delivered to the site against the roll numbers on the manufacturer's QC test data submittals to ensure they match. Ensure the geonet meets the property requirements outlined in the specifications for material type and physical properties.

(2) Check the transmissivity test results to make sure the tests were run using the specified normal stress, gradient, and boundary conditions.

(3) Inspect geotextiles which have been heat bonded to geonets to make sure the geotextiles have not been damaged or thinned by the bonding process.

(4) If a geotextile is attached to one or both sides of the geonet by adhesives, check to make sure excessive adhesive has not filled the void spaces in the geonet.

3.6-3. EXECUTION.

a. Installation.

(1) A QA Representative should be present at all times during geonet installation.

(2) Prior to placement of the geonet, verify the subgrade is smooth and will not damage or clog the geonet.

(3) Do not allow geocomposite to be dragged across the surface of a textured geomembrane. This can result in damage to the geocomposite.

(4) The geonet should be unrolled down slope keeping the net in slight tension to minimize wrinkles and folds.

(5) Adequate ballast (e.g. sandbags) should be placed to prevent uplift by wind.

(6) Overlaps and Fasteners.

(a) Ensure roll ends and edges are overlapped the specified distance. Typically, roll edges are overlapped a minimum of 75 mm (4 inches) and roll ends are overlapped a minimum of 160 mm (6 inches).

(b) Ensure plastic fasteners are used to join adjacent rolls. Metallic fasteners should not be allowed because they can puncture geomembranes.

(c) Ensure fasteners are placed at the specified spacings. Fasteners are typically spaced a maximum of 1.5 m (5 feet) apart along down slope roll overlaps and a maximum of 150 mm (0.5 feet) apart along cross slope roll overlaps.

(d) Fasteners should be of contrasting color from the geonet to facilitate visual inspection.

(e) Geonets should never be welded to geomembranes.

(f) If horizontal overlaps are required on side slopes, they should be staggered for adjacent rolls.

(g) When more than one layer of geonet is required, verify that end and edge overlaps are staggered so that joints do not lie above one another.

(h) Stacked geonet layers should always be laid in the same direction to maintain transmissivity requirements. However, they should be laid on top of each other such that interlocking does not occur.

(i) Do not allow geocomposites to be dragged across the surface of a textured geomembrane because the geotextile will be damaged.

(j) No personnel working on the geonet should smoke or wear shoes which could damage the geosynthetics.

(k) Verify that any area requiring repair is clearly marked.

b. Repairs.

(1) Holes or tears in the geonet are typically repaired by placing a patch of geonet extending a minimum of 610 mm (2 feet) beyond the edges of the hole or tear.

(2) Fasteners are typically spaced every 150 mm (6 inches) around patches.

(3) If a tear is present across more than 50 percent of the width of the geonet on side slopes, require the entire length of geonet to be removed and replaced.

c. Covering. Refer to Chapter 3.9 Cover Soil Layer for additional information on cover soil placement.

3.6-4. <u>GRANULAR DRAINAGE LAYER</u>. Granular drainage layers are generally composed of sand or gravel and usually have a minimum thickness of 300 mm (12 inches). If the drainage material will be placed adjacent to a geomembrane, the maximum particle size is typically required to be no greater than 12.5 mm (0.5 inches). The drainage layer should generally not be compacted since this may increase the percent fines, decrease the hydraulic conductivity, and damage underlying geosynthetics. A natural or geotextile filter is often provided on top of the granular drainage layer to prevent clogging.

a. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Materials Handling Plan which describes the processing and placement of the granular drainage layer.

(2) Borrow Source Assessment Report. At a minimum, one set of borrow assessment tests should be performed for each borrow source. A set of borrow source assessment tests generally consists of gradation, hydraulic conductivity, and possibly carbonate content.

(3) Samples of granular drainage material (if required).

b. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Borrow classification test results.

(2) Hydraulic conductivity test results.

c. Granular Drainage Layer Material.

(1) Check the properties of the drainage material (grain size distribution and hydraulic conductivity) being submitted against the requirements listed in the specifications. During construction, require additional testing if the properties of the drainage material appear to be changing.

(2) Hydraulic Conductivity Test Results. Consider requiring the contractor to perform additional testing prior to placement if pre-construction test results just barely meet the hydraulic conductivity requirements stated in the specifications. The reproducibility of hydraulic conductivity tests is not good, therefore, a material may just barely meet the hydraulic conductivity standard in one test but fail to meet minimum requirements in another test. Also, additional fines will be generated every time a drainage material is handled. The additional fines can significantly decrease hydraulic conductivity.

(3) Verify that oversize and angular material which could damage geosynthetic layers has been removed prior to placement.

d. Installation.

(1) Verify drainage material is being placed to the lines and grades shown on the drawings.

(2) Granular materials placed on top of geosynthetic components on side slopes should be placed from the bottom of the slope up.

(3) When granular drainage material is placed on top of geosynthetics and spread with a dozer, the sand or gravel should be lifted and tumbled forward to minimize shear forces on the underlying geosynthetics.

(4) Inspect the placement operation by observing the front of the working face as the materials are being spread to ensure that the underlying geosynthetics are not being damaged.

e. Protection.

(1) Verify that wind-borne and water-borne fines do not contaminate the drainage layer after placement.

(2) Watch for ponding on top of the drainage layer. This may indicate fines have contaminated the drainage layer.

(3) Areas of erosion should be repaired and grades reestablished.

CHAPTER 3.7
GEOTEXTILE

CHAPTER 3.7 GEOTEXTILE

3.7-1. GENERAL. Geotextiles consist of woven or nonwoven textile sheets supplied to the job site in large rolls. The majority of geotextiles used in landfill systems are made from either polypropylene or polyester. When ready for placement, the rolls are removed from their protective covering, properly positioned and unrolled over the subgrade. Geotextiles can be used for separation of materials, filtration, reinforcement, and erosion control. This section will focus on geotextiles used for separation and filtration. A separation/filtration layer is normally required between a soil layer and an underlying drainage layer. The separation/filtration layer ensures consistent drainage properties by preventing migration of fine grained soil particles into the void spaces of the drainage layer.

a. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Manufacturer's QC test results.

(2) For needle punched geotextiles, the manufacturer should certify that the geotextile has been continuously inspected using permanent in-line full-width metal detectors and does not contain any needles which could damage other geosynthetic layers.

(3) Proposed thread type for sewn seams along with data sheets showing the physical properties of the thread. The thread typically is made from polypropylene, polyester, nylon, or a proprietary material.

(4) Geotextile samples (if required).

b. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

Seam strength test results (if required).

c. Delivery, Storage and Handling.

(1) A QA Representative should be present during delivery and unloading of the geotextile to inspect for damage.

(2) Verify that rolls are labeled with the manufacturers name, product identification, lot number, roll number, roll dimensions, and date manufactured.

(3) The QA Representative should record roll numbers, date delivered, name of manufacturer, and product type. This data is used to verify manufacturer’s QC data sheets have been submitted for the rolls being delivered.

(4) Verify each geotextile roll is wrapped around a central core and covered with an opaque, waterproof, protective covering. Require that tears in the packaging be repaired using tape and plastic sheeting to restore a waterproof protective barrier around the geotextile.

(5) Rolls should be immediately rewrapped after QA/QC samples have been collected.

(6) Geotextile rolls should be handled and unloaded with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly should be used.

(7) Do not allow rolls to be dragged, lifted by one end, or dropped to the ground.

(8) Field storage should not be in areas where water can accumulate. Rolls of geotextile should either be elevated off the ground or placed on a sacrificial sheet of plastic. Saturated geotextile if difficult to handle.

(9) Rolls should not be stacked so high that the cores are crushed or the geotextile is damaged.

3.7-2. PRODUCTS.

Geotextile.

(1) Cross check the roll numbers of the geotextile delivered to the site against the roll numbers on the manufacturer's QC test data submittals to ensure they match. Ensure the geotextile meets the property requirements outlined in the specifications for material type and physical properties.

(2) More than one type of geotextile is often required on a job, verify the correct geotextile type is being used for each component of the job.

3.7-3. EXECUTION.

a. Subgrade Preparation. Inspect the surface underlying the geotextile prior to installation.It should be smooth and free of ruts or protrusions which are greater than the specified requirements (typically 25 mm (1 inch)). Verify the lines and grades of the subgrade are correct prior to geotextile placement.

b. Installation.

(1) A QA Representative should be present at all times during geotextile placement.

(2) Geotextile should be laid smooth so that it is free of tensile stresses, folds, and wrinkles.

(3) On slopes greater than 5 horizontal on 1 vertical, the geotextile should be unrolled parallel to the direction of maximum slope.

(4) Do not allow geotextile to be dragged across the surface of a textured geomembrane. This will result in damage to the geotextile.

(5) Inspect the geotextile for damage if it has been placed on a textured geomembrane surface and then removed from the membrane.

(6) No personnel working on the geotextile should smoke or wear

shoes which could damage the geosynthetics.

(7) Any area requiring repair should be clearly marked.

c. Protection.

(1) Ensure that geotextile is protected during installation from clogging, tears, and other damage.

(2) Ensure ballast (typically sand bags) is used to prevent wind damage to deployed geotextile.

(3) Check the specifications to determine the maximum allowable exposure time for the deployed geotextile. In general, geotextiles made from polypropylene should not be left uncovered for more than 14 days during installation. Geotextiles made from polyester may be left uncovered for up to 28 days. If the allowable exposure period has been exceeded, one method of determining if the geotextiles have been damaged is to require the contractor to perform QC tests to verify the physical properties of the textile have not diminished due to exposure.

(4) The use of staples or pins to hold geotextiles in place should not be allowed in applications where the geotextile will be located adjacent to other geosynthetics.

d. Seaming. Review the drawings and specifications to determine if overlap, sewn, or thermally bonded seams are required. Geotextile seams are typically overlapped in flat areas such as landfill liner bottoms. On landfill side slopes, the geotextiles are generally sewn.

(1) Overlap Seams.

(a) Ensure overlaps meet the minimum specified requirements. Typically, geotextile edges are overlapped a minimum of 300 to 600 mm (12 to 24 inches). If the geotextile is being placed on a soft subgrade, the overlap distance may need to be greater.

(b) Where it is required that seams be oriented across the slope, the upper layer should be lapped over the lower layer.

(c) Inspect for openings in the seams during placement of cover soil.

(2) Sewn Seams. If sewn seams are used, check the specifications to determine if trial seams are required.

(a) Ensure sewn seams are continuous. Spot sewing is generally not allowed.

(b) Verify seams are sewn at the locations shown on the drawings.

(c) Determine if the specifications require a specific type of stitch be used for sewn seams.

(d) Verify that the minimum distance from the geotextile edge to the stitch line nearest to that edge is as recommended by the manufacturer.

(e) The thread at the end of each seam run should be tied off to prevent unraveling.

(f) Inspect for skipped stitches or discontinuities. These areas should be sewn with an extra line of stitching with 450 mm (18 inches) of overlap on each side.

(g) Check the specifications to determine if the sewn seams must be tested for strength.

e. Repairs.

(1) Require geotextile damaged during installation to be repaired by placing a patch of the same type of geotextile over the damaged area. Patches generally extend a minimum of 300 mm (12 inches) beyond the edge of the damage or defect.

(2) Patches should be continuously fastened using a hand or machine sewn seam or other approved method. The machine direction of the patch should be aligned with the geotextile being repaired. Machine direction is defined as the long direction of the geotextile.

f. Covering. Refer to Chapter 3.9 Cover Soil Layer for information on cover soil placement.

CHAPTER 3.8
PIPE AND APPURTENANCES

CHAPTER 3.8 PIPE AND APPURTENANCES

3.8-1. GENERAL. This section will focus on the installation of plastic pipe. PVC and HDPE are the two most common types of plastic pipe used at hazardous waste sites. Some uses of plastic pipe at hazardous waste sites include:

drainage layers in landfill covers and liners;

ground water monitoring, extraction, and recharge wells;

ground water extraction and recharge trenches; and

soil vapor extraction, bioventing and air sparging systems.

Additional information on construction of pipe systems is available in Volume 1 of the Quality Assurance Representative's Guide, in the chapter titled "Underground Pipe Systems".

a. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Manufacturer's pipe installation recommendations.

(2) Manufacturer's QC manual and QC test results.

(3) Samples of pipe (if required).

(4) Samples of pipe bedding material (if required).

(5) Samples of warning tape used to mark pipe locations (if used).

(6) Samples of backfill material (if required).

(7) If required, the QA Representative should see that QA test samples are obtained upon delivery of the pipe.

(a) Ensure that the pipe is identified according to its proper ASTM standard.

(b) Ensure that QA test results are approved prior to pipe deployment.

b. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

Results of leak and/or pressure tests (if required).

c. Delivery, Storage, and Handling. Both PVC and HDPE pipe are manufactured in lengths of approximately 6.1 m (20 ft) with varying wall thicknesses and configurations. They are placed on wooden pallets and bundled together with plastic straps for bulk handling and shipment.

(1) The QA Representative should be present during delivery and unloading of pipe to inspect for damage.

(2) The QA Representative should record applicable pipe numbers, date delivered, name of manufacturer, and product type. This data is used to verify manufacturers QC data sheets have been submitted for the pipe being delivered.

(3) Steel cables and chains should not be used to handle pipe.

(4) Ensure that field storage is in an area where water can not accumulate. The pallets of pipe should be placed on level ground and oriented so the pipes do not pond water.

(5) Pallets of pipe should not be stacked more than three high. They should also be protected from direct sunlight if recommended by the manufacturer.

(6) Gaskets for bell and spigot pipe connections should not be stored in direct sunlight.

3.8-2. PRODUCTS.

a. General.

(1) Ensure the correct material type, strength, and diameter of pipe has been delivered to the job site.

(2) Verify the size, number and location of pipe perforations are as specified.

(3) Pipe with external gouges deeper than 10 percent of the wall thickness should be discarded or repaired before used.

(4) Out-of-round pipe which cannot be properly joined together should be repaired or rejected.

b. PVC Pipe. PVC pipe typically consists of resin, fillers, carbon black, pigment, and additives. PVC pipe does not contain any liquid plasticizers.

(1) Pipe tolerances and properties must meet the applicable standards required by the plans and specifications. ASTM D-1785 or ASTM D-2241 are often referenced when specifying PVC pipe.

(2) PVC pipe fittings are generally constructed in accordance with ASTM D-3034. The pipes are joined by couplings or bell and spigot ends.

c. HDPE Smooth Wall Pipe.HDPE pipe material consists of resin, carbon black, and additives. The pipes are generally joined together using butt-end fusion welds. Other joining methods such as bell and spigot, male-to-female and threading are also used.

d. HDPE Corrugated Pipe. Corrugated HDPE pipe is also called "profiled" pipe. This type of pipe can be perforated or slotted and the inside can be either smooth or corrugated depending on the site-specific requirements. The pipes should be joined together by couplings made by the same manufacturer as the pipe itself. This is important since the couplings are generally not interchangeable among the different manufacturer's products.

3.8-3. EXECUTION.

a. Placement. This section focuses on placement of pipe in trenches and landfill drainage layers.

(1) If pipe is to be placed above a geomembrane, check the specifications to see if a bedding layer should be placed between the pipe and membrane.

(2) Check compaction requirements for any bedding layers located around the pipe. The density of the material beneath, adjacent, and immediately above plastic pipe greatly affects its load-carry capacity.

(3) Pipe should be carried to the place of installation and not dragged.

(4) Inspect pipe carefully before it is placed. Reject any defective or damaged pipe.

(5) Pipe laying should proceed upgrade, beginning at the lower end of the pipeline.

(6) Ensure that pipe is not laid when trench conditions or weather is unsuitable. Under no circumstances should pipe be installed if standing water is present. Ensure the contractor has dewatered the trench prior to pipe placement.

(7) Ensure that pipe is placed at the lines and grades indicated in the plans and specifications.

(8) Perforated pipe should be installed with the perforations facing down unless otherwise specified.

(9) Pipe fittings or joints should be installed according to requirements stated in the specifications. Ensure pipe and fittings are clean of all dirt, debris, oil or any other contaminant which may inhibit the construction of a sound joint.

(10) Inspect and approve all in-place pipe before allowing backfill placement. Ensure all required leak tests are performed prior to backfilling.

b. Sumps, Manholes and Risers. A piping system may be specified as part of the primary or secondary leachate collection system of a landfill liner. Pipes used in landfill liners are usually made of high density polyethylene (HDPE). The purpose of the piping system is to rapidly remove leachate from the liner. Perforated feeder pipes are usually designed to flow to a central trunk line. The trunk line may or may not be perforated, depending on site-specific design requirements. The trunk line flows by gravity to a low point in the liner system referred to as a sump. The sump is typically filled with coarse granular material which provides storage for leachate. The leachate is periodically removed from the sump through a riser pipe using a submersible pump. Sumps can also consist of prefabricated vertical risers with a manhole extension rising through the waste and final cover.

(1) Sumps are very labor intensive and difficult to construct. Careful visual inspection is required in sump areas since these are the low points in the liner system where water will collect.

(2) Check compaction requirements for the subgrade material located beneath the sump.

(3) Carefully inspect placement of sump stone because its large diameter can easily damage underlying geosynthetics. The drop height of the first lift of sump stone should be small enough that underlying geosynthtics are not damaged (typically 300 mm (12 inches) or less).

(4) Check the specifications for pipe perforation requirements. Sump riser pipes for primary and secondary leachate removal are generally not perforated, except for the lowest section of pipe which allows leachate to enter the pipe.

(5) Carefully inspect riser pipe joints for primary and secondary leachate removal since neither destructive nor nondestructive tests can usually be performed.

(6) Verify that test operation of pumps, level alarms, valves, switches, and controls have been performed in accordance with manufacturer's recommendations.

c. Double Wall Containment Pipe. Double wall containment pipe is often required for carrying hazardous liquids outside the landfill liner system.

(1) Check the specifications to determine if and where double wall containment pipe is required.

(2) Check the specifications for special testing requirements for double wall containment pipe.

(3) Some double wall pipe requires the use of potentially hazardous glue to make pipe connections. Manufacturer's recommended safety precautions should be followed if this is the case.

(4) If piping is glued, ensure the glue is allowed to set within the recommended temperature range.

(5) If piping is glued, ensure there is adequate ventilation since the glue may be both hazardous and flammable.

(6) A double wall pipe manufacturer's representative should generally be on site at the beginning of pipe installation for training, and periodically during installation to ensure correct procedures are used.

(7) If an electrical leak detection system is used, it is critical to ensure ends of the containment piping are sealed overnight and when work is not ongoing. Dirt or water which enters the annular space will interfere with the leak detection cable and could cause operational problems.

(8) Inner (carrier) pipes should be hydrostatically tested and outer (containment) pipes should be pneumatically tested at the specified pressures.

(9) Frequently, double wall pipe is sloped so that if there is a leak in the carrier pipe, the fluid flows by gravity in the containment pipe to a sump or tank.

CHAPTER 3.9
COVER SOIL LAYER

CHAPTER 3.9 COVER SOIL LAYER

3.9-1. GENERAL. This chapter lists QA responsibilities during placement of cover soil above geosynthetics. Placement of cover soil is a critical step since the underlying geosynthetic materials are relatively thin layers which can be easily damaged. In a liner system, the cover soil will typically consist of a drainage layer or a clay barrier layer. Cover soil placed above geosynthetic layers in a landfill cover is commonly referred to as select fill.In addition to protection of geosynthetics, the select fill layer also protects the low-permeability clay layer from freezing temperatures and desiccation. The select fill layer in a landfill cover should be composed of soil that is capable of sustaining a vegetative cover throughout dry periods. The select fill also provides water holding capacity to slow down rainfall infiltration to the drainage layer.

The type of soil used for select fill is a site specific decision. Typically, select fill will consist of medium-textured soils for both function and constructibility. Cohesionless silts and sands are undesirable because these soils have low water retention capacity and nutrients are easily leached from them. However, high plasticity clays can damage underlying geosynthetics during placement. The best materials are usually cohesive but not highly plastic. Consult the specifications for the soil type that has been deemed "suitable" by the designer.

The maximum particle size specified for select fill will typically range from 12.5 to 25 mm (0.5 to 1 inch) depending on the type of geosynthetics present beneath the select fill. The use of angular material should also be avoided because of increased potential for damaging geosynthetics.

The select fill layer (including topsoil) should generally be a minimum of 600 mm (24 inches) thick or equal to the maximum frost depth, whichever is greater.

a. Equipment. Verify that the equipment used to place the cover soil is in accordance with the specifications. Contact the designer if equipment requirements for cover soil placement are not discussed in the specifications. The following paragraphs provide general guidance on equipment requirements.

(1) Equipment should not be allowed to travel directly on top of geosynthtics. This includes cars and light trucks.

(2) Check the specifications to see if all terrain vehicles (ATV) with low ground pressure tires can be operated on top of the geosynthetics. If ATVs are allowed to operate on top of the geosynthetics, they should move at a slow rate of speed, travel in straight lines or large arcs, not start or brake abruptly, and not turn sharply. Refueling should be performed outside the limits of the liner or cover system.

(3) Tracked equipment with a ground pressure of less than 35 kPa (5 psi) should be used to spread the first lift of cover soil.

(4) The required cover soil thickness needed to allow safe operation of full scale construction equipment is site specific and depends on the type of geosynthetics being covered, the cover soil type, and the subgrade. Contact the design engineer if the specifications do not indicate the minimum thickness of the cover soil layer prior to allowing operation of full scale construction equipment.

b. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Borrow Source Assessment Report for the cover soil.

(2) Chemical contamination test results to verify the borrow is not contaminated.

c. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Borrow source classification test results.

(2) In-place moisture content and density test results.

d. Weather Limitations.

(1) In general, backfilling in warm climates or during summer months should be performed during the coolest part of the day to minimize wrinkles in geomembranes.

(2) In extreme cases, of excessively high temperatures, backfilling may need to be performed during non-typical work hours, e.g., sunrise to 10:00 AM or 5:00 PM to sunset.

(3) If cover soil placement is performed at night, ensure the contractor is using adequate lighting to safely work.

3.9-2. PRODUCTS.

Cover Soil. Verify cover soil borrow source assessment testing has been performed. Ensure the proposed cover soil meets the specified requirements for grain size distribution, Atterberg limits, maximum particle size, and all other physical properties specified.

(1) Periodic classification testing should be performed on the borrow as it is excavated during construction. Check borrow test results (sieve analysis and Atterberg limits) to verify that the material meets the specified requirements. Require additional classification testing if the properties of the borrow source appear to be changing.

(2) Perform daily inspections of the cover soil to see if there are visible changes in the properties of the borrow. Carefully inspect for oversize particles.

3.9-3. EXECUTION.

a. Installation.

(1) A QA Representative should be present at all times during backfilling over the geosynthetics. Check the specifications to determine the maximum allowable exposure time for the deployed geosynthetics prior to covering.

(2) Ensure placement of cover soil proceeds from a stable working area adjacent to the deployed geosynthetic material and gradually progresses outward. For slopes, cover soil should be

placed by starting at the toe and working up the slope.

(3) Cover soil should be pushed forward in an upward tumbling motion using a bulldozer or front end loader.

(4) Cover soil should not be dumped or dropped directly onto the underlying geosynthetic material from a height greater than 1 meter (3 feet).

(5) The contractor should be allowed to place access routes over the geosynthetics to speed up cover soil placement. The access routes will allow use of larger construction equipment to carry cover soil out onto the geosynthetic layers. Cover soil thickness for access routes will generally be a minimum of 900 mm (3 feet).

(a) Tracks and wheels of full-scale construction equipment must remain on the access routes at all times.

(b) Inspect access routes daily to see if thinning of the cover soil is occurring. The contractor should be required to repair any areas of the access route which are thinning.

(6) Verify that the cover soil lift thicknesses are in accordance with the specifications. Typically, the first lift of cover soil is a minimum 200-mm (8-inches) to 300-mm (12-inches) in thickness.

(7) Do not allow large stockpiles of cover soil to be placed on the underlying geosynthetic materials.

(8) Carefully inspect placement and compaction of soil placed above geosynthetic layers. Look for slippage of the compaction equipment on slopes. This can cause damage to the geosynthetics.

(9) Look for thin areas of cover soil which could allow the geosynthetics to be punctured or torn by construction equipment.

(10) Do not allow compaction equipment to be operated at speeds exceeding specified limits (generally 2.2 meters per second (5.0 miles per hour)).

(11) Watch for construction equipment braking suddenly while on top of the cover soil.

(12) Do not allow wrinkles in the geosynthetic layers which fold over onto themselves. To help prevent wrinkles, fingers of backfill are sometimes pushed out over the geosynthetics with controlled amounts of geosynthetic slack between the fingers.

(13) Penetrations.

(a) Verify that soil placed around penetrations does not contain voids and is adequately compacted.

(b) Inspect pipes which penetrate the cover soil layer for damage due to compaction equipment.

(14) Verify the cover soil layer is placed to the lines and grades shown on the drawings.

(15) Verify the final lines and grades of the cover soil layer are correct.

b. Compaction. Both method and performance specifications have been used to place cover soil layers. Compaction requirements are usually waived for the first lift of cover soil placed above geosynthetic layers.

(1) Method Specification.

(a) Verify the correct size and type of equipment is being used to compact the cover soil layer.

(b) Periodically check that the contractor is making the required number of passes to compact all areas of the cover soil layer.

(2) Performance Specification. Verify the cover soil is placed and compacted within the specified moisture content and density ranges. Verify moisture content and density tests are performed using specified test procedures on each lift of cover soil. Refer to Chapter 3.3 Low Permeability Clay Layer for a description of moisture and density testing procedures.

c. Repairs. If the cover soil layer does not conform to the specifications, the first step is to define the extent of the area requiring repair.

(1) Require the contractor to repair the lift of cover soil out to the limits defined by passing QC or QA tests.

(2) Do not allow the contractor to guess at the extent of the area that requires repair. Additional tests are often required to define the area requiring repair.

(3) After repairs have been made, the repaired areas should be tested at the same frequency as required for the rest of the project.

d. Protection.

(1) Require excess moisture to be removed from the surface of the cover soil layer prior to placement of additional fill.

(2) Look for areas of erosion after each rainfall. Also look for tire ruts and other thin areas in the cover soil layer. Require the contractor to repair these damaged areas and reestablish grades.

(3) Do not allow the placement of stockpiles on top of the completed cover soil layer.

CHAPTER 3.10
VEGETATIVE COVER LAYER AND EROSION CONTROL

CHAPTER 3.10 VEGETATIVE COVER LAYER AND EROSION CONTROL

3.10-1. GENERAL. Vegetative cover plays a key role in controlling erosion by shielding the topsoil from precipitation, holding soil particles together, and reducing the velocity of runoff. Well-developed vegetation also consumes subsurface water between rainfall events through evapotranspiration. For landfill cover applications, vegetation should be chosen based on the following criteria:

Locally adapted, perennial plants resistant to droughts, temperature extremes, and other local climatological extremes;

Root systems which do not disrupt the infiltration layer and create pathways for percolation;

Ability to thrive with a minimum of nutrient additions;

High enough plant density to minimize soil erosion; and

Low mowing and maintenance requirements.

a. Equipment. Check the specifications to determine if there are any requirements for pesticide application equipment, seeding equipment, or mulching equipment. Additional information is available in Volume 1 of the Quality Assurance Representative's Guide, in the chapter titled "Establishing Grass and Plant Material".

b. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Pesticides application plan including manufacturer's information discussing physical characteristics and application instructions for pesticides.

(2) Seed analysis.

(3) Lime analysis.

(4) Fertilizer analysis.

(5) Pesticide analysis.

(6) Soil tests for topsoil. Tests may include pH, organic content, particle size, nutrient analysis, and mechanical analysis.

3.10-2. SEEDING AND TURF PROTECTION.

a. Seeding Times and Conditions.

(1) Ensure that specified planting periods are adhered to.

(2) Work should be stopped if unsatisfactory conditions exist for planting. Examples of unsatisfactory conditions include excessive moisture and drought.

b. Site Preparation.

(1) Ensure that finished grades are completed prior to planting. Finished grades should be free of stones and debris and should be protected from vehicles and erosion.

(2) Seeded surfaces should be graded to transition smoothly to areas undisturbed by construction.

(3) Soil amendments such as lime and fertilizer should be applied at rates determined by topsoil analysis or as recommended in the specifications. Lime and fertilizer are often incorporated as part of the tillage operation.

c. Seeding.

(1) Immediately prior to the start of seeding operations, ensure that the equipment to be used is calibrated correctly.

(2) Seeding is often performed using two passes with each pass off-set 90 degrees from the other. Each pass should apply seed at half the rate specified.

(3) Ensure mulching is performed the same day as seeding. Check the specifications to see if mulch should be disced into the soil or if hydromulch should be used.

(4) Pesticides should be applied by a state-certified applicator (where applicable).

d. Protection and Maintenance of Turfed Areas.

(1) Ensure that the area is protected against traffic immediately after mulching operations have been completed.

(2) The turf establishment period should be stated in the specifications. Contact the designer if it is not.

(3) The definition of a satisfactory stand of turf should be stated in the specifications. Contact the designer if it is not.

(4) Ensure that the contractor performs maintenance of the turfed areas, including eradicating weeds, protecting embankments and ditches from erosion, maintaining erosion control materials, protecting turfed areas from traffic, and mowing (if specified).

(5) Ensure that damaged, eroded, or barren areas are re-established by the contractor, including repair or replacement of mulch.

(6) Terms for measurement and acceptability of turf should be stated in the specifications. Contact the designer if they are not.

3.10-3. SURFACE DRAINAGE/EROSION CONTROL. Landfill erosion control structures are designed to reduce soil erosion by minimizing the velocity of surface water and concentrating flows into protected channels. Prevention of erosion requires temporary erosion control protection and continuous maintenance until the permanent vegetative growth is established. Permanent erosion control systems such as benches, terraces, channels, and drainage ditches may also be required.

a. Benches and Channels. Benches and channels are permanent erosion control structures that carry surface water from the landfill cap to sedimentation basins. Perimeter berms may also be needed to divert storm water from surrounding areas away from the landfill.

(1) Ensure that materials used (rip-rap, geotextiles, bedding soil) meet specified requirements.

(2) Verify benches and channels are constructed to the cross-sections and grades indicated on the plans and specifications.

(3) Visually inspect for dips and reverse grades along bench and channel bottoms.

(4) Ensure that the contractor is disposing of or reusing the excavated material in accordance with the specifications.

(5) Ensure soils used to construct benches are placed at the specified moisture content and compacted to the specified density.

(6) For channels at the toe of a landfill cover, verify the outlet pipes for the cover drainage layer are not obstructed or damaged during construction of the toe channel.

b. Gabions. Gabions are welded wire fabric structures that enclose rip-rap and hold it in place. They are used as permanent erosion protection for channels.

(1) Ensure that basket wire, lacing wire, and stone fill are as specified.

(2) Ensure that the foundation is prepared as specified. Inspect the foundation surface for smoothness immediately prior to placing the filter fabric.

(3) Ensure that the gabions are placed at the slopes and elevations called for on the drawings.

(4) All adjoining empty gabion units should be connected by wire lacing along the perimeter of their contact surfaces. Ensure that lacing is accomplished as described in the specifications.

(5) The initial line of gabion baskets should be anchored by partially filling them.

(6) Verify that stone filling operations proceed by careful placement by hand or machine so welded wire fabric structures are not damaged and to assure a minimum of voids between the stones.

(7) Along all exposed faces, the outer layer of stone should be carefully placed and arranged by hand to ensure a neat and compact appearance. The last layer of stone should be leveled with the top of the gabion to allow for proper closing of the lid and to provide an even surface that is uniform in appearance.

(8) Ensure that lids are stretched tight over the stone fill using crowbars or lid closing tools until the lid meets the perimeter edges of the front and end panels. The lid should be tightly laced with tie wire along all edges, ends, and internal cell diaphragms by continuous stitching. Ensure that all projections or wire ends are turned into the baskets.

(9) Do not allow the use of clip connections for the purpose of

final lid closing.

(10) Where a complete gabion unit cannot be installed, the basket should be cut, folded, and wired together to suit existing site conditions. The mesh must be cleanly cut and the surplus mesh cut out completely, or folded back and neatly wired to an adjacent gabion face.

c. Grout Bags. Grout bags are sometimes used to armor steep channels to resist erosive flow velocities. Specifications and manufacturer's directions should be consulted for installation instructions.

(1) Ensure grout bags are not pulling out of the anchor trenches as the bags are filled with grout.

(2) Ensure grout bags are fully expanded with grout.

(3) Excess grout on the edges of the anchor trench should be removed.

d. Sedimentation Basins. Sedimentation basins are impoundments constructed to collect surface runoff and control its release to prevent adverse impacts to adjoining properties and receiving waterways. Construction of sedimentation basins is similar to construction of other earthen embankments. Additional information is available in Volume 2 of the Quality Assurance Representative's Guide in the chapter titled "Levee Construction and Earth Embankment Construction for Dams".

e. Silt Fences. Silt fences are made of woven geotextile fabrics which are resistant to deterioration due to ultraviolet light and heat exposure. The geotextile is attached to wooden stakes using metal staples.

(1) Verify the silt fence meets the specified material requirements.

(2) Ensure the silt fence is securely fastened to the wooden stakes. Typically, a minimum of 3 staples should be used to attach the silt fence.

(3) Ensure that silt fence is installed where indicated by the plans and specifications. However, try to be flexible in the placement location so that areas where trenching will be difficult can be avoided.

(4) Verify the bottoms of the silt fence is buried to the depth indicated on the plans and specifications (typically, 150 to 200 mm (6 to 8 inches)). The geotextile should be positioned on the uphill side and the stake to the downhill side of the trench.

(5) The trench should be backfilled so that at least 50 to 100 mm (2 to 4 inches) of the silt fence geotextile forms a "J" shape, with the lower portion of the "J" pointing uphill. The trench should be backfilled and the soil compacted over the geotextile so it is level with the surrounding grade.

(6) Check the silt fences at least once per month for damage or excessive silt accumulation. Additional inspections should be made after large rainfalls and high winds.

f. Hay Bales. Hay bales serve the same function as silt fences.

(1) Verify that bales are tied firmly with wire or plastic ties and are secured by wood stakes.

(2) Verify bales are partially buried and staked in accordance with the specifications.

g. Erosion Control Blankets. Erosion control blankets provide temporary protection from erosion until the vegetative cover can be established. They are typically made of interlocking wood fibers or knitted straw. These materials are covered on both sides with a biodegradable plastic mesh or interwoven thread. As the vegetative cover becomes established, the erosion control blanket biodegrades and disappears.

(1) Verify that the area to be covered is properly prepared, fertilized, and seeded before the erosion control blanket is applied. All ground surfaces should be relatively smooth so that the erosion control blanket lies in complete contact with the underlying soil.

(2) Biodegradable erosion control blankets are very sensitive to water and ultraviolet light. Make sure these materials are stored in dry conditions and protected from sunlight until needed.

(3) Ensure that the weight and type of the blanket is as specified. If the erosion control material has defects or damage, it should be rejected or repaired prior to use.

(4) If the material is to be repaired, torn or punctured sections should be removed by cutting a cross section of the material out and replacing it with a section of undamaged material.

(5) Ensure overlaps are shingled in the direction of flow.

(6) Verify ends and edges of the erosion control blanket are pinned tightly to the ground so water cannot flow beneath the blankets and cause erosion.

(7) Ensure that staples used to hold the blanket in place are as required in the specifications. The staples should be applied vertically, keeping the blanket taut.

(8) Make sure staples are not so long that they penetrate the cover soil and damage underlying geosynthetics.

(9) Check the specifications and manufacturer's recommendations for overlap and pin placement requirements. The following can be used as general guidance:

Adjacent rolls of erosion control material should be overlapped a minimum of 75 mm (3 inches);

Staples should secure the overlaps at 750 mm (2.5 ft) intervals;

Roll ends should overlap a minimum of 450 mm (18 inches); and

The end overlaps should be stapled at 450 mm (1.5 ft) intervals.

CHAPTER 3.11
TEST FILL

CHAPTER 3.11 TEST FILL

3.11-1. GENERAL.A test fill is a simulated section of the landfill cover or liner. Test fills are constructed prior to full scale construction for the following reasons:

To verify the contractor can construct the landfill cover or liner as specified without damaging the geosynthetics;

To determine if interface frictional resistance between the various components of the landfill cover or liner is adequate to prevent slope failures;

To allow the contractor to determine placement methods for natural soil components;

To allow sealed double ring infiltrometer (SDRI) testing to be performed (Refer to ASTM D 5093 and EPA/600/R-93/182 if a SDRI test will be performed as a component of the test fill evaluation process); and

To verify whether the field placement methods will achieve the required hydraulic conductivity of the low permeability clay layer.

Test fills are typically 10-15 m (30-50 ft) wide and 20-30 m (65-100 ft) long. The length of time which a test fill will be monitored after construction varies from project to project and depends on the type of testing which will be performed.

a. Equipment.

Ensure that equipment used for the test fill is the same type that is specified for full scale construction.

b. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Other specifications require submittals related to the cap or liner system. These submittals should be made and approved in advance of the test fill section construction.

(2) Test Fill Plan describing the proposed test fill section construction. The plan should include the following:

Drawings including plan views, sections, and details;

Sequence of operations;

Survey marker layout including monitoring to be performed;

Surface water controls and diversion; and

Equipment to be used including proposed operating speeds, traffic pattern, and number of passes.

c. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Weekly Post-Construction Monitoring Reports including the most up to date test results and survey data from the test fill.

(2) Final Test Fill Construction Report which includes as-built drawings, videos, all survey data and test results, and conclusions related to test fill construction and monitoring.

3.11-2. PRODUCTS. Ensure all materials used to construct the test fill are the same as will be used for construction of the full-scale landfill.

3.11-3. EXECUTION.

a. General.

(1) Verify the contractor is constructing the test fill to the specified dimensions at the location shown on the drawings. Typically, the test fill should be a minimum of 3 to 4 times wider than the compaction equipment and long enough to allow construction equipment to achieve normal operating speed.

(2) Verify the completed test fill slope is correct. The test fill slope is critical if the purpose of the test fill is to determine if interface frictional resistance is adequate between the various layers of geosynthetics.

(3) Layout.

(a) If surveys are to be performed on the test fill, a coordinate system should be established with one axis parallel to the bottom and top edges and the other axis parallel to the sides of the test fill section.

(b) The contractor should also establish a benchmark outside of the landfill boundaries to ensure accurate surveys are made.

b. Placement.

(1) Verify the area where the test fill will be placed is cleared and grubbed as required by the specifications.

(2) Drainage controls should be constructed to divert runoff around the test fill area. The drainage controls should be maintained until the completion of the post-construction monitoring period.

(3) Verify the subgrade (existing landfill surface) is compacted as described in the specifications.

(4) Foundation soil should be placed on top of the subgrade to establish the required slope.

(5) Check the plans and specifications to determine the minimum thickness of the foundation soil layer beneath the test fill. This layer is typically a minimum of 300 mm (12 inches) thick.

(6) Anchor Trench.

(a) Check the plans and specifications to determine if the test fill should include an anchor trench.

(b) Verify the anchor trench is constructed to the correct dimensions along the full width of the top of the test fill.

(c) Check the plans and specifications to determine which geosynthetics should be placed in the anchor trench.

(d) Verify the anchor trench is backfilled as specified.

(7) Survey Control Points.

(a) Survey control points typically consist of 450 mm (18 inch) long steel pins set in the soil on top of and back from the edge of the test fill.

(b) Verify permanent marks are placed (painted) on each layer of geosynthetic material to allow relative movements to be determined.

(c) Survey control points are usually surveyed immediately after construction and every 5 to 7 days thereafter over the life of the test fill.

(d) Horizontal and vertical movement is typically monitored to the nearest 3.0 mm (.01 feet). Verify the specifications address the maximum allowable relative movement of the test fill. Contact the designer if this information is not provided.

c. Tests.

(1) Post-Construction Monitoring.

(a) Ensure the contractor inspects the test fill daily and reports its condition in the Construction Quality Control Daily Reports.

(b) Video taping is often required during construction and post-construction monitoring to document the condition of the test fill.

(2) Low-Permeability Clay Layer.

(a) Inspect the clay layer during construction to verify materials and placement methods are as specified for full scale construction.

(b) If Shelby tube samples are taken for hydraulic conductivity testing, they should be taken from the clay layer at locations you specify.

(c) Shelby tube samples should be extruded and visually examined for signs of inadequate bonding between lifts.

(d) Generally, at least one set of classification tests (ASTM D 422, ASTM D 1140, and ASTM D 4318) should be performed on each lift of clay placed.

(e) The contractor should also perform field density, moisture content, and hydraulic conductivity tests (ASTM D 5084) on each lift of the test fill clay layer. The specifications should indicate the number of tests which should be performed per lift.

(4) Geosynthetics Testing. Determine if leak, peel, and shear

tests are required to be performed on the geomembrane seams.

(5) Dismantling.

(a) After construction and monitoring of the test fill is complete, the contractor should carefully remove the soil layer from a small area (typically 3 m X 6 m (10 feet by 20 feet)) above the geosynthetics.

(b) Visually inspect the geosynthetics and document areas of damage.

(c) Additional areas of the test fill section should be examined in a similar manner if it appears the geosynthetics have been damaged. The inspection operation is often videotaped.

d. Approval. Excessive slippage or damage to geosynthetics resulting from the contractor's placement methods should result in rejection of the contractor's placement methods.

e. Removal.

(1) After approval of the Final Test Fill Construction Report, the contractor should remove the test fill section.

(2) Determine the suitability of natural soils for reuse. If reused, the contractor should stockpile and protect these materials.

(3) Geosynthetics are usually removed and discarded.

f. Full-Scale System Placement.

(1) Do not allow the contractor to begin construction of the full-scale liner or cover system until approval of the Final Test Fill Construction Report.

(2) Only methods and equipment used during test fill construction should be used for full-scale construction unless otherwise approved.

CHAPTER 3.12
GEOGRID

CHAPTER 3.12 GEOGRID

3.12-1. GENERAL. Cover soil stability often becomes an issue for slopes of 4 horizontal on 1 vertical or steeper. Geogrids are reinforcement geosynthetics used in landfill covers and liners to hold cover soils in place on steep slopes. Geogrids are formed by intersecting and joining sets of longitudinal and transverse ribs with the resulting open spaces called apertures. Two different classes of geogrids are currently available: (a) stiff, unitized, geogrids made from polyethylene or polypropylene sheet material, and (b) flexible, textile-like geogrids made from high strength polyester yarns which are joined at their intersections and coated with a polymer or bitumen. Geogrids are classified as uniaxial or biaxial. Uniaxial grids provide reinforcement in one direction only while biaxial grids provide reinforcement in all directions.

Geotextiles are also used for reinforcement. Review Section 3.8 in addition to this section for QA inspection responsibilities for reinforcement geotextiles.

a. Preconstruction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Manufacturer's QC test results.

(2) Manufacturer's QC manual.

(3) Geogrid layout plan along with anchorage and connection details.

(4) Pull-out resistance test results.

(5) If mechanical geogrid connections are required, strength test results for the connections should also be submitted.

(6) Sample of geogrid (if required).

b. Delivery, Storage, and Handling.

(1) A QA Representative should be present during delivery and unloading of the geogrid to inspect for damage.

(2) Verify that rolls are labeled with the manufacturer's name, product identification, lot number, roll number, roll dimensions and date manufactured. If the geogrid has a primary strength direction it should also be identified.

(3) The QA Representative should record roll numbers, date delivered, name of manufacturer, and product type. This data is used to verify manufacturer's QC data sheets have been submitted for the rolls being delivered.

(4) Reject any rolls of geogrid damaged during delivery, storage, or handling. No repairs should be allowed on damaged geogrid or reinforcement geotextile.

(5) Do not allow rolls of geogrid to be dragged, lifted by one end, or dropped to the ground.

(6) Temporary storage at the job site should be in a well

drained smooth area.

(7) The storage area should also be shaded or the geogrid should be placed beneath an opaque cover.

3.12-2. PRODUCTS.

Geogrid.

(1) Cross check the roll numbers of the geogrid delivered to the site against the roll numbers on the manufacturer's QC test data submittals to ensure they match. Ensure the geogrid meets the property requirements outlined in the specifications for material type and physical properties.

(2) Verify the pull-out resistance test results meet the strength requirements specified between the geogrid and adjacent soils.

(3) Verify the same soil borrow source was used for the pull-out resistance testing as will be used for full scale construction.

3.12-3. EXECUTION.

a. Installation.

(1) A QA Representative should be present at all times during geogrid installation.

(2) Do not allow personnel working on the geogrid to smoke or wear shoes that could damage the geogrid.

(3) Geogrid is usually unrolled down slope and kept in slight tension prior to cover soil placement.

(4) Check the plans and specifications to see how the upper end of the geogrid should be anchored. Proper anchorage is critical if the grid is to function correctly.

(5) Connections.

(a) Geogrid reinforcement may be joined with mechanical connections or overlaps. Check the specifications to determine which type of connection is required.

(b) Mechanical connections should be installed per the specifications and manufacturer's recommendations.

(c) Verify the mechanical connection strength meets the specified requirements.

(d) For overlap connections, check the specifications and manufacturer recommendations for minimum overlap requirements.

(e) Splicing rolls of geogrid together on slopes greater than 4 horizontal on 1 vertical should generally not be allowed. If permitted, the splices should be located as close to the bottom of the slope as possible.

(f) If connections are required on slopes, they should be staggered (generally a minimum of 2 meters (6 feet)) above or below connections for adjacent rolls.

(g) The sides of adjacent geogrid rolls generally do not need to be overlapped for slope reinforcement. However, ensure 100 percent of the slope is covered with geogrid.

b. Penetrations.

(1) For pipe penetrations through the geogrid, only transverse members of the geogrid should be cut.

(2) Verify That the load carrying longitudinal (roll direction) members are spread around the penetration.

c. Covering. Refer to Chapter 3.9 Cover Soil Layer for information on cover soil placement.

CHAPTER 3.13
GAS VENTING/COLLECTION

CHAPTER 3.13 GAS VENTING/COLLECTION

3.13-1. GENERAL. Landfill gas production results from vaporization, chemical reactions, and biological decomposition. Biological decomposition of organic materials results in the production of carbon dioxide and methane. Other gases may also be generated depending on the composition of the waste material. The following is a list of potential impacts of landfill gas.

Explosion hazard. Methane can migrate through the subsurface and collect in adjacent structures creating a potential explosion hazard.

Vegetation distress. Landfill gases can distress the vegetation on a landfill cover.

Odor. Odor control becomes a potential concern if the landfill is located adjacent inhabited areas.

Physical disruption of cover components. Gas buildup beneath the geomembrane can force the geomembrane to protrude or "bubble out" from the cover. Landfill gases can also cause desiccation cracking on the underside of the clay layer resulting in an increase in permeability.

Toxic gases. Gases produced by landfills can be toxic or may not comply with regulatory emission criteria.

Gas control systems consist of collection, conveyance and outlet components and are designed to vent either passively or actively. A passive system allows the landfill gas to exit the collection system without mechanical assistance whereas an active system utilizes blowers to extract the gas. The gas is then either dispersed into the atmosphere, flared, or collected and treated. This chapter briefly discusses collection and conveyance systems and QA aspects for each type of system.

Additional information which may be applicable to landfill gas collection systems can be found in the following chapters:

Chapter 2 - Ground Water Extraction Systems;

Chapter 3 - Drainage Layer;

Chapter 3 - Geotextile;

Chapter 3 - Pipe and Appurtenances; and

Chapter 4 - Soil Vapor Extraction Systems.

3.13-2. COLLECTION SYSTEMS. The following paragraphs discuss different types of landfill gas collection systems. If intrusive drilling or trenching is performed within or near the landfill to construct the gas collection system, check that the safety plan addresses fire hazards associated with the possible presence of methane gas. At a minimum, air should be monitored for flammable gases and oxygen level.

a. Continuous Blanket Systems.

(1) General. A continuous blanket system consists of a layer of granular fill or a geonet located below the impermeable barrier layer. Perforated horizontal collection pipes are sometimes incorporated into the blanket to aid in the withdrawal of landfill gas. Geotextile materials are sometimes used to prevent clogging of the blanket system by fine grained soils. Vertical vent pipes are used to vent the gas directly to the atmosphere or to transfer the gas to a treatment system.

(2) Quality Assurance.

(a) Check granular soils to assure that gradations meet the specified requirements.

(b) Verify granular soils are placed to the specified thickness. No density criteria is normally specified.

(c) Verify that pipes and geosynthetic materials conform to the specifications.

(d) Geosynthetic materials should be kept clean prior to use.

b. Well Systems.

(1) General. Well systems consist of a series of gas extraction wells (perforated or slotted pipes) that penetrate into the waste materials. The components of the wells are similar to that of soil vapor extraction wells (i.e. riser, screen, gravel pack). Gases collected in the well system are either passively vented to the atmosphere or collected by an active system for treatment.

(2) Quality Assurance.

(a) Check that drill cuttings are disposed of as required by the specifications.

(b) Check that the materials used for the casing, screen, filter pack, and bentonite seal are as specified.

(c) Check that the well is set straight and true to line.

(d) Check that the surface completion of the well is as shown on the drawings.

(e) Assure that the completed well is visibly marked and protected to prevent damage during future construction of the cover system.

(f) Verify that an as-built installation diagram is submitted for each well. The specific information to be included in the installation diagram should be described in the specifications.

c. Collection Trenches.

(1) General. Gas collection trenches consist of granular materials placed in a trench installed either in the waste material or along the perimeter of the waste. Sometimes geomembranes are incorporated to provide an additional barrier to gas migration. Gases collected in the trench are either passively vented to the atmosphere or collected with an active system for treatment.

(2) Quality Assurance.

(a) Check that the trench is constructed at the proper depth and alignment.

(b) Assure that granular backfill, geosynthetics, and pipes meet specified requirements.

(c) Check that any collection pipes in the trench are placed at the proper lines and grades.

(d) If geosynthetics are included in the trench, ensure that subgrade/sidewall protrusions or backfill placement does not puncture or damage the geosynthetics.

d. Piping and Conveyance Systems.

(1) General. Piping and conveyance systems for landfill gas removal consist of well heads and non-perforated header piping. Generally, all piping will converge to a single header pipe which goes to the gas treatment facility.

(2) Quality Assurance.

(a) Assure that the collection piping materials are as specified. Pipes are usually made of either HDPE or PVC.

(b) Check that pipe connections are tight and non-perforated header pipes have been leak tested.

(c) Check that the proper burial depths and pipe slopes are maintained.

(d) Verify that the pipes slope towards condensate collection tanks and do not have any dips or low spots where condensate can collect and clog the pipe.

(e) Check that the specified valves, gages, gas monitoring ports, and flexible couplings are installed at the well head.

e. Gas Monitoring Probes.

(1) General. In order to assure that the gas collection and removal system is operating properly, a series of gas monitoring probes are sometimes located around the perimeter of the landfill to detect landfill gases that may be migrating off site. The monitoring probes are small diameter wells which allow soil gas samples to be collected.

(2) Quality Assurance.

(a) Generally, gas monitoring probes should be installed prior to the installation of the landfill cover system. This allows the probes to be monitored for off-site migration of landfill gases during construction of the landfill cover system.

(b) Check that the materials used for the casing, screen, filter pack, and bentonite seal are as specified.

(c) Check that the probe is set straight and true to line.

(d) Check that the surface completion of the probe is as shown on the drawings.

(e) Assure that the completed probe is visibly marked and protected to prevent damage from the future construction of the cover system.

(f) Assure that an as-built installation diagram is submitted for each probe. The information to be included on the installation diagram should be described in the specifications.

CHAPTER 3.14
OPERATION AND MAINTENANCE

CHAPTER 3.14 OPERATION AND MAINTENANCE

3.14-1. GENERAL. Operation and maintenance activities are required to maintain the effectiveness of completed landfill covers and liners. Repairs may be required to correct the effects of settlement, subsidence, or erosion. Gas extraction and leachate removal are required for some landfills. Parameters such as ground water quality, air quality, and underground gas migration are also monitored at some landfills. The construction contractor is often required to perform operation and maintenance on landfills for a specified period of time (typically one year) after construction. The construction contractor may also be required to write an operation and maintenance manual during the year in which he operates the landfill. In other cases, the operation and maintenance manual is written by the designer. This chapter discusses the QA Representative's responsibilities if the construction contractor is required to perform operation and maintenance for a specified period of time following construction.

Operation and Maintenance Submittals. The contractor should provide operation and maintenance submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Operation and Maintenance Manual. The manual may include one or more of the following:

Air sampling and analysis plan;

Ground water sampling and analysis plan; and

Operation and maintenance procedures for the landfill cover, sumps, leachate treatment facility, gas extraction system, and gas treatment facility.

(2) Monthly Inspection and Operation Report.

(3) Monthly Water Treatment Plant Operation Report.

(4) Monthly Gas Treatment Plant Operation Report.

(5) Air, water, and leachate sampling reports.

(6) Notification of maintenance activities.

(7) Maintenance completion reports.

3.14-2. EXECUTION.

a. Ground Water.

(1) Up gradient and down gradient monitoring wells should be sampled after closure at the specified frequencies. Samples are typically collected once every one to three months during the first year after construction.

(2) Verify that before each round of sampling, the ground water elevation is determined for each well.

(3) Verify samples are collected in accordance with the sampling and analysis plan.

(4) Review the ground water sampling data for significant changes in contaminant concentrations.

b. Landfill Leachate.

(1) Ensure that leachate levels within sumps are monitored at the specified frequency.

(2) Verify that Leachate is collected from sumps to maintain a head of less than 0.3 meters (12 inches) on the liner.

(3) Treatment and disposal criteria are site specific. Review the plans and specifications to determine what these criteria are.

c. Landfill Gas.

(1) Verify the contractor periodically inspects the surface of the landfill cover for bulges which may be an indication that gas is collecting beneath the geomembrane.

(2) The contractor should also monitor landfill gas concentrations at compliance points every two to four weeks for the first year after construction. Verify gas concentrations are at acceptable levels.

(3) Compliance points may include gas monitoring probes, boundary monitoring stations, well heads for passive systems, or flares for active systems.

(4) Verify samples are collected in accordance with the sampling and analysis plan.

d. Settlement.

(1) Verify the contractor is performing periodic inspections of the landfill surface. The landfill cover should typically be inspected monthly for signs of settlement and slope stability problems.

(2) Require additional select fill and top soil be placed in areas where minor settlement has occurred. These areas should then be reseeded.

(3) If a large depression develops which results in reverse slopes, repairs to the low permeability layer and drainage layer may be required to reestablish the correct slope.

e. Vegetative Cover. Verify that the contractor is maintaining the effectiveness of the final cover by performing the following tasks:

(1) Maintaining temporary erosion control structures until the vegetative cover is established and repairing erosion damage;

(2) Reseeding areas with poor vegetative cover;

(3) Mowing as appropriate for local conditions after the vegetative cover has been established; and

(4) Keeping the surface of the landfill free of burrowing animals and large vegetation.

f. Runoff Controls. Verify the contractor is inspecting the following runoff control features.

(1) Drainage terraces, ditches, and drop structures should be inspected monthly by the contractor to ensure that erosion or other problems are not present.

(2) Detention ponds should be inspected monthly to ensure there is sufficient storage available for runoff and the outlet works are operating properly.

(3) Outlets to the cover subdrainage system should also be inspected monthly and kept clean and free flowing.

g. Other Features. Other features such as fences and perimeter access roads should be maintained by the contractor during the one year maintenance period.

h. Maintenance Work.

(1) The contractor should provide notification in writing in advance of conducting any non-routine or major maintenance activities.

(2) A Government representative should be present during all major maintenance activities.

(3) A maintenance completion report should be submitted by the contractor when the work has been completed.

(4) The ultimate user/O&M representative should be involved during the one year contractor O&M period. This will aid in a smooth transition and ultimate acceptance of the completed project.

CHAPTER 4
SOIL-BENTONITE SLURRY WALLS

CHAPTER 4 SOIL-BENTONITE SLURRY WALLS

4-1. GENERAL. At hazardous waste sites, Soil-Bentonite (S-B) slurry walls function as relatively impermeable barriers to either contain contaminated ground water or redirect clean ground water around contaminated areas. S-B slurry walls are typically a minimum of 600 to 1500 mm (2 to 5 feet) wide and are required to have an in-place permeability of less than or equal to 1 X 10^{-7} cm/s.

The major construction activities involved in building an S-B slurry wall are preparation of the site, slurry mixing, slurry hydration, trench excavation, backfill preparation, backfill placement, and site cleanup. The slurry is used to hold the trench open until backfill can be placed. Slurry is composed of water with 4-8 percent sodium bentonite added.

S-B backfill typically consists of a minimum of 2 percent bentonite, 20-40 percent fines (silt and clay), and has a moisture content of 25-40 percent. The density of the slurry in the trench must be at least 240 kg/m^3 (15 pounds per cubic foot) less than the density of the S-B backfill so that the S-B backfill will displace the slurry in the trench during construction. The mix design used for the S-B backfill can be specified by the Government or proposed by the contractor based on preconstruction compatibility testing.

a. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) S-B Backfill Testing Plan describing the equipment, procedures, and materials to be used to determine an S-B backfill mix design.

(2) S-B Backfill Testing Report. This report should include a description of test results including proposed mix proportions, gradations, slumps, densities, permeabilities, and moisture contents.

(3) Slurry Trench Implementation Plan describing the general work sequence and layout of operations. The plan should include locations for storage and slurry preparation areas, contractor qualifications, equipment, utilization of excavated materials, trench cleaning methods, slurry and S-B backfill preparation, and site cleanup. Also, the contractor's plan should include a description of QC equipment and test procedures, and the name of the off-site laboratory proposed for use.

(4) Bentonite. A sample of the proposed bentonite is often submitted for QA testing.

(5) Backfill material. A sample of each type of backfill material is often submitted for QA testing.

(6) Water. Verify that mixing water test results comply with the requirements indicated in the specifications.

b. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Bentonite test results and a certificate of compliance for each lot of bentonite shipped to the site.

(2) Backfill gradation test results. Verify the backfill material conforms to the specified ranges gradation, Atterberg limits, and moisture content.

(3) As-built profile. Scale drawing and a profile of the completed slurry trench. If S-B backfill materials were prepared in batches, each batch should be delineated on the profile.

(4) Record of soundings taken during construction.

(5) Bentonite slurry mix. Record of bentonite slurry mix quantities, proportions of additives utilized, and adjustments in the slurry mix.

(6) S-B backfill material mix. A record of S-B backfill material mix quantities and adjustments.

(7) QC test results.

4-2. PRODUCTS.

a. Materials.

(1) Bentonite.

(a) Check that the bentonite conforms to the specifications. A certificate of compliance from the supplier should provide the specified criteria.

(b) Bentonite powder should be kept dry during storage.

(2) Water. Check that mixing water complies with the standards specified. If the local water supply does not meet the specifications the contractor may need to condition the water prior to use.

(3) Backfill Material. Check that the backfill material to be used for the S-B backfill material conforms to the gradations specified. In addition, Atterberg limits and moisture contents for the backfill should conform to the specified values.

b. Equipment.

(1) All equipment should be inspected in accordance with the provisions of EM 385-1-1 and the inspection checklist should be submitted by the contractor prior to use of the equipment.

(2) Trench Excavation Equipment.

(a) Check that the excavation equipment is capable of excavating the trench width in a single pass. Buckets utilized may be perforated to allow the drainage of slurry, and may include bottom cutter teeth.

(b) Check that the excavation equipment is capable of reaching at least 1.5 m (5 feet) deeper (or other depth as specified) than the maximum excavation depth as shown on the drawings.

(3) Mixing and Slurry Placement Equipment.

(a) Slurry mixing equipment should be capable of achieving complete dispersion of bentonite and additives to produce a uniform slurry. Typically, venturi mixers are used for this operation, in conjunction with high-speed/high-shear centrifugal pumps.

(b) Check that stored slurry is mechanically or hydraulically agitated while in slurry storage ponds or tanks.

(4) Field Laboratory Equipment. Check that the specified field laboratory equipment is on site and in good working condition.

c. Mixes.

(1) Initial Bentonite Slurry. Check that the proper percentage of dry bentonite is added to produce the slurry, and that the slurry conforms to the properties listed in the specifications.

(2) Trench Bentonite Slurry.

(a) Verify slurry in the trench conforms to the properties listed in the specifications. Check the specifications for testing frequency of the trench slurry.

(b) Verify that slurry is allowed to hydrate (typically, for a minimum of 8 hours) prior to being placed in the trench.

(c) Slurry additives to increase or decrease viscosity should be approved prior to use. It is advisable to consult with the designers about the use of additives to control or adjust slurry properties.

(3) S-B Backfill Material.

(a) Verify S-B backfill material meets the properties listed in the specifications.

(b) Look for poorly mixed S-B backfill. S-B backfill should be thoroughly mixed so that all particles are coated with slurry.

d. Quality Assurance Testing. Check the specifications or QA Plan to see if samples need to be submitted for QA testing. Typically, samples for QA testing should be collected at the same time as QC samples, however, at a reduced frequency. This allows comparison of the QA and QC test results. Ensure QA and QC sample numbers are correlated so that test results can be easily compared.

4-3. EXECUTION.

a. Work Platform. Check that the work platform is constructed to the lines and grades shown on the drawings. Check for proper compaction and material requirements as described in the specifications.

b. Trench Excavation.

(1) The up-gradient portion of the slurry trench should be excavated before the down-gradient portion of the slurry trench.

(2) Check that the excavation is vertical (within 2 percent). This is normally accomplished with plumb line measurements.

(3) Check that the full depth of the trench has been excavated

prior to placement of the S-B backfill.

(4) Measure the depth of the trench when the top of the key layer has been reached, and also after the key has been excavated into the key layer. The soil that is excavated should be continuously logged by QA personnel to verify that subsurface conditions are similar to those anticipated.

(5) Generally, the trench excavation should not precede the toe of the S-B backfill slope by less than 9 meters (30 feet) or more than 30 meters (100 feet). Just prior to extended non-work periods, S-B backfill may be brought to the toe of the excavation (to minimize the amount of open trench).

(6) Check that the full depth of the trench has been reached and overlapped at all intersecting segments of the wall. Generally, a minimum overlap of 1500 mm (5 feet) of overlap is required.

(7) Check for trench collapses by depth probing. Ensure that collapsed soils are removed prior to S-B backfill placement.

c. Placement of Slurry.

(1) Slurry should be placed in the trench at the start of excavation.

(2) Monitor the slurry level within the trench. Typically, slurry is maintained a minimum of 900 mm (3 feet) above the ground water level and no more than 600 mm (2 feet) below the surface of the work platform.

(3) Check the density of the slurry, especially near the middle and bottom of the trench, to ensure that density requirements are met. Check the specifications for testing frequencies.

(4) If the density of the slurry in the trench is too high (generally greater than 1360 kg/m^3 (85 pcf)), desanding of the slurry may be required. This process may involve the use of desanding equipment, or replacing the slurry in the trench with fresh slurry.

d. Excavated Material.

(1) Check that the excavated materials are properly stockpiled. They may have to be covered if vapor emissions are a problem.

(2) Check that stockpile placement is not too close to the trench, which may cause trench collapse. Stockpile placement distances should be described in the specifications. Contact the designer if they are not.

e. Trench Cleaning. Verify that the trench bottom has been cleaned prior to S-B backfill placement. Often, the trench bottom is cleaned by the use of an air lift pump to remove material which has settled out of the slurry. The trench bottom should be checked after periods of inactivity such as an overnight work stoppage.

f. Soil-Bentonite Backfill Mixing and Placement.

(1) Check that the S-B backfill material has been thoroughly mixed into a homogeneous mass. Depending on the project, S-B backfill may be mixed in a separate mixing area and trucked to the trench or mixed along the side of the trench with a dozer. If mixed

using a dozer, verify the mix is not being diluted with subgrade soils.

(2) The S-B backfill should be initially placed into the bottom of the trench by tremie or clamshell methods. A sloped starter trench outside the limits of the work can also be constructed. the starter trench allows the S-B backfill to slide down to the bottom of the trench.

(3) Subsequent batches of S-B backfill should be placed at the top of the backfill slope.

(4) The slope of the S-B backfill face should be probed to assure that a constant slope is maintained. This will assure that no pockets of slurry are trapped within the S-B backfill.

g. Soundings.

(1) Check that soundings of the excavation and S-B backfill are taken every 6 meters (20 feet) or as otherwise specified.

(2) The following elevations are typically recorded: a) Top of key stratum; b) Bottom of trench excavation; c) Bottom of trench prior to backfilling; and d) Profile of the backfill slope.

(3) An "as-built" profile should be kept by the contractor which includes descriptions of materials encountered, extent of excavation after each day's work, and S-B backfill batch placement locations.

h. Treatment of the Top of Completed Slurry Trench.

(1) Check the specifications to determine if a temporary soil cover should be placed over completed portions of the slurry trench. Generally, the final trench cover should not be installed immediately after S-B backfill placement to allow settlement to occur.

(2) Prior to the installation of the final trench cover, settled areas should be filled with approved material.

i. Cleanup. Excess trench spoils, unused S-B backfill, and excess slurry should be properly disposed of as indicated in the specifications.

CHAPTER 5
SOLIDIFICATION/STABILIZATION

CHAPTER 5 SOLIDIFICATION/STABILIZATION

5-1. GENERAL. Solidification/stabilization (S/S) refers to treatment processes that are designed to accomplish one or more of the following:

improve the handling and physical characteristics of the waste;

decrease the surface area of the waste mass across which leaching of contaminants can occur; and

reduce the solubility of hazardous constituents in the waste.

S/S is performed by mixing contaminated materials with one or more reagents such as cement, lime, or fly ash. S/S is applicable for the treatment of contaminated liquids, soils, and sludges. The final product of an S/S process may vary from a granular, soil-like material to a cohesive solid depending on the amount of reagents added and the type of waste being treated. S/S can be performed as an in-situ process or the contaminated material can be excavated and treated above ground in some type of mixing unit.

a. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Solidification/Stabilization Work Plan. Review the work plan to ensure the following items are adequately addressed.

(a) Information to demonstrate the S/S contractor meets the qualification requirements specified.

(b) The proposed mix design to be used in treating the contaminated material.

(c) Bench scale treatability study test results (if required).

(d) Equipment proposed for mixing, batching, and process control. Process flow diagrams, mixing times, and processing rates. Any anticipated pretreatment of the contaminated material should also be identified.

(e) Drawings indicating dimensions and layout of the S/S system.

(f) Air emissions, dust, and noise from the system should be identified and estimated. Control systems proposed for use should be described.

(g) QC procedures which covers control of batch proportions, control of mixing time, and post-treatment testing.

(h) Proposed stockpile design. Ensure the stockpile design meets the criteria outlined in the specifications.

b. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Qualifications of key personnel. Do not allow individuals identified in the specifications as key personnel to start work until their qualifications have been submitted and approved.

(2) A field demonstration report including pre-treatment and post-treatment test results, batch proportions, mixing time, and mixing speed.

(3) Reagent certificates of analysis should accompany each shipping unit.

(4) QC test results.

(5) Mixing time, mixing speed, and mix proportions for each batch of material treated.

5-2. PRODUCTS.

a. Materials.

(1) Water. Require chemical testing of the proposed water source when the water is of questionable quality.

(2) Reagents. Verify the reagents meet the specified requirements. Reagents should be shipped in properly labeled containers with instructions for handling and storage.

b. Equipment. Verify that mixing equipment has a positive means for controlling the mix proportions, maintaining the time of mixing constant, and maintaining the appropriate speed of rotation of the mixing unit.

(a) Check the reagent silos and feeders during operation to ensure caking of the reagents is not occurring which could cause variations in the reagent feed rate.

(b) Verify that scales, meters, and volumetric measuring devices used for measuring contaminated material, reagents, and water for S/S processing are accurate to within the specified limits.

(c) Verify measuring devices are being calibrated at the specified frequency.

5-3. EXECUTION.

a. Utility Clearances. Check that all utility clearances have been received for any subsurface work and that there are no overhead hazards that will interfere with the S/S unit.

b. Stockpiles. Verify stockpiles are constructed in accordance with the specifications. Typically, stockpiles for storing contaminated material include the items listed in the following paragraphs.

(1) A chemically resistant impermeable geomembrane liner. Make sure the ground surface on which the geomembrane is placed is free of objects which could damage the membrane.

(2) An impermeable geomembrane cover with a minimum thickness of 10 mils.

(3) Berms surrounding the stockpile to prevent run on and runoff of liquids.

(4) Check to see if leachate is collecting within the stockpile liner. Ensure leachate collected from the stockpile is handled in accordance with the specifications. Typically it will be analyzed (and treated, if necessary) prior to disposal or it may be reused in the S/S process.

c. Field Demonstration.

(1) Prior to full-scale S/S operations, a field demonstration is often performed on a representative amount of the contaminated material.

(2) Verify the full-scale processing equipment is being used for the field demonstration. Reagents (including water source), mix ratios, and mixing procedures used during the field demonstration should be the same as those used for the remainder of the S/S work.

(3) Verify contaminated material used for the field demonstration is obtained from locations outlined in the specifications.

(4) Prior to performing the field demonstration, contaminated material to be used for the field demonstration is usually tested to verify it contains representative levels of contamination.

(5) Verify the treated material from the field demonstration meets the physical and chemical criteria listed in the specifications.

(6) Require additional test runs if the treated material does not meet the specified requirements.

(7) The estimated increase in volume resulting from S/S treatment is often determined during the field demonstration. Volume increase is determined by comparison of the volume of contaminated material to be treated to the volume of treated material.

(8) Determine if the specifications allow the contractor to continue to process contaminated material while waiting for test results from the test run.

d. Operation.

(1) Weather Conditions.

(a) Check the specifications to see if there is a minimum temperature below which solidification/stabilization should not be performed.

(b) Do not allow contaminated material to be treated if it contains any frozen material.

(c) Do not allow S/S to be performed during periods of heavy rainfall if this will result in the addition of excess water to the mixture.

(2) Ensure that dissimilar materials which testing has indicated will require the use of different S/S mix ratios are not mixed together.

(3) Visually monitor the physical appearance of the material being treated. If there is an obvious change in color, odor, or texture of the material, consideration should be given to requiring additional QA testing.

(4) Oversize Material. Verify oversize material that cannot be handled by the S/S unit is removed, treated and disposed of in accordance with the specifications.

(5) Verify the contractor is not diluting the soil to be treated by excavating and treating materials which are outside the specified area of treatment.

(6) Verify confirmation samples are taken at the specified frequency for the side walls and bottoms of excavations to verify all contaminated material has been removed. Excavations should generally not be backfilled until confirmation tests confirm that all contaminated material has been removed.

e. Tests.

(1) Verify mixing time, mixing speed, and the amounts of contaminated material, reagents, and water added to each batch are recorded by the contractor and maintained within the limits specified in the approved S/S Work Plan.

(2) Verify treated material is segregated into stockpiles for post-treatment testing so that material can be retreated if it does not meet the post-treatment testing criteria. Stockpile size should be equal to or less than the volume at which the most frequent QC test is run. Each stockpile should have a visible number to aid in the tracking process. The numbers should be correlated to the QA/QC samples which have been collected.

(3) If the treated material will be placed directly into an on-site landfill, verify the contractor is segregating and tracking the location of each batch of material so that it can be located if reprocessing is necessary.

(4) Post-treatment testing specified should be performed on representative samples of treated material. Require the contractor to perform additional testing on treated material that appears to be poorly mixed or have improper mix proportions.

(5) Verify QC specimens are allowed to cure as described in the specifications.

(6) Typically up to 6, 2-4 inch diameter samples are made for each round of QC testing. The samples are allowed to cure (typically 1 to 7 days) and then tested for leachability of contaminants. Physical tests such as unconfined compressive strength and hydraulic conductivity are also sometimes required.

(7) For in situ S/S jobs, verify the specifications indicate the depth below ground surface at which QA/QC samples are to be collected. Ensure the contractors method of sample collection can obtain a sample which is representative of the specified depths.

(8) Require reprocessing and/or retesting to be performed on treated material that does not meet the physical and chemical requirements listed in the specifications. The specifications should address how retesting and reprocessing will be handled QC or QA tests

fail. Contact the designer if retesting and reprocessing is not addressed.

(9) The S/S mix design may be changed by the contractor based on the characteristics of the material being treated. Require additional test runs if there is a question about the new mix design proposed.

(10) Check the specifications or QA Plan to see if samples need to be submitted for QA testing. Typically, samples for QA testing should be collected at the same time as QC samples, however, at a reduced frequency. This allows comparison of the QA and QC test results. Ensure QA and QC sample numbers are correlated so that test results can be easily compared.

(11) Ensure the treated material from the S/S process, upon meeting the physical and chemical testing criteria, is disposed of as required by the specifications.

f. In Situ Solidification/Stabilization. In situ S/S is typically performed using large diameter augers which inject reagents into the soil and mix the reagents and soil together. The following are inspection items which are specific to in situ S/S.

(1) Verify the auger is drilling vertically into the contaminated material. This is especially critical where the contaminated soil is deep.

(2) Typically, the rate of entry and withdrawal of the auger is controlled and synchronized with the rate of injection. Verify reagents are being injected uniformly and in the right proportion throughout the zone of contamination.

(3) Closely monitor the depth of penetration of the auger to ensure the entire depth of contaminated soil is treated.

(4) Samples are usually collected from the treated soil at specific depths within the treated soil column. Verify the method of sample collection can retrieve an isolated sample from the specified depth.

CHAPTER 6
SOIL VAPOR EXTRACTION SYSTEMS

CHAPTER 6 SOIL VAPOR EXTRACTION SYSTEMS

6-1. GENERAL. This section describes the installation of soil vapor extraction (SVE) systems. SVE systems are intended to remove volatile contaminants from the soils above the water table by either evaporation or biodegradation. The air is extracted from wells or trenches (and in some cases injected) using air blowers or vacuum pumps and associated above ground equipment. SVE projects include system installation, start-up, and usually limited operations and maintenance. This section does not cover vapor treatment or air discharge permit requirements. Refer to EM 1110-1-4001, Soil Vapor Extraction and Bioventing for more detail on the design, construction, and operation of soil vapor extraction systems.

a. Equipment.

(1) Well Drilling Equipment.

(a) Use only drilling equipment not requiring the use of liquids (water, drilling mud) for installation of air injection or extraction wells.

(b) If the soil vapor extraction wells will also be used for the extraction of ground water and/or floating product, refer to the checklist on Ground Water and Leachate Collection for appropriate equipment. Use of fluids should be avoided if possible in any event.

(2) Refer to Chapter 3 on covers and liners for equipment appropriate for installation of any required surface cover.

(3) Trenching equipment for below-grade piping installation only need be large enough to reach required excavation depth and provide necessary trench width.

b. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Drilling and Well Installation Plan which describes:

the drilling method and equipment;

well installation procedures;

soil/rock logging procedures and forms;

soil sampling and sample handling procedures; and

well construction diagrams.

Verify that the drilling subcontractor has read the well installation specifications prior to mobilization to the site.

(2) Qualifications for the driller should be submitted if licensed drillers are required in that state. Verify that the qualifications meet the specifications and any state requirements. The qualifications, including education and experience, of the geologist or engineer responsible for logging the materials encountered in drilling should also be submitted for information.

(3) Catalog information on:

well screen and casing;

cement and/or bentonite well sealant;

precast well head vaults (if applicable);

piping;

blower(s) and associated equipment (or package unit containing these items);

gauges and controls; and

electrical components.

(4) Gradation test results for filter pack material and piping bedding/backfill, if required.

(5) Shop drawings on any fabricated above-ground equipment.

c. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Boring logs for extraction, injection, or monitoring wells.

(2) Proposed well locations or well screen placement may be a submittal if well construction was left to the contractor based on conditions encountered. Proposed locations and construction must achieve the objectives of the system. Contact the designer if uncertainty exists about the adequacy of the proposal.

(3) Well construction diagrams for all wells installed under the contract. Include copies of any permits required by state or local authorities.

(4) Airflow test results for individual extraction (or injection) wells. These are determined by testing air yields at various pressures/vacuums and are used to verify design assumptions.

(5) Leak test results on wells, piping, and above-ground equipment.

(6) Backfill density test results, if required.

(7) Well chemical sampling results from initial sampling.

(8) Alignment test results, for blower and motors.

d. Start-up Submittals. The contractor should provide start-up submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Completed Pre-startup Checklist. This checklist requires that a review be made of the equipment and controls to assure that the system will perform safely and as expected. This would include testing of blower alignment and rotation, control circuits, alarm settings and operation. Verify items on the checklist with the contractor, if possible.

(2) Start-Up Monitoring Plan. This plan identifies procedures for initial start-up of the system including step-by-step procedures for valve settings, circuit checks and energizing, and monitoring.

(3) Start-up monitoring results. These results must be provided within the time required by the specifications or the regulators.

(4) Operations and Maintenance Plan.

(5) Air Discharge Permit. The requirements for obtaining an air discharge permit vary by project and by state. Verify coordination with applicable regulatory agencies prior to startup. Such coordination is best started during design.

e. Related Requirements. Consult other Quality Assurance Representative Guides for ground water extraction well installation (if water extraction is conducted jointly with soil vapor extraction), piping systems, underground utility systems, and ventilation, air supply and distribution systems.

f. Site Evaluation.

(1) Other Contaminant Sources. Evaluate the potential for other nearby contaminant sources or air-flow pathways prior to initiation of construction. These can include building basements, utility corridors, industrial shops, aboveground/underground fuel (or waste oil, solvent) storage tanks. Alert the designer to any such condition that was not considered in design.

(2) Power Supply. Verify that adequate utility services (e.g. electrical power) are available for the equipment.

(3) Noise. Identify any constraints on the acceptable noise levels at the site. This may require use of silencers or equipment housings.

6-2. PRODUCTS.

a. Above-Ground Equipment. There are several above-ground components in a soil vapor extraction system. These may be specified separately or as a package system. If specified as a package system, there may be overall requirements for total pressure drop; air throughput; electrical phase, current draw, voltage; and maximum inlet vacuum/pressure. There may be specifications for specific components of the package system as well. Specifications must be carefully reviewed prior to approving use of a package system. Verify that equipment installed is consistent with the contract documents and catalog information submitted prior to construction.

(1) Blower/Motor. SVE requires a blower or vacuum pump typically driven by electric motor. Compliance with the specifications for type and size of blower, motor rating and horsepower, or vacuum/pressure range and airflow rate must be assured. The motor must be appropriately rated for the area classification.

(2) Condensate Tank. The condensate tank must meet specifications, particularly for capacity, pressure/vacuum rating, construction, and level sensors. Verify that the tank has a suitable means to drain condensate. Confirm that any rental equipment is empty and was cleaned following the last use.

(3) Particulate Filter. Verify that the particulate filter meets specifications for type, pressure drop, and filter size or removal efficiency.

(4) Silencers. Silencers must meet specification for flow capacity and noise reduction in the frequency range emitted by the blower.

(5) Piping. All piping for above- and below-grade installation must meet specifications for material, diameter, schedule, and joints. Piping may be installed above ground. If PVC or other plastic piping is installed above ground, verify that the piping is resistant to degradation from sunlight.

(6) Off-gas Treatment Equipment. Not covered here.

b. Below-Ground Equipment.

(1) Screen. Verify that well screen slot type, slot size and shape meet specified requirements. Also verify material composition and wall thickness are consistent with the specifications. Well screen should be new and cleaned and wrapped at the factory. On-site storage should be in a clean, safe location where the screen will not be damaged by other equipment.

(2) Casing. Verify that well casing schedule and material meet specified requirements. Assure that joints can be made air-tight. Well casing should be new and cleaned and wrapped at the factory. On-site storage should be in a clean, safe location where it will not be damaged by other equipment.

(3) Filter Pack. The filter pack must meet the specified requirements gradation. If none is given, check that the filter pack is uniform sand or gravel of gradation large enough to prevent entry of the pack through the screen slots. Uniform means it has a uniformity coefficient of 2.5 or less. The uniformity coefficient is the sieve aperture passing 60 percent of the material divided by the sieve aperture passing 10 percent of the material.

(4) Well Seal. Bentonite used for well seals must be sodium type and provided in the form required by the specifications; dry powder is not appropriate for bentonite seal installation. Pellets or granules are preferred for bentonite seals. Bentonite powder is acceptable for use in cement-bentonite grout.Cement must meet specified requirements for type and must be mixed with the appropriate amount of water. In the absence of a specified mix, allow the use of 26-35 liters (6-8 gallons) of water to one 43 kg (94 pound) bag of cement. Bentonite may be mixed with the cement to reduce shrinkage. If not specified, allow a 3-5 percent addition of bentonite in the cement by weight. The bentonite powder should be mixed with the water before adding the cement to assure adequate mixing.

(5) Well vaults. Assure compliance with specification. Verify consistent diameters of vault penetrations with associated casing, piping, or utility conduits. Vault covers must be appropriate for traffic conditions if flush-mounted. Assure that adequate means of opening large vault covers are provided.

(6) Piping. Piping must meet requirements for schedule, diameter, and joints. Above-ground piping must be UV resistant.

6-3. EXECUTION.

a. Installation.

(1) Wells. Well installation is difficult to evaluate after the wells are completed. Direct oversight of installation process is recommended.

(a) Permits. Confirm that the necessary notifications/drilling permits have been obtained from the installation, State, County or appropriate agency before any drilling commences.

(b) Utility Clearances. Check that all utility clearances have been received for the subsurface work and that there are no overhead hazards that will interfere with raising or lowering the drill mast.

(c) Decontamination. Well drilling equipment must be decontaminated prior to use on the site and between boreholes.

(d) Locations.Verify that the drilling location conforms to the specifications. If it is impossible to install the wells in a specified location, determine the best alternative location that meets the requirements of the design. If there are any questions as to the design goals or a possible location, contact the project designer to confirm a new location.

(e) Borehole Diameter. Borehole diameter must meet specifications. In the absence of a specified size, require boreholes 4 inches in diameter larger than specified well screen and casing. If the well or monitoring point is placed by direct push methods, no requirement for borehole size is applicable.

(f) Borehole Depth. Borehole depth must either meet specification or achieve the objective. Depths are often tailored in the field based on conditions encountered. Instructions to the field from the designer must clearly identify the objectives of the wells. If there is any doubt about the adequacy of the borehole depth, contact the designer.

(g) Safety. Confirm that safe drilling procedures are used and that an exclusion zone is well defined around the drill rig. Also determine that required safety equipment is present and that it is operated in accordance with the requirements of the SSHP.

(h) Cuttings Disposal. If required, confirm that all drill cuttings and or liquids are drummed and disposed of in accordance with the approved work plan.

(i) Sampling and Logging. Adequate logs must be made by a qualified geologist or engineer of the materials encountered. Soil sampling should be performed to support the logging. Verify that soil samples are obtained for chemical analysis as directed by the sampling and analysis plan. Chemical samples provide a baseline contaminant level against which later sample results obtained following operation can be compared. Such samples are more appropriately obtained from monitoring points rather than extraction wells since soils at the extraction wells will be subjected to the most intense remediation and are not representative of the majority of soils at the site.

(j) Screen and Casing Placement. Length of screen and casing must match specified requirements. Verify that joints are air-tight and secure. Screen and casing must be suspended in the hole to assure proper alignment. Centralizers may also be required.

(k) Filter Pack Placement. Filter pack should be placed dry via a tremie pipe. Pack material must be kept clean. Verify depth to pack after placement to assure adequate thickness.

(l) Seal and Grout Placement.

Place bentonite seal materials dry via tremie pipe, unless placement depth is less than 10 feet.

Verify proper thickness and location of bentonite. Bentonite must not be placed in the screened interval.

Bentonite seal must be adequately hydrated with clean or distilled water. Hydration must be conducted for a period of time and by a method meeting the specifications. In the absence of specified requirements, hydration must be allowed for a minimum of 1 hour and a maximum of 4 hours prior to placement of the grout.

Grout must be placed by tremie pipe submerged in the grout until the grout flows to the surface.

Require the contractor to "top off" the grout as exfiltration causes the grout to settle.

(m) Wellhead Completion and Vault Placement. Well vault placement depends on the type of vault. The contractor must use care to avoid damage to well casing during vault placement. Below-grade completions must prevent surface water from running in. Open drain holes are not compatible with air-tight surface seal requirements.

(n) Surveys. Well locations and elevations must be surveyed. Wells are typically surveyed to the nearest 1 foot horizontally and .01 foot vertically.

(2) Collection Trenches and Below-Grade Piping. Underground piping installation requirements are covered in detail in Volume 1, General Information and Site Work. General guidance is provided here. Normal excavation techniques are assumed; use of pipe jacking, directional drilling, or trenching/pipe laying machines have other requirements not covered here.

(a) Trench Dimensions. The trench width is typically 610 mm (24 inches) plus pipe diameter.

(b) Trench Bottom Preparation and Pipe Placement. Thrust blocking is typically not required for air conveyance piping. Proper preparation and placement includes the following steps:

level to required grade to promote drainage of condensate or other liquids;

remove rocks and angular debris from the subgrade;

scarify trench bottom and lower sides if trench is to be used as a collection (not utility) trench and ensure excessive mud/clay smeared on trench surfaces is removed;

install screen and piping in manner minimizing debris in the lines;

prevent surface water from running in;

join pipe and/or screen in a manner consistent with material and manufacturer's instructions; and

comply with all safety requirements.

(c) Access Port. An access port to allow later survey or measurement should be required in collection trenches. Verify that no fitting or joint will prohibit survey or maintenance equipment from accessing the piping.

(d) Trench Spoil Disposal. Verify that potentially contaminated soils excavated from the trench are appropriately stockpiled and disposed of in accordance with the specifications and/or regulation.

(e) Filter Pack/Backfill Placement. Filter pack or coarse bedding material as required by the specifications should be placed in the trench before piping/screen placement. Filter pack should be placed at least 150 mm (6 inches) above the pipe prior to any compaction for typical 100 mm (4 inch) diameter PVC schedule 40 pipe/screen. Larger diameters or weaker pipe material may require more cover prior to compaction. Remainder of specified backfill must be compacted to required density in the prescribed lifts. If lift thickness is not specified, allow up to 200 mm (8 inch) lifts.

(f) Cleaning.Contractor should blow all debris from the lines prior to start-up. Debris must not be blown into the screen or condensate tank.

(3) Above-Ground Equipment and Piping. Volume 4, Special Construction, Conveying Systems, Mechanical, and Electrical Features covers many of the electrical, above ground piping, and air handling systems which are applicable to soil vapor extraction. General guidance is provided here. A project-specific Pre-startup Checklist is recommended to assure that all components are properly installed.

(a) Blowers. Blowers must be:

vibration isolated;

aligned with drive motors;

checked for rotation direction;

inspected for appropriate guards, housing, and shields, as per manufacturer’s recommendation and safety requirements; and

lubricated in accordance with manufacturer's requirements.

(b) Above-Ground Piping and Valves. Above ground piping must be:

protected from UV degradation if not inherently resistant;

protected from traffic or vandalism;

cleaned of all debris;

suitably supported and anchored;

securely joined by air tight connections, including flexible connections;

sloped to drain/collect condensate; and

checked for proper valve operation.

Flow control valves must be provided at each trench header pipe or well head. Verify clear access to all valve boxes.

(c) Condensate Knock-outs, Particulate Filter, and Relief Valves. Verify:

condensate tank has proper connection to air piping and drain line, or if the drain is not connected that the valve is shut;

easy access is provided to condensate tank drain and particulate filter;

particulate filter is equipped with the specified filter;

vacuum relief valve is provided upstream of the blower and pressure relief valve is provided downstream and both operate properly; and

all connections are tight.

(d) Electrical, Control and Instrumentation System. Verify:

gauges are calibrated, provided in specified locations and have ranges that are appropriate for conditions expected;

gauges should read in the middle 50 percent of range during operation;

electrical continuity and appropriate grounding is provided for equipment operation and lighting;

electrical connections are placed according to the plans and specifications. Also verify the connections are securely made and insulated;

shut down controls and alarms function as required; and

process control logic is consistent with contract documents.

b. Tests.

(1) Leak Tests.

(a) Piping should be checked for leaks using either a hydrostatic, air-pressure, or vacuum tests. Ensure valves are closed at all well-heads and at the blower. If leakage is discovered, verify the tightness of each connection.

(b) Well short-circuiting is difficult to verify. Look for drastically lower than expected well head vacuum at design flow rates, or pressurize well, wet area around well head with soapy solution and observe any bubbling indicating air leakage around casing or well head.

(2) Soil Testing.

(a) Confirmatory QC or QA gradation tests on filter pack or bedding material may be required. If testing procedures are not specified, require ASTM D 422, Particle Size Analysis of Soils.

(b) Density testing of trench backfill above the filter pack may be required to ensure the backfill provides an air-tight seal. Compaction testing to determine maximum density and optimum moisture should follow ASTM D 698, Testing Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. In-place density testing should be measured using ASTM D 2922 (Nuclear Density Gauge Method), ASTM D 1556 (Sand Cone Method), and/or ASTM D 2167 (Rubber Balloon Method).

(3) System Checks. A start-up checklist should be completed prior to operating the system. This requires tests of electrical, control, and instrumentation systems. See paragraphs above for additional detail.

c. Start-up. Start-up procedures are very site-specific. Refer to Chapter 7, Start-Up Requirements, EM 1110-1-4001, Soil Vapor Extraction and Bioventing for a discussion of start-up strategy and procedures. The start-up process can take days to weeks and is often dependent on the "fine tuning" of off-gas treatment equipment.

(1) System Operator Qualifications. The qualifications of the operator in charge of start-up should be reviewed for adequate experience and education on the type of equipment used at the site. Note that the "operator" may be the construction contractor or a subcontractor or may be hired as a separate contractor.

(2) Pre-Startup Checklist. The pre-startup checklist must be carefully followed to assure that the equipment is properly installed and wired prior to start-up. Appropriate valve settings must be checked prior to blower start to assure air flow to the blower.

(3) Start-up.

(a) Start-up should be initiated with the atmospheric air bleed valve fully open. Once blower(s) are started, these can be incrementally closed to draw in subsurface air without risk to the blower(s).

(b) The operator must monitor all flow rates and vacuums at individual wells and at blower inlet and outlet and compare to design assumptions. The operator must then balance flow based on system objectives and subsurface response. Verify that all gauges are reading in an acceptable range. If not, the contractor should replace gauges as necessary.

(c) Operator must check for plugging of particulate filters and collection of condensate soon after the system is started, particularly if there was the possibility of debris or moisture in the line.

(d) Vacuum (or pressure) response at monitoring points should be recorded at system start-up to verify proper well operation and to estimate air permeability. These data should be compared to design assumptions and should be used as a basis for deciding when steady-state flow conditions are reached. Steady-state flow is necessary to complete start-up.

(e) Temperatures upstream and downstream of the blower(s) should be observed for abnormal rise. Blower motor current draw should also be noted for comparison to motor specifications. Any indication of abnormal conditions may be basis for blower shutdown and system repair or adjustment.

(f) Chemical sampling of soil, extracted soil gas, and/or condensate should be performed as required for determining treatment system performance. Verify that sampling is done according to the approved contractor Chemical Data Quality Management Plan.

(g) Start-up Report. A report documenting all monitoring and sampling results should be prepared.

d. Operation and Maintenance. It is important for QA Representatives overseeing contractor operations to understand the basic principles of soil vapor extraction and the project objectives. Proper operation of the system is as critical as proper construction. Construction personnel often are responsible for overseeing a year or more of operation.

(1) Refer to the Soil Vapor Extraction and Bioventing Engineer Manual, EM 1110-1-4001, Chapter 8, Operations and Maintenance for further information.

(2) Verify that all equipment is maintained in accordance with the vendor's requirements.

(3) Condensate recovery and disposal must be done in accordance with applicable specification requirements and regulations.

(4) Check particulate filters for plugging (most likely only a problem early in the system operation).

(5) Monitor air flow rate (flow from each well and total flow), well head vacuum, monitoring point vacuums, blower inlet and outlet temperatures, blower amperage, water table response (water levels), and vapor concentrations (contaminants, oxygen, etc. from each well and before and after treatment) as required by the O&M plan. Refer to EM 1110-1-4001 for more information.

(6) Operational strategy is very site specific. In some cases, as the contaminant concentrations go down, cycling the operation of wells may allow more efficient use of the blower. In other cases, the flow rate from wells may be reduced as contaminant concentrations diminish. For petroleum contaminated sites, a conversion from soil vapor extraction to bioventing may be appropriate after contaminant removal rates drop.

(7) High fuel vapor concentrations in the extracted air can result in potentially explosive conditions or operating problems for the off-gas treatment system. High fuel vapor concentrations may require bleeding in of atmospheric air through a relief valve.

(8) Maintain adequate records of the data collected.

CHAPTER 7.1
GENERAL INFORMATION
FOR GROUND WATER TREATMENT FACILITIES

CHAPTER 7.1 GENERAL INFORMATION FOR GROUND WATER TREATMENT FACILITIES

7.1-1. GENERAL. The following chapters of this document were developed to assist QA Representatives with inspections during construction and operation of ground water treatment facilities. The information provided covers items commonly overlooked or inadequately covered in specifications and questions that commonly arise during construction and operation activities. The EPA guidance document entitled "Remedial Technologies Screening Matrix and Reference Guide" (EPA/542/b-94/013) provides additional information about the treatment processes discussed in this document.

a. Presubmittal Conferences.

To facilitate major equipment submittals for a ground water treatment facility, presubmittal conferences may be held to clarify supplier requirements. The project designer, construction personnel, contractor, supplier, and applicable subcontractors are normally in attendance at these meetings.

b. Submittals.

(1) Almost all ground water treatment processes are comprised of several separate units that are connected by pumps and piping. Contractor submittals for each unit must be reviewed carefully prior to installation to ensure the units conform with the plans and specifications.

(2) The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements:

(a) Permits or substantive requirements of permits;

(b) Contractor requirements for experience;

(c) Site, facility, and equipment layout; and

(d) Warranties.

7.1-2. PRODUCTS.

Material/Equipment Requirements.

(1) Many ground water treatment plants use chemicals and equipment that are very specialized. The chemicals can be hazardous. Review the Health and Safety precautions before using.

(2) Verify the materials and chemicals conform to the specifications. Seemingly small differences or oversights could result in serious failures.

(3) Materials must be compatible with all chemicals that they will come into contact with. For example, acids may require the use of special pipe. Deviation from the specifications could result in the pipe rapidly corroding and failing. An air stripper blower that is either over or under sized will cause the air stripper to perform below design standards. This might not be recognized until the

process is in operation and discharge permit limits are not being met.

(4) Assure that all ferrous materials and materials damaged by exposure to sunlight or water have been properly coated per the specifications.

(5) Verify that tank and piping dimensions are correct.

7.1-3. EXECUTION. It is important that during the initial startup and debugging of the plant that stream compositions, temperatures, pressures and flow rates of each unit in the process be measured to ensure they conform to the design. The designer of the plant and the equipment vendor should provide the detailed procedures to perform these tasks. The contractor should submit a detailed start-up and testing plan. The plan should be reviewed by the designer. Verify that the plant is operating according to design before entering the operations and maintenance phase. The failure of any one unit to perform as designed could cause the whole process to perform poorly or fail. Close cooperation with the designer and the vendor is critical to the timely startup and debugging of a new treatment process.

7.1-4. OPERATION AND MAINTENANCE.

a. Operator's Requirements. Licenses and certifications for treatment plant operators and supervisors vary from state to state. Operator licenses/certifications must be checked for compliance with contract specifications. Many processes/operations do not have full time operators. Contact the designer if it appears that the number of hours are not adequate to safely/properly operate the plant.

b. Operation and Maintenance Manuals. Verify that each piece of equipment has an O&M manual and a description of how that piece of equipment fits into the overall process. Verify that O&M manuals are complete and understandable. There should be one comprehensive O&M manual that describes how all equipment operates together. The operator should become familiar with the manuals. Keep track of each Government copy of the O&M manual. These manuals tend to disappear. Verify that all O&M activities are tracked in a log.

c. Piping and Instrumentation Diagrams. Verify that complete and detailed piping and instrumentation diagrams (P&ID's) and computer logic diagrams for the entire process are supplied. These are needed to troubleshoot and isolate process control problems during startup and operation. Verify that the equipment safety shutdowns and safety interlocks are functioning.

d. Spare Parts. Ensure spare parts and special tools required in the specifications are provided. The contractor should inventory spare parts on a regular basis and provide reports indicating spare parts inventory and usage.

7.1-5. MONITORING SYSTEMS.

a. Instrumentation Controls. Instrumentation and controls are perhaps the most important aspect of the ground water treatment facility. The use of a pre-submittal conference between the designer, contractor, and instrumentation/control supplier can prevent problems during construction. Adherence to plans and specifications is especially critical during installation of control sequences. All control loops should be physically verified to be sure they have been correctly installed and operate correctly. Close interaction with the designer to rectify problem areas will prevent future problems. Verify that each instrument has operating, calibrating and maintenance instructions and operates correctly.

b. Plant Operations and Compliance Monitoring. Typically there are three types of chemical sampling and monitoring required during plant operation. These are initial operation monitoring, routine operation monitoring and permit compliance monitoring.

(1) Verify that the purge line on the sampler has a location to discharge to (floor drain, etc.).

(2) Verify that the sampler has the capability of controlling the sample rate when sampling a pressurized line.

c. Laboratory Equipment and Supplies.

(1) Verify that the construction package has defined all utilities required within the laboratory area. For example, many laboratory hoods require gas piping for operation. If this is the case, ensure that the utility drawings indicate a gas feed.

(2) Determine if vacuum connections are required.

(3) Verify that all specified refrigeration units, cabinets, automated samplers, and equipment are provided.

(4) Perform an inventory of glassware, tubing, spare parts, etc. to be provided by the contractor before turnover of the plant.

CHAPTER 7.2
PUMPS, PIPING, VALVES AND TANKAGE

CHAPTER 7.2 PUMPS, PIPING, VALVES, AND TANKAGE

7.2-1. GENERAL. Pumps, piping, valves, and tanks should be pressure and leak tested in accordance with the specifications. Care should be taken to ensure that the specified testing pressure is used. Fifty percent over maximum operating pressure is often selected to provide an adequate factor of safety. If hydraulic surges are a system possibility, the test pressure should reflect the anticipated maximum surge pressure plus a factor of safety.It is especially critical to verify that all equipment that contains acids or bases is constructed according to specifications. Failure to do this could result in serious equipment failure and injury. Secondary containment systems should be leak tested prior to acceptance.

7.2-2. PROCESS PIPING AND VALVES.

a Pressure Testing. When pressure/leakage testing double wall piping, ensure that an acceptable method for pipe repair has been defined in the event the carrier pipe or containment pipe does not meet pressure testing requirements.

b. Pipe Layout. The specifications should require the contractor to provide an as-built pipe legend which defines pipe type (air, process water, potable water, chemical feed, etc.) with respect to color and pipe labeling. For example, process water may be labeled as "PW" on a green pipe. This should be reflected on the pipe legend. Ensure that there is no cross connection between process water, fire protection water, and potable water. Process water is the non-potable water that is typically utilized for general house-keeping activities, wash down, backwash water,pump seal water, and cooling. Non-potable water is utilized as process water to reduce overall water consumption within a treatment facility. Piping should be laid out to allow ample room for maintenance and removal of equipment.

c. Piping Schedule. It is critical that the contractor complies with the plans and specifications for pipe sizes, materials of construction, interior linings, exterior coatings, thickness class, secondary containment, insulation and freeze protection, joint and pressure test requirements, and listed standards. Typically, a piping schedule is provided by the designer for clarity. The piping schedule should define all piping used in the treatment facility, including air, process water, potable water, and chemical feed. The actual layout of the piping in the building is field determined and will be submitted by the contractor for approval.

d. Process Valves, Flow Meters, and Miscellaneous Appurtenances. Ensure that the contractor provides valves, flow meters, and appurtenances of the same type and by the same manufacturer to the greatest extent possible. The design package should contain a valve schedule and labeling system for ease of construction.

e. Shop Drawings. Accurate, contractor provided, shop drawings for piping, valves and appurtenances are critical. The valve schedule/labeling system is important to allow the contractor to provide complete, concise shop drawings.

f. Variations. As construction progresses, and the piping systems come together, there will be many small changes in piping configuration and location of appurtenances which may require the designer's approval. The majority of the time, these changes are a result of variations in prefabricated equipment, ease of installation, improved O&M, safety, etc. These changes will ultimately result in a better overall product. It is very important that these variations are documented on the shop drawings daily and checked by the QA Representative weekly.

7.2-3. PROCESS/SLUDGE PUMPS AND BLOWERS.

a. Process and Sludge Pumps. A variety of pumps and blowers are required for a ground water treatment system. Typically, a pump schedule is provided in the plans and specifications to indicate pump use, type, flow and head requirements.

(1) Verify that blowers and pumps are the specified size.

(2) Verify that the pump rotation is correct by bumping the motor (briefly turning the pump on).

(3) Verify the pump and motor are aligned according to the specified procedures prior to operation.

b. Seal Water. Determine if seal water must be provided to cool bearings or seals in any of the pumps. A drain must also be provided if seal water is required.

c. Pump Pads.Pump pad locations should be defined on the contract drawings. Ensure that pumps are leveled during installation on the pad.

d. Diaphragm Pumps. For diaphragm pumps, ensure that the air feed to the pump is of adequate quality. This may require the installation of a dryer system to prevent freeze-up. Check the vendor literature to determine if a particulate filter and lubricator are required.

e. Factory and Field Testing. Following installation, it is the contractor’s responsibility to ensure that the pumps are tested for operability. The supplier normally provides performance curves for the pumps.

f. Blowers. Blowers may need to be balanced to prevent vibration. Large blowers may require anti-surge protection, flexible piping connections, and vibration isolation of the foundation.

7.2-4. PROCESS TANKS AND TOWERS.

a. Coatings and Nozzles. Coatings and linings as well as pipe nozzle sizes and locations should be shown on the shop drawings and verified on the tanks when delivered.

b. Supports. Ensure that adequate external support per the specifications is provided for tanks over 1 meter (3 feet) tall and for elevated tanks.

c. Carbon Steel Tanks and Towers. Check that the tank finish conforms with the required mil thickness (if painted). Verify that the primer is compatible with the paint. Sandblasting is often required prior to painting. Review the specifications to determine what type of material should be used for blasting and what finish (near-white versus white) is required.

d. Paint Defects. Inspect for abrasions on all painted surfaces. Require the contractor to repair any abrasions, cuts, and scratches.

e. Footings. Verify that footings and anchor bolts are constructed according to the specifications.

f. Large Tank Construction. Ensure that all sections of the tank shell have been accurately rolled and do not have a “dished” or “egg-shape” appearance.

g. Pressure Tanks. Verify that tanks which will be pressurized are designed, constructed, and tested in accordance with applicable ASME pressure codes. Verify the ASME seal is present on the tank name plate.

h. Operations and Maintenance.

(1) Inspect pumps, piping, valves and tankage for leaks and corrosion.

(2) Ensure the contractor is routinely removing sand and other material from tanks and towers.

(3) Tank site glasses need to be checked periodically to determine tank liquid levels and verify automated tank liquid level sensors are functioning properly.

CHAPTER 7.3
METALS PRECIPITATION

Paragraph **Page**

CHAPTER 7.3 METALS PRECIPITATION

7.3-1. GENERAL. Precipitation is a technology used to remove toxic dissolved metal contaminants from ground water. In ground water treatment applications, the metal precipitation process is also used to remove non toxic metals (iron, calcium, and manganese) that could cause fouling and plugging of other treatment processes such as air stripping, carbon adsorption, and chemical oxidation. Metal precipitation converts dissolved heavy metal ions to insoluble salts that will precipitate (settle) out of the water. The precipitate is then removed from the treated water by physical methods such as clarification (settling) and filtration.

Precipitation is often performed in several tanks in series and consists of pH adjustment, coagulation, flocculation and settling. In the first tank, the pH is raised by the addition of a reagent such as lime or caustic. The water then flows to a second tank where the dissolved metals react with the reagent to form insoluble salts (coagulate). These insoluble salts combine into larger floc particles (flocculate). The water is then moved with low shear pumps or by gravity to a clarifier where the floc particles settle relatively quickly to the bottom of the tank. Additional chemicals are sometimes added to enhance the precipitation. In some designs, multiple operations identified above may be done in one tank. The resulting sludge in the bottom of the tank is then removed. Typically, the treated process water requires filtration to remove any traces of floc prior to the next treatment process.Often times, the sludge is further concentrated using a sludge thickening tank and a filter press. The thickened sludge is often a hazardous waste and must be disposed of in a RCRA hazardous waste treatment, storage, and disposal facility.

7.3-2. PRODUCTS

a. Equalization Tank. Ground water is often pumped directly into an equalization tank prior to treatment. The purpose of the equalization tank is to reduce variation in ground water characteristics such as flow rate and contaminant concentration. The equalization tank is usually cylindrical in shape and may be made of metal, plastic or concrete. The tank may have a mechanical mixer or air sparger to help keep the contents mixed. If the ground water contains volatiles, the tank may be covered and vented (using a blower) to an air pollution control device such as a carbon adsorber. The tank may also contain a mechanical device to remove sludge or it may need periodic manual cleaning.

b. pH Adjustment Tank. In many cases, ground water flows by gravity or is pumped from the equalization tank into a pH adjustment tank where the pH is raised, causing metals to become insoluble and precipitate. The most common chemicals used are lime and caustic. If lime is used, a lime slaker unit will be installed that mixes the dry lime with water and pumps it into the pH adjustment tank. If caustic is used it is pumped into the tank from a drum or caustic storage tank. Verify that pH adjustment tanks are accessible as lime or caustic supplies will need to be routinely replenished. Also, verify that the tank is made of the materials stated in the specifications. Automatic instruments measure the pH in the tank and control the rate of lime or caustic addition. The pH adjustment tank is kept mixed with a mechanical mixer.

c. Coagulation Tank. Ground water flows from the pH adjustment tank into a coagulation tank. This tank is equipped with a mechanical mixer which allows dissolved metals to react and form insoluble salts.

d. Flocculation Tank. Ground water flows from the coagulation tank into a flocculation tank.Here the insoluble metal salts form large insoluble particles called floc. Sometimes a chemical (typically a polymer) is pumped into the tank to help in the formation of floc. Floc is kept in suspension in the water by gently mixing with a mechanical mixer.

e. Clarifier Tank. Ground water flows from the flocculation tank to the clarifier tank. Here the floc settles and is removed. Clarifiers may be cylindrical or rectangular in shape and made from either metal or plastic. In other cases, a more complex clarifier unit with inclined plates may be specified. The unit may have a scraper on the bottom to remove the settled floc (sludge), a sloped bottom with a drain for removing the sludge, or a flat bottom that must be cleaned manually. Clarifier operation is usually controlled by weirs which must distribute flow evenly. It is also critical that the weir be set at the correct elevation to control the hydraulics.

f. Filter. A filter is used to remove any floc that does not settle out in the clarifier. The filter unit could be a low pressure or high pressure sand filter or a cartridge filter if the system is small. The solids filtered out are returned to the clarifier tank. A further discussion of filters is found in section 7.4.

g. Sludge Thickener. The sludge from the clarifier tank usually contains about two per cent solids. This sludge is pumped to a sludge thickener where it is allowed to consolidate to a concentration of about five per cent. Chemicals (polymers) are sometimes added to improve thickening (dewatering). A further discussion of sludge thickening is contained in section 7.8.

h. Sludge Filtration. The thickened sludge is further dewatered in a filter. Most often, the filter type is a plate and frame filter press, however, a vacuum belt filter is also occasionally used. The filtered material (filter cake) is generally a hazardous waste and must be disposed of off site in a RCRA hazardous waste landfill. Further discussion of sludge filtration is contained in section 7.8

7.3-3. <u>EXECUTION</u>.

a. Level Mounting Surface. For small, pre-fabricated units, an obvious concern is that a level surface is constructed for system mounting. This is especially important for clarifiers where each weir must be carefully leveled.

b. Construction Connections. Construction of the connection between the tank wall and the concrete floor of the treatment facility is critical in preventing leaks.

c. Access Port. If an access port is cut in a tank side to facilitate construction, the opening should have rounded corners to allow for ease of repair.

d. Finished Floor. If a scraper mechanism is used in the bottom of a clarifier, the finished floor must be smooth enough to allow the scraper to operate properly. Normally this is accomplished through the placement of grout and use of the scraper mechanism in the clarifier to ensure a flat surface with acceptable tolerance. If the scraper mechanism is utilized to finish the floor, ensure that the squeegees are adequately cleaned following use.

e. Unit Clearance. If the top of the clarifier unit is placed near the ceiling, adequate clearance for the removal of the drive mechanism must be maintained. This may also be accomplished through the use of a sky light.

f. Appurtenances. All equipment and controls required to operate chemical precipitation units should be provided in easily accessible locations to facilitate system operation and maintenance. This includes items such as flow controls, level controls, pH probes, and ORP (Oxidation-Reduction Potential) probes.

g. Operation. Operation of the metals precipitation unit involves monitoring system performance. Metal precipitation units must be closely controlled. Small changes in pH (0.1 - 0.3 pH units) can significantly reduce the amount of metals that precipitate, potentially resulting in violation of discharge permit limits.

(1) Verify the operator addresses items such as even flow distribution, inadequate settling, insufficient or overdosing of chemicals, incorrect pH/ORP and effluent clarity.

(2) The operator should develop a sludge wasting schedule to remove settled solids from the metals precipitation clarifier.

(3) Look for potential problems with metals precipitation units such as algal blooms, poor floc formation, and poor settling characteristics. Algal blooms may be avoided by covering the unit to prevent exposure of the water to sunlight. Poor floc formation and poor settling characteristics may indicate improper chemical reagent use and/or dosages.

(4) Verify that the sludge cake conforms to the acceptance requirements of the disposal facility. High moisture content may cause the sludge to be rejected.

(5) Verify that the sludge is manifested correctly before being shipped off site. Correct manifesting can be complex. Refer to EP 200-1-2 for additional information on manifesting.

CHAPTER 7.4
FILTRATION

CHAPTER 7.4 FILTRATION

7.4-1. GENERAL. Filtration removes suspended solids and precipitated metals from water by forcing the water through a porous medium using a pressure differential. Filtration can be used as a pretreatment or post-treatment process. There are various filtration systems available to meet project specific requirements. These include: gravity filtration, pressure filtration, continuous backwash filtration, bag filtration, and cartridge filtration.

7.4-2. PRODUCTS. The most commonly used filter types are granular media filters, precoat filters, cartridge filters, and bag filters. Verify filters conform to the plans and specifications for size, dimensions, and materials of construction.

7.4-3. EXECUTION.

a. Air Blowers. If air scour is used to clean the filter, ensure that the air blower meets applicable decibel requirements for noise control.

b. Filter Media.Placement of the filter media in a filtration system is critical to the successful operation of the unit. Normally, it is the supplier's responsibility to ensure that the filter media is placed appropriately. Verify correct placement of the media during installation.

7.4-4. OPERATION AND MAINTENANCE. Commonly encountered problems in the filtration of ground water include turbidity (suspended solids) breakthrough, mud ball formation, buildup of grease, oil and carbonates, development of cracks and contraction in the filter bed, loss of filtering media, air binding, gravel mounding, and media upset.

a. Turbidity Breakthrough. Unacceptable levels of turbidity may occur in the effluent before terminal head loss is reached. This problem is corrected by pretreating with filter aid chemicals upstream of the sedimentation tank or the filter.

b. Mud Ball Formation. Masses of solids, dirt, and media sometimes clump together and create mud balls which sink into the filter bed, reducing the effectiveness of filtering and backwash. Auxiliary washing processes (e.g.,air scour, surface wash) with, or followed by, water wash should be used to correct this situation.

c. Buildup of Oil and Grease. Emulsified oil or grease can accumulate within the filter bed. Air and surface wash usually help eliminate this problem. It may be necessary to install a washing system using sodium hypochlorite or special solutions.

d. Carbonate Buildup.Carbonate buildup can occur on media after lime neutralization. For small systems, improving process control over the neutralization step or an acid rinse should be used to correct this situation.

e. Back Washing. Back washing is performed to remove materials which have accumulated in filters. Operational problems of filtration units are usually associated with blinding and bridging within the media. This is indicated by more frequent backwash demands and reduced unit effectiveness. This problem must normally be rectified through modification of upstream processes. Other operational concerns deal with the frequency of back washing. Control systems may be set on a timer, calling for backwash after a preset time frame. The timer setting should be adjusted to optimize the length of filter runs without excessive head loss. The length of filter backwash and rinse may be manually adjustable to allow complete cleaning of the filter without wasting backwash water. This method of control is contrasted by another type which relies upon differential pressure through the filter bed. In either event, backwash is normally an automated process which requires little operator attention. Air scouring of filters is sometimes performed if backwashing is no longer effective at restoring clogged filters. Occasionally, the filter material must be replaced or replenished.

f. Cracks/Contraction. Cracks can develop when the filter is not cleaned properly. The backwash and air scour operations should be adjusted if this occurs.

g. Loss of Media. Loss of media can occur during back washing or through the underdrain system. This can be caused by backwash rates that exceed the recommended flow.

h. Air Binding. Air binding occurs when the head loss at any point in the filter exceeds the static head (water depth) above that point. When this occurs, dissolved gases in the water are released and form bubbles in the bed, further aggravating the head loss problem. Sometimes excessive air or water backwash rates that exceed the suppliers recommendations can entrap air in the beds as well. To correct this situation, the contractor should backwash the filter to allow 20 percent maximum bed expansion or at a rate recommended by the media supplier, and then allow water to stand in the bed for a period adequate to allow entrapped gases to escape.

i. Gravel Mounding. Gravel mounding occurs when support gravel is disrupted during the backwash cycle. The contractor should correct this situation by overlaying the support gravel with a layer of high density material such as ilmenite or garnet, or modify the backwash process.

j. Media Upset. Filter media can be upset (mixed) if the backflow wash water rate is reduced to quickly.

CHAPTER 7.5
CARBON ADSORPTION

CHAPTER 7.5 CARBON ADSORPTION

7.5-1. GENERAL.

a. Liquid Phase Carbon Adsorption. Liquid phase carbon adsorption is a technology in which water is pumped through a vessel containing granular activated carbon (GAC) to which dissolved contaminants adsorb (are removed from the water). Carbon is "activated" for this purpose by processing the carbon to create porous particles with a large internal surface area that attracts and adsorbs organic molecules as well as certain metals and some inorganic molecules. Carbon adsorption is effective at removing contaminants to low concentrations. Commercial grades of granular activated carbon (GAC) are available specifically for use in liquid applications. These carbons differ from the activated carbon used in vapor-phase applications. When the concentration of contaminants adsorbed reaches a certain level, the contaminants begin to leave (breakthrough) the bed. At that time the carbon must be regenerated or replaced.

b. Vapor Phase Carbon Adsorption. Vapor phase carbon adsorption is a remedial technology in which pollutants are removed from an air stream by physical adsorption onto activated carbon grains. Commercial grades of activated carbon are available for specific use in vapor phase applications. These carbons have a finer pore structure and are more expensive than those used in liquid phase carbon adsorption applications.

7.5-2. PRODUCTS.

a. Carbon Units. Carbon units are typically fabricated off site and delivered ready for installation. Carbon vendors are required to provide the proper piping configuration for the systems. Carbon adsorption units normally consist of one or more vessels filled with carbon and connected in series or parallel. The vessels range in size from large steel vessels that hold up to 20,000 pounds of activated carbon to "55-gallon" drums. The large vessels are often cylindrical tanks mounted horizontally or vertically. Some are similar in shape to large garbage roll-off dumpsters. The large units come as either skid mounted units which are ready to use or as separate tanks that must be installed, piped, and filled with carbon. Small drums come filled with carbon but all piping and connections to the contaminated air stream must be made on site.

b. Carbon.

(1) Check to ensure that the carbon type delivered to the project is in conformance with the specification.

(2) Check to see if regenerated carbon or virgin carbon is specified for use.

7.5-3. EXECUTION.

a. Piping. Some carbon vessels have the influent line at the top and some at the bottom. Verify that the unit is piped correctly. The piping and valving are complex and can easily be installed incorrectly. A detailed inspection is needed to assure the installation is correct.

b. Liners. Ensure that the GAC vessel lining is as specified.

c. Air Release Valves. Ensure that air release valves in liquid phase units are provided on the high points of the piping, normally on the carbon piping skid.

d. Vessel Finish. Verify that all scratches on the vessel surface are repainted in accordance with the manufacturer's recommendation.

e. Safety Features. Ensure that vapor phase carbon vessels are equipped with pressure relief and internal fire suppression (sprinklers) systems as shown on the plans and specifications.

7.5-4. OPERATION AND MAINTENANCE.

a. Plugged Media. Plugged media can be unplugged by back washing. Recurring media plugging problems should be referred to the supplier or the design district.

b. Carbon Disposal.

(1) A plan for off-site disposal or regeneration of carbon should be established well before the carbon is spent.

(a) A written disposal agreement with an EPA/state approved disposal facility may be required.

(b) Manifesting may also be required if the contaminants adsorbed make the carbon a hazardous waste. Refer to EP 200-1-2 for additional information on manifesting.

(2) Adsorption of some organic materials can cause the carbon to ignite when exposed to air as it is removed for regeneration or disposal. Determine whether the organic chemicals being adsorbed present this problem before removing carbon from the vessel. If the specifications do not address the potential for fires, contact the design district or the carbon vendor before removing carbon from the vessel.

c. Regeneration.

(1) Regeneration can be accomplished on or off site. It is regenerated on site by steam desorption. It is regenerated off site by thermal desorption. Regeneration is often carried out off site due to economic constraints.

(2) Following breakthrough of a primary carbon column, a secondary column is normally placed on line as the primary column while the exhausted column is replaced.

d. Biofouling. A potential operational problem associated with granular activated carbon involves the growth of microorganisms on the carbon bed. In some cases, this growth may become so prolific that the differential pressure through the carbon bed becomes too great to allow for efficient operation. The contractor, or operator, can correct this problem through periodic "back-flushing" of the carbon bed, or through pretreatment activities to destroy the microorganisms in the influent.

e. Breakthrough. The contractor should supply the design district with the predicted breakthrough time. The design district will compare the predicted to the actual breakthrough time. If the actual time of breakthrough is much less than the design, require the contractor to determine the cause.

CHAPTER 7.6
AIR STRIPPING

CHAPTER 7.6 AIR STRIPPING

7.6-1. GENERAL. Air stripping is a technology in which dissolved volatile organic chemicals are removed from water by increasing the surface area of the contaminated water exposed to air. This allows the volatile chemicals to escape into the air. It is also effective for removing inorganic contaminants such as carbon dioxide and ammonia. Air stripping is not effective for the removal of organic contaminants with low volatility (low Henry's Law constants). Henry's Law provides a means to estimate the tendency of a chemical to volatilize from water. Examples of organic contaminants that easily volatilize are BETX, TCE, DCE, and PCE. The types of air stripping equipment commonly used are packed towers, diffused aerators, tray aerators (low profile air strippers) and spray aerators. In most cases, some type of treatment is required for the contaminated off gas (air containing the volatiles). The typical packed tower air stripper is filled with polypropylene packing that has a large surface area. The contaminated water is pumped to the top of the tower above the packing and is sprayed onto the top of the packing with a spray nozzle to distribute the contaminated water uniformly over the packing. A forced air blower is located at the bottom of the column that forces air up through the bed of packing at the same time the water is "trickling" down through the packing (i.e. countercurrent flow). As the water and air pass each other the volatiles in the water leave the water (volatilize) and enter the air stream. The air stream then carries the volatiles up and out of the top of the column. A sump at the bottom of the tower collects the cleaned water. Auxiliary equipment that can be added to the basic air stripper includes an air heater to improve removal efficiencies, automated controls, explosion proof components and off-gas treatment systems.

7.6-2. PRODUCTS.

a. Packed Tower. The packed tower is typically made of steel lined with a protective coating, aluminum or fiberglass. The tower is mounted vertically on a concrete or similar base. Verify that the base is constructed according to the specifications. The base must be able to support the column if it should accidentally become filled with water.

b. Packing.The packing usually has small open shapes and is made of polypropylene. The packing is often delivered to the site in cardboard boxes. The packing is dumped from the boxes into the top of the column during construction.

c. Spray Nozzle. Spray nozzles or other devices are located at the top of the column to distribute the water evenly over the top of the packing.

d. Demister. A demister (mesh) fits at the top of the column to remove the water mist from the air before the air leaves the top of the column.

e. Blower. Blowers convey air through the air stripper.

f. Insulation. Verify that insulation has been installed, if required.

7.6-3. EXECUTION.

a. Hydraulic Testing. Testing should be completed prior to filling the tower with packing.

b. Welding. In the event the tower is constructed of steel or a material that requires welding, do not allow welding on the tower exterior when packing is in the tower. This may melt the packing.

c. Permitting. Determine if there are permitting and monitoring requirements for the release of off gas. Verify there is an approved emission monitoring plan to determine when breakthrough occurs and carbon must be replaced or regenerated.

d. Maintenance. Replacement of column packing from the top of the tower, or from elevated stacks, may cause safety concerns.

7.6-4. Operation and Maintenance.

a. Packing.

(1) Operational concerns associated with air stripper towers are normally directed towards maintenance of the packing material.

(2) Check the packing material for evidence of fouling. Fouling reduces the air flow rate and increases the pressure drop through the column. Fouling is caused by oxidation of dissolved minerals (such as iron and manganese) in the feed water or by precipitation of calcium carbonate. Biological growth on the packing material can also result in fouling of the packing. This problem may be remedied through periodic replacement of the packing media or through acid washing of the media inside the tower.

b. Off-Gas Control.

(1) In the event vapor phase carbon is utilized for off-gas control, verify that a heat exchanger has been installed ahead of the carbon to adjust the humidity of the air stream entering the carbon to approximately 50 percent or less.

(2) The design district, or the design contractor, should be asked to verify that the controls associated with the blower and off-gas heater are coordinated with the air stripper and other unit processes to allow for successful operation of the unit.

CHAPTER 7.7
ULTRAVIOLET OXIDATION

Paragraph **Page**

CHAPTER 7.7 ULTRAVIOLET OXIDATION

7.7-1. GENERAL. Ultraviolet (UV) oxidation is a destructive process that oxidizes organic chemicals and explosives in water by the addition of ozone or hydrogen peroxide in the presence of UV light. If complete destruction is achieved, the final products are carbon dioxide, water, and salts. Ozone is a gas that is generated on site and bubbled into the waste water stream either immediately upstream of or inside the enclosed reactor vessel containing the UV lights. Hydrogen peroxide is purchased as a liquid solution of 35 or 50 percent hydrogen peroxide mixed in water. This solution is pumped into the waste water stream. If hydrogen peroxide is used as the oxidant, it is fed into the waste stream before it enters the enclosed reactor which houses the UV lights. A wide variety of organic and explosive contaminants can be treated with UV oxidation, including petroleum hydrocarbons, solvents, pesticides, and explosives such as TNT, RDX and HMX. UV light, ozone and hydrogen peroxide are hazardous, therefore, vendor information should be reviewed for safe handling and operating procedures.

7.7-2. PRODUCTS.

a. Hydrogen Peroxide (H_2O_2). Storage tank and pump (if H_2O_2 is used).

b. Ozone (O_3) Generator. Unit that generates gaseous ozone from atmospheric air.

c. UV Reactor. Unit containing UV light(s) in which the organic materials are destroyed.

7.7-3. EXECUTION.

a. Interface. Ensure that the controls and interface required between the UV oxidation system and other plant components are clearly identified, and adhered to, per the contract specifications.

b. Cooling Loops. When an ozone generator is supplied as part of the process equipment, make sure that cooling loops are not run through electrical circuitry, where condensate from the tubing can lead to electrical shorts.

c. Off-Gas Control. If ozone is used as part of the treatment package, off-gas control to destroy residual ozone is normally provided. The off-gas control typically consists of a heated catalyst bed. It is imperative that no condensate or water be allowed to contact the catalyst bed since moisture destroys the integrity of the catalyst. Ensure connecting piping slopes away from the unit.

d. Cooling Water. If ozone is produced on site, water will be required to cool the ozone generator. Verify that the contractor has a permit for the discharge of the ozone generator cooling water (if required).

e. Hydrogen Peroxide. Hydrogen peroxide storage is typically handled like other process chemicals. Spill containment is normally provided on the process floor.

f. Air Handling. When air handling is a system requirement, ensure that the valving/dampening is provided according to specifications.

7.7-4. OPERATIONS AND MAINTENANCE. The UV oxidation system will require periodic replacement of ultraviolet bulbs, however, fouling of the quartz sheaths that house the bulbs may also become a problem. Excessive fouling may require that the system be taken off line in order to remove the encrusted material.

CHAPTER 7.8
CHEMICAL HANDLING AND SLUDGE MANAGEMENT

Paragraph **Page**

CHAPTER 7.8 CHEMICAL HANDLING AND SLUDGE MANAGEMENT

7.8-1. GENERAL. Chemical handling and sludge management systems typically consist of mixing and storage systems for the chemicals, pumps, control systems, and piping.

7.8-2. PRODUCTS.

a. Chemicals. Treatment chemicals are one of the greatest hazards associated with a ground water treatment facility. Material safety data sheets for each chemical must be available at the site. The construction of suitable chemical handling systems is critical to the safety of personnel during operation. Material requirements for pumps, piping and storage systems must be carefully checked with the specifications. In addition to the hazards associated with the chemicals themselves, care must be exercised to prevent mixing of chemicals due to chemical reactions which may occur.

b. Chemical Metering Pumps. Chemical metering pumps should be supplied with adequate turndown capacity to allow for varying flow conditions. Capacity and materials of construction for pump internals are critical to pump performance. Ensure that the specification has been closely followed with respect to required internal components.

c. Chemical Feed Systems. To the greatest extent possible, the chemical feed system should be provided as a system with all components coming from the same manufacturer. Each chemical has unique equipment requirements with regard to sizing, materials of construction, control, etc. Ensure that the specifications have been closely followed with respect to using a single vendor.

d. Sludge Management. Sludge thickeners are typically used for storage and thickening of sludge. Sludge thickeners are normally fed using positive displacement diaphragm pumps or progressive cavity pumps. Sludge generated from biological or metals precipitation treatment processes requires some type of collection, pumping, thickening/conditioning and dewatering. The goal of the sludge management system is to reduce the sludge volume as much as possible to reduce disposal costs. This is accomplished by dewatering the sludge.

7.8-3. EXECUTION.

a. Chemical Handling.

(1) Safety. Operation of the chemical feed and storage system is potentially the most hazardous activity for the plant operator. It is imperative that all safety precautions of the material safety data sheets for each chemical be closely followed. Personnel should wear protective equipment and never work on chemical tanks and pipes alone. Water should never be added to concentrated acids or bases because violent reactions may occur. However, concentrated acids or bases may be added cautiously to water.

(2) Acid. Refer to the specifications for installation and materials requirements. Acid piping requires special attention for safety reasons. Ensure the contractor takes appropriate measures to

address the expansion and contraction that occurs over normal temperature variations.

(3) Caustic. When 50 percent sodium hydroxide (caustic) is utilized in northern climates, storage of the 50 percent caustic is a concern due to potential freezing at relatively high temperatures (13 degrees C (55 degrees F)). The potential for freezing at these temperatures will necessitate providing storage within the process area, or provisions for heat tracing of the piping and heating of the tank contents.

(4) Lime. Lime is used to enhance the conditioning of sludge in the sludge dewatering process and may also be used for pH elevation. Hydrated lime is provided in a powder form, while quicklime is usually provided in granular or nugget form. Quicklime is normally used only in very large applications. When quicklime is used, the grit produced during formation of lime slurry (slaking) must be disposed of. Hydrated lime does not produce a grit requiring disposal. Depending upon the size of the application and the lime requirements, the lime may be stored in a silo or handled using bags. If a lime silo is required, the plans and specifications should be carefully followed. If a carbon steel slurry mix tank is provided, ensure that the interior of the tank is coated to prevent rusting.

(5) Polymer. Polymer is utilized to assist in the agglomerization of particles in solution and to reduce solids loading on downstream processes. Polymer may come in powder or liquid (neat) form. When polymer is mixed to the application strength (typically one percent), the solution usually has a limited shelf life. When spilled, polymers will present a slip hazard.

(6) Oxidants. As previously discussed, oxidants such as hydrogen peroxide are used in a variety of applications within a ground water treatment facility. Oxidants are very hazardous. Verify that the procedures in the specifications regarding safe handling and storage are followed closely.

(7) Chemical Piping. As a safety consideration, chemical piping should not be run overhead without using a tray guard or other method to capture the chemical in the event of a pipe rupture. If this is not specified, contact the designer.

(8) Chemical Tank Requirements. Secondary containment is typically provided around the chemical storage tanks in the event of spills or a catastrophic failure of the primary storage tank. Tank labels and material safety data sheets should be in place prior to filling the tanks.

(9) Controls. The control system may be manual, on/off, or proportional based on liquid level, flow, pH, ORP or other process measurement. If tied to a supervision, control and data acquisition (SCADA) system, ensure compliance with the provisions in the specifications.

b. Sludge Management.

(1) Sludge Collection. Sludge accumulates in the bottom of biological and metals precipitation treatment processes and is periodically pumped to a sludge thickening and storage tank. The design of the system is based upon a predicted sludge generation rate. However, it is ultimately up to the contractor/operator of the facility, based upon the sludge accumulation and treatment

efficiency, to determine when and how often to pump sludge from the treatment system. Typically, sludge sampling ports are provided on the equipment to assist operators with the sludge pumping determination.

(2) Sludge Pumping. Sludge pumps are capable of pumping fluids with high solids content. Sludge pumps are typically of the pneumatically operated diaphragm type or progressive cavity type. Ensure that appropriate air quality (see manufacturers recommendations) is used to operate diaphragm pumps.

(3) Sludge Thickening/Conditioning. Sludge thickening on most HTRW projects is usually a batch process. During the thickening and conditioning, lime and/or polymer is added to enhance sludge dewatering. The supernatant (water) from the sludge is usually returned to the front of the treatment plant for further treatment. The contractor is required to optimize sludge thickening/conditioning to maximize the solids content and minimize the volume of sludge requiring dewatering. Efficient use of chemicals should also be considered. Verify that access has been provided to remove the internal mechanism of the sludge thickener for maintenance activities. Contact the design district if adequate access has not been provided.

(4) Sludge Dewatering. The contractor is responsible for providing and operating some type of sludge dewatering system. This is often a container where the sludge has time to settle further followed by a plate and frame filter press to dewater the sludge.

(5) Sludge Dewatering Equipment. Sludge filter presses mechanically "squeeze" the water from the sludge. Housekeeping is normally a concern when operating a filter press. Hose bibs (spigots) should be provided near the sludge filter press to assist in general cleanup. Verify that sufficient thought has been given to the placement of the roll-off containers to be used to collect the dewatered sludge. This is important to prevent spillage/over splash of contaminated sludge material on to the ground. If not, contact the design district. If a sludge dryer is utilized to further reduce the water content in the sludge, be aware that the dryer tends to produce large amounts of dust.

(6) Sludge Disposal. Options for off-site disposal of sludge should be determined well in advance of the time for disposal. The sludge may be classified as a hazardous waste. A written agreement with an EPA/state approved disposal facility may be required. Manifesting may also be required. Refer to EP 200-1-2 for additional information on manifesting.