NM1 - ___66_____

CONSTRUCTION PLANS

Cell E-2

Jones, Brad, EMNRD

From: Barr, Leigh, EMNRD
Sent: Friday, October 28, 2022 3:07 PM
To: Jones, Brad, EMNRD
Subject: Fwd: [EXTERNAL] North Ranch Surface Waste Management Facility (Permit NM1-66) - Notice of New Cell Construction - Cell E-2
Attachments: 01_CELL E2_COMPLETE.pdf; NRLF - PERMITTED CQA-REV102822.pdf

FYI

From: Bradford, Michael <MBradford@scsengineers.com>
Sent: Friday, October 28, 2022 3:06 PM
To: Barr, Leigh, EMNRD <leighp.barr@emnrd.nm.gov>
Cc: Ravi Vemulapalli <ravi@hr-epc.com>
Subject: [EXTERNAL] North Ranch Surface Waste Management Facility (Permit NM1-66) - Notice of New Cell Construction - Cell E-2

CAUTION: This email originated outside of our organization. Exercise caution prior to clicking on links or opening attachments.

Good Afternoon,

I am sending this complete set of construction drawings and updated CQA Plan to you on behalf of NGL Waste Service, LLC, (NGL) operator of the North Ranch Surface Waste Management Facility (Permit No. NM1-66). Permit NM1-66 Stipulation 6.C requires that the Operator funish OCD with a complete set of drawings, updated CQA plan, and major construction milestone schedule at least 30-days prior to start of construction of new units. This submittal is to provide the OCD with 30-day notice that NGL intends to begin construction of a new disposal unit at the Facility in compliance with Permit Stipulation 6.C. You'll find that these plans substantially comply with the engineer designs provided in the permit application document.

The attached documents comprise the documents to be used for the construction and certification of Cell E-2 at the Facility.

The following is a major milestone schedule for the project:

- Mass excavation and grading as shown on Sheet 5 of the Plans will commence on or after November 27, 2022.
- Base Liner System Installation is anticipated at this time to begin on or before January 30, 2023.
- Base Liner system installation is anticipated at this time to be completed on or before March 30, 2023.
- Installation of the contact water pumping system anticipated to be performed in the first week of April of 2023, marking substantial completion of the project.

I will provide the OCD with milestone schedule updates as they become available throughout the construction activities.

Please let me know if you have any questions or comments.

Thank you.

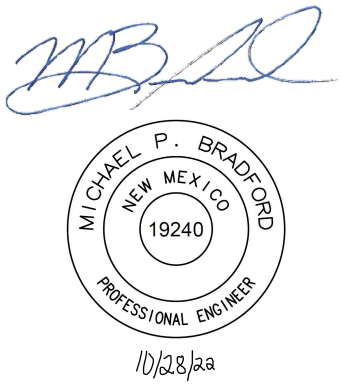
Michael Bradford, P.E.
(Licensed in AR, AZ, FL, NC, NM, NV, TX, WY)
SCS Engineers
Mobile: 602-826-9398
mbradford@scsengineers.com

Construction Quality Assurance Plan

North Ranch Surface Waste Management Facility
Lea County, New Mexico

September 2019
Amended – March 2022 by SCS Engineers
Updated - October 2022 by SCS Engineers

Terracon Project No. 35187378
SCS File #. 01222034.02



Prepared for:
NGL Waste Services, LLC
3773 Cherry Creek Dr., Suite 1000
Denver, CO 80209
303-815-1010

Amended/Updated by:
SCS ENGINEERS
SCS Engineers
6100 Maple Ave, Suite 118
Tempe, Arizona 85283
(602) 840-2596

Prepared by:
Terracon Consultants, Inc.
25809 Interstate 30 South
Bryant, Arkansas 72022
(501) 847-9292

Record of Updates and Amendments

Update/Amendment Description	Organization	Date
Addition of Concrete CQA requirements	SCS Engineers	3/22
Updates to ASTM, GRI, and Industry standards	SCS Engineers	10/22

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EXHIBITS

SECTION 1
GENERAL

1.0 INTRODUCTION

The purpose of this document is to present a Quality Assurance and Quality Control Plan (QA/QC Plan) for the North Ranch Surface Waste Management Facility an up stream oil and gas exploration and production waste disposal facility. This plan is prepared in general accordance with New Mexico Administrative Code (NMAC) 19.15.36.14.D as it pertains to Landfill liner construction and NMAC 19.15.36.17.B as it pertains to evaporation pond liner construction to ensure excavations and liners used in the facility operations are designed, constructed, installed, and maintained properly. The QA/QC Plan describes procedures for the installation and maintenance of the soil and geosynthetic components used in the composite liners system as specified by the facility design plans.

CQA of the selection, evaluation, treatment, placement, and compaction of soils for earthwork, low-permeability soil liners, granular drainage systems, and final cover layers is included in the scope of this plan. CQA applicable to manufacturing, fabricating, shipping, handling, and installing of all geosynthetics is also included. This CQA Plan does not address design guidelines, installation specifications, or selection of soils, geomembranes, and other geosynthetics (which include chemical compatibility between geosynthetics and contained material). In particular, this document addresses the requirements for CQA monitoring, testing and documentation of activities related to the production, construction, and installation of landfill lining systems, leachate collection systems, and cover systems. When applicable and deemed appropriate by the New Mexico Oil Conservation Division (NMOCD), deviations from this plan must be consistent with changes in applicable State and Federal Regulations, Facility Permit Conditions, and/or accepted practices in the field of Engineering.

The CQA Plan includes references to test procedures and standards of the American Society for Testing and Materials (ASTM), Corps of Engineers (COE), the Federal Test Method Standards (FTMS), the Geosynthetic Research Institute (GRI), and current industry practice.

1. Generic Construction Quality Assurance Plan for the Lining and Cover Systems; Geosyntec Consultants; September 1992;
2. ASTM Standards and Other Specifications and Test Methods on the Quality Assurance of Landfill Liner Systems; ASTM; 1916 Race Street; Philadelphia, PA 19103; 1994;
3. “New Mexico Administrative Code, Title 19 Chapter 15, Part 36, Surface Waste Management Facilities”; Effective February 14, 2007;
4. Waste Containment Facilities-Guidance for Construction, Quality Assurance and Quality Control of Liner and Cover Systems; David E. Daniel and Robert M. Koerner; 1995.
5. Geosynthetic Research Institute Test Methods and Standards; Latest versions as of the date of this CQA Plan.

2.0 DEFINITIONS RELATED TO CQA

This section describes CQA associated with the construction of liner and cover systems and defines terminology used throughout this document. **EXHIBIT A** provides detailed definitions for common quality assurance and landfill terminology used in this document.

2.1 Construction Quality Assurance and Construction Quality Control

This CQA Plan is devoted to Construction Quality Assurance and Construction Quality Control. In the context of this CQA Plan, Construction Quality Assurance and Construction Quality Control are defined as follows:

Construction Quality Assurance (CQA) - A planned and systematic pattern of all means and actions designed to provide adequate confidence that items or services meet contractual and regulatory requirements, and will perform satisfactorily in service.

Construction Quality Control (CQC) - Those actions which provide a means to measure and control the characteristics of an item or service to contractual and regulatory requirements.

2.2 Use of the Terms in This Plan

In the context of this plan:

1. CQA refers to means and actions employed by the CQA Consultant to assure conformity of the lining and cover system component production and installation with this CQA Plan, the Project Plans, and the Project Specifications. CQA is provided by a party independent from production and installation.
2. CQC refers to those actions taken by Manufacturers, Fabricators, Installers, or the CQC Firm to insure that the materials and the workmanship meet the requirements of the Project Plans and Specifications.

3.0 CQA AND CQC PARTIES

This section summarizes the CQA parties that will be involved in any liner/cover system installation corresponding to the proposed Landfill and Evaporation Pond.

3.1 Description of CQA Parties

The following section summarizes the CQA Parties who will be either directly or indirectly involved in the construction/installation associated with the bottom liner or final cover system corresponding to the proposed Landfill and Leachate Evaporation Pond. Where applicable, proposed Landfill Operator and/or Owner will be responsible for insuring that each of the Parties selected have the necessary experience and qualifications associated with bottom liner and final cover system installations. In addition, each party shall be aware of its obligations and responsibilities as defined in this plan. Depending on the size and/or scope of the project, a

person or firm may act as more than one of the parties listed below, as long as third party and conflict of interest matters are addressed.

3.1.1 Owner

The Owner owns and/or is responsible for the facility, including components constructed and governed by the scope of this document. The Owner is responsible for managing all aspects of the project including planning, cost control, design, permitting, regulatory liaison, contract acquisitions, construction oversight, quality control, and certification. Unless otherwise noted, the proposed Landfill and Leachate Evaporation Pond will be the owner of any liner/final cover system constructed in association with the Landfill. The proposed Landfill Operator and/or Owner will be responsible for negotiating contracts between other CQA Parties, and for insuring that qualified agencies, firms, contractors, etc. are selected who will satisfy the requirements of this CQA Plan and who will be responsible for insuring that the project is completed in accordance with applicable Project Plans, Specifications, Regulations, and within established cost constraints.

3.1.2 Project Manager

The Project Manager is the official representative of the Owner. The Project Manager, along with the Design Engineer, will be the central point of contact for the Owner and CQA Consultant. Depending on the size or scope of the Project, the Project Manager may be a 3rd Party Firm or Agency contracted directly with the Owner to oversee the Project. In some situations, the Project Manager may act jointly as the Project Manager and Design Engineer. The Owner and/or Project Manager shall carefully consider the size and scope of the project when determining whether it is necessary to have separate individuals to fill the role of Design Engineer and Project Manager. Although not specifically required in the NMAC, it is highly recommended and is industry best practice that the Design Engineer and/or CQA Manager be represented as a firm/agency independent of the Owner (i.e., 3rd Party). While considering this, the Design Engineer and/or CQA Manager shall have no corporate ties, which could be construed as a conflict of interest.

3.1.3 Design Engineer

The Design Engineer is responsible for the design of the liner and/or cover systems, and for the preparation of the Project Plans and Specifications. The Design Engineer may be an employee of the Owner/Operator or a 3rd Party firm or agency hired by the Owner/Operator.

3.1.4 CQA Consultant

The CQA Consultant is directly responsible for verifying that construction materials, practices, and procedures, are consistent with the requirements of this plan, the project specifications, plans, and applicable regulations. The CQA Consultant will work directly with the CQC Firm and/or labs in order to efficiently manage all aspects of project quality assurance. The CQA Consultant shall be an independent 3rd Party firm or agency with no direct corporate ties to the Owner, which may be construed as a conflict of interest.

3.1.4.1 CQA Certifying Engineer

The CQA Certifying Engineer is a party, independent from the Owner, Manufacturer, Fabricator, and Installer, that is responsible for the overall observation, testing and documentation activities related to the CQA of the earthwork at the site and the production and installation of the geosynthetic components of the lining and cover systems, i.e., the geotextiles and geocomposite on this facility. The CQA Certifying Engineer also is responsible for issuing a certification report, sealed by a Registered Professional Engineer associated with the installation of the liner and collection system. Depending on the size and/or scope of the Project, the CQA Certifying Engineer may also serve as the CQA Consultant, and/or CQA Manager.

3.1.4.2 CQA Manager

The CQA Manager reports to the Certifying Engineer and is responsible for observing, testing and documenting activities related to the CQA of the earthwork at the site and the production and installation of the geosynthetic components of the lining and cover systems, i.e., the geomembranes, geotextiles, and geocomposites on this facility.

3.1.4.3 CQA Monitor

The CQA Monitor reports to the CQA Manager and/or the Certifying Engineer and is responsible for observing, testing and documenting activities related to the CQA of the earthwork at the site and the production and installation of the geosynthetic components of the lining and cover systems, i.e., the geomembranes, geotextiles, and geocomposites on this facility.

3.1.4.4 Soils Testing Laboratory

The Soils CQC Firm is responsible for conducting tests in the field and in the laboratory on samples of soils associated with liner and cover system installations. The Owner or the General Contractor may retain the third party CQA Firm.

3.1.4.5 Geosynthetics Laboratory

The Geosynthetics Laboratory is a party, independent from the Owner, Manufacturer, Fabricator, and Installer, that is responsible for conducting tests on samples of geosynthetics taken from the site. The Geosynthetics Laboratory testing services cannot be provided by any party involved with the manufacture, fabrication, or installation of any of the geosynthetic components. The geosynthetics installer, if deemed acceptable by the CQA consultant, may perform the CQC field-testing. The CQA consultant shall be present during all such testing. In no case shall the geosynthetics installer or subcontractor conduct laboratory testing for conformance or destructive analysis. A firm independent of the geosynthetics installer shall conduct this analysis.

3.1.4.6 CQA Surveyor

The CQA Surveyor is a party that is independent from the Contractor that is responsible for surveying the subgrade and liner during construction.

3.1.5 General Contractor

The General Contractor is responsible for construction of the bottom liner and final cover systems. The General Contractor may perform directly or subcontract out various elements of the construction, including subgrade preparation, geosynthetics, and soil placement. The General Contractor may also be responsible for other construction at the Facility either directly or indirectly related to the waste disposal area.

3.1.6 Soils Contractor

The Soils Contractor excavates and/or delivers soil material to the General Contractor and/or project site. Depending on the size and/or scope of the Project, the General Contractor may also serve as the Soils Contractor.

3.1.7 Geosynthetics Manufacturer

The Geosynthetics (Geomembrane, Geotextile, Geosynthetic Clay, Geonets or Geocomposites) Manufacturer (Manufacturer) is responsible for the production of geomembranes or geonet rolls from resin. The geosynthetics manufacturer may also produce geosynthetic clay liners from bentonite and/or geotextile rolls from resin fibers.

3.1.8 Geosynthetics Installer

The Geosynthetics Installer (Installer) is responsible for field handling, storing, placing, seaming, loading, and other aspects of the geosynthetics installation. The Installer may also be responsible for transportation of these materials to the site and for construction of the anchor trenches if so defined in the project specifications.

3.1.9 Geosynthetics Transporter

The Transporter transports the geosynthetics, including rolls of geotextiles, geocomposites, and geonets between the Manufacturer and the site; or between the Manufacturer and the Fabricator, and/or between the Fabricator and the site.

3.2 Qualifications of the Parties

The following qualifications shall be required of all parties involved with the design, manufacture, fabrication, installation, transportation, and CQA of all lining and cover system materials to be utilized at the Landfill.

3.2.1 Project Manager

The selection of the Project Manager is the responsibility of the Owner. Qualifications for this position are determined by the Owner independently of the CQA Plan and will be based on the objectives and constraints of the Project as determined by the Owner.

3.2.2 Design Engineer

The Design Engineer shall be a qualified professional engineer with registration in the State of New Mexico. The Design Engineer shall have demonstrated experience associated with previous similar solid waste/hazardous waste projects. In particular, the Design Engineer shall

have a history which demonstrates familiarity with geosynthetics and/or soils, as appropriate, including detailed design and construction methods commonly used in the field of Civil and/or Sanitary Engineering.

3.2.3 CQA Consultant

The CQA Consultant shall be a designated firm or agency independent of the Owner with demonstrated knowledge and experience with geosynthetics and soil liner/cover systems. The CQA Consultant is responsible for the CQA Manager, CQA Monitors, Soils Testing Laboratory, Geosynthetics Laboratory, and CQA Surveyor.

The CQA Consultant shall be a well-established engineering firm incorporated (or otherwise registered) in the United States. The CQA Consultant shall be experienced in providing CQA services for soils, including low-permeability and high-permeability soils. The CQA Consultant shall be experienced in the preparation of quality assurance documentation including quality assurance forms, reports, certifications, and manuals.

In addition, the CQA Consultant shall provide the following in writing, if required, to the Owner before entering into contractual agreements with the Owner:

1. Corporate background and information; and
2. Quality assurance capabilities:
   - a summary of the firm's experience with soils;
   - a summary of the firm's experience in quality assurance, including installation quality assurance of soils;
   - a summary of the CQA documentation and methods used by the firm, including sample CQA forms, reports, certifications, and manuals prepared by the firm;
   - a summary of the firm's experience with geosynthetics, including geomembranes, geocomposites, geonets, and geotextiles;
   - a summary of the firm's experience in quality assurance, including installation quality assurance of geomembranes, geocomposites, geonets, and geotextiles; and
   - a summary of CQA documentation and methods used by the firm, including sample CQA forms, reports, certifications, and manuals prepared by the firm.

In addition, the CQA Consultant shall provide the following in writing, if required, to the Owner before beginning work on this project:

1. Resumes of personnel to be involved in the project including the CQA Certifying Engineer, CQA Manager, and CQA Monitors;

2. Proof of Professional Engineering registration in the project state of the engineer to be designated the CQA Certifying Engineer; and
3. Proof of quality assurance experience of the CQA personnel with emphasis on geomembranes, geocomposites, geonets, and geotextiles.

3.2.3.1 CQA Certifying Engineer

The CQA Certifying Engineer shall represent a designated firm or agency, independent of the Owner, with demonstrated knowledge and experience with geosynthetics and soil liner/cover systems. The CQA Certifying Engineer shall be a New Mexico Registered Professional Engineer who will be responsible for preparing and sealing a certification report upon the successful completion of the project.

Third Party CQA Firm – An independent third party shall provide Construction quality assurance (CQA). If the certifying firm or individuals have any relationship with the owner or operator of the facility, which could be interpreted as a conflict (such as belonging to a firm under the same corporate umbrella), these shall be disclosed in advance of the construction.

Required Presence – A qualified member of the CQA firm shall be present at the site continuously during liner or final cover barrier construction. The professional certifying the construction shall at a minimum visit the site at least once prior to construction, once during construction and once after construction is substantially completed unless such visits are not practical. Additional visits by the professional certifying the construction shall be required if additional visits are prescribed in the approved Quality Assurance Plan or if site conditions warrant.

3.2.3.2 Soils Testing Laboratory

The Soils Testing Laboratory shall have experience in soils testing, meet all regulatory requirements, and have demonstrated experience utilizing the standards specified in this Plan. The Soils Testing Laboratory shall be capable of providing test results in accordance with the test methods described in the specifications. **The Soils Testing Laboratory shall be capable of providing a minimum of ten flexible wall permeability test results in six (6) days or less**.

3.2.3.3 Geosynthetics Laboratory

The Geosynthetics Laboratory shall have experience in testing geosynthetics and be familiar with American Society for Testing and Materials (ASTM), National Sanitation Foundation (NSF), and Geosynthetic Research Institute (GRI) test methods and standards. The Geosynthetics CQC Firm shall be capable of providing destructive test results within 24 hours of receipt of samples and shall maintain that standard throughout the installation.

3.2.4 Soils Supplier

Qualifications of the soils supplier are specific to the construction contract. The soils supplier shall have a demonstrated history of providing soils with consistent properties (when applicable).

3.2.5 Earthwork Contractor

Qualifications of the Earthwork Contractor are specific to the construction contract. The Earthwork Contractor shall have a demonstrated history of successful earthwork construction. In particular, the Contractor shall have successfully completed liner or cover systems for solid waste, hazardous waste, or surface water containment. Documentation of this experience shall be submitted with the Contractor's Bid to the Owner or Project Manager.

3.2.6 Geosynthetics Installer

The Geosynthetics Installer shall be trained and qualified to install geosynthetics. Prior to confirmation of any contractual agreements, the Geosynthetic Installer shall provide the Project Manager with the following written information:

1. Corporate background and information;
2. Installation capabilities;
3. Equipment and personnel;
4. Daily anticipated production;
5. Quality control manual for installation;

3.2.7 Transporter

All personnel responsible for the loading, transport and unloading of the geosynthetics must be aware of the consequences of damage to the geosynthetics, and be familiar with the handling and transport constraints required by the Manufacturer and/or Fabricator.

3.3 Duties of the CQA Personnel

In this CQA Plan, the roles of the CQA Certifying Engineer, CQA Manager, Soils CQA Monitor, and Geosynthetics CQA Monitor are described separately. Individuals or consultants may be responsible for each particular aspect of the liner/cover system construction.

1. The CQA Manager, who depending on the size and/or scope of the project may direct CQA activities from the offices of the CQA Consultant's firm and visit the site periodically; The CQA Manager may designate CQA Monitors depending on the size and/or scope of the project to oversee certain aspects of the project. The CQA Monitors will report directly to the CQA Manager.
2. The CQA Monitors will be on site during all aspects of construction pertaining to the liner/cover system installation.

As described in earlier sections, the CQA Manager may also serve as the Soils CQA Monitor and the Geosynthetics CQA Monitor depending on the size and/or scope of the project. It is likely that a CQA Manager will be designated for both the Soils and Geosynthetics components of the liner/cover system installation on large projects.

3.3.1 CQA Certifying Engineer

The CQA Certifying Engineer will be responsible for:

1. Review of all project related designs, plans, and specifications;
2. Reviews all other site-specific documentation, including bid documents, proposed layouts, soils and groundwater investigation reports, and for geosynthetics, the manufacturer's and installer's literature;
3. Attends the resolution meetings;
4. Administers the CQA program (i.e., assigns and manages all CQA personnel, reviews all field reports, and provides engineering review of all CQA related issues);
5. Provides quality control of the CQA personnel, including site visits;
6. Reviews all changes to the design, plans, and specifications; and
7. Prepares/approves the final certification report, including a review of the Record Drawing(s).

3.3.2 CQA Manager

The CQA Manager may also be the CQA Monitor depending on the size and/or scope of the project and will be responsible for:

1. Familiarizes self and/or all CQA Monitors with the site and the project requirements;
2. Manages the daily activities of the CQA Monitors;
3. Attending CQA-related meetings (resolution, pre-construction, daily, weekly, etc.);
4. Prepares or oversees the ongoing preparation of the Record Drawings(s);
5. Assigns locations for testing and sampling;
6. Reviews results of laboratory testing and makes appropriate recommendations;
7. Reviews all CQA Monitors' daily reports and logs;
8. Reports to the Project Manager, and logs in his daily field report any relevant observations reported by the CQA Monitors;
9. Prepares daily report;
10. Prepares weekly summary of CQA activities; and

11. Delegate's responsibilities to a senior CQA Monitor whenever absent from the site while operations are ongoing.

In addition, the CQA Manager shall be responsible for insuring:

1. Periodically checks stockpile or borrow pit sources for variability of the soils, and insures that conformance testing is carried out;
2. Establishes additional test requirements beyond those in the specifications, where necessary to confirm permeability or density requirements;
3. May perform site visit and review of manufacturing plant facilities (as deemed necessary), methods, and quality control;
4. Reviews all Supplier, Manufacturer, and Installer certifications and documentation and makes appropriate recommendations;
5. Reviews the Installer's personnel qualifications for conformance with those pre-approved for work on site; and
6. Notes any on-site activities that could result in damage to the geosynthetics.

3.3.3 CQA Monitors

The duties of the CQA Monitors include, as assigned by the CQA Certifying Engineer and/or CQA Manager: monitoring, logging, and/or documenting all appropriate operations. The duties to be performed, and operations to be monitored by the Soils CQA Monitors include:

1. Soils delivery, dumping, and placement;
2. Soils moisture content, and moisture conditioning, if required;
3. Compaction of soils, and in situ testing of compacted density and moisture content;
4. Collection of samples for laboratory testing for moisture/density relationships, permeability; and other testing as outlined in the specifications;
5. Operations to protect completed areas before the covering materials are placed;
6. Measurement of loose and compacted lift thickness;
7. Verification of bonding between lifts;
8. Observation of equipment type, number of passes and equipment contact pressure;
9. Examination of the soil surface for signs of excessive wetting, desiccation, or other disturbance prior to placement of any cover materials; and
10. Scarification, rewetting, recompaction, or proof rolling required to repair deteriorated areas; and
11. Reports any unresolved deviations from the CQA Plan to the CQA Manager.

The operations to be monitored by the Geosynthetics CQA Monitors, for all geosynthetics include:

1. Material delivery and "spotting";
2. Unloading and on-site transport and storage;
3. Marking samples for conformance testing;
4. Sampling for conformance testing by the Geosynthetics CQC Firm;
5. All placement operations;
6. Condition of panels as placed;
7. All joining and/or seaming operations; and
8. Repair operations.

All CQA Monitors shall take note of on-site activities that could result in damage to the soils or geosynthetics components of the lining system. Any observations so noted shall be reported as soon as possible to the CQA Manager.

4.0 SITE AND PROJECT CONTROL

In order to coordinate various aspects of the construction project and develop time frames for completion of the project, various project coordination meetings will be required associated with all liner/cover system installations. The Owner will be responsible for organizing or selecting a representative to organize the various project coordination meetings. A person shall be designated at the beginning of all meetings to document and transmit the minutes to all parties.

4.1 Resolution Meeting

Following the completion of the design, plans, and specifications for the project, a Resolution Meeting shall be held. This meeting shall include all parties then involved, including the Owner, Project Manager, and Design Engineer. This meeting may be combined with the pre- construction meeting depending on the size and scope of the project.

The purpose of this meeting is to begin planning for coordination of tasks, anticipate any problems, which might cause difficulties and delays in construction, and present the CQA Plan to all the parties involved. It is very important that the rules regarding testing, repair, etc., be known and accepted by all. The first part of the Resolution Meeting may be devoted to a review of the design drawings and specifications for completeness and clarity. This is different from the peer review of the design, including design calculations, which shall have been carried out previously. This meeting shall include all of the following activities:

1. Communicate to all parties any relevant documents;

2. Review critical design details of the project;
3. Review the seam layout drawing provided by the Designer, the Fabricator, or the Installer;
4. Review the project-specific CQA Plan;
5. Make any appropriate modifications to the CQA Plan to insure that it specifies all CQA activities that are necessary (within the context of the regulatory agency approval if necessary);
6. Make any appropriate modifications to the design criteria, plans, and specifications so that the fulfillment of all design specifications or performance standards can be determined through the implementation of the site-specific CQA Plan;
7. Reach a consensus on the CQA Plan and quality control procedures, especially on methods of determining the acceptability of the soils and geosynthetics comprising the lining system;
8. Assign the responsibilities of each party;
9. Decide the number of soil density testing units to be maintained on site;
10. Establish work area security and safety protocol;
11. Select testing equipment and review protocols for testing and placement of soil materials;
12. Confirm the methods for documenting and reporting, and for distributing documents and reports; and
13. Confirm the lines of authority and communication.

4.2 Pre-Construction Meeting

A Pre-Construction Meeting shall be held at the site. At a minimum, the Owner, Project Manager, Design Engineer, CQA Manager, Earthwork Contractor, and Geosynthetics Installer shall attend the meeting. If deemed appropriate by the Project Manager, the Pre-Construction Meeting may be separated into two separate meetings; one for the Earthwork Contractor and one for the Geosynthetics Installer.

Specific topics considered for this meeting include:

1. Make any appropriate modifications to the CQA Plan (within the context of regulatory agency approval as necessary);
2. Review the responsibilities of each party;
3. Review lines of authority and communication;
4. Review methods for documenting and reporting, and for distributing documents and reports;

5. Establish protocols for testing;
6. Establish protocols for handling deficiencies, repairs, and retesting;
7. Review the time schedule for all operations;
8. Conduct a site walk-around to verify that earthwork construction is proceeding on schedule, and to review material storage locations;
9. Establish soil stockpiling locations; and

4.3 Progress Meetings

Periodic progress meetings shall be held between the Soils and Geosynthetics CQA Monitors, the Installer's superintendent, the Project Manager, and any other concerned parties. These meetings shall discuss current progress, planned activities for the next period, and any new business or revisions to the work. The CQA Monitors shall log any problems, decisions, or questions arising at this meeting in their daily reports. Any matter requiring action, which is raised in this meeting, shall be reported to the appropriate parties. The CQA Monitor's logs shall be submitted to the CQA Manager for inclusion in the Certification Report if deemed pertinent and appropriate.

4.4 Problem or Work Deficiency Meetings

A special meeting shall be held when and if a problem or deficiency is present or likely to occur. At a minimum, the affected contractor, the Project Manager, and the appropriate CQA Manager(s) shall attend the meeting. If the problem requires a design modification, the Design Engineer shall also be present. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

1. Define and discuss the problem or deficiency;
2. Review alternative solutions; and
3. Implement an action plan to resolve the problem or deficiency.

4.5 Project Control Visits

4.5.1 Periodic Visits

Periodically, the CQA Manager, and the Certifying Engineer(s) shall visit the construction site. This visit shall be coordinated with a similar visit by the Design Engineer when appropriate. The professional certifying the construction shall at a minimum visit the site at least once prior to construction, once during construction and once after construction is substantially completed, unless such visits are not practical. Additional visits by the professional certifying the construction shall be required if additional visits are prescribed in the approved Quality Assurance Plan or if site conditions warrant. The Project Manager and/or Owner may also inform state regulatory officials of these designated inspection dates if deemed appropriate.

4.5.2 Manufacturing Plant Visits

A representative of the Owner, Project Manager, Design Engineer, or CQA Manager may carry out a geosynthetic manufacturing plant visit in order to verify manufacturing practices or quality control procedures. These visits be arranged on an “as needed” basis if deemed appropriate by the Project Manager. Project specific plant visits for the manufacture and fabrication of the geosynthetics (geomembranes, geotextiles, geocomposites, and geonets) are optional. These plant visits shall be carried out at the discretion of the Owner, by the Owner, or his designated alternate.

SECTION 2
SURVEYING CONSTRUCTION QUALITY ASSURANCE

1.0 INTRODUCTION

Surveying of lines and reference elevations is conducted on an ongoing basis during the construction of the compacted soil liner materials, synthetic layers, and leachate collection system components. Accurate surveying is essential to insure that the liner/cover and hydraulic transport systems function as designed. The Contractor will be responsible for establishing grade control and the preparation of accurate record drawings (as built). The CQA Consultant will be responsible for reviewing all surveying activity performed by the Contractor to insure that construction adheres to the Project Plans and Specifications.

2.0 SURVEY CONTROL

At least one permanent elevation benchmark and at least two horizontal control benchmarks will be established for the project in a location convenient for reference during construction. The reference control points will be consistent with State Plane Coordinates and the established facility grid/survey coordinate system. The vertical and horizontal control for the benchmarks shall be established within normal land surveying standards. All initial survey controls either are in place as of the date of this writing, or will be established by the Design Engineer prior to execution of the Project.

3.0 LINES AND GRADES

The following surfaces shall be surveyed by the Contractor and verified by the CQA Consultant to document the lines and grades achieved during placement and compaction.

1. For the berms and other earthworks:
   - original grade surface;
   - compacted surface of cut slopes; and
   - finished grade surface.
2. For the compacted soil liners:
   - original contours;
   - prepared subgrade surface; and
   - finished compacted soil liner surface.
3. For the soil cover materials:
   - prepared surface; and
   - finished soil cover surface.

In addition, the lateral and vertical extent of all synthetic components as well as critical leachate collection system components shall be provided on the record drawings for future reference (if necessary).

4.0 FREQUENCY AND SPACING

All surveying shall be carried out immediately upon completion of a given installation to facilitate progress and avoid delaying commencement of the next installation. Any surveying conducted by the CQA team, is to be conducted as a check on the Contractor, but is not intended to alleviate the Contractor from his/her responsibilities for insuring that all construction is within the required grades and lines shown in the project plans and specifications.

The following minimum spacing's and locations shall be provided for survey points:

1. All "flat" surfaces, such as the base of the landfill, with gradients less than 10 percent, shall be surveyed on a square grid not wider spaced than 100 feet;
2. On all slopes greater than 10 percent, a square grid not wider than 100 feet shall be used, but in any case, a line at the crest, midpoint, and toe of the slope shall be taken;
3. A line of survey points no further than 100 feet apart must be taken along any slope break (this will include the inside edge and outside edge of any bench on a slope);
4. A line of survey points no further than 100 feet apart must be taken at the invert of any pipes or other appurtenances to the liner;
5. At the corners and midpoints of the top and bottom of all sumps;
6. At the midpoint of the crest of the outside berms; and
7. At appropriate spacing to define geosynthetics panel layouts.

5.0 DOCUMENTATION

The Surveying CQA Managing Engineer shall retain copies of all field survey notes provided. The findings from the field surveys shall be documented on a set of Survey Record (As Built) Drawings.

The Record Drawings shall include the following information when applicable:

1. Site Layout Drawing showing:
    a. Layout of Prepared Area in Relation to Permitted Boundaries;
    b. Property boundaries and/or corners;
    c. Monitoring wells and piezometers (if scale permits);

d. Leachate risers, manholes and collection piping related to the specific cell and/or construction;
e. Limits of existing/future oil field waste disposal areas and limits of liner or final cover barrier;
f. Labeling and Miscellaneous Information:
   - Descriptions of what each line style represents;
   - Drawing scale;
   - Legend; and
   - North Arrow.
g. Existing Contours (prior to construction activity corresponding to this project);
h. A key map showing the location of the construction related to the permitted design, along with an identification of areas previously constructed and areas yet to be constructed;
i. If necessary to document leachate head level compliance, the report shall also indicate the lowest point of the liner constructed not including leachate trenches and sumps;
j. In addition, the certifying professional shall make a statement that the cell was constructed in accordance with the permit drawings and narrative. The report shall also include a list of any deviations from the permitted drawings, if they exist, and any reasons for the deviations; and
k. Any other features deemed significant.

2. Subgrade Drawing showing:
   a. Prepared Subgrade Surface (Plan View);
   b. The limits of excavation including all slopes;
   c. The location of slope breaks, leachate sump and trenches, berms; and
   d. Any other features deemed significant.

3. Top of Liner System showing:
   a. The top and bottom of liner or final cover elevations referenced to the site grid coordinate system at 100’ intervals;
   b. The location and elevation of slope breaks, leachate piping, leachate sump and trenches, berms; and any other features which are material to the disposal area construction; and
   c. Any other features deemed significant.

4. Top of Drainage Layers or Liner Protection Layers showing:
   a. If a granular blanket is utilized in the design, top of blanket elevation shall be identified at 100’ intervals;

b. The location of slope breaks, leachate sump and trenches, berms; and any other features which are material to the disposal area construction; and

c. Any other features deemed significant.

5. Top of Waste
   a. Verify top of waste elevations are at or below permitted elevations prior to placing final cover. The elevations shall be referenced to the site grid coordinate system at 100' intervals.

6. Top of Final Cover Layers showing:
   a. The top and bottom of the vegetative support/topsoil layers referenced to the site grid coordinate system at 100' intervals;
   b. The location of slope breaks, trenches, berms; and trenches, berms; and any other features which are material to the disposal area construction; and
   c. Any other features deemed significant.
   d. NOTE: Depth verification may be required due to possible settlement of waste during construction of the final cover system.

The Contractor will be responsible for submitting these record drawings (as-builts) if applicable to the CQA Consultant for review. The applicable record drawings are to be included in the Certification Report along with the CQA Consultant's Certifying Engineer's seal. The report shall then be submitted to the Design Engineer and Owner for review prior to being submitted to the NMOCD.

SECTION 3
CONSTRUCTION QUALITY ASSURANCE INVOLVING SOILS

1.0 INTRODUCTION

This CQA document covers five types of soil that are used in the construction of an industrial landfill liner and/or cover system. The following types of soil layers will be used in some form in the construction of liner and cover systems corresponding to the proposed landfill and leachate evaporation pond.

1. Subgrade Surface;
2. Drainage layers or media (free-draining, high-permeability soils, usually clean sand or gravel);
3. Liner Protective Cover Layers; and
4. Topsoil (soil demonstrating the ability to support plant growth).

2.0 SOIL MATERIALS SPECIFICATIONS

Except when otherwise noted in the Project Specifications or Plans, soil materials to be utilized in each component of the liner system shall conform to the following minimum materials specifications.

2.1 Subgrade Surface

The subgrade soils require treatment in the form of compaction or recompaction, prior to the placement of any of the lining system materials. This supporting layer is comprised of natural in-place materials, so this document will only address the compaction criteria. If the subgrade is disturbed, through undercutting of unsuitable material etc.; the subgrade is to be replaced, moisture conditioned, and compacted to the standards established in the Project Specifications. When possible, the subgrade surface shall be relatively smooth and free of non angular rocks, sticks, or other debris in excess of ½-inch in maximum dimension which could compromise the liner system. The subgrade will not require any subgrade compaction testing as the contractor shall excavate down to subgrade. If material is over excavated, testing shall be determined by CQA Firm.

The upper portion of the subgrade can be damaged by excess moisture (causing softening) and insufficient moisture (causing desiccation and shrinkage), or by freezing. These conditions are normally not discovered until after the design phase of the project. At a minimum, the Soils CQA Monitor shall determine the suitability of the subgrade for fill placement by one or more of the following methods:

1. Continuous visual inspection during proof-rolling;
2. Pocket penetrometer or Torvane shear tests in suspect soil areas; and
3. Other tests identified in **TABLE 3**.

The main requirement for the subgrade is it must have sufficient compaction and strength to enable the placement of liner. The subgrade also must be stable to prevent large differential settlements that would be conducive to damage of the liner system or the pooling of leachate.

2.2 Drainage Layers

Materials to be utilized in the construction of lateral drainage layers, particularly in leachate collection systems shall be comprised of clean washed river sand or gravel with a minimum hydraulic conductivity as specified and as determined utilizing the Hydrologic Evaluation of Landfill Performance (HELP, Version 3.0) Model. The hydraulic conductivity value shall be determined by the Design Engineer and made a part of the Project Specifications. These drainage materials shall consist of clean sands and/or gravel or other permeable material classified as SW, SP, GW, or GP that contains less than 10% (by dry weight) passing the US. No. 200 sieve with 100% (by dry weight) passing the 3” sieve. Gravel placed in sumps and around perforated pipes shall be classified as GW, GP, or GW-GM with no more than 10% passing the No.200 sieve. The frequencies and criteria for preconstruction and construction testing of the appropriate drainage materials are shown on **TABLE 3**. Testing shall be performed on off-site borrow sources or on-site stockpiles. Drainage geocomposites may be utilized in place of a soil drainage layer as long as the material and installation requirements of Section 5 are adhered to.

The installer shall insure that all soil materials such as sand and gravel are placed in such a manner as to insure that no damage occurs to the geomembrane liner and that no excess tensile stresses occur in the geomembrane. The following details will be followed during construction of the drainage media system.

1. A geotextile or other cushion approved by the designer will be installed between the drainage media and the geomembrane if any of the following conditions are met:
   - The drainage layer material contains angular aggregate; and/or
   - The drainage layer contains aggregate over 1 inch in nominal size as determined by a gradation test (ASTM D422);
2. A minimum of 12 inches of drainage media will be maintained between the dozer and the geomembrane at all times and thicker layers are required for heavier dozers (Larger than a D6). Typical minimum thicknesses used for the ground pressure exerted by the equipment is described in **TABLE 1**.
3. In areas of heavy traffic such as access ramps, the thickness shall be at least 2 to 3 feet. This material can be common protective cover or the material used for the drainage media.

2.3 Protective Cover Layers

The protective cover materials above the lining system and primary leachate collection system components are to be as follows: The protective cover materials used to protect the leachate collection system, shall consist of fine grained sandy soils, gravels or geosynthetic cushion materials as per the Project Specifications. Protective cover in the cover system (frost protection layer) shall consist of native soils with no particles over 1 inch in nominal size and shall be placed in accordance with standard construction practices.

2.4 Vegetative Soil Layer[1]

Vegetative soil cover material shall be of quality to support vegetative growth and shall be placed in accordance with standard construction practices. No lab or field testing specifications are required for the installation of the vegetative soil layer beyond permeability testing discussed in **Section 2.5**. This layer will be installed at a minimum 12-inch[1] thick layer as the uppermost layer of the final cover system

2.5 Intermediate and Final Cover Materials[1]

Soil materials from borrow areas or stockpiles to be utilized for final cover system, (intermediate cover, infiltration barrier, and erosion/vegetation layers) must be tested for permeability prior to construction. Soils with a permeability of $1x10^{-5}$ cm/s or less shall be constructed as defined in the Closure and Post Closure Care Plan (**Appendix H** of the Permit Narrative). Soils with high permeabilities must be re-evaluated using the HELP model to determine required thickness to achieve 0.0 inches of percolation through the lower most layer. All new HELP modeling and revised thicknesses must be submitted to the NMOCD for review and approval prior to initiating construction.

2.5 Soils Testing

2.5.1 Test Methods

All testing used to evaluate the suitability or conformance of soils materials shall be carried out in accordance with the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures. The test methods indicated in **TABLES 2** and **3** are to be utilized for evaluating soil materials (when applicable) for adherence to the project specifications and the materials standards specified in this CQA Plan. All pre-construction and construction testing shall be performed at the frequency given in the **TABLES 2** and **3**.

2.5.2 Soils Testing Requirements

All soils testing shall be conducted under the direct supervision of the Soils CQA Consultant and/or qualified Soils CQC Firm. Nuclear densometer methods shall be used for field density testing in all cases. The drive cylinder (ASTM D2937) test or other approved method shall be used in cases of uncertainty, or as a check of the machine calibration. The Soils CQA Consultant and/or CQA Manager shall resolve any conflict over the results.

The test frequencies presented in **TABLES 2** and **3** are specified as minimum test frequencies. The CQA Manager or Soils CQA Consultant can increase the actual frequency of testing

1 - Section revised by SCS Engineers on March 31, 2022 in response to NMOCD comment.

required as necessary in order to insure adequate quality control associated with all soil liner/cover systems. For example, the actual test frequencies may be increased in order to consider local soil variability (if applicable).

3.0 GEOSYNTHETIC CLAY LINERS

3.1 Manufacturing

The Geosynthetic Clay Liner (GCL), shall consist of a layer of natural sodium bentonite clay encapsulated between two geotextiles and shall comply with all of the criteria listed in this Section. Reinforced GCL must be used as designated by the Engineer.

Acceptable reinforced GCL products are Bentomat® ST, as manufactured by CETCO, 1350 West Shure Drive, Arlington Heights, Illinois 60004 USA (847-392-5800), or an engineer- approved equal.

The reinforced GCL and its components shall be tested for the properties shown in **TABLE 4**.

The reinforced GCL shall have 10,000 hour test data for large-scale constant-load (creep) shear testing under hydrated conditions. The constant shear load shall be 0.56 kN and the normal load shall be 1.1 kN.

The minimum acceptable dimensions of full-size GCL panels shall be 150 feet (45.7 m) in length. Short rolls [(those manufactured to a length greater than 70 feet (21 m) but less than a full-length roll)] may be supplied at a rate no greater than 3 per truckload or 3 rolls every 36,000 square feet (3,500 square meters) of GCL, whichever is less.

A 6-inch (150 mm) overlap guideline shall be imprinted on both edges of the upper geotextile component of the GCL as a means for providing quality assurance of the overlap dimension. Lines shall be printed in easily visible, non-toxic ink.

The GCL manufacturer shall provide the Project Manager or other designated party with manufacturing QA/QC certifications for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer and shall include:

A. Certificates of analysis for the bentonite clay used in GCL production stating the parameters swell index and fluid loss.
B. Manufacturer's test data for finished GCL product(s) of bentonite mass/area, GCL tensile strength and GCL peel strength (reinforced only).
C. GCL lot and roll numbers supplied for the project (with corresponding shipping information).

These conformance tests shall be performed in accordance with the test methods specified on **TABLE 4**. Other conformance tests may be required by the project specifications.

Manufacturer's Quality control tests must be performed in accordance with the test methods and frequency's specified in **TABLE 4**.

The CQA Consultant shall examine all manufacturer's certifications to insure that the property values listed on the certifications meet or exceed those specified by the project specifications and the measurements of properties by the manufacturer are properly documented, test methods acceptable and the certificates have been provided at the specified frequency properly identifying the rolls related to testing. Any deviations shall be reported to the Project Manager.

3.2 Roll Label Requirements

The GCL manufacturer shall identify all rolls with the following:

A. Manufacturer's name
B. Product identification
C. Lot number
D. Roll number
E Roll Dimensions (length, width, and weight)

The CQA Monitor shall examine rolls upon delivery and any deviation from the above requirements shall be reported to the Project Manager.

3.3 Shipping, Handling, and Storage

The GCL rolls shall be wrapped in polyethylene sheets or otherwise protected against dust and dirt during shipping and storage. The wrapping shall be removed just prior to the deployment of the rolls.

The manufacturer shall be responsible for initial loading the GCL. Shipping will be the responsibility of the party paying the freight. Unloading, on-site handling and storage of the GCL are the responsibility of the Contractor, Installer or other designated party.

A visual inspection of each roll shall be made during unloading to identify if any packaging has been damaged. Rolls with damaged packaging shall be marked and set aside for further inspection. The packaging shall be repaired prior to being placed in storage.

The party responsible for unloading the GCL shall contact the Manufacturer prior to shipment to ascertain the appropriateness of the proposed unloading methods and equipment.

Storage of the GCL rolls shall be the responsibility of the installer. A dedicated storage area shall be selected at the job site that is away from high traffic areas and is level, dry and well drained. Rolls shall be stored in a manner that prevents sliding or rolling from the stacks and

may be accomplished by the use of chock blocks. Rolls shall be stacked at a height no higher than that at which the lifting apparatus can be safely handled (typically no higher than four). All stored GCL materials and the accessory bentonite must be covered with a plastic sheet or tarpaulin until their installation.

3.4 Conformance Testing

3.4.1 Testing Requirements

Upon delivery of the rolls of GCL, the CQA Consultant shall take conformance samples of the GCL, to ensure conformance to both the design specifications and the list of Manufacturer guaranteed properties. **TABLE 4** presents the conformance testing requirements.

3.4.2 Sampling Procedures

Samples shall be taken across the entire width of the roll and shall not include the first linear meter (three feet). The geosynthetic testing laboratory shall be contacted to determine the sampling size necessary for laboratory testing of the GCL.

3.4.3 Test Results

The CQA Monitor shall examine all results from laboratory conformance testing and shall report any non-conformance to the Project Manager. Any lots not meeting conformance testing specifications will result in the rejection of the lot.

3.5 Installation of the GCL

3.5.1 Earthwork

The Installer shall take whatever steps are necessary to insure that any underling layers are not damaged during the placement of the GCL or that the GCL is damaged in any way, which shall include but is not limited to the following conditions.

Any earthen surface upon which the GCL is installed shall be prepared and compacted in accordance with the project specifications and drawings. The surface shall be smooth, firm, and unyielding, and free of:

A. Vegetation.
B. Construction Debris.
C. Sticks.
D. Sharp rocks (1/2 inch maximum dimension, non-angular)
E. Void spaces.

F. Ice.
G. Abrupt elevation changes.
H. Standing water.
I. Cracks larger than one-quarter inch (6 mm) in width.
J. Any other foreign matter that could contact the GCL.

Subgrade surfaces consisting of granular soils or gravel shall be inspected due to their large void fraction and puncture potential. Immediately prior to GCL deployment, the subgrade shall be final-graded to fill in all voids or cracks and then smooth-rolled to provide the best practicable surface for the GCL. At completion of this activity, no wheel ruts, footprints or other irregularities shall exist in the subgrade. Furthermore, all protrusions extending more than one-half inch (12 mm) from the surface shall either be removed, crushed or pushed into the surface with a smooth-drum compactor. Prior to the placement of all GCL panels, the Installer shall certify in writing that the soil subgrade is acceptable and meets the manufacturer approved installation conditions.

It shall be the Installer's responsibility thereafter to indicate to the Design Engineer changes in the condition of the subgrade that could cause the subgrade to be out of compliance with any of the requirements listed in this Section.

At the top of sloped areas of the job site, an anchor trench for the GCL shall be excavated or an equivalent runout shall be utilized in accordance with the project plans and specifications and as approved by the CQA Inspector. When utilizing an anchor trench design, the trench shall be excavated and approved by the CQA Inspector prior to GCL placement. No loose soil shall be allowed at the bottom of the trench and no sharp corners or protrusions shall exist anywhere within the trench.

The CQA Monitor will note any deficiencies or non-compliance and report it to the Project Manager.

3.5.2 GCL Placement

GCL rolls shall be delivered to the working area of the site in their original packaging. Immediately prior to deployment, the packaging shall be carefully removed without damaging the GCL. The orientation of the GCL (i.e., which side faces up) shall be in accordance with the Design Engineer's recommendations.

Equipment, which could damage the GCL, shall not be allowed to travel directly on it. If the installation equipment causes rutting of the subgrade, the subgrade must be restored to its originally accepted condition before placement continues.

Care must be taken to minimize the extent to which the GCL is dragged across the subgrade in order to avoid damage to the bottom surface of the GCL. A temporary geosynthetic subgrade covering commonly known as a slip sheet or rub sheet may be used to reduce friction damage during placement.

The GCL panels shall be placed parallel to the direction of the slope.

All GCL panels shall lie flat on the underlying surface, with no wrinkles or folds, especially at the exposed edges of the panels.

Only as much GCL shall be deployed as can be covered at the end of the working day with soil, a geomembrane, or a temporary waterproof tarpaulin. The GCL shall not be left uncovered overnight. If the GCL is hydrated when no confining stress is present, it may be necessary to remove and replace the hydrated material. The Design Engineer, CQA inspector, and GCL supplier shall be consulted for specific guidance if premature hydration occurs.

3.5.3 Anchorage

As directed by the project drawings and specifications, the ends of the GCL rolls shall be placed in an anchor trench at the top of the slope or an equivalent run out design shall be utilized. When utilizing an anchor trench design, the front edge of the trench shall be rounded so as to eliminate any sharp corners. Loose soil shall be removed from the floor of the trench. The GCL shall cover the entire trench floor but not extend up the rear trench wall.

3.5.4 Seaming

The GCL seams are constructed by overlapping their adjacent edges. Care shall be taken to ensure that the overlap zone is not contaminated with loose soil or other debris. Supplemental bentonite is required for reinforced GCL. All GCL shall be installed according to the manufacturer's recommendations.

The minimum dimension of the longitudinal overlap shall be 6 inches (150 mm). End-of-roll overlapped seams shall be similarly constructed, but the minimum overlap shall measure 24 inches (600 mm).

Seams at the ends of the panels shall be constructed such that they are shingled downhill in the direction of the grade to prevent the potential for runoff flow to enter the overlap zone.

Bentonite-enhanced seams are constructed between the overlapping adjacent panels described above. The underlying edge of the longitudinal overlap is exposed and then a continuous bead of granular sodium bentonite is applied along a zone defined by the edge of the underlying panel and the 6-inch (150-mm) line. A similar bead of granular sodium bentonite is applied at

the end-of-roll overlap. The granular bentonite shall be applied at a minimum application rate of one quarter pound per lineal foot (0.4 kg/m).

3.5.5 Detail Work

The GCL shall be sealed around penetrations and embedded structures embedded in accordance with the design drawings and the GCL Manufacturer.

Cutting the GCL shall be performed using a sharp utility knife. Frequent blade changes are recommended to avoid damage to the geotextile components of the GCL during the cutting process.

3.5.6 Damage Repair

If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by cutting a patch to fit over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 12 inches (300 mm) is achieved around all of the damaged area. Granular bentonite or bentonite mastic shall be applied around the damaged area prior to placement of the patch. It may be desirable to use an adhesive to affix the patch in place so that it is not displaced during cover placement.

3.5.7 Cover Placement

If soil cover is to be placed in direct contact, cover soils shall be free of angular stones or other foreign matter that could damage the GCL. Cover soils shall be approved the Design Engineer with respect to particle size, uniformity and chemical compatibility. Cover soils with high concentrations of calcium (e.g., limestone, dolomite) are not acceptable.

Soil cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. A minimum thickness of 1 foot (300 mm) of cover shall be maintained between the equipment tires/tracks and the GCL at all times during the covering process. This thickness recommendation does not apply to frequently trafficked areas or roadways, for which a minimum thickness of 2 feet (600 mm) is required (see **TABLE 1**).

Soil cover shall be placed in a manner that prevents the soil from entering the GCL overlap zones. Cover soil shall be pushed up slopes, not down slopes, to minimize tensile forces on the GCL.

Although direct vehicular contact with the GCL is to be avoided, lightweight, low ground pressure vehicles (such as 4-wheel all-terrain vehicles) may be used to facilitate the installation of any geosynthetic material placed over the GCL. The GCL supplier or CQA engineer shall be contacted with specific recommendations on the appropriate procedures in this situation.

When a textured geomembrane is installed over the GCL, a temporary smooth geosynthetic covering known as a slip sheet or rub sheet shall be used to minimize friction during placement and to allow the textured geomembrane to be more easily moved into its final position.

4.0 DOCUMENTATION

The CQA Manager shall document that quality assurance requirements have been addressed and satisfied. The CQA Manager shall provide the Project Manager with signed descriptive remarks, data sheets, and logs to verify that all monitoring activities have been carried out. The CQA Manager shall also maintain at the job site a complete file of plans and specifications, a CQA plan, checklists, test procedures, daily logs, and other pertinent documents.

4.1 Daily Recordkeeping

Standard reporting procedures shall include preparation of a daily report, which at a minimum, will consist of: (a) field notes, including memoranda of meetings and/or discussions with the Contractor; (b) observation logs and testing data sheets; and (c) construction problems and solution data sheets. This information will be regularly submitted to and reviewed by the Project Manager.

4.1.1 Memorandum of Discussion with Earthwork Contractor or Subcontractors

A memorandum will be prepared each day, if required, summarizing discussions between the Soils CQA Monitor and Contractor. At a minimum, the memorandum will include the following information:

1. Date, project name, location, and other identification;
2. Name of parties to discussion;
3. Relevant subject matter or issues;
4. Activities planned;
5. Constraints or suggestions;
6. Schedule; and
7. Signature of the CQA Monitor and/or CQA Manager.

4.1.2 Observation Logs and Testing Data Sheets

Observation and testing data sheets shall be prepared daily with a Site Plan diagram prepared at the end of each week. At a minimum, these data sheets shall include the following information:

1. An identifying sheet number for cross referencing and document control;
2. Date, project name, location, and other identification;
3. Data on weather conditions;
4. A scaled Site Plan (weekly) showing all active and proposed work areas and test locations;

5. Descriptions and locations of ongoing construction;
6. Equipment and personnel in each work area, including subcontractors;
7. Descriptions and specific locations of areas of work being tested and/or observed and documented (identified by lift and location);
8. Locations where tests and samples were taken;
9. A summary of test results;
10. Calibration or recalibrations or test equipment, and actions taken as result of recalibration;
11. Off-site materials received, including quality verification documentation;
12. Decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality; and
13. The CQA Monitor signature.

In any case, all logs must be completely filled out with no items left blank.

4.2 Construction Problems and Solution Data Sheets

Sheets describing special construction situations shall be cross-referenced with specific observation logs and testing data sheets, and must include the following information, where available:

1. An identifying sheet number for cross-referencing and document control;
2. A detailed description of the situation or deficiency;
3. The location and probable cause of the situation or deficiency;
4. How and when the situation or deficiency was found or located;
5. Documentation of the response to the situation or deficiency;
6. Final results of any responses;
7. Any measures taken to prevent a similar situation from occurring in the future; and
8. The signature of the CQA Monitor and signature indicating concurrence from the Project Manager.

The Project Manager shall be made aware of any significant recurring non-conformance with specifications. The Project Manager shall then determine the cause of the non-conformance and recommend appropriate changes in procedures or specifications. When this type of evaluation is made, the results must be documented, and the Owner and the Design Engineer shall approve any revision to procedures or specifications.

A summary of all supporting data sheets, along with final testing results and the CQA Manager's approval of the work, shall be required upon completion of construction.

4.3 Photographic Reporting Data Sheets

Photographic reporting data sheets, where used, shall be cross-referenced with observation and testing data sheet(s), and/or construction problems and solution data sheet(s). These photographs will serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain digital color prints; the digital photos will also be stored on appropriate media. These records shall be presented to the Project Manager upon completion of the project and all CQA documentation will be stored in the POR.

4.4 Design and/or Specification Changes

Design and/or specification changes may be required during construction. In such cases, the CQA Manager shall notify the Project Manager and the Design Engineer. Design and/or specification changes shall be made only with written agreement from the Project Manager and the Design Engineer, and shall take the form of an addendum to the specifications.

4.5 Progress Reports

The CQA Manager shall prepare a summary progress report each week, or at time intervals established at the pre-construction meeting. As a minimum, this report shall include the following information:

1. A unique identifying sheet number for cross-referencing and document control;
2. The date, project name, location, and other information;
3. A summary of work activities during progress reporting period;
4. A summary of construction situations, deficiencies, and/or defects occurring during progress reporting period;
5. A summary of test results, failures and retests; and
6. The signature of the CQA Manager.

4.6 Signatures and Final Report

At the completion of the work, the CQA Engineer shall submit to the Project Manager and/or Design Engineer a signed final Report. This report shall certify that the work has been performed in compliance with the plans and specifications except as properly authorized and implemented, and that the summary document provides the necessary supporting information.

At a minimum, this report shall include: (a) summaries of all construction activities; (b) observation logs and testing data sheets including sample location plans; (c) construction problems and solutions data sheets; (d) changes from design and material specifications; (e) Record Drawings; and (f) a summary statement sealed and signed by a registered Professional

Engineer. The Record Drawings shall include scaled drawings depicting the location of the construction details pertaining to the extent of construction (depths, plan dimensions, elevations, soil component thickness, etc.). This document shall be prepared by the CQA Consultant and included as part of the CQA documentation. CQA documentation will be submitted to the NMOCD and retained in the Facility POR.

SECTION 4
GEOSYNTHETICS CONSTRUCTION QUALITY ASSURANCE

1.0 GEOMEMBRANE MANUFACTURING, SHIPPING, & CONFORMANCE TESTING

1.1 Manufacturing

1.1.1 Raw Material

The raw material to be utilized in the manufacturing of the geomembrane shall be first quality polyethylene resin. The resin shall be virgin material with no more than 10% rework. If rework is used, it must be a similar HDPE as the parent material. The base polyethylene resin shall be mixed with carbon black and a proprietary additive package of heat stabilizers and anti-oxidants. The percent distribution of these components including recycled polymer shall be as per the project specifications.

The raw material shall be first quality polyethylene resin and shall be tested by the Manufacturer for the specifications in **TABLES 5A** and **5B**.

Raw materials (resin, carbon black, and additive package) may be mixed during the production stage using a “masterbatch” carrier resin containing the carbon black and other additives or during a compounding process prior to production.

Conformance testing shall be carried out by the Manufacturer to demonstrate that the product meets this specification. At the Owner's discretion, additional testing may be carried out for purposes of conformance by the Geosynthetics CQC Firm, and paid for by the Owner. If the results of the Manufacturer's and the Geosynthetics CQC Firm's testing differ, the testing shall be repeated by the Geosynthetics CQC Firm, and the Manufacturer shall be allowed to monitor this testing. The results of this latter series of tests will prevail, if the applicable test methods have been followed.

Prior to the installation of any geomembrane material, the Manufacturer shall provide the Project Manager and the Geosynthetics CQA Monitor with the following information:

1. The origin (Resin Supplier's name and resin production plant), identification (brand name, number) and production date of the resin;
2. A copy of the quality control certificates issued by the Resin Supplier to include specific gravity (ASTM D1505) and melt index (ASTM D1238 Condition , 190ºC/2.16 kg); and
3. A statement that no reclaimed polymer is added to the resin (however, the use of polymer recycled during the manufacturing process may be permitted if done with appropriate cleanliness and if recycled polymer does not exceed 2% by weight).

The CQA Monitor shall review these documents and shall report any discrepancies to the Project Manager.

1.1.2 Geomembrane Manufacturing

The Project Manager shall provide to the CQA Monitor the plans, specifications and drawings for the lining system prepared by the Design Engineer. **TABLES 5A** and **5B** provide the frequency of testing for the geomembrane. The CQA Monitor shall verify that the specifications include at least all properties listed in **TABLES 5A** and **5B**, measured with the same methods or equivalent.

If the specifications do not fulfill the above conditions, the Design Engineer shall complete the required alterations of the specifications. The Geomembrane Manufacturer shall provide the Project Manager and the CQA Monitor with the following:

1. A properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the specifications, or equivalent;
2. A list of quantities and descriptions of materials other than the base polymer which comprise the geomembrane;
3. The sampling procedures and results of testing; and
4. A certification that property values given in the properties sheet are guaranteed by the Geomembrane Manufacturer.

The CQA Monitor shall verify that:

1. the property values certified by the Geomembrane Manufacturer meet all of the specifications; and
2. the measurements of properties by the Geomembrane Manufacturer are properly documented and that the test methods used are acceptable.

In addition, the Geosynthetics CQA Monitor may, at the request of the owner, undertake a manufacturing plant visit, preferably during the production of the particular geomembrane for this project, in order to evaluate the Manufacturer's quality control procedures.

1.1.3 Rolls

Prior to shipment, the Geomembrane Manufacturer shall provide the Project Manager and the CQA Consultant with a quality control certificate for every roll of geomembrane to be provided for the particular project. A responsible party employed by the Geomembrane Manufacturer, such as the production manager, shall sign the quality control certificate. The quality control certificate shall include:

1. Roll numbers and identification; and

2. Sampling procedures and results of quality control tests - as a minimum, results shall be given for thickness, tensile strength, and tear resistance, evaluated in accordance with the methods indicated in the specifications or equivalent methods approved by the Designer.

The CQA Monitor shall:

1. Verify that the quality control certificates have been provided at the specified frequency, and that each certificate identifies the rolls related to it; and
2. Review the quality control certificates and verify that the certified roll properties meet the specifications.

1.2 Roll Label Requirements

All rolls delivered to the site must be labeled containing the following information:

1. Roll Number;
2. Material Type;
3. Nominal Thickness; and
4. Batch Number.

The geomembrane rolls are to be packaged with a label placed on the outside of the roll and one within the roll core. If both of these labels are missing or ineligible, the roll will be rejected.

1.3 Shipping, Handling, and Storage Requirements

1.3.1 Shipping

Shipping of the geomembrane is the responsibility of the Geomembrane Manufacturer, Fabricator, Installer, or other party as agreed upon. All handling on site is the responsibility of the Installer.

Upon delivery at the site, the Installer and the Geosynthetics CQA Consultant shall conduct a surface observation of all rolls or factory panels for defects and for damage. This inspection shall be conducted without unrolling rolls or unfolding factory panels unless defects or damages are found or suspected. The Geosynthetics CQA Consultant shall indicate to the Project Manager:

1. Rolls, factory panels, or portions thereof, which shall be rejected and removed from the site because they have severe flaws; and
2. Rolls or factory panels that include minor repairable flaws.

1.3.2 Handling

The geomembrane temporary tagging area on site shall be coordinated with the on-site CQA Manager and the Installer to insure ease of transportation and placement in an area were the geomembrane will not be damaged or in the way of daily operations of the landfill. Two high strength carrying straps must be placed around the outside of the roll to assist in transportation and handling of the material on the construction site.

1.3.3 Storage Requirements

The Installer shall be responsible for the storage of the geomembrane on site. The Project Manager shall provide storage space in a location (or several locations) such that on-site transportation and handling are optimized if possible. Storage space shall be protected from theft, vandalism, passage of vehicles, etc. If the geomembrane is to be exposed to the weather for an extended period of time, it shall be covered until installed. The designated storage area shall be a firm, smooth surface free of large and/or sharp stones or any other sharp objects that could damage the liner. If the area is sloped or the rolls are stacked, precautions shall be taken to insure that the rolls will not shift or move causing possible damage to the rolls are injuring workers.

1.4 Conformance Testing of Geomembrane

1.4.1 Tests and Procedures

Upon or prior to delivery of the rolls of geomembrane, the CQA Monitor shall insure that samples are removed at the specified frequency and forwarded to the Geosynthetics CQC Firm for testing to insure conformance to both the design specifications and the list of guaranteed properties. The test procedures shall be as indicated in **TABLES 5A** and **5B** based on material type or as specified in the project plans. Additionally, the Geomembrane shall meet or exceed the following specifications:

1. Conformance testing (1 test set every lot or every 100,000 ft^2 whichever is greater). Material lots found not in conformance will be rejected.
   a. Density (ASTM D1505);
   b. Carbon Black Content (ASTM D1603);
   c. Carbon Black Dispersion (ASTM D5596);
   d. Thickness (ASTM D5994);
   e. Tensile Properties (ASTM D6693/Type IV); and
   f. Tear Resistance (ASTM D1004, Die C).
2. Seam Testing:
   a. Trial seams tested in field tensiometer or at testing laboratory at the beginning of everyday and every five working hours; and
   b. Air pressure and vacuum testing of all field seam lengths (ASTM D4437).

1.4.2 Sampling Procedures

Samples shall be taken across the entire width of the roll and shall not include the first three linear feet. Unless otherwise specified, samples shall be 3 feet long by the roll width. The CQA Monitor shall mark the machine direction on the samples with an arrow. The required minimum sampling frequencies are provided in **TABLES 5A** and **5B** .

1.4.3 Test Results

The CQA Monitor shall examine all results from laboratory conformance testing and shall report any non-conformance to the Project Manager.

2.0 INSTALLATION OF GEOMEMBRANE

2.1 Earthwork

2.1.1 Subgrade Preparation

The CQA Monitor shall verify that:

1. A qualified land surveyor has verified all lines and grades;
2. A qualified geotechnical engineer, normally the Soils CQA Consultant, has verified that the supporting soil meets the density specification;
3. The surface to be lined has been rolled and compacted to be free of irregularities, protrusions, loose soil, and abrupt changes in grade;
4. The surface of the supporting soil does not contain stones larger than ½" in diameter and non-angular which may be damaging to the geomembrane; and
5. There is no area excessively softened by high water content.

The Installer shall certify in writing that the surface on which the geomembrane will be installed is acceptable. The certificate of acceptance shall be given by the Installer to the Project Manager prior to commencement of geomembrane installation in the area under consideration. The CQA Consultant shall be given a copy of this certificate by the Project Manager.

After the supporting soil has been accepted by the Installer, it shall be the Installer's responsibility to indicate to the Project Manager any change in the supporting soil condition that may require repair work. If the Geosynthetics CQA Monitor concurs with the Installer, then the Project Manager shall insure that the supporting soil is repaired.

At any time before and during the geomembrane installation, the Geosynthetics CQA Monitor shall indicate to the Project Manager locations that may not provide adequate support to the geomembrane.

2.1.2 Anchor Trench System

All anchor trench systems will be excavated in accordance with the lines and widths as shown on the contract drawings, before geosynthetics placements. The CQA Consultant shall verify that the anchor trench has been constructed according to design drawings.

If the anchor trench is excavated in a clay liner susceptible to desiccation, no more than the amount of trench required for the geomembrane to be anchored in one day shall be excavated (unless otherwise specified) to minimize desiccation potential of the anchor trench clay soils. The corners of the anchor trench where geosynthetic enters the trench shall be slightly rounded to avoid sharp bends in the geosynthetics. No loose soil shall be allowed to underlie the geomembrane in the anchor trench. No large rocks or clay lumps will be allowed to underlie the geomembrane in the anchor trench.

Backfilling of the anchor trench shall be conducted utilizing suitable backfill materials as deemed appropriate by the CQA Manager. All anchor trenches shall be backfilled in 12” compacted lifts meeting 90% maximum dry density per ASTM D-698 or D1557. The uppermost 12-inch lift of compacted backfill within the anchor trenches shall be tested at a frequency of one test per 100 feet of trench (each lift).

2.2 Geosynthetic Placement

2.2.1 Installation Schedule

Field panels may be installed using any one of the following schedules:

1. All field panels are placed prior to field seaming (in order to protect the subgrade from erosion by rain);
2. Field panels are placed one at a time and each field panel is seamed immediately after its placement (in order to minimize the number of unseamed field panels exposed to wind), and
3. Any combination of the above.

If a decision is reached to place all field panels prior to field seaming, installation normally shall begin at the low point area and proceed toward the low point with "shingle” overlaps to facilitate drainage in the event of precipitation. It is also usually beneficial to proceed in the direction of prevailing winds. Accordingly, an early decision regarding installation scheduling shall be made if, and only if, weather conditions can be predicated with certainty. Otherwise, scheduling decisions must be made during installation, in accordance with varying conditions. In any event, the Installer is fully responsible for the decision made regarding placement procedures.

The CQA Monitor shall evaluate changes in the schedule proposed by the Installer and advise the Project Manager on the acceptability of that change. The CQA Monitor shall verify that the condition of the supporting soil has not changed detrimentally during installation. The CQA Monitor shall record the identification code, location, and date of installation of each field panel.

2.2.2 Field Panel Location and Identification

Field panels are to be located by the CQA Monitor in a manner consistent with the specifications and in a manner best suited to existing site conditions (i.e., a field panel is a roll or a portion of roll cut in the field).

A field panel is the unit area of geomembrane which is to be seamed in the field. Two cases can be considered:

1. If the geomembrane is fabricated into panels in a factory, a field panel is a factory panel or a portion of factory panel cut in the field.
2. If the geomembrane is not fabricated into factory panels, a field panel is a roll or a portion of roll cut in the field.

It shall be the responsibility of the CQA Monitor to insure that each field panel is given an "identification code" (number or letter-number) consistent with the layout plan. The Project Manager, Installer and CQA Monitor shall agree upon this identification code. This field panel identification code shall be as simple and logical as possible. (Note that roll numbers established in the manufacturing plant must be traceable to the field panel identification code.)

The CQA Consultant shall establish documentation showing correspondence between roll numbers, factory panels, and field panel identification codes. The Field panel identification code shall be used for all quality assurance records. The CQA Consultant shall verify that field panels are installed at the location indicated in the Designer's layout plan, as approved or modified.

2.2.3 Weather Conditions

Geomembrane placement shall not proceed at an ambient temperature below 5°C (40°F) unless otherwise authorized. Geomembrane placement shall not be done during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponding water, or in the presence of excessive winds.

The CQA Monitor shall verify that the above conditions are fulfilled. Additionally, the CQA Consultant shall verify that the supporting soil has not been damaged by weather conditions. The Geosynthetics CQA Monitor shall inform the Project Manager if the above conditions are not fulfilled.

2.2.4 Method of Placement

The Geosynthetics CQA Monitor shall verify the following:

1. Construction equipment used to deploy geomembranes shall not create excessive rutting in the subgrade;
2. If the substratum is a geosynthetic material, deployment may be by hand, by use of small jack lifts on pneumatic tires having low ground contact pressure, or by use of all-terrain vehicles (ATVs) having low ground contact pressure;
3. Any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means;
4. The prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement;
5. Any geosynthetic elements immediately underlying the geomembrane are clean and free of debris;
6. All personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane;
7. The method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil;
8. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels);
9. Adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., adjacent sand bags, is recommended along edges of panels to minimize risk of wind flow under the panels);
10. Direct contact with the geomembrane is minimized; i.e., the Geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected;
11. No bridging or stressed conditions in the material; and
12. Pipes or other objects that penetrate the liner are connected to the liner material in a way that prevents leakage and unnecessary stresses.

The Geosynthetics CQA Monitor shall inform the Project Manager if the above conditions are not fulfilled.

2.2.5 Damage

The Geosynthetics CQA Monitor shall inspect each panel, after placement and prior to seaming, for damage. The Geosynthetics CQA Manager shall advise the Project Manager which panels, or portions of panels, shall be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected shall be marked and their removal from the work area recorded by the Geosynthetics CQA Consultant. Repairs shall be made according to procedures described in Section 2.4.

2.3 Seaming and Joining

2.3.1 Seam Layout

The Installer shall provide the Project Manager and the Geosynthetics CQA Monitor with a seam layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The Geosynthetics CQA Monitor shall review the seam layout drawing and verify that it is consistent with accepted industry practice. No panels may be seamed in the field without the Project Manager's approval. In addition, no panels not specifically shown on the seam layout drawing may be used without the Project Manager's prior approval.

Seams will be made by overlapping sheets approximately three inches (3”) for extrusion welding and approximately four inches (4”) for hot wedge welding. In general, seams shall be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope, In corners and odd shaped geometric locations, the number of seams shall be minimized. No horizontal seam shall be less than 5 feet from the toe of the slope, or areas of potential stress concentrations, unless otherwise authorized.

A seam numbering system compatible with the panel numbering system shall be agreed upon at the Resolution and/or Pre-Construction Meeting.

2.3.2 Requirements of Personnel

All personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests. At least one seamer shall have experience seaming a minimum of 5,000,000 ft^2 of polyethylene geomembrane using the same type of seaming apparatus to be used to fabricate the site-specific geomembrane. The most experienced seamer, the "master seamer", shall provide direct supervision over less experienced seamers.

The Installer shall provide the Project Manager and the Geosynthetics CQA Consultant with a list of proposed seaming personnel and their experience records. The Project Manager and the Geosynthetic CQA Monitor shall review this document.

2.3.3 Seaming Equipment and Products

The approved processes for field seaming are extrusion welding and hot wedge (fusion) welding. Proposed alternate processes will be documented and submitted to the owner or his representative for approval. The hot wedge welding system is generally the primary system for geomembrane installation and the extrusion welding system is utilized for repairs and detail work. Only apparatus, which have been specifically approved by make and model, shall be used. The Project Manager and the Geosynthetics CQA Monitor shall approve all seaming processes and apparatus.

The Installer will verify the following general conditions during the seaming of the liner:

1. Equipment used for seaming is not likely to damage the geomembrane;
2. The electric generator is placed on a smooth base such that no damage occurs to the geomembrane;
3. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and
4. The geomembrane is protected from damage in heavily trafficked areas.

2.3.3.1 Hot Wedge Welding/Fusion System

The hot wedge welding apparatus (typically called a fusion welder) is self-propelled and produces a double seam with an enclosed air channel for testing. The fusion welding consists of placing two heated wedge mounted self-propelled unit, between two overlapped sheets of polyethylene liner. The heated plate heats and fuses the two sheets together. The fusion welder must meet the following requirements:

1. A temperature readout device that continuously monitors the temperature of the wedge;
2. For cross seams, the edge of the cross seam is ground to a smooth incline (top and bottom) prior to welding;
3. A smooth insulating plate or fabric is placed beneath the hot welding apparatus after usage; and
4. The geomembrane is protected from damage in heavily trafficked areas.

2.3.3.2 Extrusion (Fillet) Welding System

The extrusion-welding apparatus shall be equipped with gauges giving the extrudate temperature in the apparatus and at the nozzle. The Installer shall provide documentation regarding the extrudate to the Project Manager and the Geosynthetics CQA Monitor, and shall certify that the extrudate is compatible with the specifications, and in any event is comprised of the same resin as the geomembrane sheeting.

The Geosynthetics CQA Monitor and the Installer shall log apparatus temperatures, extrudate temperatures, ambient temperatures, and geomembrane surface temperatures at appropriate intervals. The Geosynthetics CQA Monitor shall verify that the extruder is purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel. The welder also must be equipped with gauges giving the temperature in the apparatus and the preheat temperature at the nozzle.

2.3.4 Seam Preparation

The Installer shall insure that:

1. Before seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material;
2. If seam overlap grinding is required, the process is completed according to the Geomembrane Manufacturer's instructions, within one hour of the seaming operation and in a way that does not damage the geomembrane; and
3. Seams are aligned with the fewest possible number of wrinkles and "fish mouths".

2.3.5 Seaming in Various Weather Conditions

The high temperature limit for welding is based on two factors:

1. The well-being of the crew. Black lining material will get very hot when exposed to sunlight. It is possible that the elevated sheet temperature in conjunction with immoderate ambient conditions could place the well-being of the crew at risk. (It is the responsibility of the Installer to determine if their crew can work in the weather conditions at the site).
2. Material capability.

The highest temperature at which the material can be welded is dependent upon ambient temperature, wind, subgrade conditions exposure to light, material type, and material thickness.

Thinner materials and low density products are the most difficult to seam at high liner temperatures. The problem typically is characterized by frequent burnouts (places in the liner weld where the rollers lose traction and the machine stops moving causing the wedge to burn through the liner). The number of burnouts can often be reduced by adjusting the speed or the temperature at which the welder is operating. If the Installer determines the sheet temperature has reached a temperature in which to large a number of burnouts occurs they can stop welding until favorable conditions return.

The lowest allowable temperature at which welding may be permitted is dependent on ambient temperature, wind, subgrade conditions exposure to light, material type, and material thickness.

Typically during cold weather it is necessary to reduce the welders speed and increase the temperature. Pre-heating the liner in advance of the welding apparatus may also be done by using a hot air blower.

At low temperatures, special attention must be made to the pre-weld destructive samples (trial welds). In cold conditions trial welds shall be performed under the same conditions that will be seen during actual seaming conditions. The lowest temperature at which welding may occur is at the temperature which consistent passing trial seams can be performed under actual seaming conditions. In order to obtain passing results, it may be necessary to preheat the sheet in advance and/or shield the sheets from the wind. This is allowable as long as it is done during the actual welding of the liner.

The normally required weather conditions for seaming are as follows:

1. Unless authorized in writing by the Project Manager, no seaming shall be attempted at an ambient temperature below 5°C (40°F) or above 40°C (104°F);
2. In all cases, the geomembrane shall be dry and protected from wind.

If the Installer wishes to use methods which may allow seaming at ambient temperature below 5 °C (40°F) or above 40°C (104°F), the Installer shall demonstrate and certify that such methods produce seams which are entirely equivalent to seams produced at ambient temperatures above 5°C (40°F), and that the overall quality of the geomembrane is not adversely affected. In addition, an addendum to the contract between the Owner and the Installer is required which specifically states that the seaming procedure does not cause any physical or chemical modification to the geomembrane that will generate any short or long term damage to the geomembrane. Then, the temperatures in the above quality assurance procedure shall be modified accordingly.

The Geosynthetics CQA Monitor shall verify that these weather conditions are fulfilled and will advise the Project Manager if they are not. The Project Manager shall then decide if the installation shall be stopped or postponed.

2.3.6 Trial Seams

Trial seams shall be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. Such trial seams shall be made at the beginning of each seaming period, and at least once each five hours, for each seaming apparatus used that day. In addition, each seamer shall make at least one trial seam each day. Trial seams shall be made under the same conditions as actual seams.

An extrusion welded trial seam sample shall be at least 3 feet long by 1 foot wide (after seaming) with the seam centered lengthwise. Fusion welded trial seam samples shall be at least 15 feet long by 1 foot wide (after seaming) with the seam centered lengthwise.

Ten adjoining specimens, each 1 inch wide, shall be cut from the trial seam sample by the Installer. Three specimens shall be tested for shear strength and three shall be tested for peel using a gauged tensiometer. If a specimen fails to meet the seam requirement set forth in the Project Specifications, the entire operation shall be repeated. If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams achieved.

The CQA Monitor shall observe all trial seam procedures. The remainder of the successful trial seam sample shall be assigned a number and marked accordingly by the CQA Monitor, who shall also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description. At the discretion of the CQA Consultant, samples of trial seams may be submitted to the Geosynthetics Laboratory for analysis.

After completion of the above described tests, the remaining portion of the trial seam sample can be discarded. Alternatively, if agreed upon between the parties involved and documented by the CQA Monitor in his daily report, the remaining portion of the trial seam sample can be subjected to destructive testing. If a trial seam sample fails a test conducted by the Geosynthetics Installer, then adjustments to the welding apparatus may be made and a new trial weld sample may be taken for field testing. If the welding apparatus fails three (3) attempts to achieve passing trail welds, then the welding apparatus is deemed defective and may not be used for welding until repaired and shown to be operating properly.

2.3.7 Seaming Procedures

Unless otherwise specified, the general seaming procedure used by the Installer shall be as follows:

1. For fusion welding, a movable protective layer of plastic may be required to be placed directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture build-up between the sheets to be welded;
2. The rolls of the membrane will be overlapped wide enough to weld and test properly; this is usually 3” for extrusion welding and 4” for fusion welding;
3. Fish mouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap. The cut fish mouths or wrinkles shall be seamed and any position where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches beyond the cut in all directions;
4. If seaming operations are carried out at night, adequate illumination shall be provided at the Contractor's expense; and

5. Seaming shall extend to the outside edge of panels to be placed in the anchor trench.

The CQA Monitor shall verify that the above seaming procedures are followed, and shall inform the Project Manager if they are not.

2.3.8 Non-Destructive Testing

The Installer shall non-destructively test all field seams over their full length using a vacuum test unit or air pressure test (for double fusion seams only), or other approved method. The purpose of nondestructive tests is to check the continuity of seams. It does not provide any information on seam strength. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.

The CQA Monitor shall:

1. Observe all continuity testing;
2. Record location, date, test unit number, name of tester, and outcome of all testing;
3. Inform the Installer and Project Manager of any required repairs;
4. Observe the repair and re-testing of the repair;
5. Mark on the geomembrane that the repair has been made; and
6. Document the results.

The seam number, date of observation, name of tester, and outcome of the test or observation shall be recorded by the CQA Monitor.

2.3.8.1 Vacuum Testing

The equipment shall be comprised of the following:

1. A vacuum pump that is fuel or electric powered and capable of sustaining the required vacuum for the test;
2. A vacuum gauge capable of registering to 10 psi (70 kPa) in increments of ¾ psi (5 kPa);
3. A foaming solution shall be pre-mixed with water at a ratio to form bubbles. It shall be dispensed by spray, brush, or other means. The solution shall be compatible with the geomembrane;
4. A vacuum chamber shall have an open bottom and a clear viewing panel on top. It shall be an appropriate size and shape, made of rigid materials, and equipped with a vacuum gauge, valve, and soft pliable gasket around the periphery of the open bottom.

The following procedures shall be followed:

1. The area to be tested shall be clean and free of soil or foreign objects to promote a good seal;
2. Energize the vacuum pump;
3. Wet the seam and surrounding area approximately twice the width and length of the vacuum chamber with a foamy solution;
4. Place the vacuum chamber over the test area such that the gasket is in complete contact with the geomembrane;
5. Apply a force to the top of the vacuum chamber to obtain a seal and open the vacuum valve;
6. Ensure a leak tight seal is created. A minimum vacuum of 1 to 4 psi (28 to 55 kPa) registered on the gauge shall be appropriate;
7. With the force applied, observe the geomembrane seam through the viewing port for bubbles through any defects in the seam. The vacuum shall hold for a duration not less than 10 seconds;
8. If bubbles appear on the geomembrane seam, open the valve to release the vacuum and remove the chamber from the seam. The defective area shall be marked for repair;
9. If no bubble appears after 10 seconds, open the valve to release the vacuum and remove the vacuum chamber from the seam.
10. Move the vacuum chamber to the adjoining portion of the seam or test area overlapping the previously tested area by no less than 10% of the chamber length or at least 2”(50mm), whichever is greater and repeat the procedure for the entire seam.
11. All areas where soap bubbles appear shall be marked and repaired in accordance with Section 2.4.

2.3.8.2 Air Pressure Testing (Fusion Welded Seams)

The following procedures are applicable to those processes that produce a double seam with an enclosed space. The equipment shall be comprised of the following:

1. An air pump (manual or motor driven) equipped with pressure gauge capable of generating and sustaining a pressure of 50 psi and mounted on a cushion to protect the geomembrane;
2. A rubber hose with fittings and connections;
3. A sharp hollow needle, or other approved pressure feed device;
4. A knife capable of cutting the liner material; and
5. A pressure gauge capable of indicating air pressure in 1 psi within the test range.

The following procedures shall be followed:

1. Seal both ends of the seam to be tested;
2. Insert needle or other approved pressure feed device into the tunnel created by the fusion weld;
3. insert a protective cushion between the air pump and the geomembrane;
4. Energize the air pump to a pressure of 30 psi, close valve, and sustain pressure for at least 2 minutes, the record a 5-min subsequent period with < 4psi loss;
5. Cut opposite end of tested seam after completion of the 5-minute pressure hold period to verify complete testing of the seam. If the pressure gauge does not indicate a release of pressure, locate blockage of the air channel and retest until entire seam is tested; and
6. Remove needle or other approved pressure feed device and seal.

2.3.9 Destructive Testing

Destructive testing provides direct evaluation of seam strength and bonding efficiency which indicates seam strength and durability. Destructive seam tests shall be performed at selected locations. Seam strength testing shall be done as the seaming work progresses, not at the completion of all field seaming.

Destructive testing involves two techniques (1) shear testing and (2) peel testing. Shear testing applies a tensile stress from the top of the sheet through the weld and into the bottom sheet. Peel testing, on the other hand, peels the top sheet back against the overlapped edge of the bottom of the sheet in order to observe how separation occurs. The peel test indicates whether the sheets are continuously and homogeneously connected through the seam.

2.3.9.1 Location and Frequency

The Geosynthetics CQA Monitor shall select locations where seam samples will be cut out for laboratory testing. Those locations shall be established as follows:

- A minimum frequency of one test location per 500 feet of seam length as indicated in **TABLES 5A** and **5B**. This minimum frequency is to be determined as an average taken throughout the entire facility;
- A maximum frequency shall be agreed upon by the Installer, Project Manager and Geosynthetics CQA Monitor at the Resolution and/or Pre-Construction Meeting; and
- Test locations shall be determined during seaming at the Geosynthetics CQA Manager's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The Installer shall not be informed in advance of the locations where the seam samples will be taken.

Note: For either test, sample failure shall be a Film Tear Bond (FTB) as outlined in NSF 54, Appendix A.

2.3.9.2 Sampling Procedure

Samples shall be cut by the Installer as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The CQA Monitor shall:

1. Observe sample cutting;
2. Assign a number to each sample, and mark it accordingly;
3. Record sample location on layout drawing; and
4. Record reason for taking the sample at this location (e.g., statistical routine, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in Section 2.4. The continuity of the new seams in the repaired area shall be tested according to Section 2.3.8.1. At a given sampling location, two types of samples shall be taken by the Installer.

First, two samples for field testing shall be taken. Each of these samples shall be 1 inch wide by 12 inch long, with the seam centered parallel to the width. The distance between these two samples shall be 42 inches. If both samples pass the field test described in Section 2.3.9.3, a sample for laboratory testing shall be taken. The sample for laboratory testing shall be located

between the two samples for field testing. The sample for laboratory testing shall be 12 inches wide by 42 inches long with the seam centered lengthwise. The sample shall be cut into three parts and distributed as follows:

1. One portion to the Installer for archive storage, (12 in. x 12 in.);
2. One portion for Geosynthetics CQA Firm testing, (12 in. x 18 in.); and
3. One portion to the Owner for archive storage, (12 in. x 12 in.).

Final determination of the sample sizes shall be made at the Pre-Construction Meeting.

2.3.9.3 Field Testing

The ten, 1-inch wide strips mentioned in Section 2.3.9.2 shall be tested in the field, by gauged tensiometer, for peel and shear respectively and shall not fail in the seam in addition to meeting the requirements outlined in the specifications. If any field test sample fails to pass, then the procedures outlined in Section 2.3.9.5 shall be followed.

The CQA Monitor shall witness all field tests and mark all samples and portions with their number. The CQA Monitor shall also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description.

2.3.9.4 Laboratory Testing

Destructive test samples shall be packaged and shipped, if necessary, under the responsibility of the CQA Monitor in a manner which will not damage the test sample. The Project Manager will verify that packing and shipping conditions are acceptable. The Project Manager will be responsible for storing the archive samples. This procedure shall be fully outlined at the Resolution Meeting. Test samples shall be tested by the Geosynthetics CQC Firm. The Geosynthetics CQA Consultant shall select the Geosynthetics CQC Firm, with the concurrence of the Project Manager.

Testing shall include "Bonded Seam Strength and Peel Adhesion". At least 5 specimens shall be tested for each test method. Specimens shall be selected alternately be test from the samples (i.e., peel, shear, peel, shear...). A passing test shall meet the minimum required values in 5 out of 5 specimens.

The Geosynthetics CQC Firm shall provide test results no more than 24 hours after they receive the samples. The Geosynthetics CQA Manager shall review laboratory test results as soon as they become available, and make appropriate recommendations to the Project Manager.

2.3.9.5 Procedures for Destructive Test Failure

The following procedure shall apply whenever a sample fails a destructive test, whether the Geosynthetics CQA Firm or the gauged tensiometer conducted that test.

1. The Installer shall trace the welding path to an intermediate location at 10 feet minimum from the point of the failed test in each direction and take a small sample for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the tests, then the seam is reconstructed between these locations. If either sample fails, then the process is repeated to establish the zone in which the seam shall be reconstructed.

All acceptable seams must be bonded by two locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 feet of reconstructed seam, a sample taken from the zone in which the seam has been reconstructed must pass destructive testing. Repairs shall be made in accordance with Section 2.4. The CQA Monitor shall document all actions taken in conjunction with destructive test failures.

2.4 Defects and Repairs

2.4.1 Identification

All seams and non-seam areas of the geomembrane shall be examined by the CQA Monitor for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination or foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be broomed or washed by the Installer if the amount of dust or mud inhibits examination.

2.4.2 Evaluation

Each suspect location both in seam and non-seam areas shall be non-destructively tested using the methods described in Section 2.3.8.1 as appropriate. Each location that fails the non-destructive testing shall be marked by the CQA Monitor and repaired by the Installer. Work shall not proceed with any materials which will cover locations which have been repaired until laboratory test results with passing values are available.

2.4.3 Repair Procedures

Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the Project Manager, Installer, and CQA Monitor. The procedures available include:

1. Patching - used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;
2. Buffing and re-welding - used to repair small sections of extruded seams;
3. Spot welding or seaming - used to repair small tears, pinholes, or other minor, localized flaws;
4. Capping, used to repair large lengths of failed seams;
5. Removing bad seam and replacing with a strip of new material welded into place (used with large lengths of fusion seams); and
6. Welding of the flap, used to make a new extrusion weld adjacent to an unsatisfactory fusion weld (this procedure may be used only if the flap created by the overlap of the top and bottom panels beyond the fusion weld has not been cut back to the outer edge of the fusion weld).

In addition, the following provisions shall be satisfied:

1. Surfaces of the geomembrane which are to be repaired shall be abraded no more than one hour prior to the repair;
2. All surfaces must be clean and dry at the time of the repair;
3. All seaming equipment used in repairing procedures must be approved;
4. The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the Project Manager, Geosynthetics Construction Quality Assurance Manager, and Installer; and
5. Patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 3 inches.

2.4.4 Repairs - Non-destructive Testing

Each repair shall be non-destructively tested using the methods described in Section 2.3.8.1 as appropriate. Repairs, which pass the non-destructive test, shall be taken as an indication of an adequate repair. Failed test indicate that the repair must be redone and retested until a passing result is obtained.

2.5 Backfilling of Anchor Trench

The anchor trench, if any, shall be adequately drained, to prevent ponding or otherwise softening of the adjacent soils while the trench is open. The anchor trench shall be backfilled and compacted by the Earthwork Contractor of the Installer, as outlined in the specifications and/or bid documents. Care shall be taken when backfilling the trenches to prevent any damage to the geosynthetics. The Geosynthetics and/or Soils CQA Monitor shall observe the backfilling operation and advise the Project Manager of any problems.

Since backfilling the anchor trench can affect material bridging at the toe of the slope, consideration shall be given to backfilling the liner at its most contracted state, preferably during the cool of the morning or extended period of overcast skies.

2.6 Lining System Acceptance

The Installer and the Manufacturers shall retain all ownership and responsibility for the geosynthetics in the lining system until acceptance by the Owner. The geosynthetic lining system shall be accepted by the Owner when:

- The installation of all materials are deployed an welded;
- Verification of the adequacy of all seams and repairs, including associated testing, is complete;
- All documentation of installation is completed including the Geosynthetics CQA Consultant's final report; and
- The Project Manager has received certification, including “as built” drawing, sealed by a registered professional engineer.

The Geosynthetics CQA Monitor shall certify that installation has proceeded in accordance with the Geosynthetics CQA Plan for the project except as noted to the Project Manager.

2.7 Materials in Contact with the Geomembrane

The quality assurance procedures indicated in this section are only intended to assure that the installation of these materials does not damage the geomembrane. Additional quality assurance procedures would be necessary to assure that systems built with these materials would be constructed in such a way to enable proper performance.

2.7.1 Soils

The Project Manager shall give a copy of the specifications, prepared by the Designer for placement of soils, to the Geosynthetics CQA Consultant. The Geosynthetics CQA Consultant shall verify that these specifications are consistent with current industry practices.

2.7.2 Concrete

The Project Manager shall give a copy of the specifications, prepared by the Design Engineer for placement of concrete, to the Geosynthetics CQA Monitor. The Geosynthetics CQA Monitor shall verify that these specifications are consistent with the state of the art, including the use of geosynthetic layers between concrete and geomembrane. The Geosynthetics CQA Consultant shall verify the geosynthetic layers are placed between the concrete and the geomembrane according to design specifications. He will also verify that construction methods used are not likely to damage the geomembrane.

2.7.3 Sumps and Appurtenances

The Project Manager shall give a copy of the specifications, prepared by the Design Engineer for sumps and appurtenances, to the Geosynthetics CQA Monitor. The Geosynthetics CQA Monitor shall review these specifications and verify the use of geosynthetic layers between concrete and geomembranes.

The Geosynthetics CQA Monitor shall verify that:

1. Installation of the geomembrane in sump and appurtenance areas, and connection of geomembrane to sumps and appurtenances have been made according to specifications;
2. Care is taken while welding around appurtenances, since neither non-destructive nor destructive testing may be feasible in these areas;
3. The geomembrane has not been damaged while making connections to sumps and appurtenances; and

3.0 DOCUMENTATION

3.1 Daily Reports

Each of the Geosynthetics CQA Monitors shall complete a daily report and/or logs on prescribed forms, outlining all of his or her monitoring activities for that day. The areas, panel numbers, seams completed and approved, and measures taken to protect unfinished areas overnight shall be identified. Failed seams or other panel areas requiring remedial action shall be identified with regard to nature of action, required repair, and precise location. Repairs completed shall also be identified. Any problems or concerns with regard to operations on site shall be noted. This report must be completed at the end of each monitor's shift, and submitted to the Geosynthetics CQA Manager daily, if possible, but at least by the end of each week.

The Geosynthetics CQA Manager shall review the daily reports submitted by the Geosynthetics CQA Monitors and incorporate a summary of their reports into his own daily report. Any matters requiring action by the Project Manager shall be highlighted. This report shall be completed daily, summarizing the previous day's activities, and a copy submitted to the Project Manager daily, if possible, but at least within his weekly summary each week.

3.2 Destructive Test Reports

The Geosynthetics CQA Monitor shall collate the destructive test reports from all sources. This includes field tests, and Geosynthetics CQC Firm tests. A summary

list of test samples pass/fail results shall be prepared by the Geosynthetics CQA Manager on an ongoing basis, and submitted with the periodic progress reports.

3.3 Progress Reports

Progress Reports shall be prepared by the Geosynthetics CQA Manager and submitted to the Owner. This report shall include: an overview of progress to date; an outline of any changes made to the plans, drawing, or specifications; any problems or deficiencies in operations at the site, and an outline of any action taken to remedy the situation(s); a summary of weather conditions; and a brief description of activities anticipated for the next reporting period. All Destructive Test Reports for the period shall be appended to each Progress Report.

3.4 Construction Problem and Solution Data Sheets

Sheets describing special construction situations shall be cross-referenced with specific observation logs and testing data sheets, and must include the following information, where available:

1. An identifying sheet number for cross-referencing and document control;
2. A detailed description of the situation or deficiency;
3. The location and probable cause of the situation or deficiency;
4. How and when the situation or deficiency was found or located;
5. Documentation of the response to the situation or deficiency;
6. Final results of any responses;
7. Any measures taken to prevent a similar situation from occurring in the future; and
8. The signature of the CQA Manager/Monitor and signature indicating concurrence from the Project Manager.

The Project Manager shall be made aware of significant recurring non-conformance with specifications. The Project Manager shall then determine the cause and recommend appropriate changes in procedures or specifications. When this type of evaluation is made, the results shall be documented, and the Owner and Design Engineer shall approve any revision to procedures or specifications.

A Summary of all supporting data sheets, along with final testing results and the CQA Engineer's approval of the work, shall be required upon completion of construction.

3.5 Design and/or Specification Changes

Design and/or specifications changes may be required during construction. In such cases, the CQA Engineer shall notify the Project Manager and Design Engineer. Design and/or

specifications changes shall be made only with written agreement of the Project Manager and the Design Engineer, and shall take the form of an addendum to the specifications.

3.6 Record Drawings

Record drawings shall be prepared by the Contractor and approved by the CQA Consultant. A third party independent surveyor shall perform the survey. Record drawings shall include, as a minimum, the following information for geomembranes:

1. The limits of the liner or final cover barrier construction;
2. The top and bottom liner or final cover barrier elevation at 100' intervals referenced to the site grid coordination system;
3. If a granular drainage blanket is utilized in the design, top of blanket elevation shall be identified at 100' intervals;
4. The location and elevation of slope breaks, leachate piping, leachate sumps and trenches, berms, and any other features which are material to the disposal area construction;
5. A key map showing the location of the construction in relation to the permitted design, along with an identification of areas previously constructed and areas yet to be constructed;
6. Dimensions of all geomembrane field panels;
7. Location, as closely as possible, of each panel relative to the surveyors plan (furnished by the Owner);
8. Identification of all seams and panels with appropriate number or "identification codes" (see Section 2.2.1);
9. Location of all patched and repairs; and
10. Location of all destructive testing samples.

The Record drawing shall address each layer of geomembrane, and if necessary, another drawing shall identify problems or unusual conditions of the geotextile or geonet layers. In addition, applicable cross-sections shall show layouts of geonets, geotextiles or Geogrids which are unusual or differ from the design drawings.

3.7 Photographic Reporting Data Sheets

Photographic reporting data sheets, where used, shall be cross-referenced with observation and testing data sheet(s) and/or construction problem and solution data sheets(s).

These photographs shall serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain digital color prints; the digital photos will also be stored on

appropriate media. These records shall be presented to the Project Manager upon completion of the project and all CQA documentation will be stored in the POR.

3.8 Final Report

A Final Report shall be submitted upon completion of the work. This report shall include all reports prepared by the CQA Consultant personnel, summarize the activities of the project, and document all aspects of the quality assurance program performed. The Final Report shall include as a minimum the following information:

- Personnel involved with the project;
- Scope of work;
- Outline of project;
- Construction quality assurance methods;
- Test results (destructive and non-destructive, including laboratory tests);
- Sealed and signed by a registered professional engineer; and
- Record drawings, sealed and signed by a registered professional engineer.

3.9 Storage of Records

During construction, the Geosynthetics CQA Monitor shall be responsible for submitting the facility Record drawings. The owner/operator, in a manner that will allow for easy access, shall store the document originals. CQA documentation will be submitted to the NMOCD as required and a copy shall be retained in the Facility POR.

SECTION 5
OTHER

1.0 GEOTEXTILES

1.1 Manufacturing

The geotextile manufacturer shall provide the Project Manager with a list of guaranteed "minimum average roll value" (MARV) properties for the type of geotextile to be delivered. The geotextile manufacturer shall also provide the Project Manager with a written quality control certification signed by a responsible party employed by the manufacturer that the materials actually delivered have property "minimum average roll values" which meet or exceed all property values guaranteed for that type of geotextile. The quality control certificates shall include:

1. Roll identification numbers;
2. Sampling procedures; and
3. Results of quality control testing.

The geotextile manufacturer shall provide, as a minimum, test results for the following in accordance with **TABLE 6**:

1. Mass per unit area;
2. Grab strength;
3. Trapezoidal Tear strength;
4. Puncture strength;
5. Apparent opening size (AOS);
6. Thickness; and
7. Permittivity and apparent opening size.

The geotextile manufacturer shall provide a written certification that the nonwoven, needle-punched geotextiles are continuously inspected and found to be needle-free. Quality assurance tests shall be performed in accordance with the test methods specified in **TABLE 6** for every 100,000 ft^2 of geotextile produced for the project.

The CQA Consultant shall examine all manufacturer certifications to insure the following: property values listed on the certifications meet or exceed those specified for the particular type of geotextile; the measurements of properties by the Manufacturer are properly documented; test methods are acceptable; and the certificates have been provided at the specified frequency properly identifying the rolls related to testing. Any deviations shall be reported to the Project Manager.

1.2 Roll Label Requirements

The geotextile manufacturer shall identify all rolls of geotextile with the following:

1. Manufacturer's name
2. Product identification;
3. Lot number;
4. Roll number; and
5. Roll dimensions.

Additionally, if any special handling of the geotextile is required, it shall be so marked on the top surface of the geotextile, e.g., "This Side Up" or "This Side Against Geonet". The CQA Monitor shall examine rolls upon delivery and any deviation from the above requirements shall be reported to the Project Manager.

1.3 Shipping, Handling & Storage

During shipment and storage, the geotextile shall be protected from ultraviolet light exposure, precipitation or other inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions. To that effect, geotextile rolls shall be shipped and stored in relatively opaque and watertight wrappings.

Geotextiles shall not be exposed to precipitation prior to being installed. Wrappings protecting geotextile rolls shall be removed less than one hour prior to unrolling the geotextile. After the wrapping has been removed, a geotextile shall not be exposed to sunlight for more than 15 days, unless otherwise specified and guaranteed by the geotextile manufacturer.

The CQA Consultant shall observe rolls upon delivery at the site and any deviation from the above requirements shall be reported to the Project Manager. Any damaged rolls shall be rejected and replaced at no cost to the Owner.

1.4 Conformance Testing

Upon delivery of the rolls of geotextiles, the CQA Monitor shall insure that samples are removed and forwarded to the Geosynthetics Laboratory for testing to ensure conformance to both the design specifications and the list of guaranteed properties. The material may also be sampled at the manufacturing facility by a third party and forwarded to the Geosynthetic Laboratory. As a minimum, the following tests shall be performed on geotextiles:

1. Mass per unit area;
2. Grab strength;
3. Grab elongation;

4. Puncture strength; and
5. Apparent opening size.

These conformance tests shall be performed in accordance with the test methods specified in the project specifications. Other conformance tests may be required by the specifications. Testing frequency for the geotextiles is presented in **TABLE 6**.

1.4.1 Sampling Procedures

Samples shall be taken across the entire width of the roll and shall not include the first three linear feet. Unless otherwise specified, samples shall be 3 feet long by the roll width. The CQA Monitor shall mark the machine direction on the samples with an arrow. Unless otherwise specified, samples shall be taken at a rate of one per lot or one per 100,000 ft^2, whichever is least, as indicated in **TABLE 6** for geotextiles.

1.4.2 Test Results

The CQA Consultant shall examine all results from laboratory conformance testing and shall report any non-conformance to the Project Manager.

1.5 Handling and Placement

The Installer shall handle all geotextiles and geocomposites in such a manner to ensure they are not damaged in any way. The following shall be complied with:

1. On slopes, the geotextile and geocomposites shall be securely anchored in the anchor trench and then rolled down the slope in such a manner as to continually keep the geotextile or the geocomposite sheet in tension;
2. In the presence of wind, all geotextiles and geocomposites shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with earth cover material;
3. Geotextiles/Geocomposites shall be cut using an approved geotextile cutter only. If in place, special care must be taken to protect other materials from damage which could be caused by the cutting of the geotextiles/geocomposites; and
4. The Installer shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextile or the geocomposite.

In addition, the following applies to geotextiles only:

1. During placement of geotextiles, care shall be taken not to entrap in the geotextile: stones, excessive dust, or moisture that could generate clogging of drains or filters, or hamper subsequent seaming; and

2. A visual examination of the geotextile shall be carried out over the entire surface, after installation, to ensure that no potentially harmful foreign objects, such as needles, are present.

1.6 Seams and Overlaps

On slopes steeper than 10 horizontal/1 vertical, all geotextiles shall be continuously sewn (i.e., spot sewing is not allowed). Geotextiles shall be overlapped 0.15m (6 in.) prior to seaming. No horizontal seams shall be allowed on side slopes (i.e., seams shall be along, not across, the slope), except as part of a patch. The Design Engineer must approve other seaming options.

On bottom and slopes flatter than 10/1 (horizontal/vertical), geotextiles can be either seamed as indicated above, or thermally bonded. The Installer and CQA Monitor shall pay particular attention at seams to insure that no earth cover material could be inadvertently inserted beneath the geotextile. Any sewing shall be done using polymeric thread with chemical and ultraviolet resistance properties equal to or exceeding those of the geotextile.

1.7 Defects and Repairs

Any holes or tears in the geotextile shall be repaired as follows:

1. On slopes: A patch made from the same geotextile shall be double seamed into place [with each seam 5 mm to 20 mm (1/4 in. to 3/4 in.) apart and no closer than 25 mm (1 in.) from any edge]. Shall any tear exceed 10% of the width of the roll, that roll shall be removed from the slope and replaced.
2. Non-slopes: A patch made from the same geotextile shall be spot-seamed in place with a minimum of 0.60m (24 in.) overlap in all directions.

Care shall be taken to remove any soil or other material which may have penetrated the torn geotextile. The CQA Consultant shall observe any repair, note any non-compliance with the above requirements and report them to the Project Manager.

1.8 Placement of Soil Materials

The Installer shall place all soil materials located on top of a geotextile or geocomposite, in such a manner as to insure:

1. No damage of the geotextile or geocomposite;
2. Minimal slippage of the geotextile or geocomposite on underlying layers; and
3. No excess tensile stresses in the geotextile.

Unless otherwise specified by the Designer, all lifts of soil material shall be in conformance with the guidelines in **TABLE 1**.

Any non-compliance shall be noted by the CQA Consultant and reported to the Project Manager. If portions of the geotextile or the geocomposite are exposed, the CQA Consultant shall periodically place two (or more, at his discretion) marks on the geotextile or the geocomposite 3 m (10 ft.) apart along the slope and measure the elongation of the geotextile or the geocomposite during the placement of soil. The Designer shall relate this elongation to the tensile stress in the geotextile or the geocomposite.

2.0 GEONETS AND GEOCOMPOSITES

2.1 Manufacturing

The geonet, unless otherwise specified, shall be made from the same type of resins used to manufacture HDPE geomembranes. The raw material will consist of polyethylene resin, heat stabilizers, and anti-oxidant additives.

The geonet and geocomposite manufacturer shall provide the Project Manager with a list of guaranteed "minimum average roll value" properties for the type of geonet and/or geocomposite to be delivered. The manufacturer shall also provide the Project Manager with a written quality control certification signed by a responsible party employed by the manufacturer that the materials actually delivered have property "minimum average roll values" which meet or exceed all property values guaranteed for that type of geonet. The quality control certificates shall include:

1. Roll identification numbers;
2. Resin batch numbers;
3. Nominal thickness;
4. Sampling procedures; and
5. Results of quality control testing:
   - Polymer specific gravity;
   - Mass per unit area; and
   - Thickness.

These conformance tests shall be performed in accordance with the test methods specified in the project specifications. Other conformance tests may be required by the project specifications.

The manufacturer shall provide the origin, identification, and production date of the resin and quality control certificates for the resin used in the manufacture of the geonets and/or geocomposite. Quality assurance tests shall be performed in accordance with the test methods

specified in **TABLE 6** for every 100,000 ft^2 of geonet and/or geocomposite produced for the project.

The CQA Consultant shall examine all manufacturer's certifications to insure the following: property values listed on the certifications meet or exceed those specified; the measurements of properties by the manufacturer are properly documented; test methods are acceptable; and the certificates have been provided at the specified frequency properly identifying the rolls related to testing. Any deviations shall be reported to the Project Manager.

2.2 Roll Label Requirements

The manufacturer shall identify all rolls of geonets and/or geocomposite with the following:

1. Manufacturer's name;
2. Product identification;
3. Lot number;
4. Roll number; and
5. Roll dimensions.

The CQA Monitor shall examine rolls upon delivery and any deviation from the above requirements shall be reported to the Project Manager.

2.3 Shipping, Handling, and Storage

Protecting the geonet and/or geocomposite for cleanliness is important to ensure proper drainage characteristics are maintained. The CQA Consultant shall verify that geocomposite and/or geonet rolls are wrapped in polyethylene sheets or otherwise protected against dust and dirt during shipping and storage. The wrapping shall be removed just prior to the deployment of the rolls. The CQA Consultant shall verify that geonets and/or geocomposite are free of dirt and dust just before installation. The CQA Consultant shall report the outcome of this verification to the Project Manager. If the geonets and/or geocomposite are judged dirty, they shall be cleaned by the Installer prior to installation.

2.4 Conformance Testing

2.4.1 Testing Requirements

Upon delivery of the rolls of geonets, the CQA Consultant shall take conformance samples of the geonet and/or geocomposite, to ensure conformance to both the design specifications and the list of guaranteed properties. The material may also be sampled at the manufacturing facility by a third party and forwarded to the Geosynthetic Laboratory. The tests presented in **TABLE 6** shall be performed on the geonet and/or geocomposite.

2.4.2 Sampling Procedures

Samples shall be taken across the entire width of the roll and shall not include the first three linear feet. Unless otherwise specified, samples shall be 3 ft wide by the roll width.

2.4.3 Test Results

The CQA Monitor shall examine all results from laboratory conformance testing and shall report any non-conformance to the Project Manager. Any lots not meeting conformance testing specifications will result in the rejection of the lot.

2.5 Installation of the Geonet

2.5.1 Handling and Placement

The Installer shall take steps necessary to insure that any underlying layers are not damaged during the placement of the geonet and/or geocomposite. These steps shall include but are not limited to the following conditions:

1. During placement of geonets and/or geocomposite, care shall be taken not to entrap in the geonet, dirt or excessive dust that could cause clogging of the drainage system. If dirt or excessive dust is entrapped in the geonet, it shall be hosed clean prior the placement of the next material on top of it. In this regard, care shall be taken with the handling of sandbags, to prevent rupture or damage of the sandbag;
2. Geonets and/or geocomposite shall only be cut using scissors or curved blade (hook blade) utility knife that will not damage underlying geosynthetics;
3. On slopes, the geonets and/or geocomposite shall be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geonet sheet in tension. If necessary, the geonet and/or geocomposite shall be positioned by hand after being unrolled to minimize wrinkles. Geonets and geocomposites can be placed in the horizontal direction (i.e., across the slope) in some special locations (e.g., at the toe of a slope, if an extra layer is required, this extra layer can be placed in the horizontal direction). The Designer shall identify such locations in the design drawings. Designers shall note that placement of layers at 90 degree angles to each other will result in a partial loss of effective thickness and transmissivity; and
4. In the presence of wind, all geonets and/or geocomposite shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

The CQA Monitor will note any deficiencies or non-compliance and report it to the Project Manager.

2.5.2 Stacking Geonets/Geocomposites

When several layers of geonets and/or geocomposite are stacked, care shall be taken to prevent strands from one layer from penetrating the channels of the next layer, thereby significantly reducing the transmissivity. This cannot happen if stacked in the same direction. A stacked geonet shall never be laid in perpendicular directions to the underlying geonet (unless otherwise specified by the Designer). In the corners of side slopes of rectangular landfills, adjacent overlapping geonets are usually perpendicular and special precautions shall be taken as discussed below. The CQA Monitor shall note any non-compliance and report it to the Project Manager.

2.5.3 Joining and Splicing

Adjacent geonets and/or geocomposite shall be joined according to construction drawings and specifications. As a minimum, the following requirements shall be met:

1. Geonets and geocomposites shall be joined at the ends with a shingled overlap of 1.5-ft; and joined along the panel edge with a shingled overlap of 0.5 ft.
2. Nylon/plastic cable ties will be applied to the ends at 0.5 feet intervals and along the panel edge at five feet intervals; and
3. End splices will be made as follows:
   - On slopes, the ends will overlap two feet with the uphill panel on top with two rows of cable ties applied; and
   - In flat areas, the end will be overlapped a minimum of two inches and one row of cable ties applied.

The CQA Monitor shall note any non-compliance and report it to the Project Manager.

2.5.4 Defects and Repairs

If the geonet and/or geocomposite are damaged, it can be repaired by the following methods at the discretion of the CQA Monitor. Holes and tears in the geonet shall be repaired by placing a patch extending 2 feet beyond edges of the hole or tear. The patch shall be secured to the original geonet by spot welding or tying every 6 inches. Tying devices shall be as indicated in Section 2.5.3. If the hole or tear width across the roll is more the 50% the width of the roll, the damaged area shall be cut out and the two portions of the geonet shall be joined as indicated in Section 2.5.3.

The CQA Monitor shall observe any repair, note any non-compliance with the above requirements and report them to the Project Manager.

3.0 OTHER PROJECT CONSTRUCTION

The CQA Consultant shall be responsible for reviewing, verifying and testing all aspects of the Construction Project. The Scope of the CQA Consultant's responsibilities shall include the review and quality control testing of all road installations, concrete structure installations, and other construction addressed in the Contractor's Project Specifications, but not discussed in this CQA Plan. Performance Criteria, and Quality Control Testing frequencies for construction not associated with the landfill footprint is addressed in applicable sections of the Project Specifications.

Quality Assurance for incidental Items – Quality assurance procedures for other materials deployed in the construction, such as geotextiles, geonets, granular drainage blankets, etc., shall also be included in the QA plans. There above requirements are only intended to act as minimum values and will not relieve the facility of the burden to prepare a project specific quality assurance plan.

3.1 CAST-IN-PLACE CONCRETE

The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary for the manufacture, storage, delivery, and installation of cast-in-place concrete, as specified herein, and as shown on the Drawings. The Contractor shall coordinate the installation of the cast-in-place concrete with other construction activities and subcontractors at the site.

3.1.1 REFERENCES

The following sections reference the latest versions of American Society for Testing and Materials (ASTM) standards:

1. ASTM A 185 Specification for Welded Steel Wire Fabric for Concrete Reinforcement.
2. ASTM A 427 Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement.
3. ASTM A 615 Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
4. ASTM C 31 Standard Methods of Making and Curing Concrete Test Specimens in the Field.
5. ASTM C 33 Standard Specification for Concrete Aggregates.
6. ASTM C 39 Standard Method of Compressive Strength of Cylindrical Concrete Specimens.
7. ASTM C 94 Standard Specification for Ready-Mixed Concrete.
8. ASTM C 143 Standard Test Method for Slump of Portland Cement Concrete.
9. ASTM C 150 Standard Specification for Portland Cement.
10. ASTM C 171 Standard Specification for Sheet Materials for Curing concrete.
11. ASTM C 172 Standard Test Method for Sampling Freshly Mixed Concrete.
12. ASTM C 231 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
13. ASTM C 260 Specification for Air - Entraining Admixtures for Concrete.
14. ASTM C 494 Specifications for Chemical Admixtures for Concrete.

15. ASTM C 618 Specification for Fly Ash and Raw or Calcined Pozzolans for use in Portland Cement Concrete.

And the latest version of American Concrete Institute (ACI) standards:

1. ACI 211.1 Selecting Proportions for Normal Weight Concrete.
2. ACI 214 Evaluation of Compression Test Results of Field Concrete.
3. ACI 301-16 Specifications for Structural Concrete for Buildings.
4. ACI 304 Measuring, Mixing, Transporting and Placing Concrete.
5. ACI 305 Hot Weather Concreting.
6. ACI 318 Requirements for Reinforced Concrete.

3.1.2 SUBMITTALS

The Contractor shall provide the following to the Owner for approval prior to placement of concrete:

1. certifications as required by ASTM C 94;
2. shop drawings for all reinforcing steel;
3. certificates of Compliance for the following items:
   a. cement;
   b. aggregates;
   c. admixtures; and
   d. reinforcing steel.
4. Design Mixes: At least 30 days prior to start of placing concrete, the Contractor shall submit design mixes for each Class and Type of concrete specified, indicating that the concrete ingredients and proportions will result in a concrete mix meeting the requirements specified.

5. Compression Test Data:

   a. Compression test cylinders from all concrete used on the project, except for precast concrete items, will be made by the Owner and tested in accordance with the ACI Code and ASTM C 39.

   b. Concrete which does not meet the specifications will be required to be removed and replaced at the Contractor's expense or may be subjected to a load test, also at the Contractor's expense.

6. Batch Tickets:

   a. Submit certificate to the Owner before unloading concrete at the site or submit a delivery ticket to the Owner from the concrete supplier for each batch of concrete delivered to the site. The certificate or delivery ticket shall set forth the following information:

      - name of supplier;
      - name of batching plant and location;
      - serial number of ticket or certificate;
      - date;
      - truck number;
      - specific job designation (contract number and location);
      - the volume of concrete (cubic yards);
      - specific Class and Type of concrete (in conformance with the Specifications);
      - time loaded;
      - type and brand of cement;
      - weight of cement;
      - maximum size of aggregates;
      - weights of coarse and fine aggregates, respectively;
      - amount of water added at the plant and maximum amount of water to be added at the site, if any; and
      - kind and amount of admixtures.

7. Following installation, the Contractor shall submit a Placement Log for all cast-in-place concrete items including the following information:

   a. date of placement;
   b. location and extent of placement;
   c. quantity of concrete;
   d. air temperature; and
   e. tests and samples taken.

3.1.3 CONSTRUCTION QUALITY ASSURANCE

Ready Mixed Concrete Plant shall be currently certified to comply with approval requirements of one or more of the following:

1. Concrete Materials Engineering Council;
2. National Ready Mixed Concrete Association; and

3. Prestressed Concrete Institute.

Testing and Inspection Agency shall be currently accredited by one or more of the following:

1. Concrete Materials Engineering Council; and
2. Other accreditation authority of equivalent standing to the above, on the basis of its compliance with the requirements of ASTM C 1077.

3.2 CONCRETE MATERIALS

Concrete mix shall conform with ASTM C 94, and shall be ready-mixed, normal weight, air entrained, minimum compressive strength 4,500 psi at 28 days, except concrete for anti-flotation collars, buttresses, and pipe encasement shall have a minimum compressive strength of 2,500 psi. The concrete slump shall be 3 ± 1 inches. Cement shall conform to ASTM C 150, Type I or II. Aggregate shall conform with ASTM C 33. Maximum size of coarse aggregate shall be the smallest of 1-1/2 inches, 3/4 of the minimum clear spacing between reinforcing bars, or 1/3 the thickness of slabs.

All deformed billet reinforcing steel shall conform to ASTM A 615 Grade 60. All wire fabric reinforcement shall be welded steel in conformance with ASTM A 185.

3.3 CONCRETE MIXING

The Ready Mix Concretes shall comply with requirement of ASTM C 94 for mixing time and water addition. Total mixing time for concrete shall be determined in accordance with ASTM C 94 for type of mixing equipment used. Concrete that has been in truck for more than 1-1/2 hours after addition of water, or had more than 300 revolutions, or concrete which has become hard or non-plastic, shall not be used. When concrete arrives at the site with a slump below that specified herein, water may be added only if neither the maximum specified water/cement ratio nor the maximum specified slump is exceeded. The additional water should be incorporated into the mix by increasing the mixing time at least 1-1/2 times the total mixing time required by ASTM C 94. However, the Contractor shall bear total responsibility for the effects of adding water on the quality and strength of the concrete.

During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C 94 may be required.

3.4 NON-SHRINK GROUT

Non-shrink grout shall conform to Corps of Engineers Specification CRD C621 (588).

3.5 FAMILIARIZATION

Prior to implementing any of the work described in this Section, the Contractor shall become thoroughly familiar with all portions of the work falling within this Section.

Inspection shall adhere to the following:

1. Prior to implementing any of the work in this Section, the Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of this Section may properly commence without adverse impact.

2. If the Contractor has any concerns regarding the installed work of other Sections, the Contractor shall notify the Owner in writing within 48 hours of the site inspection. Failure to inform the Owner in writing or installation of cast-in-place concrete shall be construed as Contractor's acceptance of the related work of all other Sections.

3.6 EXAMINATION AND PREPARATION

The Owner's Representative shall examine formwork, reinforcing steel, embed inserts, sleeves, and joint materials prior to placement of concrete. Defective material shall be removed and replaced with new material at no cost to the Owner.

The Contractor shall clean all formwork and structural excavations of foreign matter, debris, loose material, and water.

The Owner's Representative shall be notified at least two working days in advance of a scheduled delivery to allow time for adequate observation of the site.

3.7 PLACING REINFORCEMENT

Reinforcement shall be placed to the dimensions shown on the Drawings. Stirrups and tie bars shall be bent around a pin having a diameter not less than two times the minimum thickness of the bar. Bends for other bars shall be made around a pin having a diameter not less than six times the minimum thickness except for bars larger than one

inch, in which case the bends shall be made around a pin of eight bar diameters. All bars shall be bent cold.

Reinforcement shall be shipped to the site with bars of the same size and shape securely fastened in bundles with wired metal identification tags containing the bar size. The identification tags shall be labeled with the same designation as shown on submitted bar schedules and shop drawings. All bars shall be stored off the ground and shall be protected from moisture and kept free from dirt, oil, and other foreign substances.

Unless otherwise shown on the Drawings, splices in reinforcement bars shall be lapped not less than 24 diameters. All bar splices shall be staggered wherever possible. When splicing bars of different diameters, the length of lap is based on the larger bar.

Before placing in position, reinforcement shall be thoroughly cleaned of loose mill and rust scale, dirt, and other coatings that may reduce or destroy bond. Where there is delay in depositing concrete after reinforcement is in place, bars shall be re-inspected and cleaned when necessary.

3.8 PLACING CONCRETE

Formwork and joints shall be erected, and accessories shall be installed in accordance with the Drawings. Concrete shall not be placed until the forms, reinforcement and other conditions are approved for pouring by the CQA Firm and until all pipes, conduits, sleeves, thimbles, hangers, anchors, flashing and other work required to be placed in the concrete have been properly installed. Water shall be removed from the space to be occupied by concrete, and any continuous flows of water shall be diverted to a sump or removed by pumping.

Hardened concrete and foreign materials shall be removed from the inner surfaces of mixing and conveying equipment before concrete is mixed. Before depositing concrete, forms shall be thoroughly wetted and all debris removed.

Concrete Placement shall adhere to the following:

1. Practices shall comply with ACI 304 and as herein specified.
2. Concrete shall be deposited in horizontal layers not deeper than 24 inches in such a manner as to prevent flow of concrete. Concrete shall be deposited to maintain a plastic surface which is approximately horizontal and in a manner to avoid inclined construction joints.

3. Where placement consists of several layers, each layer shall be placed while the preceding layer is still plastic to avoid cold joints.
4. Concrete shall be consolidated by internal mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping in accordance with ACI 304 during and immediately after placing.
5. Reinforcing, inserts, embeds, and joints shall be maintained in proper position during concrete placement.
6. Pumping placement of concrete shall be done with pumps, pipelines, and accessory equipment provided in accordance with ACI 304 and ACI 304-2R.

Concrete shall be deposited continuously, or in layers of such thickness that no concrete will be deposited against concrete which has hardened. If a section cannot be placed continuously, construction joints may be located at points as provided for in the Drawings or approved by the Owner's Representative. Before depositing new concrete against old concrete, the forms shall be retightened, the hardened surfaces cleaned and covered with a coating of neat cement grout.

In the event of rain during concrete placement, the placement shall be terminated as soon as practicable at a point approved by the Owner's Representative and freshly placed concrete shall be protected with a waterproof covering that shall prevent marring or damage of surfaces.

Concrete shall not be placed without consent of the Owner's Representative when the temperature is 50 degrees Fahrenheit or less, or when there is reason to expect a drop in temperature to below 50 degrees Fahrenheit within 12 hours of the conclusion of the pour. Concrete placed at air temperature below 40 degrees Fahrenheit shall have a minimum temperature of 60 degrees Fahrenheit. When the air temperature is below 40 degrees Fahrenheit or near 40 degrees Fahrenheit and falling, the water and aggregates shall be heated before mixing. Accelerating chemicals shall not be used to prevent freezing. Hot weather placement of concrete shall comply with ACI 305.

3.9 CRACKING CONTROL

In general, contractor shall control potential cracking of the concrete by adhering to the concrete mix design, structural plans, construction specifications and installations shall be in strict compliance with the requirement so ACI 301-16, Section 1-5 and 11. A copy of ACI 301-16, Section 1-5 and 11 are provided in Exhibit B.

3.10 CONCRETE CURING AND PROTECTION

Freshly placed concrete shall be protected from premature drying and excessive cold or hot temperatures. Curing procedures shall begin immediately after placement in accordance with ACI 301 procedures to provide continuous moist curing above 50 degrees Fahrenheit for at least seven days.

Curing of concrete shall be performed by moist curing and by moisture retaining cover curing, as herein specified. Moisture curing shall be provided by one of the following methods: covering with water, sprinkled with water, continuous water fog spray, and covering concrete surface with specified absorptive cover, thoroughly saturating cover with water, and keeping continuously wet. The Contractor shall submit for approval by the Owner's Representative the methods proposed for use against low temperatures. No salt, manure, or other chemicals shall be used for protection.

Protection of Completed Work shall adhere to the following:

1. Concrete shall be protected from damaging mechanical disturbances, water flow, loading, shock, and vibration during the entire curing period.

2. Concrete surfaces shall be kept free from all foot and vehicular traffic and all other sources of abrasion for not less than 72 hours after finishing.

3. Any protective coverings shall be maintained continuously during entire curing period, and damage to coverings shall be repaired immediately at no additional expense to the Owner.

4. Finished surfaces and slabs shall be protected from the direct rays of the sun to prevent checking and crazing.

3.11 REPAIRS

Repair of rock pockets, honeycombs, and sand streaks shall be done by: cutting and removing concrete to at least one inch deep with sides perpendicular to surface; flushing with clean water; coating with neat cement paste; filling with cement dry pack mix; curing as specified for concrete; and grinding smooth and flush with adjacent surfaces.

3.12 FIELD QUALITY CONTROL

The Owner shall provide a CQA Firm to perform tests and to submit test reports, except

as designated otherwise. Sampling fresh concrete shall be performed in accordance to ASTM C 172, except modified for slump to comply with ASTM C 94:

Slump test according to ASTM C 143 shall be measured according to:

a. one test at point of discharge for each set of compression cylinders taken, The concrete slump shall be 3 ± 1 inches;
b. additional tests when concrete consistency appears to have changed; and
c. one test on each truck load of concrete delivered to the site.

Molded concrete compression cylinders shall be sampled in accordance with ASTM C 172, processed and cured in accordance with ASTM C 31, and prepared and tested in accordance with ASTM C 39:

a. One set of four cylinders shall be obtained for each 50 cubic yards, or fraction thereof, for each day's placement of each mix design.
b. One cylinder shall be tested at age three days or seven days, as required by job conditions, and two cylinders for one valid strength test at 28 days.
c. The fourth cylinder shall be cured and held for testing at 42 days if 28-day test indicated deficient results, or as a spare in case of cylinder damage.

Certified written reports shall be promptly submitted with the following additional data:

1. time concrete batched and time sampled;
2. water added at site;
3. strength class;
4. delivery ticket number;
5. concrete suppliers mix designation; and
6. location of concrete in the work.

3.13 PRODUCT PROTECTION

The Contractor shall use all means necessary to protect all prior work, including all materials and completed work of other Sections. In the event of damage to prior work

or work specified in this Section, the Contractor shall immediately make all repairs and replacements necessary to the approval of the Owner and at no additional cost to the Owner.

TABLES

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Table 1
Minimum Protective Soil Thickness

Equipment Ground Pressure (psi)	Minimum Lift Thickness (in.)
<= 5	12
5 - 8	18
8 - 16	24
>16	36

Table 1 is based off of EPA technical guidance document from "Quality Assurance and Quality Control for Waste Containment Facilities", EPA/600/R-93/182, dated September 1993, page 167, Table 3.7. Although this Facility is also incorporating a geocomposite to protect the geomembrane, this guidance should be followed during construction and operation.

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TABLE 2
Pre-construction & Construction Intermediate and Final Cover Materials

Pre-Construction Testing			
Test	**Method(1)**	**Testing Frequency**	**Min. Requirements**
Cover Material			
Standard Proctor	ASTM D698	1 test per source	Not Applicable
Atterberg Limits	ASTM D4318	1 test per source	P.I. >10
Moisture	ASTM D2216	1 test per source	0 to 10% above optimum moisture
Permeability	ASTM D5084	1 test per 6,500 CY of material to be placed	Not Applicable
Construction Testing			
Cover Material			
In-Place Field Density/Moisture	ASTM D6938	3 test per acre per cover placed	95% and 0% to 10% of OMC(2)
Standard Proctor	ASTM D698	1 test per 5,000 yd^3 or change of material or borrow area.	Not Applicable
Moisture	ASTM D2216	1 test per 1,000 yd^3 or change of material or borrow area.	0 to 10% above optimum moisture
Atterberg Limits	ASTM D4318	1 test per 1,000 yd^3 or change of material or borrow area.	P.I. >10
Permeability	ASTM D5084	1 test per lift per acre	To maintain average permeability determined duing preconstruction testing.

1. Test to be performed according to the latest test method as approved by the certifying engineer.
2. Optimum Moisture Content as determined by ASTM D 698 in Pre-Construction testing

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TABLE 3
Pre-constrution and Construction Testing of Subgrade, Protective Cover Material, & Gravel

Pre-Construction Testing			
Test	**Method(1)**	**Testing Frequency**	**Min. Requirements**
Subgrade Material			
USCS Classification	ASTM D 2487	Once Per Source	Report
Atterberg Limits	ASTM D 4318	Once per 20,000 yd^3 or Source Change	Report
Gradation (3" thru # 200 sieve)	ASTM D 422	Same as above	Report
Standard Proctor	ASTM D 698/D1557	Same as above	Report
Protective Cover Material			
Gradation	ASTM D 422	Once per Source	Report
Permeability (3)	ASTM D 2434	Once Per Source	1.0 x 10^{-5} cm/sec or greater
Collection System Gravel			
Gradation	ASTM D 422	Once per Source	Minimum 90% larger than pipe perforations (typically 3/4 inch sieve)
USCS Classification	ASTM D 2487	Once Per Source	GW or GP
Permeability (3)	ASTM D 2434	Once Per Source	1.0 x 10^{-2} cm/sec or greater
Construction Testing			
Subgrade and Clay Berm Material			
Recompacted (5)	ASTM D 6938/3017	12 tests per acre per lift	As Specified in Plan (2)
Protective Cover Material			
Permeability (3)	ASTM D 2434	Once Per Source	1.0 x 10^{-5} cm/sec or greater

1. Test to be performed according to the latest test method as approved by the certifying engineer.
2. Optimum Moisture Content as determined by ASTM D 698 or D1557 in Pre-Construction testing
3. Permeability testing not required on final cover protective soil.
4. Minimum 90% larger than the pipe perforations (Normally 3/4 inch).
5. No subgrade testing required unless material is over-excavated.

TABLE 4
Geosynthetic Clay Liner Specifications

Manufacturer's Quality Control				
Test	**Method(1)**	**Testing Frequency**	**Units**	**Min. Requirements**
Reinforced				
Bentonite Swell Index[2]	ASTM D 5890	1 per 100,000 lbs	mL/g	≥ 24 / 2 (min)
Bentonite Fluid Loss[2]	ASTM D 5891	1 per 100,000 lbs	mL	≤ 18 (max)
Bentonite Mass per Area[3]	ASTM D 5993	40,000 ft^2	lb/ft^2	≥ 0.75 (min)
GCL Grab Strength[4]	ASTM D 6768	200,000 ft^2	lbs/in	≥ 30 MARV
GCL Peel Strength[4]	ASTM D 6496	40,000 ft^2	lbs/in	≥ 3.5 MARV
GCL Index Flux[5]	ASTM D 5887	30,000 $yd.^2$	$m^3/m^2/s$	≤ 1 x 10^{-8} (max)
GCL Permeability[5]	ASTM D 5887	30,000 yd.2	cm/sec	≤ 5 x 10^{-9} (max)
GCL Hydrated Internal Shear Strength[6]	ASTM D 6243	Periodic (6)	psf	≥ 500 typical @ 200 psf (min)
Conformance Testing by CQA Engineer				
Bentonite Mass per Area[3]	ASTM D 5993	100,000 ft^2	lb/ft^2	0.75 (min)
GCL Grab Strength[4]	ASTM D 6768	100,000 ft^2	lbs/in	≥ 30 MARV
GCL Peel Strength[4]	ASTM D 6496	100,000 ft^2	lbs/in	≥ 3.5/NA MARV
GCL Permeability[5]	ASTM D 5887	100,000 ft^2	cm/sec	5 x 10^{-9} (max)

1. Test to be performed according to the latest test method as approved by the certifying engineer. Test methods that have been superceded by updated or different methods that are then accepted as industry standard will be replaced by the updated standards.

2. These parameters are for the bentonite incorporated into the GCL and do not necessarily reflect the properties of the bentonite in the finished product.

3. Bentonite mass per area is exclusive of the average weight of the geotextiles and is normalized to 0 percent moisture content per ASTM D 5993.

4. All tensile testing is performed in the machine direction, with results as minimum average roll values unless otherwise indicated.

5. Index flux and permeability testing with deaired distilled/deionized water at 80 psi cell pressure, 77 psi headwater pressure and 75 psi tail water pressure. Reported value is equivalent to 925 gal/acre/day. This flux value is equivalent to a permeability of 5 x 10- 9 cm/sec for typical GCL thickness. This flux value should not be used for equivalency calculations unless gradient used represent field conditions. A flux test using gradients that represent field conditions must be performed to determine equivalency. The last 20 weekly values prior to end of the production date of the supplied GCL may be provided.

6. ASTM D5321-08 (geosynthetics) or D 6243 (GCLs) internal direct shear performed on GCL sample hydrated under 200 psf normal load and then sheared at 0.2 in./min. max for Procedure A and 0.04 in/min for Procedure B. Use wet conditions as per ASTM D5321. The testing is required prior to construction of the first E&PW Cell.

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TABLE 5A
60 mil HDPE Textured MQC Specifications

Resin Manufacturer (1)			
Test	**Method(2)**	**Testing Frequency**	**Min. Requirements (5)**
Density	ASTM D 1505	200,000 lb and per batch	≥ 0.932 g/cm^3
Melt Flow Index	ASTM D 1238 (190°C/2.16 kg)	200,000 lb and per batch	≤ 1.0 g / 10 min.
Manufacturer's Quality Control			
Thickness, nominal	ASTM D 5199	Each Roll	60 mil
Thickness, Min. ave	ASTM D 5199	Each Roll	57 mil
Thickness, lowest indiv. For 8 of 10 spec.	ASTM D 5199	Each Roll	54 mil
Thickness, lowest indiv. For 1 of 10 spec.	ASTM D 5199	Each Roll	51 mil
Asperity Height (Min. ave.) [3]	GRI GM13 ASTM D 7466	Each Roll	16 mil
Density	ASTM D 1505	Per 200,000 lb.	0.94 g/cm^3
Carbon Black Dispersion[4]	ASTM D 5596	Per 45,000 lb	Category 1 or 2
Carbon Black Content [6]	ASTM D 4218	Per 20,000 lb	2 to 3 %
Tensile Properties:			
Break Strength Elongation Yield Strength Elongation	ASTM D 6693 Type IV Dumbbell, 2 ipm G.L. = 2.0 inches	Per 20,000 lb	 90 lb/in 100% 126 lb/in 12%
Tear Resistance	ASTM D 1004	Per 45,000 lb	42 lb
Puncture Resistance	ASTM D 4833	Per 45,000 lb	90 lb
Oxidation Induction Time (OIT)			
Standard OIT	ASTM D 3895	200,000 lb and per batch	100 min
High Pressure OIT	ASTM D 5885		400 min
Oven Aging @ 85^{0}C			
Standard OIT	ASTM D 3895	Per each formulation	55%
High Pressure OIT	ASTM D 5885		80%
UV Resistance			
High Pressure OIT	ASTM D 5885	Per each formulation	50%

1. The resin shall be virgin material with no more than 10% rework. If rework is used, it must be a similar HDPE as the parent material. No post consumer resin (PCR) of any type shall be added to the formulation.

2. Test to be performed according to the latest test method as approved by the certifying engineer. Test methods that have been superceded by updated or different methods that are then accepted as industry standard will be replaced by the updated standards.

3. Textured geomembrane shall generally have uniform texturing appearance. It shall be free from agglomerated texturing material and such defects that would affect the specified properties of the geomembrane.

4. Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

5. If 60-mil HDPE smooth is used, it must meet GRI-GM13 standards. Use of smooth geomembrane instead of textured geomembrane must be approved by the certifying engineer.

6. Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

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TABLE 5B
60 mil HDPE Textured Conformance & Field Testing Specifications

Test	Method(1)	Testing Frequency	Min. Requirements
Conformance Testing by CQA Engineer			
Thickness, nominal	ASTM D 5199	1 per 100,000 sf	60 mil
Thickness, Min. ave	ASTM D 5199		57 mil
Thickness, lowest indiv. For 8 of 10 spec.	ASTM D 5199		54 mil
Thickness, lowest indiv. For 1 of 10 spec.	ASTM D 5199		51 mil
Asperity Height (Min. ave.)	GRI GM13 ASTM D 7466	1 per 100,000 sf	16 mil
Density	ASTM D 1505	1 per 100,000 sf	0.94 g/cm^3
Carbon Black Dispersion [2]	ASTM D 5596	1 per 100,000 sf	A-1, A-2 or B-1 rating
Carbon Black Content [3]	ASTM D 4218	1 per 100,000 sf	2 to 3 %
Tensile Properties:			
Break	ASTM D 6693 Type IV	1 per 100,000 sf	
Strength	Dumbbell, 2 ipm		90 lb/in
Elongation	G.L. = 2.0 inches		100%
Yield			
Strength			126 lb/in
Elongation			12%
Tear Resistance	ASTM D 1004	1 per 100,000 sf	42 lb
Trial Seams			
Shear	ASTM D 6392 GRI GM 19	Every 5 (five) hours of seaming.	Shear 120 ppi
Peel Fusion[4]			Peel 91 ppi
Peel Extrusion[4]			Peel 78 ppi
Destructive Seam Testing			
Shear	ASTM D 6392 GRI GM 19	1 per 500 linear feet (LF) of seam	Shear 120 ppi
Peel Fusion[4]			Peel 91 ppi
Peel Extrusion[4]			Peel 78 ppi
Shear Elongation at break	GRI GM19	1 per 500 linear feet (LF) of seam	
Fusion [4]			50%
Extrusion [4]			50%
Peel Separation	GRI GM19	1 per 500 linear feet (LF) of seam	
Fusion			25%
Extrusion			25%
Non-destructive Seam Field Testing			
Air Pressure	ASTM D5280/D4437	Dual track fusion weld seams	Min 30 psi, wait 2 minutes, then record a 5-min period; losing < 4 psi; puncture opposite end after test to check for continuity
Vacuum	ASTM D 4437	Extrusion Seams	1-4 psi held for ≥ 10 sec.

1. Test to be performed according to the latest test method as approved by the certifying engineer. Test methods that have been superceded by updated or different methods that are then accepted as industry standard will be replaced by the updated standards.

2. Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

3. Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

4. Five (5) out of five (5) specimens must meet the requirements. The 5th specimen can be as low as 80% of the listed values. For peel adhesion, seam separation shall not extend more than 25 percent in the same interface. Testing shall be discontinued when the sample has visually yielded a sample. Elongation measurements should be omitted for field testing.

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TABLE 6
Geonet, Geotextile, & Geocomposite MQC & Conformance Testing Specifications

Manufacturer's Quality Control			
Geonet			
Test	**Method (1)**	**Testing Frequency**	**Min. Requirements**
Thickness	ASTM D5199	1/50,000 sf	200±20 mil
Density	ASTM D1505	1/50,000 sf	0.94 g/cm^3
Tensile Strength (2)	ASTM D7179	1/50,000 sf	45 lb/in
Transmissivity (3)	ASTM D4716	1/540,000 sf	2.0 x 10^{-3} m^2/s
Carbon Black Content	ASTM D4218	1/50,000 sf	2%
Geotextile			
Mass per Unit Area	ASTM D 5261	1/90,000 sf	≥8 oz/sq. yd.
Grab Tensile	ASTM D 4632	1/90,000 sf	220 lbs.
Grab Elongation	ASTM D 4632	1/90,000 sf	50%
Trapezoid Tear Strength	ASTM D 4533	1/90,000 sf	90 lbs.
Puncture Strength	ASTM D 6241	1/90,000 sf	120/575 lbs.
Permittivity, T	ASTM D 4491	1/540,000 sf	1.26 Sec^{-1}
AOS (largest opening size)	ASTM D 4751	1/540,000 sf	80 Sieve Size
Geocomposite			
Ply Adhesion	ASTM D 7005	1/50,000 sf	1.0 lb./in (MARV)
Transmissivity (3)	ASTM D 4716	1/540,000 sf	1.0 x 10^{-4} m^2/s
Conformance Testing by CQA Engineer			
Geonet			
Test	**Method**	**Testing Frequency**	**Min. Requirements**
Thickness	ASTM D5199	1/100,000 sf	200±20 mil
Density	ASTM D1505	1/100,000 sf	0.94 g/cm^3
Tensile Strength (1)	ASTM D7179	1/100,000 sf	45 lb/in
Transmissivity (4)	ASTM D4716	1/100,000 sf	2.0 x 10^{-3} m^2/s
Carbon Black Content	ASTM D4218	1/100,000 sf	2%
Geotextile			
Mass per Unit Area	ASTM D 5261	1/100,000 sf	≥8 oz/sq. yd.
Grab Tensile	ASTM D 4632	1/100,000 sf	220 lbs.
Grab Elongation	ASTM D 4632	1/100,000 sf	50%
Puncture Strength	ASTM D 6241	1/100,000 sf	120/575 lbs.
AOS (largest opening size)	ASTM D 4751	1/100,000 sf	80 Sieve Size
Geocomposite			
Ply Adhesion	ASTM D 7005	1/100,000 sf	1.0 lb./in (MARV)
Transmissivity (4)	ASTM D 4716	1/100,000 sf	1.0 x 10^{-4} m^2/s

1. Test to be performed according to the latest test method as approved by the certifying engineer. Test methods that have been superceded by updated or different methods that are then accepted as industry standard will be replaced by the updated standards.

2. Machine Direction

3. Measured using water @ 20° C with a gradient of one, between two steel plates, after 15 minutes. Confining pressure 10,000 psf.

4. Transmissivity conformance testing only required on the geonet when the geonet and geotextile are installed separately. If a geocomposite is used, then the transmissivity testing will be performed on the geocomposite material.

EXHIBIT A
DEFINITIONS

SOIL RELATED TERMS

Aggregate - any combination of sand, gravel and crushed stone in their natural or processed state.

Atterberg limits - The liquid limit, plastic limit, and shrinkage limit for soil. The water content where the soil behavior changes from liquid to the plastic state is the liquid limit; from plastic to semisolid state is plastic limit; and from the semisolid to the solid state is the shrinkage limit.

Backfill - Soil material placed back into an area that has been excavated, such as against structures, in anchor trenches and in pipe trenches

Borrow - Soil material obtained from an off-site source for the clay liner, leachate collection layer, daily cover, or other construction projects.

Clays - Very small soil particles having a crystalline (layer structure, created as the result of the chemical alteration of primary rock minerals. Since the clay particles are very small, the air voids are very small and the flow of water through the soil material is very slow.

Coarse Aggregate - is generally considered to be a crushed stone or gravel almost all of which is retained on a No. 4 sieve.

Compaction - The process of increasing the density or unit weight of a soil by rolling, tamping, vibrating, or other mechanical means.

Density - The mass per unit volume.

Fine Aggregate - is considered to be any aggregate material that will pass a 3/8 in. sieve and essentially all of which will pass a No. 4 sieve and is predominately retained on a No. 4 sieve.

Liquid Limit - The water content where the soil behavior changes from liquid to the plastic state.

Hydraulic Conductivity - the property that reflects the ability of a material to conduct a fluid or vapor through a porous media such as soil or geotextiles.

In situ - Refers to soil when it is at its natural location in the earth and in its natural condition

Permeability - A generic term for the property that reflects the ability of a material to conduct a fluid or vapor through a porous media such as soil or geotextiles. Properly called *hydraulic conductivity*.

Plastic Limit - The water content where the soil behavior changes from plastic to semisolid state.

Plasticity - Term applied to fine-grained soils (particularly clays) to indicate the soils' (plus included waster's) ability to flow or be remolded without raveling or breaking apart.

Sand - The category of coarse-grained soil whose particles size range between about 0.07 mm and 5 mm in diameter.

Silt - The category of fine-grained soil particles whose mineralogical composition remains similar to the rock they were derived from.

Shrinkage Limit - The water content where the soil behavior changes from the semisolid to the solid state.

Sump - Small excavation or pit provided in the floor of a structure, or in the earth, to serve as a collection basin for surface water and leachate.

Water content - The ratio of the quantity of water in a soil (by weight) to the weight of the soil solid (dry soil), typically expressed as a percentage.

GEOTEXTILE AND GEOTEXTILE-RELATED* TERMS

Actinic degradation - The strength of fibers and fabrics due to exposure to sunlight or an accelerated weathering light source.

Arching - The formation of soil particles upstream of a geotextile where the particles arch (or bridge) over the fabrics' voids.

Basis weight* - A deprecated term for *mass per unit area*.

Blinding - The condition in which soil particles block the voids at the surface of a geotextile, thereby reducing the hydraulic conductivity of the geotextile.

Blocking - A synonym for *blinding.*

Bonding - The process of combining fibers, filaments, or films into sheets, webs, or bats by means of mechanical, thermal, or chemical binding.

Clogging - The movement by mechanical action or hydraulic flow of soil particles into the voids of a fabric and retention therein, thereby reducing the hydraulic conductivity of a geotextile.

Composite - *See* Fabric, composite.

Cross-plane - The direction of a geosynthetic which is perpendicular to the plane of its manufactured direction. Referred to in hydraulic situations.

Deformation - The change in length of a geosynthetic under load from its original manufactured dimensions.

Denier - The weight in grams of 9000 m of yarn.

Density* - The mass per unit volume.

Direction, cross-machine - The direction perpendicular to the long, machine, or manufactured direction (synonyms: *woven geotextiles, weft direction*).

Direction, machine - In textiles, the direction in a machine-made fabric parallel to the direction of movement the fabric followed in the manufacturing process (synonym: *lengthwise,* or *long direction*, and for woven geotextiles, *wrap direction*).

Downstream - The direction of the opposite side of a geotextile from which liquid is moving.

Elongation - The increase in length produced in the gage length of the test specimen by a tensile load.

Elongation at break - The elongation corresponding to the maximum load.

Elongation, percent - For geosynthetics, the increase in length of a specimen expressed as a percentage of the original gage length (i.e., engineering strain).

Fabric - Term used interchangeably with geotextile, particularly after placement in the manner described in this book.

Fabric, composite - A textile structure produced by combining nonwoven, woven, or knit manufacturing methods.

Fabric, knit - A textile structure produced by interlooping one or more ends of yarn or comparable material.

Fabric, nonwoven - For geotextiles, a planar and essentially random textile structure produced by bonding, interlocking of fibers or both, accomplished by mechanical, chemical, thermal, or solvent means and combinations thereof.

Fabric, woven - A planar textile structure produced by interlacing two or more sets of elements, such as yarns, fibers, rovings, or filaments, where the elements pass each other, usually at right angles, and one set of elements are parallel to the fabric axis.

Filament yarn - The yarn made from continuous filament fibers.

Fill - A deprecated term for *filling*.

Filing - The yarn running from selvedge to selvedge at right angles to the wrap in a woven fabric.

Filling Direction - *See* Direction, cross-machine. *Note*: For use with woven fabrics only.

Filter cake - The soil structure developed upstream of a geotextile by separating the suspended soil from liquid as the mixture attempts to pass through a soil fabric system.

Filter cloth - A deprecated term for *geotextile*.

Geocell - A three-dimensional structure filled with soil, thereby forming a mattress for increased stability when used with loose or compressible subsoils.

Geocomposite - A manufactured material using geotextiles, geogrids, geonets, and/or geomembranes in laminated or composite form.

Geogrid - A deformed or nondeformed gridlike polymeric material formed by intersecting ribs joined at the junctions used for reinforcement with foundations, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project structure or system.

Geomembrane - An essentially impermeable membrane used a s liquid or vapor barrier with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project, structure, or system.

Geonet - A netlike polymeric material formed form intersecting ribs integrally joined at the junctions used for drainage with foundation, soil, rock, earth, or any other geotechnical-related material as an integral part of a human-made project, structure, or system.

Geopipe - Any plastic pipe used with foundation, soil, rock, earth, or any other subsurface related material as an integral part of a human-made project, structure, or system.

Geosynthetic clay liner (GCL) - Factory-manufactured hydraulic barriers consisting of a layer of bentonite clay or other very low permeability material supported by geotextiles and/or geomembranes, and mechanically held together by needling, stitching, or chemical adhesives.

Geosynthetics - The generic term for all synthetic materials used in geotechnical engineering applications; it includes geotextiles, geogrids, geonets, geomembranes, and geocomposites.

Geotechnical engineering* - The engineering application of geotechnics.

Geotechnics* The application of scientific methods and engineering principles to the acquisition, interpretation, and use of knowledge of materials of the earth's crust to the solution of engineering problems, it embraces the filed of soil mechanics, rock mechanics, and many of the engineering aspects of geology, geophysics, hydrology, and related sciences.

Geotextile* - Any permeable textile used with foundation, soil, rock, earth, or any other geotechnical engineering-related material as an integral part of a human-made project, structure, or system.

Gradient - The degree of slope or a rate of change of a parameter measured over distance.
Heat bonded Thermally bonded by melting the fibers to form weld points.

Hydrophilic - A material's attraction to water.

Hydrophobic - A material's repulsion of water.

In-plane - The direction of a geosynthetic that is parallel to its long, manufactured, or machine direction. Referred to in hydraulic situations.

Knit - *See* Fabric, knit.

Mass per unit area - The proper term to represent and compare to the amount of material per unit area (units are oz./yd^2 or g/m^2). Often incorrectly called "weight" or "basis weight."

Melt bounded - *See* Heat bonded.

Modulus of elasticity - The initial linear portion of the stress-versus-strain test of a geosynthetic during its evaluation in a tensile strength test (units are lb./in.^{2}, kPa, lb./in., or kN/m).

Needle-punched - Mechanically bonded by needling with barbed needles.

Nonwoven - *See* Fabric, nonwoven.

Normal direction* - For geotextiles, the direction perpendicular to the plane of a geotextile.

Permeability - A generic term for the property that reflects the ability of a material to conduct a fluid or vapor through a porous media such as soil or geotextiles. Properly called *hydraulic conductivity*.

Permittivity - For a geotextile, the volumetric flow rate of water per unit cross-section area, per unit head, under laminar flow conditions, in the normal direction through the fabric.

pH - A measure of the acidity or alkalinity of a material, liquid, or solid. pH is represented on a scale of 0 to 14; 7 represents a neutral state; 0 represents the most acid, and 14 the most alkaline.

Resin bonded - The joining of fibers at their intersection points by resin in the formation of a nonwoven geotextile or geocomposites.

Siphoning - The transferring of a liquid to a lower level over an intermediate higher elevation than both of the endpoints, which can be achieved by saturated geotextiles in planar flow.

Staple - Short fibers in the range 0.5 to 3.0 in. (1 cm to 8 cm) long.

Staple yarn - Yarn made from staple fibers.

Tenacity - The fiber strength on a grams per denier basis.

Tex - Denier multiplied by 9 and is the weight in grams of 1000 m of yarn.

Transmissivity - For a geotextile, the volumetric flow rate per unit thickness under laminar flow conditions, within the in-plane direction of the fabric.

Transverse direction - A deprecated term for *cross-machine direction*.

Ultraviolet degradation - The breakdown of polymeric structure when exposed to natural light.

Upstream - The direction from which flowing liquid approaches a filter or drain.

Voids - The open spaces in a geosynthetic material through which flow can occur.

Wrap - The yarn running the length of the fabric in the machine direction when manufacturing woven fabrics.

Wrap direction - *See* Direction, machine. *Note*: For use with woven fabrics only.

Water table - (1) The upper limit of the part of the soil or underlying rock material that is wholly saturated with water. (2) The upper surface of the zone of saturation in ground water in which the hydrostatic pressure is equal to atmospheric pressure.

Weft - The cross-machine direction when manufacturing woven geotextiles.

Width - For a geotextile, the cross-direction edge-to-edge measurement of a fabric in a relaxed condition on a flat surface.

Woof - A deprecated term for *cross-machine direction*.

Woven - *See* Fabric, woven.

Woven, monofilament - The woven fabric produced with monofilament yarns.

Woven, multifilament - The woven fabric produced with multifilament yarns.

Woven, slit-film - The woven fabric produced with yarns produced from slit film.

Yarn* - A generic term for continuous strands of textile fibers or filaments in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric. *Yarn* may refer to (1) a number of fibers twisted together, (2) a number of filaments laid together without twist (a zero- twist yarn), (3) a number of filaments laid together with more or less twist, or (4) a single filament with or without twist (a monofilament).

** Those items marked by an asterisk (*) are from ASTM's Committee D35 on Geotextiles Tentative Terminology Standard.*

GEOMEMBRANE AND GEOMEMBRANE-RELATED* TERMS

Adhesion - The state in which two surfaces are held together by interfacial forces which may consist of molecular forces or interlocking action or both. Measured in shear and peel modes.

Air lance - A device used to test, in the field, the integrity of field seams in plastic sheeting, It consists of a wand or tube through which compressed air is blown.

Alloys, polymeric - A blend of two or more polymers (e.g., a rubber and plastic) to improve a given property (e.g., impact strength).

Antioxidants - Primary types include phenols and amines that scavenge extraneous free radicals. Secondary types decompose peroxides as a source of free radicals.

Berm - The upper edge of an excavation on which the ends of a geomembrane are buried to hold it in place or to anchor the material.

Blocking - Unintentional adhesion usually occurring during storage or shopping between plastic films or between a film and another surface.

Bodied solvent adhesive - An adhesive consisting of a solution of the geomembrane compound used in the seaming of geomembranes.

Boot - A bellows-type covering to exclude dust, dirt, moisture, etc., from a geomembrane protrusion.

Breaking factor - Tensile strength at break in force per unit of width. Expressed in Newtons per meter or pounds per inch.

Calender - A machine equipped with three or more heavy internally heated or cooled rolls, revolving in opposite directions. Used for preparation of continuous sheeting or plying up of polymer compounds and frictioning or coating of fabric with rubber or plastic compounds.

Catalysts - Used in the polymerization process to make plastics. Generally they do not become part of the polymers. Typical examples are metal oxides (to make polyolefins) and the Ziegler-Natta systems containing aluminum allklys and transition metal salts.

Chlorosulfonated polyethylene (CSPE) - Family of polymers that is produced y polyethylene reacting with chlorine and sulfur dioxide. Present CSPEs contain 25 to 43% chlorine and 1.0 to 1.4% sulfur. They are used in both vulcanized and nonvulcanized forms. Most membranes based on CSPE are nonvulcanized. (ASTM designation for this polymer is CSM.)

Coated fabric - Fabric that has been impregnated and/or coated with a rubbery or plastic material in the form of a solution, dispersion, hot melt, or powder. The term also applies to materials resulting from the application of a performed film to a fabric by means of calendering.

Creep - The slow change in length or thickness of a material under prolonged stress.

Cross-linking - A general term referring to the formation of chemical bonds between polymeric chains to yield an insoluble, three-dimensional polymeric structure. Cross-linking of rubbers is vulcanization. *See also* Vulcanization.

Curing - *See* Vulcanization.

Denier - A unit used in the textile industry to indicate the fineness of continuous filaments. Fineness in deniers equals the mass in grams of 9000-m length of the filament.

Dielectric seaming - *See* Heat seaming.

Elasticity - The property of matter by virtue of which it tends to return to its original size and shape after removal of the stress that caused the deformation.

Elastomer - *See* Rubber.

EPDM - A synthetic elastomer based on ethylene, propylene, and a small amount of a nonconjugated diene to provide sites for vulcanization.

EVA - A family of copolymers of ethylene and vinyl acetate used for adhesives and thermoplastic modifiers. They posses a wide range of melt indexes.

Extruder - A machine with a driver screw for continuous forming of polymeric compounds by forcing through a die; regularly used to manufacture geomembranes.

Fabric reinforcement - A fabric, scrim, and so on, used to add structural strength to a two-ply (or more) polymeric sheet. Such sheeting is referred to as *supported*.

Fill - As used in textile technology refers to the threads or yarns in a fabric running at right angles to the wrap. Also called *filler threads*.

Film - Sheeting having norminal thickness not greater than 10 mils.

Heat seaming - The process of joining two or more thermoplastic geomembranes by heating areas in contact with each other to the temperature at which fusion occurs. The process is usually aided by a controlled pressure (synonym: *heat fusion*).

Hot wedge - Common method of heat seaming of thermoplastic geomembranes by a fusing process wherein heat is delivered by a hot wedge passing between the opposing surfaces to be bonded.

Lapped seam - A seam made by placing one surface to be joined partly over another surface and bonding the overlapping portions.

Leachate - Liquid that has percolated through or drained from solid waste or other human-emplaced materials and contains soluble, partially soluble, or miscible components removed from such waste.

Leno fabric - An open fabric in which two warp yarns wrap around each fill yarn to prevent the warp or fill yarns from sliding over each other.

Liner - A layer of emplaced materials beneath a surface impoundment or landfill which serves to restrict the escape of waste or its constituents from the impoundment or landfill [*Fed. Regist.*].

Membrane - A continuous sheet of material, whether prefabricated as a flexible polymeric sheeting or sprayed or coated in the field, such as a sprayed-on asphalt (synonym: *geomembrane*).

Modulus - The stress on deforming a material to a given strain value (e.g., E_{50} and E_{100}).

Modulus of elasticity - The ratio of stress to strain within the elastic range, also known as Young's modulus [ASTM].

Nylon - Generic name for a family of polyamide polymers characterized by the presence of the amide group, $CONH_2$. Used as a scrim in fabric-reinforced geomembranes.

Plastic - A material that contains as an essential ingredient one or more organic polymeric substances of large molecular weight, is solid in its finished state, and at some stage in its manufacture or processing into finished articles can be shaped by flow.

Plasticizer - A plasticizer is a material, frequently solvent-like, incorporated in a plastic or a rubber to increase its ease of workability, its flexibility, or distensibility. Adding the plasticizer may lower the melt viscosity, the temperature of the second-order transition, or the elastic modules of the polymer. Plasticizer may be monomer liquids (phthalate esters), low-molecular- weight liquid polymers (polyesters), or rubbery high polymers (EVA). The most important use of plasticizers is with PVC geomembranes, where the choice of plasticizer will dictate under what conditions the liner may be used.

Polyester fiber - Generic name for a manufactured fiber in which the fiber-forming substance is any long-chain synthetic polymer composed of an ester of a dihydric alcohol and terephthalic acid. Scrims made of polyester fibers are used for fabric reinforcement.

Polyethylene - A polyolefins formed by bulk polymerization (for low density) or solution polymerization (for high density) where the ethylene monomer is placed in a reactor under high pressure and temperature. The oxygen produces free radicals which initiate the chain polymerization. For solution polymerization the monomer is first dissolved in an inert solvent. Catalysts are sometime required to initiate the reaction.

Polymer - A macromolecular material formed by the chemical combination of monomers having either the same or different chemical composition. Plastics, rubbers, and textile fibers are all high-molecular-weight polymers.

Polymeric liner - Plastic or rubber sheeting used to line disposal sites, pits, pounds, lagoons, canals, and so on.

Polyolefin - A family of polymeric materials that includes polypropylene and polyethylene, the former being very common in geotextiles, the latter in geomembranes. Many variations of each exist.

Polyvinyl chloride (PVC) - A synthetic thermoplastic polymer prepared from vinylchloride, PVC can be compounded into flexible and rigid forms through the use of plasticizers, stabilizers, fillers, and other modifiers; rigid forms used in pipes and well screens; flexible forms used in manufacture of geomembranes.

Puncture resistance - Extent to which a material is able to withstand the action of a sharp object without perforation.

Quality assurance (QA) - A planned system of activities whose purpose it to provide a continuing evaluation of the quality control program, initiating corrective action were necessary. It is applicable to both the manufactured product and its field installation.

Quality control (QC) - Actions that provide a means of controlling and measuring the characteristics of (both) the manufactured and the field installed product.

Roll goods - A general term applied[lied to rubber and plastic sheeting, whether fabric reinforced or not. It is usually furnished in rolls.

Rubber - A polymeric material which, at room temperature, is capable of recovering substantially in shape and size after removal of a deforming force. Refers to both synthetic and natural rubber. Also called an *elastomer*.

Scrim - A woven, open-mesh reinforcing fabric made from continuous-filament yarn, that is, a high-percent--open-area geotextile. Used in the reinforcement of some geomembranes.

Seam strength - Strength of a seam of geomembrane material measured either in shear or peel modes. Strength of the seam is reported either in absolute units (e.g., pounds per inch of width) or as percent of the strength of the sheet.

Sheeting - A form of plastic or rubber in which the thickness is very small in proportion to length and width and in which the polymer compound is present as a continuous phase throughout, with or without fabric (synonym: *geomembrane*).

Slope - Deviation of a surface from the horizontal expressed as a percentage, by a ration, or in degrees, In engineering, usually expressed as a percentage of vertical to horizontal change [EPA].

Spread coating - A manufacturing process whereby a polymeric material is spread in a continuous fashion on a fabric substrate thereby forming a reinforced geomembrane composite.

Strikethrough - A term used in the manufacture of fabric-reinforced polymeric sheeting to indicate that two layers of polymer have made bonding contact through the scrim.

Support sheeting - *See* Fabric reinforcement.

Surface cure - Curing or vulcanization that occurs in a thin layer on the surface of a manufactured polymeric sheet or other items.

Tear strength - The maximum force required to tear a specified specimen, the force acting substantially parallel to the major axis of the test specimen. Measured in both initiated and uninitiated modes. Obtained value is dependent on specimen geometry, rate of extension, and type of fabric reinforcement. Values are reported in force (e.g., pounds) of force per unit of thickness (e.g., pounds per inch).

Tensile strength - The maximum force required to cause tension failure in a given test specimen. The obtained value is dependent on specimen geometry, rate of extrusion and property of material.. Values are reported in maximum stress (e.g., pounds per square inch) or force per unit thickness (e.g., pound per inch width).

Thermoplastic elastomers - New materials that are being developed and that are probably related to elasticized polyolefins. Polymers of this type behave similarly to cross-linked rubber. They have a limited upper-temperature service range which, however, is substantially above the temperature encountered in waste disposal sites (200°F may be too high for some TPEs).

Thread count - The number of threads per inch in each direction with the warp mentioned first and the fill second. A thread count of 20 X 10 means 20 threads per inch in the warp and 10 threads per inch in the fill direction.

Ultimate elongation - The elongation of a stretched specimen at the time of break. Usually reported as percent of the original length. Also called *elongation at break* (synonym: *engineering strain at failure*).

Unsupported sheeting - A polymeric sheeting consisting of one or more plies without a reinforcing-fabric layer or scrim.

Vacuum box - A device used to asses the integrity of field seams in geomembrane installations.

Vulcanize - Used to denote the product of the vulcanization of a rubber compound without reference to shape or form.

Vulcanization - An irreversible process during which a rubber compound, through a change in its chemical structure (cross-linking), becomes less plastic and more resistant to swelling by organic liquids, and during which elastic properties are conferred, improved, or extended over a greater range of temperature.

Warp - In textiles, the lengthwise yarns in a woven fabric.

Water vapor transmission (WVT) - Water vapor flow normal to two parallel surfaces of a material, through a unit area, under the conditions of a specified test such as ASTM E96.

** Many of these terms are from Lining of Waste Impoundment and Disposal Facilities, by Matrecon, Inc., for U.S. EPA Municipal Environmental Research Laboratory, Cincinnati, OH, R. Landreth, Project Officer, 1984, EPA/SW870, March 1983, G.P.O. No. 055-000-00231-2.*

Exhibit B

ACI 301-16 Sections 1-5, and 11

An ACI Standard

Specifications for Structural Concrete

Reported by ACI Committee 301

ACI 301-16

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Specifications for Structural Concrete

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American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
Phone: +1.248.848.3700
Fax: +1.248.848.3701

www.concrete.org

ACI 301-16

Specifications for Structural Concrete

An ACI Standard

Reported by ACI Committee 301

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Michael D. A. Thomas
Ralph H. Tulis
Gregory R. Wagner
William H. Wolfe
Zuming Xia

*Deceased.

Consulting Member

Eric S. Peterson

This is a Reference Specification that the Architect/Engineer can apply to any construction project involving structural concrete by citing it in the Project Specifications. A mandatory requirements checklist and an optional requirements checklist are provided to assist the Architect/Engineer in supplementing the provisions of this Specification as required or needed by designating or specifying individual project requirements.

The first five sections of this Specification cover general construction requirements for cast-in-place structural concrete and slabs-on-ground. These sections cover materials and proportioning of concrete; reinforcement and prestressing steel; production, placing, finishing, and curing of concrete; formwork performance criteria and construction; treatment of joints; embedded items; repair of surface defects; and finishing of formed and unformed surfaces. Provisions governing testing, evaluation, and acceptance of concrete as well as acceptance of the structures are included. The remaining sections are devoted to architectural concrete, lightweight concrete, mass concrete, post-tensioned concrete, shrinkage-compensating concrete, industrial floor slabs, tilt-up construction, precast structural concrete, and precast architectural concrete.

Keywords: architectural; cold weather; compressive strength; consolidation; curing; durability; finish; formwork; grouting; hot weather; industrial floors; inspection; joints; lightweight concrete; mass concrete; mixture proportions; placing; post-tensioned; precast; prestressing steel; repair; reshoring; shoring; shrinkage-compensating; slab; slabs-on-ground; steel reinforcement; testing; tilt-up; tolerance; welded wire.

ACI 301-16 supersedes ACI 301-10, was adopted April 1, 2016, and published May 2016.

CONTENTS

SECTION 1—GENERAL REQUIREMENTS

1.1—Scope

1.1.1 This Specification covers construction of cast-in-place concrete, architectural concrete, lightweight concrete, mass concrete, post-tensioned concrete, shrinkage-compensating concrete, industrial floor slabs cast on ground, tilt-up construction, precast structural concrete, and precast architectural concrete.

1.1.2 Sections 1 through 5 apply to projects where this Specification is referenced. Work covered by Sections 6 through 14 apply only if that Work is designated in Contract Documents.

1.1.3 This Specification becomes part of the Contract Document and provides requirements for Contractor.

1.1.4 This Specification governs for construction within its scope, except Contract Documents govern if there is a conflict.

1.1.5 *Work not specified*—The following Work is not in the scope of this Specification:

(a) Manufactured concrete products specified by ASTM standards
(b) Environmental concrete structures
(c) Heavyweight shielding concrete
(d) Paving concrete
(e) Terrazzo
(f) Insulating concrete
(g) Refractory concrete
(h) Nuclear containment structures
(i) Concrete piles; drilled piers; and caissons assigned to Seismic Design Categories A, B, and C
(j) Fire safety (Underwriter Laboratories [UL] designs)
(k) Shotcrete
(l) Slipformed concrete walls

1.1.6 This Specification governs if there is a conflict with referenced materials and testing standards.

1.1.7 Contractor is permitted to submit written alternatives to any provision in this Specification.

1.1.8 Ignore provisions of this Specification that are not applicable to the Work.

1.1.9 *Units*—Values in this Specification are stated in inch-pound units.

1.1.10 Unless otherwise stated, the inch-pound system of units shall be applicable in ASTM combined standards referenced in this Specification.

1.1.11 The Notes to Specifier are not part of this Specification.

1.2—Interpretation

1.2.1 Unless otherwise explicitly stated, this Specification shall be interpreted using the following principles:

1.2.1.1 Interpret this Specification consistent with the plain meaning of the words and terms used.

1.2.1.2 Definitions provided in this Specification govern over the definitions of the same or similar words or terms found elsewhere.

1.2.1.3 Headings are part of this Specification and are intended to identify the scope of the provisions or sections that follow. If there is a difference in meaning or implication between the text of a provision and a heading, the meaning of the text governs.

1.2.1.4 Notes to a table are part of this Specification. The meaning of the provision text governs in the event of a difference in meaning or implication between the provision text and a note to a table.

1.2.1.5 If a provision of this Specification involves two or more items, conditions, requirements, or events connected by the conjunctions "and" or "or," interpret the conjunction as follows:

(a) "And" indicates that all of the connected items, conditions, requirements, or events apply.

(b) "Or" indicates that the connected items, conditions, requirements, or events apply singularly.

1.2.1.6 The use of the verbs "may" or "will" indicates that the specification provision is for information to Contractor.

1.2.1.7 The phrase "as indicated in Contract Documents" means the specifier included the provision requirements in Contract Documents.

1.2.1.8 The phrase "unless otherwise specified" means the specifier may have included an alternative to the default requirement in Contract Documents.

1.3—Definitions

acceptable or **accepted**—determined to be satisfactory by Architect/Engineer.

acceptance—acknowledgment by Architect/Engineer that submittal or completed Work is acceptable.

ACI Concrete Field Testing Technician Grade I—a person who has demonstrated knowledge and ability to perform and record the results of ASTM standard tests on freshly mixed concrete and to make and cure test specimens; knowledge and ability shall be demonstrated by passing prescribed written and performance examinations and having credentials that are current with the American Concrete Institute.

aggressive environment—an environment that exposes a structure to moisture and external sources of chlorides from deicing chemicals, salt, brackish water, seawater, or spray from these sources; for stressing pockets subject to wetting or direct contact with soils during service.

Architect/Engineer or **Engineer/Architect**—Architect, Engineer, architectural firm, engineering firm, or architectural and engineering firm issuing Contract Documents or administering the Work under Contract Documents, or both.

architectural concrete—concrete that is typically exposed to view, is designated as architectural concrete in Contract Documents, and therefore requires care in selection of the concrete materials, forming, placing, and finishing to obtain the desired architectural appearance.

backshores—shores placed snugly under a concrete slab or structural member after the original formwork and shores have been removed from a small area at a time, without allowing the slab or member to deflect, or support its own weight or existing construction loads.

cast-in-place concrete—concrete that is deposited and allowed to harden in the place where it is required to be in the completed structure.

check test—test performed to verify result of previous test result of freshly-mixed concrete.

Contract Documents—a set of documents supplied by Owner to Contractor as the basis for construction; these documents contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes.

Contractor—the person, firm, or entity under contract for construction of the Work.

defective work—construction or material that does not comply with Contract Documents.

design reference sample—sample of precast architectural concrete color, finish, and texture that is submitted for initial verification of design intent.

duct—a conduit in a concrete member to accommodate the prestressing steel of a post-tensioning tendon and provide an annular space for protective coating.

encapsulated tendon—a tendon that is enclosed completely in a watertight covering from end to end, including anchorages, sheathing with coating, and caps over the strand tails.

equivalent diameter of bundle—the diameter of a circle having an area equal to the sum of the bar areas in a bundle of reinforcing bars.

expansive cement—a cement that, when mixed with water, produces a paste that, after setting, increases in volume and is used to compensate for volume decrease due to shrinkage or to induce tensile stress in reinforcement.

exposed to view—portion of structure that can be observed by the public during normal use.

high-early-strength concrete—concrete that, through the use of additional cement, high-early-strength cement, admixtures, or other acceptable methods, has accelerated early-age strength development.

jack clearance—minimum space required to safely install, operate, and remove a hydraulic jack through its full range of movement in stressing of a tendon.

licensed design engineer—an individual retained by the Contractor who is licensed to practice engineering as defined

by the statutory requirements of the professional licensing laws of the state or jurisdiction in which the project is to be constructed.

lightweight concrete—structural concrete containing lightweight aggregate conforming to ASTM C330/C330M and having an equilibrium density, as determined by ASTM C567/C567M, between 70 and 120 lb/ft^3.

mass concrete—volume of structural concrete in which a combination of dimensions of the member being cast, the boundary conditions, the characteristics of the concrete mixture, and the ambient conditions can lead to undesirable thermal stresses, cracking, deleterious chemical reactions, or reduction in the long-term strength as a result of elevated concrete temperature due to heat of hydration.

movement joint—an interface between adjacent portions of the Work that allows movement in one or more direction.

nonencapsulated tendon—a tendon that has bare metallic anchorages and sheathing that is continuous between anchorages but not connected to the anchorages.

normalweight concrete—structural concrete containing aggregate that conforms to ASTM C33/C33M and that typically has a density between 135 and 160 lb/ft^3.

Owner—the corporation, association, partnership, individual, public body, or authority for whom the Work is constructed.

placing drawing—drawing that gives size, location, and spacing of reinforcement, and other information required for site-cast concrete construction.

point of placement—location where concrete is placed in structure.

post-tensioning—a method of prestressing reinforced concrete in which tendons are tensioned after the concrete has attained a specified minimum in-place strength or a specified minimum age.

precast concrete—concrete cast elsewhere than its final position.

prestressed concrete—concrete in which internal stresses have been introduced to reduce potential tensile stresses in concrete resulting from loads (see **post-tensioning** and **pretensioning**).

prestressing sheathing—a material encasing prestressing steel to prevent bonding of the prestressing steel with the surrounding concrete, to provide corrosion protection, and to contain the corrosion-inhibiting coating.

prestressing steel—high-strength steel element; for example, strand, bars, or wire, used to impart prestress forces to concrete.

pretensioning—method of prestressing in which prestressing steel is tensioned before the concrete is placed.

Project Drawings—graphic presentation that details requirements for Work.

Project Specifications—the written document that details requirements for Work.

pull-on method—method of seating fixed-end anchorage by tensioning prestressing steel.

quality assurance—actions taken by Owner or Owner's Representative to provide confidence that Work done and materials provided are in accordance with Contract Documents.

quality control—actions taken by Contractor to ensure that Work meets the requirements in Contract Documents.

reference specification—a standardized mandatory-language document prescribing materials, dimensions, and workmanship, incorporated by reference in Contract Documents.

referenced standards—standardized mandatory-language documents of a technical society, organization, or association, including codes of local or federal authorities, which are incorporated by reference in Contract Documents.

required—required in this Specification or in Contract Documents.

reshores—shores placed snugly under a stripped concrete slab or other structural member after the original forms and shores have been removed from a large area, thus requiring the new slab or structural member to deflect and support its own weight and existing construction loads.

shop drawings—drawings that provide details for a particular portion of Work that are prepared by Contractor in accordance with Contract Documents and are reviewed by Architect/Engineer.

shore—vertical or inclined support members designed to support the weight of the formwork, concrete, and construction loads above.

shrinkage-compensating concrete—a concrete that increases in volume after setting, designed to induce compressive stresses in concrete restrained by reinforcement or other means, to offset tensile stresses resulting from shrinkage.

strength test—standard test conducted for evaluation and acceptance of concrete determined as the average of the compressive strengths of at least two 6 x 12 in. cylinders or at least three 4 x 8 in. cylinders made from the same sample of concrete, transported, and standard cured in accordance with ASTM C31/C31M and tested in accordance with ASTM C39/C39M at 28 days or at test age designated for f_c'.

structural concrete—plain or reinforced concrete in a member required to transfer gravity loads, lateral loads, or both, to the ground.

submit—provide to Architect/Engineer for review.

submittal—documents or materials provided to Architect/Engineer for review and acceptance.

surface defects—imperfections in concrete surfaces defined in Contract Documents requiring repair.

tendon—in pretensioned applications, the tendon is the prestressing steel; in post-tensioned applications, the tendon is a complete assembly consisting of anchorages, prestressing steel, and sheathing with coating for unbonded applications or ducts with grout for bonded applications.

tilt-up—a construction technique for casting concrete members in a horizontal position at the project site and then erecting them to their final upright position in a structure.

waste slab—temporary slab to provide a casting surface for tilt-up panels.

Work—the entire construction or separately identifiable parts required to be furnished under Contract Documents.

1.4—Referenced standards

1.4.1 *Referenced standards*—Standards referred to in this Specification are listed with serial designation including year of adoption or revision.

1.4.1.1 *American Concrete Institute standards*

ACI 117-10(15)—Specifications for Tolerances for Concrete Construction and Materials and Commentary

ACI 216.1-14—Code Requirements for Determining Fire Resistance of Concrete and Masonry Construction Assemblies

ACI 423.7-14—Specification for Unbonded Single-Strand Tendon Materials

ACI ITG-7-09—Specification for Tolerances for Precast Concrete

1.4.1.2 *ASTM International standards*

ASTM A36/A36M-14—Standard Specification for Carbon Structural Steel

ASTM A47/A47M-99(2014)—Standard Specification for Ferritic Malleable Iron Castings

ASTM A108-13—Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished

ASTM A123/A123M-15—Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A153/A153M-16—Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A184/A184M-06(2011)—Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement

ASTM A193/A193M-16—Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

ASTM A276/A276M-16—Standard Specification for Stainless Steel Bars and Shapes

ASTM A307-14—Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength

ASTM A325-14—Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

ASTM A416/A416M-15—Standard Specification for Low-Relaxation, Seven-Wire Steel Strand for Prestressed Concrete

ASTM A421/A421M-15—Standard Specification for Stress-Relieved Steel Wire for Prestressed Concrete

ASTM A490-14a—Standard Specification for Structural Bolts, Steel, Heat Treated, 150 ksi Minimum Tensile Strength

ASTM A500/A500M-13—Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A563-15—Standard Specification for Carbon and Alloy Steel Nuts

ASTM A572/A572M-15—Standard Specification for High Strength Low-Alloy Columbium-Vanadium Structural Steel

ASTM A615/A615M-16—Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM A666-15—Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

ASTM A675/A675M-14—Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties

ASTM A706/A706M-16—Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement

ASTM A722/A722M-15—Standard Specification for High-Strength Steel Bars for Prestressing Concrete

ASTM A767/A767M-09(2015)—Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement

ASTM A775/A775M-07b(2014)—Standard Specification for Epoxy-Coated Steel Reinforcing Bars

ASTM A779/A779M-12—Standard Specification for Steel Strand, Seven-Wire, Uncoated, Compacted, for Prestressed Concrete

ASTM A780/A780M-09(2015)—Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

ASTM A820/A820M-15—Standard Specification for Steel Fibers for Fiber-Reinforced Concrete

ASTM A882/A882M-04a(2010)—Standard Specification for Filled Epoxy-Coated Seven-Wire Prestressing Steel Strand

ASTM A884/A884M-14—Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement

ASTM A886/A886M-12—Standard Specification for Steel Strand, Indented, Seven-Wire, Stress-Relieved for Prestressed Concrete

ASTM A910/A910M-12—Standard Specification for Uncoated, Weldless, 2-Wire and 3-Wire Steel Strand for Prestressed Concrete

ASTM A934/A934M-16—Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

ASTM A955/A955M-15—Standard Specification for Deformed and Plain Stainless-Steel Bars for Concrete Reinforcement

ASTM A970/A970M-15e1—Standard Specification for Headed Steel Bars for Concrete Reinforcement

ASTM A992/A992M-11(2015)—Standard Specification for Structural Steel Shapes

ASTM A996/A996M-16—Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

ASTM A1022/A1022M-16—Standard Specification for Deformed and Plain Stainless Steel Wire and Welded Wire for Concrete Reinforcement

ASTM A1035/A1035M-16a—Standard Specification for Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement

ASTM A1044/A1044M-16—Standard Specification for Steel Stud Assemblies for Shear Reinforcement of Concrete

ASTM A1055/A1055M-10e1—Standard Specification for Zinc and Epoxy Dual-Coated Steel Reinforcing Bars

ASTM A1060/A1060M-16—Standard Specification for Zinc-Coated (Galvanized) Steel Welded Wire Reinforcement, Plain and Deformed, for Concrete

ASTM A1064/A1064M-16—Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

ASTM C31/C31M-15—Standard Practice for Making and Curing Concrete Test Specimens in the Field

ASTM C33/C33M-13—Standard Specification for Concrete Aggregates

ASTM C39/C39M-15—Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

ASTM C42/C42M-13—Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

ASTM C67-14—Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile

ASTM C94/C94M-15—Standard Specification for Ready-Mixed Concrete

ASTM C109/C109M-16—Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)

ASTM C126-15—Standard Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units

ASTM C138/C138M-14—Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete

ASTM C143/C143M-15—Standard Test Method for Slump of Hydraulic-Cement Concrete

ASTM C144-11—Standard Specification for Aggregate for Masonry Mortar

ASTM C150/C150M-15—Standard Specification for Portland Cement

ASTM C157/C157M-08(2014)e1—Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

ASTM C171-07—Standard Specification for Sheet Materials for Curing Concrete

ASTM C172/C172M-14a—Standard Practice for Sampling Freshly Mixed Concrete

ASTM C173/C173M-14—Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

ASTM C192/C192M-15—Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory

ASTM C216-15—Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)

ASTM C231/C231M-14—Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

ASTM C260/C260M-10a—Standard Specification for Air-Entraining Admixtures for Concrete

ASTM C309-11—Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

ASTM C330/C330M-14—Standard Specification for Lightweight Aggregates for Structural Concrete

ASTM C373-14a—Standard Test Method for Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products, Ceramic Tiles, and Glass Tiles

ASTM C387/C387M-15—Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar

ASTM C404-11—Standard Specification for Aggregates for Masonry Grout

ASTM C494/C494M-15—Standard Specification for Chemical Admixtures for Concrete

ASTM C567/C567M-14—Standard Test Method for Determining Density of Structural Lightweight Concrete

ASTM C578-15—Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation

ASTM C591-15—Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation

ASTM C595/C595M-15e1—Standard Specification for Blended Hydraulic Cements

ASTM C597-09—Standard Test Method for Pulse Velocity through Concrete

ASTM C618-15—Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

ASTM C642-13—Standard Test Method for Density, Absorption, and Voids in Hardened Concrete

ASTM C650-04(2014)—Standard Test Method for Resistance of Ceramic Tile to Chemical Substances

ASTM C666/C666M-15—Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing

ASTM C685/C685M-14—Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing

ASTM C803/C803M-03(2010)—Standard Test Method for Penetration Resistance of Hardened Concrete

ASTM C805/C805M-13a—Standard Test Method for Rebound Number of Hardened Concrete

ASTM C834-14—Standard Specification for Latex Sealants

ASTM C845/C845M-12—Standard Specification for Expansive Hydraulic Cement

ASTM C873/C873M-15—Standard Test Method for Compressive Strength of Concrete Cylinders Cast in Place in Cylindrical Molds

ASTM C878/C878M-14a—Standard Test Method for Restrained Expansion of Shrinkage-Compensating Concrete

ASTM C881/C881M-15—Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

ASTM C900-15—Standard Test Method for Pullout Strength of Hardened Concrete

ASTM C920-14a—Standard Specification for Elastomeric Joint Sealants

ASTM C979/C979M-16—Standard Specification for Pigments for Integrally Colored Concrete

ASTM C989/C989M-14—Standard Specification for Slag Cement for Use in Concrete and Mortars

ASTM C1012/C1012M-15—Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution

ASTM C1017/C1017M-13e1—Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete

ASTM C1064/C1064M-12—Standard Test Methods for Temperature of Freshly Mixed Hydraulic-Cement Concrete

ASTM C1074-11—Standard Practice for Estimating Concrete Strength by the Maturity Method

ASTM C1077-15a—Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation

ASTM C1107/C1107M-14a—Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

ASTM C1116/C1116M-10a(2015)—Standard Specification for Fiber-Reinforced Concrete

ASTM C1157/C1157M-11—Standard Performance Specification for Hydraulic Cement

ASTM C1218/C1218M-15—Standard Test Method for Water-Soluble Chloride in Mortar and Concrete

ASTM C1240-15—Standard Specification for Silica Fume Used in Cementitious Mixtures

ASTM C1289-16—Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board

ASTM C1293-08b(2015)—Standard Test Method for Determination Length of Change of Concrete Due to Alkali-Silica Reaction

ASTM C1315-11—Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

ASTM C1567-13—Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)

ASTM C1602/C1602M-12—Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

ASTM C1609/C1609M-12—Standard Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading)

ASTM C1611/C1611M-14—Standard Test Method for Slump Flow of Self-Consolidating Concrete

ASTM C1778-14—Standard Guide for Reducing the Risk of Deleterious Alkali-Aggregate Reaction in Concrete

ASTM D98-15—Standard Specification for Calcium Chloride

ASTM D412-15a—Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

ASTM D638-14—Standard Test Method for Tensile Properties of Plastics

ASTM D698-12e2—Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort [12 400 ft-lbf/ft^3 (600 kN-m/m^3)]

ASTM D994/D994M-11—Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)

ASTM D1621-10—Standard Test Methods for Compressive Properties of Rigid Cellular Plastics

ASTM D1751-04(2013)e1—Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)

ASTM D1752-04a(2013)---Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction

ASTM D2240-15—Standard Test Method for Rubber Property—Durometer Hardness

ASTM D2940/D2940M-15—Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports

ASTM D3575-14—Standard Test Methods for Flexible Cellular Materials Made from Olefin Polymers

ASTM D4397-10—Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications

ASTM E165/E165M-12—Standard Practice for Liquid Penetrant Examination for General Industry

ASTM E329-14a—Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

ASTM E488/E488M-15—Standard Test Methods for Strength of Anchors in Concrete Elements

ASTM E1155-14—Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers

ASTM E1444/E1444M-12—Standard Practice for Magnetic Particle Testing

ASTM E1643-11—Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill under Concrete Slabs

ASTM E1745-11—Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

ASTM F436-11—Standard Specification for Hardened Steel Washers

ASTM F593-13a—Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

ASTM F594-09(2015)—Standard Specification for Stainless Steel Nuts

ASTM F844-07a(2013)—Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use

ASTM F1554-15—Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

1.4.1.3 *Other referenced standards*—Other standards referenced in this Specification:

AASHTO LRFD (2014)—LRFD Bridge Design Specifications

AASHTO M 182-05(2012)—Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

AASHTO M 251-06—Standard Specification for Plain and Laminated Elastomeric Bridge Bearings

ANSI A118.1-14—Specifications for Dry-Set Portland Cement Mortar

ANSI A118.4-12—Specifications for Latex-Portland Cement Mortar

ANSI A118.6-10—Specifications for Standard Cement Grouts for Tile Installation

ASHRAE 90.1-13—Energy Standard for Buildings Except Low-Rise Residential Buildings

AWS C5.4-93—Recommended Practices for Stud Welding

AWS D1.1/D1.1M:2015—Structural Welding Code—Steel

AWS D1.4/D1.4M:2011—Structural Welding Code—Reinforcing Steel

AWS D1.6/D1.6M:2007—Structural Welding Code—Stainless Steel
CRD-C513-74—Specifications for Rubber Waterstops
CRD-C572-74—Specifications for Polyvinylchloride Waterstop
CRSI RB4.1-14—Supports for Reinforcement Used in Concrete
MPI #79-16—Primer, Alkyd, Anti-Corrosive for Metal
NAVY MIL-C-882E-89—Cloth, Duck, Cotton or Cotton-Polyester Blend, Synthetic Rubber, Impregnated, and Laminated, Oil Resistant
NAVY MIL DOD-P-21035A-91—Paint High Zinc Dust Content, Galvanizing Repair
SSPC-Paint 20-04-—Zinc Rich Primers IO and O
SSPC-PA1-04—Shop, Field and Maintenance Painting of Steel
SSPC-SP3-04—Power Tool Cleaning
PCI MNL 116-99—Manual for Quality Control for Plants and Production of Structural Precast Concrete Products
PCI MNL 124-11—Design for Fire Resistance of Precast/Prestressed Concrete
PTI/ASBI M50.3-12—Guide Specification for Grouted Post-Tensioning
PTI M55.1-12—Specification for Grouting of Post-Tensioned Structures

1.4.2 *Cited publications*—Publications cited in this Specification:

ACI MNL-15—Field Reference Manual: Specifications for Structural Concrete (ACI 301-16) with Selected ACI References

1.4.3 *Field references*—Keep in Contractor's field office a copy of ACI MNL-15.

1.5—Submittals

1.5.1 *General*—Provide submittals as required by this Specification in accordance with Contract Documents.

1.5.2 *Substitution*—Substitution requests shall specifically identify proposed substitution and demonstrate compliance with performance requirements.

1.5.3 *Contractor's quality control*—If required, submit a quality control plan showing means and methods to control purchase, use, and placement of materials. Provide information related to quality control in accordance with 1.6.2.

1.6—Testing and inspection

1.6.1 *General*—Concrete materials and operations may be tested and inspected by Owner as Work progresses. Failure to detect defective Work will not prevent later rejection if discovered nor shall it obligate Architect/Engineer for final acceptance.

1.6.1.1 *Testing agencies*—Agencies that perform required tests of concrete materials shall meet the requirements of ASTM C1077. Testing agencies that test or inspect placement of reinforcement shall meet the requirements of ASTM E329. Testing agencies shall be accepted by Architect/Engineer before performing testing or inspection.

1.6.1.2 *Field technicians*—Field tests of concrete required in 1.6.2 and 1.6.3.2 shall be performed by ACI Concrete Field Testing Technician Grade I or acceptable equivalent. Equivalent certification programs shall include acceptable requirements for written and performance examinations.

1.6.2 *Quality control: Responsibilities of Contractor*

1.6.2.1 Submit data on qualifications of Contractor's proposed testing agency. The use of testing services will not relieve Contractor of responsibility to complete Work and furnish materials and construction in compliance with Contract Documents.

1.6.2.2 *Duties and responsibilities*—Unless otherwise specified, Contractor assumes duties and responsibilities specified in 1.6.2.2(a) through 1.6.2.2(f).

1.6.2.2(a) Confirm proposed materials and concrete mixtures meet requirements in Contract Documents.

1.6.2.2(b) Allow access to project site or to source of materials and assist Owner's testing agency in obtaining and handling samples at project site or at source of materials.

1.6.2.2(c) Advise Owner's testing agency at least 24 hours in advance of operations that require services specified in 1.6.3.1(a) through 1.6.3.1(c) to allow for scheduling of quality assurance tests, review of project requirements, and assignment of personnel.

1.6.2.2(d) Provide space and source of electrical power on project site for testing facilities acceptable to Owner's testing agency. This is for the sole use of Owner's quality assurance testing agency for initial curing of concrete strength test specimens as required by ASTM C31/C31M.

1.6.2.2(e) Submit information documenting compliance of materials with referenced standards and test data on concrete mixture.

1.6.2.2(f) Submit concrete supplier's quality control program.

1.6.2.3 *Tests required of Contractor's testing agency*—Unless otherwise specified, provide testing services given in 1.6.2.3(a) and 1.6.2.3(b).

1.6.2.3(a) Qualification of proposed materials and establishment of concrete mixtures.

1.6.2.3(b) Other testing services needed or required by Contractor to fulfill quality control plan.

1.6.3 *Quality assurance: Duties and responsibilities of Owner's testing agency*

1.6.3.1 Unless otherwise specified, Owner's testing agency will provide services specified in 1.6.3.1(a) through 1.6.3.1(c).

1.6.3.1(a) Owner's testing agency will inspect, sample, and test materials and concrete production as required. If material furnished or Work performed by Contractor fails to conform to Contract Documents, testing agency will report deficiency to Architect/Engineer, Owner, Contractor, and concrete supplier.

1.6.3.1(b) Owner's testing agency and its representatives are not authorized to revoke, alter, relax, enlarge, or release requirements in Contract Documents, or to accept or reject portions of Work.

1.6.3.1(c) Owner's testing agency will report test and inspection results of Work to Owner, Architect/Engineer, Contractor, and concrete supplier within 7 days after tests and inspections are performed. Strength test reports will include location in Work where concrete represented by each

test was deposited, date and time sample was obtained, and batch ticket number. Strength test reports will include information on storage and curing of specimens before testing.

1.6.3.2 *Testing services*—If required by Owner or Architect/Engineer, Owner's testing agency will perform testing services given in 1.6.3.2(a) through 1.6.3.2(e) at no cost to Contractor.

1.6.3.2(a) Review and test to verify Contractor's test results on proposed materials for compliance with Contract Documents.

1.6.3.2(b) Review and test to verify Contractor's test results on proposed concrete mixture.

1.6.3.2(c) Obtain production samples of materials at plants or stockpiles during the course of Work and test for compliance with Contract Documents.

1.6.3.2(d) For each concrete mixture placed in 1 day, obtain samples of fresh concrete in accordance with ASTM C172/C172M. Truckloads or batches of concrete will be sampled on a random basis. Unless otherwise specified, at least one composite sample will be obtained for consecutive 150 yd^3 of concrete or 5000 ft^2 of surface area of slabs or walls, or fractions thereof. If total quantity of a given concrete mixture is less than 50 yd^3, strength tests may be waived by Architect/Engineer.

Sampled concrete used to mold strength test specimens (ASTM C31/C31M) will be tested for slump (ASTM C143/C143M), air content (ASTM C231/C231M or ASTM C173/C173M), temperature (ASTM C1064/C1064M), and density (ASTM C138/C138M).

1.6.3.2(e) Owner's testing agency will conduct concrete strength tests by making and standard curing test specimens in accordance with ASTM C31/C31M and testing them according to ASTM C39/C39M. Unless otherwise specified, concrete strengths for acceptance shall be tested at 28 days.

1.6.3.3 *Additional testing and inspection services*—If required, Owner's testing agency will perform additional testing and inspection services (a) through (e) to verify conformance with Contract Documents:

(a) Inspect concrete batching, mixing, and delivery operations.

(b) Inspect forms, foundation preparation, reinforcement, embedded items, reinforcement placement, and concrete placing, finishing, and curing operations.

(c) Sample concrete at point of placement and other locations as directed by Architect/Engineer and perform required tests.

(d) Review manufacturer's report for shipment of cement, reinforcement, and prestressing tendons, and conduct laboratory tests or spot checks of materials received for compliance with specifications.

(e) Other testing or inspection services as required by Architect/Engineer.

Provide Owner's testing agency with requested documentation and access to perform testing and inspection activities.

1.6.3.4 *Other testing services as needed*—Contractor shall pay for the following testing services performed, by Owner's testing agency:

(a) Additional testing and inspection required because of changes in materials or mixture proportions requested by Contractor.

(b) Additional testing of materials or concrete because of failure to meet specification requirements.

1.6.4 *Tests on hardened concrete in place*

1.6.4.1 *General*—If necessary, Owner's testing agency will perform tests on hardened concrete. Testing shall be at Contractor's expense if this Specification requires tests to verify strength of concrete in structure and subsequent testing confirms concrete does not meet acceptance criteria.

Contractor shall not be responsible for costs if tests are not required by this Specification or subsequent testing confirms concrete meets acceptance criteria.

1.6.4.2 *Nondestructive tests for uniformity*—Use of the rebound hammer in accordance with ASTM C805/C805M or the pulse-velocity method in accordance with ASTM C597 may be specified by Architect/Engineer to evaluate uniformity of in-place concrete or to select areas to be cored. These methods shall not be used to evaluate in-place strength.

1.6.4.3 *Core tests*

1.6.4.3(a) If concrete strength is in doubt as defined in 1.6.6.1(b) or core testing is required for other reasons, cores will be obtained, moisture conditioned, prepared, and tested in accordance with ASTM C42/C42M, unless otherwise specified. Cores will be tested no earlier than 48 hours after drilling or last wetting and no later than 7 days after cores were drilled from structure, unless otherwise specified.

1.6.4.3(b) At least three cores will be taken from each area of in-place concrete that is considered potentially deficient as defined in 1.6.6.1(b). Architect/Engineer determines location of cores. If, before testing, cores show evidence of having been damaged, replacement cores will be taken.

1.6.4.3(c) Contractor shall fill core holes with no-slump concrete or mortar of strength equal to or greater than original concrete. Unless otherwise specified, provide moist curing for at least 3 days.

1.6.4.4 *Floor flatness and levelness*—Unless otherwise specified, floor flatness and levelness will be measured in accordance with ASTM E1155.

1.6.5 *Evaluation of concrete strength tests*

1.6.5.1 *Standard molded and cured strength specimens*—Test results from standard molded and cured test cylinders will be evaluated separately for each specified concrete mixture. Evaluation is valid only if tests have been conducted in accordance with procedures specified. For evaluation, each specified mixture shall be represented by at least five strength tests.

1.6.5.2 *Core tests*—Core test results will be evaluated by Architect/Engineer and are valid only if tests are conducted in accordance with ASTM C42/C42M. Do not use core tests in place of standard-cured specimens specified in 1.6.5.1 for initial acceptance testing of concrete.

1.6.5.3 *In-place strength tests*

1.6.5.3(a) Results of in-place strength tests will be evaluated by Architect/Engineer and are valid only if tests are conducted using properly calibrated equipment in accordance with recognized standard procedures and an accept-

able correlation between test results and concrete compressive strength is established and submitted.

1.6.5.3(b) The use of cast-in-place cylinders in accordance with ASTM C873/C873M does not require correlation; however, measured strengths shall be corrected using factors in ASTM C39/C39M if length-diameter ratio is less than 1.75.

1.6.6 *Acceptance of concrete strength*

1.6.6.1 *Standard molded and cured strength specimens*—Strength of concrete is satisfactory provided that the criteria of 1.6.6.1(a) and 1.6.6.1(b) are met.

1.6.6.1(a) Every average of three consecutive strength tests equals or exceeds specified compressive strength, f_c'.

1.6.6.1(b) No strength test result falls below f_c' by more than 500 psi if f_c' is 5000 psi or less, or by more than $0.10f_c'$ if f_c' is greater than 5000 psi.

1.6.6.2 If either of the two requirements in 1.6.6.1 is not met, steps shall be taken to increase the average of subsequent strength test results.

1.6.6.3 *Core tests*—Strength of concrete in area represented by core tests is considered satisfactory if average compressive strength of cores is at least 85 percent of f_c', and if no single core strength is less than 75 percent of f_c'. Additional testing of cores extracted from locations represented by erratic core strength results will be permitted.

1.6.6.4 *In-place tests*—In-place tests shall not be used as the sole basis for accepting or rejecting concrete, but may be used, if specified, to evaluate concrete if strength test results of standard molded and cured cylinders fail to meet the criteria in 1.6.6.1.

1.6.7 *Acceptance of steel fiber-reinforced concrete*—Unless otherwise specified, steel fiber-reinforced concrete designated in Contract Documents for use in members to provide shear resistance is satisfactory if the criteria of 1.6.7.1 through 1.6.7.3 are met.

1.6.7.1 Compressive strength of cylinders prepared and tested in accordance with 1.6.3.2(e) comply with the criteria of 1.6.6.1.

1.6.7.2 Residual strength obtained from flexural testing in accordance with ASTM C1609/C1609M at midspan deflection of 1/300 of span length is not less than 1.6.7.2(a) and 1.6.7.2(b).

1.6.7.2(a) 90 percent of the measured first-peak strength obtained from the flexural test.

1.6.7.2(b) 90 percent of the strength corresponding to $7.5\sqrt{f_c'}$.

1.6.7.3 Residual strength obtained from flexural testing in accordance with ASTM C1609/C1609M at midspan deflection of 1/150 of span length is not less than 1.6.7.3(a) and 1.6.7.3(b).

1.6.7.3(a) 75 percent of the measured first-peak strength obtained from the flexural test.

1.6.7.3(b) 75 percent of the strength corresponding to $7.5\sqrt{f_c'}$.

1.6.8 *Field acceptance of concrete*

1.6.8.1 *Air content*—If measured air content at point of discharge from transportation unit is greater than the upper limit of 4.2.2.7(b), a check test of air content will be performed on a new sample from point of discharge from transportation unit. If check test fails, concrete has failed to meet the requirements of this Specification. If measured air content is less than lower limits of 4.2.2.7(b), adjustments will be permitted in accordance with ASTM C94/C94M, unless otherwise specified. If check test of the adjusted mixture fails, concrete has failed to meet the requirements of this Specification.

1.6.8.2 *Slump*—If measured slump at point of discharge from transportation unit is greater than specified in 4.2.2.2, a check test will be performed on a new sample from point of discharge from transportation unit. If check test fails, concrete is considered to have failed to meet the requirements of this Specification. If measured slump is less than specified in 4.2.2.2, adjustments will be permitted in accordance with ASTM C94/C94M, unless otherwise specified. If the test of slump of the adjusted mixture fails, concrete is considered to have failed to meet the requirements of this Specification.

1.6.8.3 *Temperature*—If measured concrete temperature at point of discharge from transportation unit is not within the limits of 4.2.2.5, or as otherwise specified, a check test will be performed at a new location in the sample. If check test fails, concrete is considered to have failed to meet the requirements of this Specification.

1.7—Acceptance of structure

1.7.1 *General*—Completed concrete Work shall conform to applicable requirements of this Specification and Contract Documents.

1.7.1.1 Concrete Work that fails to meet one or more requirements in Contract Documents but subsequently is repaired to bring concrete into compliance will be accepted.

1.7.1.2 Concrete Work that fails to meet one or more requirements in Contract Documents and cannot be brought into compliance is subject to rejection.

1.7.1.3 Repair rejected concrete Work by removing and replacing or by additional construction to strengthen or otherwise satisfy project requirement as directed by Architect/Engineer. To bring rejected Work into compliance, use repair methods that meet applicable requirements for function, durability, dimensional tolerances, and appearance as determined by Architect/Engineer.

1.7.1.4 Submit proposed repair methods, materials, and modifications needed to repair concrete Work to meet requirements in Contract Documents.

1.7.1.5 Repair concrete Work as necessary to be in compliance with requirements in Contract Documents.

1.7.2 *Dimensional tolerances*

1.7.2.1 Unless otherwise specified, construction tolerances shall conform to ACI 117.

1.7.2.2 Concrete members with dimensions smaller than permitted tolerances may be considered deficient in strength and subject to provisions of 1.7.4.

1.7.2.3 Concrete members with dimensions larger than permitted tolerances are subject to rejection. Remove excess materials if required by Architect/Engineer.

1.7.2.4 Concrete surfaces that do not meet tolerances are subject to rejection.

1.7.2.5 Slabs not meeting tolerances may be corrected provided they are brought into compliance with 1.7.3, 1.7.4, and 1.7.5.

1.7.2.6 Concrete members cast against formwork surfaces not meeting slope or planeness limitations are subject to rejection.

1.7.3 *Finishes*

1.7.3.1 Concrete surfaces not meeting the requirements of 5.3.3 shall be brought into compliance in accordance with 1.7.1.

1.7.4 *Strength of structure*

1.7.4.1 *Criteria for determining potential strength deficiency*—Strength may be considered deficient if Work fails to comply with requirements that control strength of structure including, but not limited to, conditions given in 1.7.4.1(a) through 1.7.4.1(f).

1.7.4.1(a) Concrete strength not meeting requirements of 1.6.6.1(b) and Contract Documents.

1.7.4.1(b) Reinforcement size, quantity, grade, position, or arrangement not meeting requirements in Contract Documents.

1.7.4.1(c) Concrete elements exceeding tolerances specified in Contract Documents.

1.7.4.1(d) Curing and protection not meeting requirements in Contract Documents.

1.7.4.1(e) Mechanical injury, construction fires, or premature removal of formwork resulting in deficient strength

1.7.4.2 *Action required if strength is potentially deficient*—If structure strength is considered potentially deficient, actions given in 1.7.4.2(a) through 1.7.4.2(e) may be required by Architect/Engineer.

1.7.4.2(a) Structural analysis, additional testing, or both.

1.7.4.2(b) Core tests in accordance with ASTM C42/C42M.

1.7.4.2(c) Load tests may be required if core testing is inconclusive or impractical or if structural analysis does not confirm the safety of the structure.

1.7.4.2(d) Strengthening with additional construction or replacement for concrete work shown deficient by structural analysis or by results of a load test.

1.7.4.2(e) Submittal of documentation for repair work proposed to bring strength-deficient concrete work into compliance with Contract Documents.

1.7.5 *Durability*

1.7.5.1 *Criteria for determining potential durability deficiency*—Durability of concrete Work may be considered deficient if it fails to comply with requirements that control structure durability, including, but not limited to, conditions given in 1.7.5.1(a) through 1.7.5.1(f).

1.7.5.1(a) Strength failing to comply with 1.6.6.1(b) or Contract Documents.

1.7.5.1(b) Materials for concrete not conforming to requirements in 4.2.1.1, 4.2.1.2, 4.2.1.3, 4.2.1.4, 4.2.1.5, or Contract Documents.

1.7.5.1(c) Concrete not conforming to durability requirements in 4.2.2.7 or Contract Documents.

1.7.5.1(d) Curing and protection not meeting requirements 5.3.6 or Contract Documents.

1.7.5.1(e) If measured, internal early-age concrete temperatures or temperature differences greater than specified in Sections 8 and 13 or in Contract Documents.

1.7.5.1(f) Concrete exceeding the maximum allowable chloride ion content requirements in Table 4.2.2.7(d) or Contract Documents.

1.7.5.2 *Action required if durability is potentially deficient*—If structure durability is considered potentially deficient, actions given in 1.7.5.2(a) through 1.7.5.2(e) may be required by Architect/Engineer.

1.7.5.2(a) Obtain and test samples of constituent materials used in the concrete.

1.7.5.2(b) Obtain concrete samples from structure by coring, sawing, or other acceptable means.

1.7.5.2(c) Laboratory evaluation of concrete and concrete materials to assess concrete's resistance to weathering, chemical attack, abrasion, or other deterioration causes, and to protect reinforcement and metallic embedments from corrosion.

1.7.5.2(d) Repair or replace concrete rejected for durability deficiency as directed by Architect/Engineer.

1.7.5.2(e) Submittal of documentation for repair work proposed to bring strength-deficient concrete Work into compliance with Contract Documents.

1.8—Protection of in-place concrete

1.8.1 *Loading and support of structural member or structure*—Do not allow construction loads to exceed the loads that a structural member or structure is capable of supporting safely without damage. Provide supplemental support if construction loads are expected to exceed the safe load capacity.

1.8.2 *Protection from mechanical damage*—Protect concrete from damage by construction traffic, equipment, and materials. During the curing period, protect concrete from damage by mechanical disturbances, including load-induced stresses, shock, and vibration.

1.8.3 *Protection from environmental conditions*—During the curing period, protect concrete from damage by weather.

SECTION 2—FORMWORK AND FORMWORK ACCESSORIES

2.1—General

2.1.1 *Scope*—This section covers requirements for design and construction of formwork.

2.1.2 *Submittals*

2.1.2.1 Unless otherwise specified, comply with 2.1.2.1(a) through 2.1.2.1(f).

2.1.2.1(a) *Form-facing materials*—Submit product information on proposed form-facing materials if different from that specified in 2.2.1.1.

2.1.2.1(b) *Construction and movement joints*—Submit location and detail of construction and movement joints if different from those indicated in Contract Documents.

2.1.2.1(c) *Testing for formwork removal*—Submit method and correlation data for determining concrete strength for formwork removal if test methods of 2.3.4.2(b) through 2.3.4.2(d) are specified or proposed.

2.1.2.1(d) *Reshoring and backshoring procedure*—Submit procedure for reshoring and backshoring, including drawings signed and sealed by a licensed design engineer. Include on shop drawings the formwork removal procedure and magnitude of construction loads used for design of reshoring or backshoring system. Indicate in procedure the magnitude of live and dead loads assumed for required capacity of the structure at time of reshoring or backshoring.

2.1.2.1(e) Submit manufacturer's product data on formwork release agent for use on each form-facing material.

2.1.2.1(f) Submit manufacturer's product data on form liner proposed for use with each formed surface.

2.1.2.2 Comply with 2.1.2.2(a) through 2.1.2.2(e) if required by Contract Documents.

2.1.2.2(a) Submit shop drawings for formwork, shoring, reshoring, and backshoring. If required by Contract Documents or by jurisdiction where the Work will be performed, shop drawings shall be signed and sealed by a licensed design engineer.

2.1.2.2(b) Submit design calculations for formwork, shoring, reshoring, and backshoring. If required by Contract Documents or by jurisdiction where the Work will be performed, design calculations shall be signed and sealed by a licensed design engineer.

2.1.2.2(c) Submit manufacturer's data sheet on form ties.

2.1.2.2(d) Submit manufacturer's data sheet on expansion joint materials.

2.1.2.2(e) Submit manufacturer's data sheet on waterstop materials and splices.

2.2—Products

2.2.1 *Materials*

2.2.1.1 *Form-facing materials*—Unless otherwise specified, form-facing material in contact with concrete shall be lumber, plywood, tempered concrete-form-grade hardboard, metal, plastic, or treated paper that creates specified appearance and texture of concrete surface.

2.2.1.2 *Formwork accessories*—Use commercially manufactured formwork accessories, including ties and hangers. Use form ties with ends or end fasteners that can be removed without damage to concrete. Where indicated in Contract Documents, use form ties with integral water barrier plates or other acceptable positive water barriers in walls. Unless otherwise specified, the breakback distance for ferrous ties shall be at least 3/4 in. for Surface Finish-2.0 or Surface Finish-3.0, as defined in 5.3.3.3. Where indicated in Contract Documents or if specified breakback distance is less than 3/4 in., use coated or corrosion-resistant ties.

2.2.1.3 *Formwork release agent*—Use commercially manufactured formwork release agent that reduces formwork moisture absorption, inhibits bond with concrete, and does not stain exposed concrete surfaces.

2.2.1.4 *Expansion joint filler*—Preformed expansion joint filler shall conform to ASTM D994/D994M, D1751, or D1752.

2.2.1.5 *Other embedded items*—Use waterstops, sleeves, inserts, anchors, and other embedded items of material and design indicated in Contract Documents. Waterstop materials shall conform to CRD C513 for rubber waterstop, or CRD C572 for polyvinyl chloride waterstop. Use factory-manufactured premolded mitered corners.

2.2.1.6 *Chamfer materials*—Unless otherwise specified, use lumber materials with dimensions of 3/4 x 3/4 in.

2.2.2 *Performance and design requirements*

2.2.2.1 Contractor is responsible for design of formwork.

2.2.2.2 Design formwork, shores, reshores, and backshores to support loads transmitted to them and to comply with applicable building code requirements. Design formwork and shoring for load redistribution resulting from stressing of post-tensioned reinforcement. Design formwork to withstand pressure resulting from placement and vibration of concrete and to maintain specified tolerances.

2.2.2.3 Unless otherwise specified, do not use earth cuts as forms for vertical or sloping surfaces.

2.2.2.4 Unless otherwise specified, limit deflection of facing materials for concrete surfaces exposed to view to 1/240 of center-to-center spacing of facing supports. For architectural concrete, refer to 6.2.2.1(a).

2.2.2.5 *Construction and movement joints*

2.2.2.5(a) Unless otherwise specified, submit details and locations of construction joints in accordance with the following requirements:

(a) Locate joints within middle one-third of spans of slabs, beams, and girders. If a beam intersects a girder within the middle one-third of girder span, the distance between the construction joint in the girder and the edge of the beam shall be at least twice the width of the larger member.

(b) For members with post-tensioning tendons, locate joints where tendons pass through centroid of concrete section.

(c) Locate joints in walls and columns at underside of slabs, beams, or girders and at tops of footings or slabs.

(d) Make joints perpendicular to main reinforcement.

2.2.2.5(b) Provide movement joints where indicated in Contract Documents or in accepted alternate locations.

2.2.2.5(c) Provide keyways where indicated in Contract Documents. Unless otherwise specified, longitudinal keyways indicated in Contract Documents shall be at least 1-1/2 in. deep, measured perpendicular to the plane of the joint.

2.2.2.5(d) Design formwork to accommodate waterstop materials in joints at locations indicated in Contract Documents.

2.2.2.6 Provide temporary openings in formwork if needed to facilitate cleaning and inspection.

2.2.2.7 For post-tensioned applications, ensure that formwork allows movement resulting from application of prestressing force.

2.2.3 *Fabrication and manufacture*

2.2.3.1 Fabricate formwork joints to inhibit leakage of mortar.

2.3—Execution

2.3.1 *Construction and erection of formwork*

2.3.1.1 Construct formwork to inhibit leakage of mortar from fresh concrete at joints in formwork and produce surface finish in accordance with 5.3.3.3. Remove leaked mortar from formwork joints before reuse.

2.3.1.2 Unless otherwise specified, place chamfer strips in corners of formwork to produce beveled edges on permanently exposed surfaces. Unless otherwise specified, do not bevel reentrant corners or edges of formed joints of concrete.

2.3.1.3 Inspect formwork and remove foreign material before concrete is placed.

2.3.1.4 At construction joints, lap form-facing materials over the concrete of previous placement. Ensure formwork is placed against hardened concrete so offsets at construction joints conform to specified tolerances

2.3.1.5 Unless otherwise specified, construct formwork so concrete surfaces conform to tolerances in ACI 117. Unless otherwise specified, class of surface for offset between adjacent pieces of formwork facing material shall be in accordance with 5.3.3.

2.3.1.6 Provide positive means of adjustment (such as wedges or jacks) of shores and struts. Do not make adjustments in formwork after concrete has reached initial setting. Brace formwork to resist lateral deflection and lateral instability.

2.3.1.7 To maintain specified elevation and thickness within tolerances, install formwork to compensate for deflection and anticipated settlement in formwork during concrete placement. Set formwork and intermediate screed strips for slabs to produce designated elevation, camber, and contour of finished surface before formwork removal. If specified finish requires use of vibrating screeds or roller pipe screeds, ensure that edge forms and screed strips are strong enough to support such equipment.

2.3.1.8 Fasten form wedges in place after final adjustment of forms and before concrete placement.

2.3.1.9 Provide anchoring and bracing to control upward and lateral movement of formwork system.

2.3.1.10 Construct formwork for openings to facilitate removal and to produce opening dimensions as specified and within tolerances.

2.3.1.11 Provide runways for moving equipment. Support runways directly on formwork or structural members. Do not support runways on reinforcement. Loading applied by runways shall not exceed capacity of formwork or structural members.

2.3.1.12 Position and secure sleeves, inserts, anchors, and other embedded items such that embedded items are positioned within ACI 117 tolerances.

2.3.1.13 Position and support expansion joint materials, waterstops, and other embedded items to prevent displacement. Fill voids in sleeves, inserts, and anchor slots temporarily with removable material to prevent concrete entry into voids.

2.3.1.14 Clean surfaces of formwork and embedded materials of mortar, grout, and foreign materials before concrete placement.

2.3.1.15 Cover formwork surfaces with an acceptable material that inhibits bond with concrete. If formwork release agent is used, apply to formwork surfaces in accordance with manufacturer's recommendations before placing reinforcement. Remove excess release agent on formwork prior to concrete placement. Do not allow formwork release agent to contact reinforcement or hardened concrete against which fresh concrete is to be placed.

2.3.1.16 Erect form-facing materials to produce surface finish in accordance with 5.3.3. Repair or replace used form-facing materials that do not produce surface finish in accordance with 5.3.3.

2.3.1.17 Install formwork to accommodate waterstop materials. Locate waterstops in joints where indicated in Contract Documents. Minimize number of splices in waterstop. Splice waterstops in accordance with manufacturer's written instructions. Install factory-manufactured premolded mitered corners.

2.3.2 *Removal of formwork*

2.3.2.1 If vertical formed surfaces require finishing, remove forms as soon as removal operations will not damage concrete.

2.3.2.2 Remove top forms on sloping surfaces of concrete as soon as removal will not allow concrete to sag. Perform repairs and finishing operations required. If forms are removed before end of specified curing period, provide curing and protection in accordance with Section 5.

2.3.2.3 Do not damage concrete during removal of vertical formwork for columns, walls, and sides of beams. Perform needed repair and finishing operations required on vertical surfaces. If forms are removed before end of specified curing period, provide curing and protection in accordance with Section 5.

2.3.2.4 Unless otherwise specified, leave formwork and shoring in place to support construction loads and weight of concrete in beams, slabs, and other structural members until in-place strength of concrete determined in accordance with 2.3.4 is at least f_c'.

2.3.2.5 Unless otherwise specified, form-facing material and horizontal facing support members may be removed before in-place concrete reaches specified compressive strength if shores and other supports are designed to allow facing removal without deflection of supported slab or member.

2.3.2.6 For post-tensioned structures, do not remove formwork supports until stressing records have been accepted by Architect/Engineer.

2.3.2.7 After ends or end fasteners of form ties have been removed, repair tie holes in accordance with 5.3.7.2.

2.3.3 *Reshoring and backshoring*

2.3.3.1 If the reshoring and backshoring procedure described in 2.1.2.1(d) is submitted, do not allow structural members to be loaded with combined dead and construction loads in excess of loads indicated in the accepted procedure.

2.3.3.2 If the reshoring and backshoring procedure described in 2.1.2.1(d) is submitted, install and remove reshores or backshores in accordance with accepted procedure.

2.3.3.3 For floors supporting shores under newly placed concrete, either leave original supporting shores in place, or install reshores or backshores. Shoring system and supporting slabs shall resist anticipated loads. Locate reshores and backshores directly under a shore position or as indicated on formwork shop drawings.

2.3.3.4 In multistory buildings, place reshoring or backshoring over a sufficient number of stories to distribute weight of newly placed concrete, forms, and construction

live loads in accordance with reshoring and backshoring procedure in 2.1.2.1(d).

2.3.4 *Strength of concrete required for removal of formwork*

2.3.4.1 If removal of formwork, reshoring, or backshoring is based on concrete reaching a specified in-place strength, mold and field-cure cylinders in accordance with ASTM C31/C31M. Test cylinders in accordance with ASTM C39/C39M.

2.3.4.2 Alternatively, if specified, use one or more of the methods listed in 2.3.4.2(a) through 2.3.4.2(d) to evaluate in-place concrete strength for formwork removal.

2.3.4.2(a) Tests of cast-in-place cylinders in accordance with ASTM C873/C873M. This option is limited to slabs with concrete depths from 5 to 12 in.

2.3.4.2(b) Penetration resistance in accordance with ASTM C803/C803M.

2.3.4.2(c) Pullout strength in accordance with ASTM C900.

2.3.4.2(d) Maturity method in accordance with ASTM C1074.

2.3.5 *Field quality control*

2.3.5.1 Establish and maintain survey controls and benchmarks in an undisturbed condition until completion of the concrete structure and its building envelope.

2.3.5.2 Before concrete is placed, inspect formwork for conformance to Contract Documents. If specified, notify representative for Special Inspection or Owner's quality assurance inspection.

SECTION 3—REINFORCEMENT AND REINFORCEMENT SUPPORTS

3.1—General

3.1.1 *Scope*—This section covers materials, fabrication, placement, and tolerances for steel reinforcement, and reinforcement supports.

3.1.2 *Submittals*

3.1.2.1 Unless otherwise specified, comply with 3.1.2.1(a) through 3.1.2.1(i) before fabrication and execution.

3.1.2.1(a) *Reinforcement*—Submit manufacturer's certified test report for reinforcement.

3.1.2.1(b) *Placing drawings*—Submit placing drawings showing fabrication dimensions and placement locations of reinforcement and reinforcement supports. Placing drawings shall indicate locations of splices, lengths of lap splices, and details of mechanical and welded splices.

3.1.2.1(c) *Splices*—Submit request with locations and details of splices not indicated in Contract Documents.

3.1.2.1(d) *Mechanical splices*—Submit data on mechanical splices demonstrating compliance with 3.2.1.2(d) and 3.2.1.10.

3.1.2.1(e) *Column dowels*—Submit request to place column dowels without using templates.

3.1.2.1(f) *Field bending or straightening*—Submit request and procedure to field-bend or straighten reinforcing bars partially embedded in concrete at locations not indicated in Contract Documents.

3.1.2.1(g) *Epoxy-coated reinforcement*—If epoxy-coated steel reinforcement is specified, submit either: 1) Concrete Reinforcing Steel Institute (CRSI) Epoxy Coating Plant Certification; or 2) inspection and quality-control program of plant applying epoxy coating if proposed plant is not certified in accordance with CRSI Epoxy Coating Plant Certification Program.

3.1.2.1(h) *Field cutting of reinforcing bars*—Submit request for field cutting, including location and type of bar to be cut and reason field cutting is required.

3.1.2.1(i) *Supports*—If coated reinforcement is required, submit description of reinforcement supports and materials for fastening coated reinforcement if not in conformance with CRSI RB4.1.

3.1.3 *Material storage and handling*

3.1.3.1 Handle and store reinforcement to maintain fabricated shape and material condition as required in 3.3.1.

3.1.3.2 When handling and storing coated reinforcement, use equipment and methods that do not damage the coating. If stored outdoors for more than 2 months, cover coated reinforcement with opaque protective material.

3.2—Products

3.2.1 *Materials*

3.2.1.1 *Steel reinforcing bars*—Reinforcing bars shall be deformed, except spirals, load-transfer dowels, and welded wire reinforcement, which may be plain. Reinforcing bars shall be grades, types of steel, and sizes required by Contract Documents and shall conform to one of the following:

(a) ASTM A615/A615M
(b) ASTM A706/A706M
(c) ASTM A955/A955M
(d) ASTM A996/A996M, rail-steel bars shall be Type R; axle steel bars shall be Type A
(e) ASTM A1035/A1035M

3.2.1.2 *Coated reinforcing bars*—If specified in Contract Documents, use zinc-coated (galvanized), epoxy-coated, or zinc and epoxy dual-coated reinforcing bars.

3.2.1.2(a) Zinc-coated (galvanized) reinforcing bars shall conform to ASTM A767/A767M and other requirements as specified in Contract Documents. Coating damage incurred during shipment, handling, and placing of zinc-coated (galvanized) reinforcing bars shall be repaired in accordance with ASTM A780/A780M. Damaged areas shall not exceed 2 percent of surface area in each linear foot of each bar or bar shall not be used. The 2 percent limit on maximum allowed damaged coating area shall include previously repaired areas damaged before shipment as required by ASTM A767/A767M.

3.2.1.2(b) Epoxy-coated reinforcing bars shall conform to ASTM A775/A775M or ASTM A934/A934M as specified in Contract Documents. Coatings shall be applied in plants that are certified in accordance with Concrete Reinforcing Steel Institute (CRSI) Epoxy Coating Plant Certification Program or an equivalent program acceptable to Architect/Engineer. Coating damage incurred during shipment, storage, handling, and placing of epoxy-coated reinforcing bars shall be repaired. Repair damaged coating areas with patching material conforming to ASTM A775/A775M or ASTM A934/ 934M as applicable and in accordance with

material manufacturer's written recommendations. Damaged coating area shall not exceed 2 percent of surface area in each linear foot of each bar or bar shall not be used. The 2 percent limit on damaged coating area shall include repaired areas damaged before shipment as required by ASTM A775/A775M or A934/A934M as applicable. Fading of coating color shall not be cause for rejection of epoxy-coated reinforcing bars.

3.2.1.2(c) Zinc and epoxy dual-coated reinforcing bars shall conform to ASTM A1055/A1055M. Coating damage incurred during shipment, storage, handling, and placing of zinc and epoxy dual-coated reinforcing bars shall be repaired. Repair damaged coating areas with patching material conforming to ASTM A1055/A1055M and in accordance with material manufacturer's written recommendations. Damaged coating area shall not exceed 2 percent of surface area in each linear foot of each bar or bar shall not be used. The 2 percent limit on damaged coating area shall include repaired areas damaged before shipment as required by ASTM A1055/A1055M. Fading of coating color shall not be cause for rejection of zinc and epoxy dual-coated reinforcing bars.

3.2.1.2(d) Mechanical splices for galvanized reinforcing bars shall be galvanized or coated with dielectric material. Mechanical splices used with epoxy-coated or dual-coated reinforcing bars shall be coated with dielectric material.

3.2.1.4 *Bar mats*—If specified, bar mats shall conform to ASTM A184/A184M. When welding bars, comply with requirements in 3.2.2.2. If coated bar mats are required, repair damaged coating in accordance with 3.2.2.2(b).

3.2.1.5 *Headed reinforcing bars*—Headed reinforcing bars shall conform to ASTM A970/A970M including Annex A1, and other specified requirements.

3.2.1.6 *Wire*—Use plain or deformed wire as indicated in Contract Documents. Plain and deformed wire shall conform to one or more of the specifications given in 3.2.1.6(a) through 3.2.1.6(c)

3.2.1.6(a) Plain or deformed steel wire shall conform to ASTM A1064/A1064M.

3.2.1.6(b) Stainless steel wire shall conform to ASTM A1022/A1022M.

3.2.1.6(c) Epoxy-coated wire shall conform to ASTM A884/A884M. Coating damage incurred during shipment, storage, handling, and placing of epoxy-coated wires shall be repaired. Repair damaged coating areas with patching material in accordance with material manufacturer's written recommendations. If damaged area exceeds 2 percent of surface area in each linear foot of each wire, wire shall not be used.

The 2 percent limit on damaged coating area shall include repaired areas damaged before shipment as required by ASTM A884/A884M. Fading of coating color shall not be cause for rejection of epoxy-coated wire reinforcement.

3.2.1.7 *Welded wire reinforcement*—Use welded wire reinforcement specified in Contract Documents and conforming to one or more of the specifications given in 3.2.1.7(a) through 3.2.1.7(e).

3.2.1.7(a) Plain welded wire reinforcement shall conform to ASTM A1064/A1064M, with welded intersections spaced no greater than 12 in. apart in direction of principal reinforcement.

3.2.1.7(b) Deformed welded wire reinforcement shall conform to A1064/A1064M, with welded intersections spaced no greater than 16 in. apart in direction of principal reinforcement.

3.2.1.7(c) *Epoxy-coated welded wire reinforcement*—Epoxy-coated welded wire reinforcement shall conform to ASTM A884/A884M. Coating damage incurred during shipment, storage, handling, and placing of epoxy-coated welded wire reinforcement shall be repaired in accordance with ASTM A884/A884M. Repair damaged coating areas with patching material in accordance with material manufacturer's written recommendations. If damaged area exceeds 2 percent of surface area in each linear foot of each wire or welded wire reinforcement, the sheet containing the damaged area shall not be used. The 2 percent limit on damaged coating area shall include repaired areas damaged before shipment as required by ASTM A884/A884M. Fading of coating color shall not be cause for rejection of epoxy-coated welded wire reinforcement.

3.2.1.7(d) Stainless steel welded wire reinforcement shall conform to ASTM A1022/A1022M.

3.2.1.7(e) *Zinc-coated (galvanized) welded wire reinforcement*—Zinc-coated (galvanized) welded wire reinforcement shall conform to ASTM A1060/A1060M. Coating damage incurred during shipment, storage, handling, and placing of zinc-coated (galvanized) welded wire reinforcement shall be repaired in accordance with ASTM A780/A780M. If damaged area exceeds 2 percent of surface area in each linear foot of each wire or welded wire reinforcement, the sheet containing the damaged area shall not be used. The 2 percent limit on damaged coating area shall include repaired areas damaged before shipment as required by ASTM A1060/A1060M.

3.2.1.8 *Headed shear stud reinforcement*—Headed studs and headed stud assemblies shall conform to ASTM A1044/A1044M.

3.2.1.9 *Reinforcement supports*—Provide reinforcement support types within structure as required by Contract Documents. Reinforcement supports shall conform to CRSI RB4.1.

3.2.1.10 *Mechanical splices*—Mechanical splices shall develop at least 125 percent of the specified yield strength of bars being spliced.

3.2.2 *Fabrication*

3.2.2.1 *Bending*—Bend reinforcement cold. Fabricate reinforcement in accordance with fabricating tolerances of ACI 117.

3.2.2.2 *Welding*

3.2.2.2(a) If welding steel reinforcing bars is specified, comply with AWS D1.4/D1.4M unless otherwise specified. Do not tack weld reinforcing bars. Welded assemblies of steel reinforcement produced under factory conditions, such as welded wire reinforcement, bar mats, and deformed bar anchors, are allowed.

3.2.2.2(b) After completing welds on zinc-coated (galvanized), epoxy-coated, or zinc and epoxy dual-coated reinforcement, coat welds and repair coating damage in

accordance with requirements in 3.2.1.2(a), 3.2.1.2(b), or 3.2.1.2(c), respectively.

3.3—Execution

3.3.1 *Preparation*—When concrete is placed, reinforcement shall be free of materials deleterious to bond. Reinforcement with rust, mill scale, or a combination of both will be considered satisfactory, provided minimum nominal dimensions, nominal weight, and minimum average height of deformations of a hand-wire-brushed test specimen are not less than applicable ASTM specification requirements.

3.3.2 *Placing*

3.3.2.1 *Tolerances*—Place, support, and fasten reinforcement to maintain its location during concrete placement in accordance with Contract Documents. Do not exceed tolerances specified in ACI 117 before concrete is placed.

3.3.2.2 *Reinforcement relocation*—If movement of reinforcement beyond specified placing tolerances is necessary to avoid interference with other reinforcement, conduits, or embedded items, submit resulting reinforcement arrangement. Placing concrete in area of relocated reinforcement is prohibited before receiving acceptance from Architect/Engineer.

3.3.2.3 *Concrete cover*—Unless otherwise specified, concrete cover for reinforcement shall conform to 3.3.2.3(a) through 3.3.2.3(e). Concrete cover tolerances shall comply with ACI 117. Position tie wire ends away from exposed concrete surfaces.

3.3.2.3(a) Nonprestressed cast-in-place concrete members shall have concrete cover for reinforcement given in Table 3.3.2.3(a).

Table 3.3.2.3(a)—Concrete cover for cast-in-place nonprestressed concrete members

Concrete exposure	Member	Reinforcement	Specified cover, in.
Cast against and permanently in contact with ground	All	All	3
Exposed to weather or in contact with ground	All	No. 6 through No. 18 bars	2
		No. 5 bar, W31 or D31 wire, and smaller	1-1/2
Not exposed to weather or in contact with ground	Slabs, joists, and walls	No. 14 and No. 18 bars	1-1/2
		No. 11 bar and smaller	3/4
	Beams, columns, pedestals, and tension ties	Primary reinforcement, stirrups, ties, spirals, and hoops	1-1/2

3.3.2.3(b) Cast-in-place prestressed concrete members shall have concrete cover for reinforcement, ducts, and end fittings given in Table 3.3.2.3(b).

Table 3.3.2.3(b)—Concrete cover for cast-in-place prestressed concrete members

Concrete exposure	Member	Reinforcement	Specified cover, in.
Cast against and permanently in contact with ground	All	All	3
Exposed to weather or in contact with ground	Slabs, joists, and walls	All	1
	All other	All	1-1/2
Not exposed to weather or in contact with ground	Slabs, joists, and walls	All	3/4
	Beams, columns, and tension ties	Primary reinforcement	1-1/2
		Stirrups, ties, spirals, and hoops	1

3.3.2.3(c) Precast nonprestressed or prestressed concrete members manufactured under plant conditions shall have concrete cover for reinforcement, ducts, and end fittings given in Table 3.3.2.3(c).

Table 3.3.2.3(c)—Concrete cover for precast nonprestressed or prestressed concrete members manufactured under plant conditions

Concrete exposure	Member	Reinforcement	Specified cover, in.
Exposed to weather or in contact with ground	Walls	No. 14 and No. 18 bars; tendons larger than 1-1/2 in. diameter	1-1/2
		No. 11 bars and smaller; W31 and D31 wire, and smaller; tendons and strands 1-1/2 in. diameter and smaller	3/4
	All other	No. 14 and No. 18 bars; tendons larger than 1-1/2 in. diameter	2
		No. 6 through No. 11 bars; tendons and strands larger than 5/8 in. diameter through 1-1/2 in. diameter	1-1/2
		No. 5 bar, W31 or D31 wire, and smaller; tendons and strands 5/8 in. diameter and smaller	1-1/4
Not exposed to weather or in contact with ground	Slabs, joists, and walls	No. 14 and No. 18 bars; tendons larger than 1-1/2 in. diameter	1-1/4
		Tendons and strands 1-1/2 in. diameter and smaller	3/4
		No. 11 bar, W31 or D31 wire, and smaller	5/8
	Beams, columns, pedestals, and tension ties	Primary reinforcement	Greater of d_b and 5/8 and need not exceed 1-1/2
		Stirrups, ties, spirals, and hoops	3/8

3.3.2.3(d) For bundled bars, concrete cover shall be the smaller of (a) and (b):

(a) Equivalent diameter of the bundle

(b) 2 in., and for concrete cast against and permanently in contact with ground, the specified cover shall be 3 in.

3.3.2.3(e) For headed shear stud reinforcement, concrete cover for the heads and base rails shall be the same as for surrounding reinforcement unless otherwise specified.

3.3.2.4 *Reinforcement supports*—Install reinforcement supports in accordance with CRSI RB4.1.

3.3.2.4(a) In walls reinforced with epoxy-coated or dual-coated reinforcement, use epoxy-coated, polymer-coated, or composite spacers between reinforcement layers to maintain spacing.

3.3.2.4(b) Fasten epoxy-coated or dual-coated reinforcement with tie wires coated with epoxy or other polymer.

3.3.2.5 *Welded wire reinforcement*—Support welded wire reinforcement in accordance with CRSI RB4.1 to maintain positioning during concrete placement.

3.3.2.5(a) *Welded wire reinforcement in slabs on composite steel deck and slabs-on-ground*—Reinforcement shall be placed into position prior to concrete placement. Unless otherwise specified, do not extend welded wire reinforcement through movement joints. Place reinforcement as indicated in Contract Documents. If reinforcement less than W4.0 or D4.0 is specified, the continuous support spacing shall not exceed 12 in. Reinforcement nearest edge of slab shall be no farther from edge of slab than greater of specified cover or 2 in. Unless otherwise specified, overlap parallel wires at edges of reinforcement not less than 2 in.

3.3.2.5(b) *Welded wire reinforcement in elevated formed slabs, slabs on noncomposite steel deck, and members not covered in 3.3.2.5(a)*—Use sheets of welded wire reinforcement. Place and support reinforcement before concrete placement to maintain location within tolerances indicated for nonprestressed reinforcement in ACI 117. If reinforcement less than W4.0 or D4.0 is specified, the continuous support spacing shall not exceed 12 in. perpendicular to the direction of span. Lap splice edges and ends of welded wire reinforcement sheets as indicated in Contract Documents.

3.3.2.6 *Dowels*—Deformed bar dowels shall be secured into position using templates or by tying into position before concrete placement.

3.3.2.7 *Splices*—Splice reinforcement as indicated in Contract Documents. Mechanical splices for reinforcing bars not indicated in Contract Documents shall not be used unless accepted by Architect/Engineer. Remove coating on reinforcing bar in area of mechanical splice if required by splice manufacturer. After installing mechanical splices on zinc-coated (galvanized), epoxy-coated, or zinc and epoxy dual-coated reinforcing bars, repair coating damage and areas of removed coating in accordance with 3.2.1.2(a), 3.2.1.2(b), or 3.2.1.2(c). Coat exposed parts of mechanical splices used on coated bars with same material used to repair coating damage.

3.3.2.8 *Field bending or straightening*—Field bending of reinforcing bars partially embedded in concrete shall not be permitted, except as indicated in Contract Documents. When bending is permitted and unless other methods are specified, bend or straighten reinforcing bars partially embedded in concrete in accordance with procedures 3.3.2.8(a) through 3.3.2.8(d).

3.3.2.8(a) Reinforcing bar sizes No. 3 through No. 5 may be bent cold one time, provided reinforcing bar temperature is above 32°F. For other bar sizes, preheat reinforcing bars before field bending or straightening.

3.3.2.8(b) *Preheating*—Apply heat by methods that do not harm reinforcing bar material or cause damage to concrete. Preheat length of reinforcing bar equal to at least five bar diameters in each direction from center of bend but do not extend preheating below concrete surface. Do not allow temperature of reinforcing bar at concrete interface to exceed 500°F. Preheat temperature of reinforcing bar shall be between 1100 and 1200°F. Maintain preheat temperature until bending or straightening is complete.

Measure preheat temperature by temperature measurement crayons or pyrometer. Do not artificially cool heated reinforcing bars until bar temperature is less than 600°F. Heat shall not be applied to low-carbon chromium reinforcement complying with ASTM A1035. Epoxy- and dual-coated reinforcing bars shall be heated by a method that not damage the epoxy coating.

3.3.2.8(c) *Bend diameters*—Bend diameters shall conform to requirements of Table 3.3.2.8. In addition, beginning of bend shall not be closer to concrete surface than specified bend diameter.

Table 3.3.2.8—Minimum diameter of bend

Bar size	Inside bend diameter
No. 3 through 8	Six bar diameters
No. 3 through 5 stirrups and ties	Four bar diameters
No. 9, 10, and 11	Eight bar diameters
No. 14 and 18	Ten bar diameters

3.3.2.8(d) *Repair of bar coatings*—After field bending or straightening zinc-coated (galvanized), epoxy-coated, or zinc and epoxy dual-coated reinforcing bars, repair coating damage in accordance with 3.2.1.2(a), 3.2.1.2(b), or 3.2.1.2(c).

3.3.2.9 *Field cutting reinforcement*—Field cut after acceptance by Architect/Engineer. Do not flame cut coated or low-carbon chromium reinforcement, including reinforcement complying with ASTM A775/A775M, A934, A1035, or A1055/A1055M.

3.3.2.9(a) If zinc-coated (galvanized) reinforcing bars are cut in field, coat bar ends with a zinc-rich formulation used in accordance with manufacturer's recommendations, and repair damaged coating in accordance with 3.2.1.2(a).

3.3.2.9(b) If epoxy-coated reinforcing bars are cut in field, coat bar ends with same material used for repair of damaged coating, and repair damaged coating in accordance with 3.2.1.2(b).

3.3.2.9(c) If zinc and epoxy dual-coated reinforcing bars are cut in field, coat bar ends with same material used for repair of damaged coating, and repair damaged coating in accordance with 3.2.1.2(c).

3.3.2.10 *Reinforcement through expansion joint*—Do not continue reinforcement or other embedded metal items bonded to concrete through expansion joints. If specified, dowels may continue through expansion joints if unbonded on one side of the joint.

SECTION 4—CONCRETE MIXTURES

4.1—General

4.1.1 *Scope*—This section covers the requirements for materials, proportioning, production, and delivery of concrete.

4.1.2 *Submittals*

4.1.2.1 *Mixture proportions*—Concrete mixture proportions and characteristics.

4.1.2.2 *Mixture strength data*—Field test records used to establish the required average strength in accordance with 4.2.3.3.

4.1.2.3 *Concrete materials*—The following information for concrete materials, along with evidence demonstrating compliance with 4.2.1:

4.1.2.3(a) For cementitious materials: types, manufacturing locations, shipping locations, and certificates showing compliance with ASTM C150/C150M, ASTM C595/C595M, ASTM C618, ASTM C845/C845M, ASTM C989/C989M, ASTM C1157/C1157M, or ASTM C1240.

4.1.2.3(b) For aggregates: types, pit or quarry locations, producers' names, aggregate supplier statement of compliance with ASTM C33/C33M, and ASTM C1293 expansion data not more than 18 months old.

4.1.2.3(c) For admixtures: types, brand names, producers' names, manufacturer's technical data sheets, and certificates showing compliance with ASTM C260/C260M, ASTM C494/C494M, ASTM C1017/C1017M, or ASTM D98.

4.1.2.3(d) For water and ice: source of supply, when nonpotable source is proposed for use, documentation on effects of water on strength and setting time in compliance with ASTM C1602/C1602M. If specified, documentation on optional requirements of ASTM C1602/C1602M.

4.1.2.4 *Field test records*—Data on material and mixture proportions with supporting test results if field test records are used as the basis for selecting proportions and documenting conformance with specified requirements, in accordance with 4.2.3.4(a).

4.1.2.5 *Trial mixture records*—Data on material and mixture proportions with supporting test results if trial mixture records are used as a basis for documenting compliance with specified requirements in accordance with 4.2.3.4(c).

4.1.2.6 *Durability requirements*—Documentation that concrete meets durability requirements of 4.2.2.7.

4.1.2.7 *Resistance to alkali silica reaction*—Information on one of the options for resistance to alkali-silica reaction listed in 4.2.2.6.

4.1.2.8 *Mixture proportion adjustments*—Requests for adjustments to mixture proportions or changes in materials made during the course of the Work, along with supporting documentation showing conformance with the Contract Documents.

4.1.2.9 *Concrete for floors*—Evaluations and test results verifying adequacy of concrete to be placed in floors when the cementitious materials content is less than that specified in Table 4.1.2.9.

Table 4.1.2.9—Minimum cementitious material content requirements for floors

Nominal maximum size of aggregate, in.	Minimum cementitious material content, lb/yd^3
1-1/2	470
1	520
3/4	540
3/8	610

4.1.2.10 *Calcium chloride*—Request to use calcium chloride and data demonstrating compliance with 4.2.2.7(d).

4.1.2.11 *Volumetric batching*—Request and description of method if concrete production by the volumetric batching method is proposed.

4.1.2.12 *Limits on discharge*—Request if maximum time or limits on mixer revolutions for discharge of concrete permitted by ASTM C94/C94M are proposed to be exceeded.

4.1.2.13 *Certification of production facilities and delivery vehicles*—Documentation of certification or approval.

4.1.3 *Quality control*

4.1.3.1 Maintain records verifying that materials used are the specified and accepted types and sizes and are in conformance with 4.2.1.

4.1.3.2 Ensure that production and delivery of concrete conform to 4.3.1 and 4.3.2.

4.1.3.3 Ensure concrete has the specified characteristics in the freshly mixed state at delivery.

4.1.4 *Material storage and handling*

4.1.4.1 *Cementitious materials*—Keep cementitious materials dry and free from contaminants.

4.1.4.2 *Aggregates*—Store and handle aggregate in a manner that will avoid segregation and prevents contamination by other materials or other sizes of aggregates. Store aggregates in locations that will permit them to drain freely. Do not use aggregates that contain frozen lumps.

4.1.4.3 *Water and ice*—Protect mixing water and ice from contamination during storage and delivery.

4.1.4.4 *Admixtures*—Protect stored admixtures against contamination, evaporation, or damage. To ensure uniform distribution of constituents, provide agitating equipment for admixtures used in the form of suspensions or unstable solutions. Protect liquid admixtures from freezing and from temperature changes that would adversely affect their characteristics.

4.2—Products

4.2.1 *Materials*

4.2.1.1 *Cementitious materials*—Unless otherwise specified, cementitious materials shall conform to 4.2.1.1(a) through 4.2.1.1(g). Use cementitious materials that meet the durability criteria of 4.2.2.7.

4.2.1.1(a) Portland cement conforming to ASTM C150.

4.2.1.1(b) Blended hydraulic cement, excluding Type IS (greater than 70), conforming to ASTM C595/C595M. For sections of the structure that are assigned Exposure Class F3,

submit certification on cement composition verifying that concrete mixture meets the requirements of Table 4.2.1.1(b).

Table 4.2.1.1(b)—Maximum cementitious materials requirements for concrete assigned to Exposure Class F3

Cementitious material	Maximum percent of total cementitious material by mass*
Fly ash or other pozzolans conforming to ASTM C618	25
Slag cement conforming to ASTM C989/C989M	50
Silica fume conforming to ASTM C1240	10
Total of fly ash or other pozzolans, slag cement, and silica fume	50†
Total of fly ash or other pozzolans and silica fume	35†

*Total cementitious material also includes ASTM C150/C150M, C595/C595M, C845/C845M, and C1157/C1157M cement. The maximum percentages above shall include:

(a) Fly ash or other pozzolans present in ASTM C1157/C1157M or C595/C595M Type IP blended cement.

(b) Slag cement present in ASTM C1157/C1157M or C595/C595M Type IS blended cement.

(c) Silica fume conforming to ASTM C1240 present in ASTM C1157/C1157M or C595/C595M Type IP blended cement.

†Fly ash or other pozzolans and silica fume shall constitute no more than 25 percent and 10 percent, respectively, of the total mass of the cementitious materials.

4.2.1.1(c) Hydraulic cement conforming to ASTM C1157/C1157M. For sections of the structure that are assigned Exposure Class F3, submit certification on cement composition verifying that concrete mixture meets the requirements of Table 4.2.1.1(b).

4.2.1.1(d) Pozzolans conforming to ASTM C618.

4.2.1.1(e) Slag cement conforming to ASTM C989/C989M.

4.2.1.1(f) Silica fume conforming to ASTM C1240.

4.2.1.1(g) Use cementitious materials of same brand and type and from same manufacturing plant as cementitious materials used in concrete represented by submitted field test records or used in trial mixtures.

4.2.1.2 *Aggregates*—Unless otherwise specified, aggregates shall conform to ASTM C33/C33M. Aggregates used in concrete shall be obtained from the same sources and have the same size range as aggregates used in concrete represented by submitted field test records or used in trial mixtures.

4.2.1.3 *Water and ice*—Unless otherwise specified, mixing water for concrete and water used to make ice shall comply with ASTM C1602/C1602M.

4.2.1.4 *Admixtures*—Unless otherwise specified, admixtures shall conform to the following:

(a) Air-entraining admixtures conforming to ASTM C260/C260M.

(b) Chemical admixtures conforming to ASTM C494/C494M.

(c) Chemical admixtures for use in producing flowing concrete conforming to ASTM C1017/C1017M.

(d) Calcium chloride conforming to ASTM D98. Use calcium chloride admixtures in solution form only.

4.2.1.4.1 Admixtures used in concrete shall be the same as those used in the concrete represented by submitted field test records or used in trial mixtures.

4.2.1.4.2 Calcium chloride admixtures shall not be used for concrete in members assigned to Exposure Classes S2 or S3. Use of chemical admixtures containing chloride ions shall be subject to limitations in 4.2.2.7(d).

4.2.1.5 *Steel fibers*—If steel fiber-reinforced concrete is specified in Contract Documents for providing shear resistance, steel fibers shall be deformed and conform to ASTM A820/A820M. Steel fibers shall have a length-to-diameter ratio of at least 50 and not exceed 100. Steel fibers for other applications shall be in accordance with Contract Documents.

4.2.1.6 *Change of materials*—If changes to brand, type, size, or source of cementitious materials; aggregates; water; ice; or admixtures are proposed, submit new field data, data from new trial mixtures, or other evidence that the change will not adversely affect the relevant properties of the concrete. Submit data before changes are made.

4.2.2 *Performance and design requirements*

4.2.2.1 *Cementitious material content*—Cementitious material content shall be adequate for concrete to satisfy the specified requirements for strength, *w/cm*, durability, and finishability. Cementitious material content for concrete used in floors shall not be less than indicated in Table 4.1.2.9, unless otherwise specified. Acceptance of lower cementitious material content will be contingent upon verification that concrete mixtures with lower cementitious material content will produce a concrete floor slab that meets the requirements of Contract Documents. If a history of finishing quality is not available, evaluate the proposed mixture by placing concrete in a slab at the project site using project materials, equipment, and personnel. The slab shall be at least 8 x 8 ft and have the specified thickness. Slump shall not exceed the specified slump. Submit evaluation results.

4.2.2.2 *Slump*—Unless otherwise specified, select a target slump or slump flow at the point of delivery for all concrete mixtures. Selected target slump shall not exceed 9 in. Selected target slump flow shall not exceed 30 in. Concrete shall not show visible signs of segregation. The target slump or slump flow value shall be enforced for the duration of the project. Determine the slump by ASTM C143/C143M. Slump tolerances shall meet the requirements of ACI 117. Determine slump flow by ASTM C1611/C1611M. Slump flow tolerances shall meet the requirements of ASTM C94/C94M.

4.2.2.3 *Size of coarse aggregate*—Unless otherwise specified, nominal maximum size of coarse aggregate shall not exceed three-fourths of the minimum clear spacing between reinforcement, one-fifth of the narrowest dimension between sides of forms, or one-third of the thickness of slabs or toppings.

4.2.2.4 *Air content*

4.2.2.4(a) Concrete shall be air entrained for members assigned to Exposure Class F1, F2, or F3. The total air content shall be in accordance with 4.2.2.7(b), unless otherwise specified.

4.2.2.4(b) Unless otherwise specified, measure air content in accordance with ASTM C173/C173M or ASTM C231.

4.2.2.4(c) Unless otherwise specified, measure air content at the point of delivery.

Table 4.2.2.7(a)—Requirements for Exposure Category S: sulfate exposure

Exposure class	Maximum *w/cm**	Minimum f_c', psi	Required cementitious materials†—types			Calcium chloride admixture
			ASTM C150/C150M	ASTM C595/C595M	ASTM C1157/C1157M	
S0	NA	2500	NA	NA	NA	No restriction
S1	0.50	4000	II‡§	IP (MS), IS(<70)(MS) IT(MS)	MS	No restriction
S2	0.45	4500	V§	IP(HS), IS(<70)(HS) IT(HS)	HS	Not permitted
S3	0.45	4500	V + pozzolan or slag cement‖	IP (HS) + pozzolan or slag cement§ or IS (<70) (HS) + pozzolan or slag cement§ or IT (HS) + pozzolan or slag cement‖	HS + pozzolan or slag cement‖	Not permitted

*The maximum *w/cm* limits do not apply to lightweight concrete.

†Alternative combinations of cementitious materials of those listed in this table are acceptable if tested for sulfate resistance and meeting the criteria in Table 4.2.2.7(a)1.

‡For seawater exposure, other types of portland cements with tricalcium aluminate (C_3A) contents up to 10 percent are acceptable if the *w/cm* does not exceed 0.40.

§Other available types of cement, such as Type III or Type I, are acceptable in Exposure Classes S1 or S2 if the C_3A contents are less than 8 or 5 percent, respectively.

‖The amount of the specific source of the pozzolan or slag cement to be used shall be at least the amount determined by test or service record to improve sulfate resistance when used in concrete containing Type V cement. Alternatively, the amount of the specific source of the pozzolan or slag used shall not be less than the amount tested in accordance with ASTM C1012/C1012M and meeting the requirements of Table 4.2.2.7(a)1.

4.2.2.4(d) Concrete for slabs to receive a hard-troweled finish shall not contain an air-entraining admixture or have a total air content greater than 3 percent.

4.2.2.5 *Concrete temperature*

4.2.2.5(a) *Minimum temperature*—If the average of the highest and lowest ambient temperature from midnight to midnight is expected to be less than 40°F for more than 3 successive days, deliver concrete to meet the following minimum temperatures immediately after placement unless otherwise specified:

(a) 55°F for sections with least dimension less than 12 in.

(b) 50°F for sections with least dimension 12 to 36 in.

(c) 45°F for sections with least dimension 36 to 72 in.

(d) 40°F for sections with least dimension greater than 72 in.

The temperature of concrete as placed shall not exceed these values by more than 20°F. These minimum temperature requirements may be terminated if temperatures above 50°F occur during more than half of any 24-hour duration.

4.2.2.5(b) *Maximum temperature*—Unless otherwise specified, the temperature of concrete as delivered shall not exceed 95°F.

4.2.2.6 *Resistance to alkali-silica reaction*—Unless otherwise specified, or unless members are assigned to Exposure Class C0, use one of the three options below for qualifying concrete mixtures to reduce the potential of alkali-silica reaction.

4.2.2.6(a) For each aggregate used in concrete, the expansion result determined in accordance with ASTM C1293 shall not exceed 0.04 percent at 1 year.

4.2.2.6(b) For each aggregate used in concrete, the expansion result of the aggregate and cementitious materials combination determined in accordance with ASTM C1567 shall not exceed 0.10 percent at an age of 16 days.

4.2.2.6(c) Alkali content in concrete (LBA) shall not exceed 4 lb/yd^3 for moderately reactive aggregate or 3 lb/yd^3 for highly reactive aggregate. Reactivity shall be determined by testing in accordance with ASTM C1293 and categorized in accordance with ASTM C1778. Alkali content shall be calculated as follows:

LBA = (cement content, lb/yd^3) × (equivalent alkali content of portland cement in percent/100 percent)

4.2.2.7 *Durability*

4.2.2.7(a) *Sulfate resistance*—Unless otherwise specified, provide concrete meeting the requirements of Table 4.2.2.7(a), based on the exposure class assigned to members for sulfate exposure. Submit documentation verifying compliance with specified requirements.

Table 4.2.2.7(a)1—Requirements for establishing suitability of cementitious materials combinations exposed to water-soluble sulfate

Exposure class	Maximum expansion when tested using ASTM C1012/C1012M		
	At 6 months	At 12 months	At 18 months
S1	0.10 percent	NA	NA
S2	0.05 percent	0.10 percent*	NA
S3	NA	NA	0.10 percent

*The 12-month expansion limit applies only when the measured expansion exceeds the 6-month maximum expansion limit.

4.2.2.7(b) *Freezing-and-thawing resistance*—Unless otherwise specified, provide concrete meeting the requirements of Table 4.2.2.7(b) based on exposure class assigned to members for freezing-and-thawing exposure in Contract Documents. Submit documentation verifying compliance with specified requirements.

Table 4.2.2.7(b)—Requirements for Exposure Category F: Freezing and thawing exposure

Exposure class	Maximum *w/cm*	Minimum f_c', psi	Air content	Additional requirements
F0	NA	2500	NA	
F1	0.55	3500	Table 4.2.2.7(b)1	NA
F2	0.45	4500	Table 4.2.2.7(b)1	NA
F3	0.40	5000	Table 4.2.2.7(b)1	Table 4.2.1.1(b)
F3 plain concrete	0.45	4500	Table 4.2.2.7(b)1	Table 4.2.1.1(b)

*The maximum *w/cm* limits do not apply to lightweight concrete.

Table 4.2.2.7(b)1—Total air content for concrete exposed to cycles of freezing and thawing

Nominal maximum aggregate size, in.	Total air content, percent*†	
	Exposure Classes F2 and F3	Exposure Class F1
3/8	7.5	6.0
1/2	7.0	5.5
3/4	6.0	5.0
1	6.0	4.5
1-1/2	5.5	4.5
2	5.0	4.0
3	5.5	3.5

*Tolerance on air content as delivered shall be ±1.5 percent.

†For f_c' > 5000 psi, reducing air content by 1.0 percentage point is acceptable.

4.2.2.7(c) *Low permeability*—Unless otherwise specified, provide concrete meeting the requirements of Table 4.2.2.7(c) based on exposure class assigned to members requiring low permeability in the Contract Documents. Submit documentation verifying compliance with specified requirements.

Table 4.2.2.7(c)—Requirements for Exposure Category W in contact with water requiring low-permeability concrete

Exposure class	Maximum *w/cm**	Minimum f_c', psi	Additional minimum requirements
W0	NA	2500	None
W1	0.50	4000	None

*The maximum *w/cm* limits do not apply to lightweight concrete.

4.2.2.7(d) *Corrosion protection of reinforcement*—Unless otherwise specified, provide concrete meeting the requirements of Table 4.2.2.7(d) based on the exposure class assigned to members requiring protection against reinforcement corrosion in Contract Documents. Submit documentation verifying compliance with specified requirements.

Water-soluble chloride ion content contributed from constituents including water, aggregates, cementitious materials, and admixtures shall be determined for the concrete mixture by ASTM C1218/C1218M at age between 28 and 42 days.

Table 4.2.2.7(d)—Requirements for Exposure Category C: Conditions requiring corrosion protection of reinforcement

Exposure class	Maximum *w/cm**	Minimum f_c', psi	Maximum water-soluble chloride ion (Cl^-) content in concrete, percent by mass of cement
Reinforced concrete			
C0	NA	2500	1.00
C1	NA	2500	0.30
C2	0.40	5000	0.15
Prestressed concrete			
C0	NA	2500	0.06
C1	NA	2500	0.06
C2	0.40	5000	0.06

*The maximum *w/cm* limits do not apply to lightweight concrete.

4.2.2.8 *Strength and* w/cm—The compressive strength and, if required, maximum *w/cm* of the concrete for each portion of the Work, shall be as specified in Contract Documents.

4.2.2.8(a) Unless otherwise specified, strength requirements shall be based on compressive strength tests at 28 days. Compressive strength is measured using 6 x 12 in. or 4 x 8 in. cylindrical specimens made and tested in accordance with ASTM C31/C31M and C39/C39M, respectively. A strength test at designated age is the average of at least two 6 x 12 in. cylinders or the average of at least three 4 x 8 in. cylinders made from the same concrete sample.

4.2.2.9 *Steel fiber-reinforced concrete*—If steel fiber-reinforced concrete is specified for providing shear resistance, the concrete mixture shall conform to ASTM C1116/C1116M. Unless otherwise specified, the mixture shall contain at least 100 lb of steel fibers per cubic yard of concrete and shall meet the requirements of 1.6.7. Steel fiber-reinforced concrete for other applications shall be in accordance with Contract Documents.

4.2.3 *Proportioning*

4.2.3.1 Proportion concrete to comply with 4.2.2 and so concrete can be worked readily into forms and around reinforcement without segregation, and to provide an average compressive strength adequate to meet acceptance requirements of 1.6.6.1. If the production facility has records of field strength tests performed within the past 24 months and spanning no less than 45 calendar days for a class of concrete within 1000 psi of that specified for Work, calculate a sample standard deviation in accordance with 4.2.3.2 and establish the required average compressive strength f_{cr}' in accordance with 4.2.3.3(a). If field strength test records are not available, select f_{cr}' from Table 4.2.3.1.

Table 4.2.3.1—Required average compressive strength f_{cr}' when data are not available to establish standard deviation.

f_c', psi	f_{cr}', psi
Less than 3000	$f_c' + 1000$
3000 to 5000	$f_c' + 1200$
Over 5000	$1.1f_c' + 700$

4.2.3.2 *Sample standard deviation*

4.2.3.2(a) *Field strength test records*—Field strength test records used to calculate sample standard deviation shall represent materials, mixture proportions, quality-control procedures, and climatic conditions similar to those expected in the Work. Test records shall comply with one of the following:

(a) Data from a single group of at least 15 consecutive compressive-strength tests with the same mixture proportions.

(b) Data from two groups of consecutive compressive-strength tests totaling at least 30 compressive-strength tests. Neither of the two groups shall consist of less than 10 tests.

4.2.3.2(b) *Calculate sample standard deviation*—Calculate the sample standard deviation s_s of the strength test records as follows:

(a) For a single group of consecutive test results

$$s_s = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{(n-1)}} \qquad (4.2.3.2(b)a)$$

where s_s is sample standard deviation; n is number of test results considered; $\bar{X}$ is average of n test results considered; and X_i is individual test result

(b) For two groups of consecutive test results

$$s_s = \sqrt{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{(n_1+n_2-2)}} \qquad (4.2.3.2(b)b)$$

where s_s is standard deviation for the two groups combined; s_1 and s_2 are standard deviations for Groups 1 and 2, respectively, calculated in accordance with Eq. (4.2.3.2(b)a); and n_1 and n_2 are number of test results in Groups 1 and 2, respectively

4.2.3.3 *Required average compressive strength*—Calculate f_{cr}' for specified class of concrete in accordance with 4.2.3.3(a) or 4.2.3.3(b).

4.2.3.3(a) Use the sample standard deviation calculated in accordance with 4.2.3.2 to establish f_{cr}' in accordance with Table 4.2.3.3(a)1. Use the k-factor in Table 4.2.3.3(a)2 to adjust for the number of test results considered in calculating the sample standard deviation. Use larger of two values of f_{cr}' calculated.

Table 4.2.3.3(a)1—Required average compressive strength f_{cr}' when data are available to establish a sample standard deviation, psi

f_c', psi	f_{cr}', psi Use the larger of:
5000 or less	$f_{cr}' = f_c' + 1.34ks_s$
	$f_{cr}' = f_c' + 2.33ks_s - 500$
Over 5000	$f_{cr}' = f_c' + 1.34ks_s$
	$f_{cr}' = 0.90f_c' + 2.33ks_s$

Notes: f_{cr}' is required average compressive strength; f_c' is specified concrete strength; k is factor from Table 4.2.3.3(a)2; and s_s is standard deviation calculated in accordance with 4.2.3.2.

Table 4.2.3.3(a)2—k-factor for increasing sample standard deviation for number of tests considered in calculating standard deviation

Total number of tests considered	k-factor for increasing sample standard deviation
15	1.16
20	1.08
25	1.03
30 or more	1.00

Note: Linear interpolation for intermediate number of tests is acceptable.

4.2.3.3(b) When field strength test records are not available to calculate a sample standard deviation, select the required average compressive strength f_{cr}' from Table 4.2.3.1.

4.2.3.4 *Documentation of average compressive strength*—Provide documentation indicating the proposed concrete proportions will produce an average compressive strength equal to or greater than the required average compressive strength. Documentation shall consist of field strength test records in accordance with 4.2.3.4(a) or 4.2.3.4(b), or trial mixtures in accordance with 4.2.3.4(c).

4.2.3.4(a) *Field strength test data for single group of strength tests*—If field strength test data are available and represent a single group of at least 10 consecutive strength tests for one mixture, using the same materials, under the same conditions, and encompassing a period of not less than 45 days, verify that the average of field strength test results equals or exceeds f_{cr}'.

4.2.3.4(b) *Field strength test data for two groups of strength tests*—If the field strength test data represent two groups of strength tests for two mixtures with average strengths that encompass f_{cr}', plot the average strength $\bar{X}_1$ and $\bar{X}_2$ of each group versus the *w/cm* of the corresponding mixture proportions and interpolate between them to establish the required *w/cm*. Establish mixture proportions for f_{cr}' based on the required *w/cm*.

4.2.3.4(c) *Trial mixtures*—Establish mixture proportions based on trial mixtures to comply with the following:

(a) Use materials and material combinations listed in 4.2.1.1 through 4.2.1.4 proposed for the Work.

(b) Determine f_{cr}' in accordance with 4.2.3.3(a) if suitable field strength test data are available, or use Table 4.2.3.1.

(c) Make at least three trial mixtures for each concrete class with a range of proportions that will produce a range of compressive strengths that will encompass f_{cr}'. For concrete made with more than one type of cementitious material, the concrete supplier must establish the *w/cm* and the relative proportions of the cementitious materials and admixtures, if any, that will produce the required average compressive strength.

(d) Proportion trial mixtures to produce a slump as specified for proposed Work, and for air-entrained concrete, air content within the tolerance specified for proposed Work.

(e) For each trial mixture, make and cure three compressive strength cylinders for each test age in accordance with ASTM C192/C192M. Test for compressive strength in accordance with ASTM C39/C39M at 28 days or at the designated test age for f_c'.

(f) Establish mixture proportions based on the trial batch data to achieve an average compressive strength of at least f_{cr}' as determined in 4.2.3.3 and to not exceed maximum *w/cm*. The proposed concrete mixture shall meet other applicable requirements of 4.2.2.7 and trial mixture records shall have been developed less than 24 months from the date of submittal.

4.2.3.5 *Field verification of selected mixture proportions*—If required, conduct field verification of the effects of placement methods on concrete mixture characteristics. Using materials and mixture proportions accepted for use in the Work, verify that concrete can be placed using the intended placing method. Place concrete mixture using project equipment and personnel. Evaluate the effect of placement methods on slump and air content. Make suitable corrections to the placing methods or to mixture proportions, if needed. Submit adjustments to mixture proportions.

4.2.3.6 *Revisions to concrete mixtures*—When 15 consecutive compressive strength test results become available from the field, calculate the average compressive strength and standard deviation. Calculate a revised value for f_{cr}' in accordance with 4.2.3.3(a).

4.2.3.6(a) If actual average compressive strength $\bar{X}$ exceeds the revised value of f_{cr}' and requirements of 1.6.6.1 are met, it is acceptable to modify mixture proportions to achieve an average strength equal to the revised value of f_{cr}'. The revised mixture shall meet requirements of 4.2.2.

4.2.3.6(b) If actual average compressive strength $\bar{X}$ is less than revised value of f_{cr}' or if either of the two requirements in 1.6.6.1 is not met, take immediate steps to increase average compressive strength of the concrete.

4.2.3.6(c) Submit revised mixture proportions for acceptance before placing the revised concrete in the Work.

4.3—Execution

4.3.1 *Measuring, batching, and mixing*—Production facilities shall produce concrete of specified quality and conforming to this Specification.

4.3.1.1 *Ready mixed and site-produced concrete*—Unless otherwise specified, measure, batch, and mix concrete materials and concrete in conformance to ASTM C94/C94M. Unless otherwise specified, concrete production facilities and delivery vehicles shall be certified by the NRMCA Program for Certification of Ready Mixed Concrete Facilities, approval by a state highway agency, or an equivalent program that audits for conformance to requirements of ASTM C94/C94M for production and delivery.

4.3.1.2 *Concrete produced by volumetric batching and continuous mixing*—Concrete produced by volumetric batching and continuous mixing shall conform to ASTM C685/C685M.

4.3.1.3 *Prepackaged dry materials used in concrete*—If packaged dry-combined materials are used, they shall conform to ASTM C387/C387M and satisfy requirements of this Specification.

4.3.2 *Delivery*—Transport and deliver concrete in equipment conforming to ASTM C94/C94M.

4.3.2.1 *Slump adjustment*—Unless otherwise specified, if concrete slump test results are below required slump, slump may be adjusted by adding chemical admixtures, or adding water up to amount allowed in accepted mixture proportions. Addition of water shall be in accordance with ASTM C94/C94M. Do not exceed specified maximum *w/cm* or *w/cm* used in proportioning the concrete or required slump. Do not add water to concrete delivered in equipment not acceptable for mixing. Measure slump and air content of air-entrained concrete after slump adjustment to verify compliance with specified requirements.

4.3.2.2 *Limits on discharge*—Unless otherwise specified, discharge limits shall comply with ASTM C94/C94M. If discharge is acceptable after more than 90 minutes have elapsed since batching, verify that air content of air-entrained concrete, slump, and temperature of concrete are as specified.

SECTION 5—HANDLING, PLACING, AND CONSTRUCTING

5.1—General

5.1.1 *Scope*—This section covers the construction of cast-in-place structural concrete. Included are procedures for handling, placing, finishing, curing, and repair of surface defects.

5.1.2 *Submittals*

5.1.2.1 Unless otherwise specified, submit the information specified in 5.1.2.1(a) through 5.1.2.1(g).

5.1.2.1(a) *Resolution of nonconformance*—Documentation of resolution of nonconformance identified on quality assurance test and inspection reports.

5.1.2.1(b) *Temperature measurement*—Proposed method for complying with requirements for measuring concrete temperatures.

5.1.2.1(c) *Qualifications of finishers*—Qualifications, as specified in 5.3.4.1, of finishing contractor and of flatwork finishers who will perform the Work.

5.1.2.1(d) *Placement notification*—Notification of concrete placement at least 24 hours before placement.

5.1.2.1(e) *Preplacement requirements*—List of preplacement activities.

5.1.2.1(f) *Preplacement meeting*—Agenda for preplacement meeting to be held before start of placement activities.

5.1.2.1(g) *Temporary form spreaders*—Request to leave spreaders in place.

5.1.2.2 If required, submit information specified in 5.1.2.2(a) through 5.1.2.2(g).

5.1.2.2(a) *Conveying equipment*—Description of conveying equipment.

5.1.2.2(b) *Surface cleaning*—If removal of stains, rust, efflorescence, and surface deposits is required as described in 5.3.7.6, submit proposed method of removal.

5.1.2.2(c) *Wet-weather protection*—Wet-weather protection activities.

5.1.2.2(d) *Hot-weather placement*—Request for concrete temperature limit different than specified in 5.3.2.1(c), including documentation and procedures to demonstrate compliance with other requirements in Contract Documents.

5.1.2.2(e) *Cold-weather placement and protection activities*—Request for acceptance of proposed cold-weather placement, temperature-measuring methods, and protection activities.

5.1.2.2(f) *Initial curing*—Methods to be used for initial curing.

5.1.2.2(g) *Retarder for exposed-aggregate surface*—Manufacturer's data on retarder and proposed method of use if surface retarder is proposed for specified exposed-aggregate surface.

5.1.2.3 If alternatives are proposed, comply with 5.1.2.3(a) through 5.1.2.3(f).

5.1.2.3(a) *Bonding agent*—If bonding material other than cement grout is proposed for two-course slabs or construction joints, submit applicable specification and manufacturer's data on bonding agent.

5.1.2.3(b) *Underwater placement*—If underwater placement is planned, submit proposed method.

5.1.2.3(c) *Contraction or expansion joints*—If contraction or expansion joints other than those indicated in Contract Documents are proposed, submit locations.

5.1.2.3(d) *Curing method*—If a moisture-preserving method other than specified in 5.3.6 is proposed, submit the proposed method.

5.1.2.3(e) *Repair materials*—If a repair material other than that described in 5.2.1.6 is proposed, submit applicable repair material specification, manufacturer's data on the proposed repair material, and proposed preparation and application procedure.

5.1.2.3(f) *Sawed joints*—If sawed joints are to be installed using methods that are different from those specified in 5.3.5, submit request of the proposed methods.

5.1.2.4 *Joints not shown in Contract Documents*

5.1.2.4(a) Submit information on proposed location and treatment of construction joints not indicated in Contract Documents.

5.1.2.4(b) If movement joints other than those indicated in Contract Documents are proposed, submit locations.

5.1.3 *Delivery, storage, and handling*—Deliver, store, and handle products in accordance with manufacturer's recommendations. Do not use products stored beyond manufacturer's recommended shelf life.

5.2—Products

5.2.1 *Materials*

5.2.1.1 *Water for curing*—Unless otherwise specified, do not use seawater or water containing substances that will discolor or impair the durability of the concrete member.

5.2.1.2 *Curing compounds*—Unless otherwise specified, use membrane-forming curing compounds that conform to ASTM C309 or ASTM C1315. Silicate-based liquid surface densifiers are prohibited as curing compounds.

5.2.1.3 *Sheet materials for curing*—Unless otherwise specified, use sheet materials that conform to ASTM C171.

5.2.1.4 *Absorbent materials*—Unless otherwise specified, absorbent materials shall meet the requirements of AASHTO M 182.

5.2.1.5 *Evaporation retarders*—Liquid applied evaporation retarders shall form a continuous monomolecular film and reduce moisture loss from fresh concrete surface.

5.2.1.6 *Surface repair materials*—Unless otherwise specified, use repair mortar to repair surface defects. For concrete exposed to view, repair mortar shall match adjacent concrete color.

5.2.1.7 *Bonding material*—Accepted bonding agent applied in accordance with the manufacturer's requirements or portland-cement grout of the same proportions as the mortar in the concrete.

5.2.1.8 *Scrub coat*—For scrub coat material, mix one part portland cement and one part sand by loose volume with water. Use sand meeting the requirements of ASTM C144 or ASTM C404.

5.2.1.9 *Air entrainment for concrete to receive hard-troweled finish*—Concrete for slabs to receive a hard-troweled finish shall not contain an air-entraining admixture or have total air content greater than 3 percent.

5.3—Execution

5.3.1 *Preparation*

5.3.1.1 Do not place concrete until data on materials and mixture proportions are accepted.

5.3.1.2 Remove hardened concrete and foreign materials from inner surfaces of conveying equipment.

5.3.1.3 Before placing concrete in forms, complete the following:

(a) Comply with formwork requirements specified in Section 2.

(b) Remove snow, ice, frost, water, and other foreign materials from surfaces against which concrete will be placed, and from reinforcement and embedded items.

(c) Comply with reinforcement placement requirements specified in Section 3.

5.3.1.4 Before placing a concrete slab-on-ground, remove foreign materials from the subgrade and complete the following:

(a) Subgrade and base shall be prepared in accordance with Contract Documents.

(b) Tolerance for the base material elevation shall be in accordance with ACI 117.

5.3.1.5 Make provisions in advance of concrete placement to limit the rate of evaporation of the water from the concrete surface during or immediately after placing or finishing.

5.3.1.6 During ambient temperature conditions described in 4.2.2.5(a), cure and protect the concrete in accordance with 5.3.6.5. Use heating, covering, or other means to maintain required temperature without drying of concrete. Do not use unvented combustion heaters.

5.3.2 *Placement of concrete*

5.3.2.1 *Weather considerations*

5.3.2.1(a) *Wet weather*—Do not place concrete while rain, sleet, or snow is falling unless protection is provided. Do not allow precipitation to increase mixing water or to damage concrete surface.

5.3.2.1(b) *Cold weather*—Concrete temperatures at delivery shall meet the requirements of 4.2.2.5. Do not place concrete in contact with surfaces less than 35°F. Unless otherwise specified, this requirement shall not apply to reinforcing steel.

5.3.2.1(c) *Hot weather*—Unless otherwise specified, concrete temperature as placed shall meet the requirements of 4.2.2.5. If temperature of reinforcement, embedments, or forms is greater than 120°F, use a fine mist of water to moisten and cool hot surfaces. Remove standing water before placing concrete.

5.3.2.2 *Conveying*—Convey concrete from mixer to final deposition using equipment in 5.3.2.3 by methods that do not result in segregation or loss of constituents.

5.3.2.3 *Conveying equipment*—Use conveying equipment of sufficient capacity to meet the requirements of 5.3.2.4. Conveying equipment in contact with concrete shall not be made of aluminum.

5.3.2.3(a) Use belt conveyors with a discharge baffle or hopper at discharge end. Slope of conveyors shall not cause segregation on belt.

5.3.2.3(b) Use metal or metal-lined chutes having rounded bottoms, and sloped between 1:2 and 1:3. Chutes longer than 20 ft and chutes not meeting slope requirements may be used provided discharge is into a hopper before distributing into forms.

5.3.2.3(c) Use pumping equipment that has sufficient capacity so that:

(a) Discharge of pumped concrete does not result in segregation.

(b) Modification of accepted concrete mixture is not required.

5.3.2.4 *Depositing*

5.3.2.4(a) Deposit concrete continuously and as near as practicable to the final position.

5.3.2.4(b) Deposit concrete in one layer or in multiple layers. Do not place fresh concrete against concrete that would result in cold joints unless construction joint requirements of 5.3.2.6 are met.

5.3.2.4(c) Do not place concrete that contains foreign material.

5.3.2.4(d) If temporary spreaders are used in forms, remove spreaders as the concrete is placed. Spreaders may be left in place if prior acceptance is obtained.

5.3.2.4(e) Do not place concrete over columns or walls until concrete in columns and walls has reached final setting.

5.3.2.4(f) Do not subject concrete to procedures that will cause segregation.

5.3.2.4(g) Place concrete for beams, girders, brackets, column capitals, haunches, and drop panels at same time as concrete for adjacent slabs.

5.3.2.4(h) If underwater placement is required, place concrete by an acceptable method. Deposit fresh concrete so concrete enters the mass of previously placed concrete and not in contact with the water.

5.3.2.5 *Consolidating*—Unless otherwise specified, consolidate concrete by vibration. Consolidate concrete around reinforcement, embedded items, and into corners of forms. Use immersion-type vibrators with nonmetallic heads for consolidating concrete around epoxy-coated or zinc and epoxy dual-coated reinforcing bars. Do not use vibrators to move concrete in a manner that will result in segregation. Spacing of immersion vibrator insertions shall not exceed 1-1/2 times the vibrator's radius of action in concrete being consolidated.

5.3.2.6 *Construction joints*—Install construction joints in accordance with 2.2.2.5. Remove laitance and thoroughly clean and dampen construction joints before placement of fresh concrete. If bond is required, use one of the following methods:

(a) Use a bonding material in accordance with 5.2.1.7.

(b) Use an acceptable surface retarder in accordance with manufacturer's recommendations.

(c) Roughen surface in an acceptable manner that exposes coarse aggregate and does not leave laitance, loosened aggregate particles, or damaged concrete at surface.

5.3.3 *Finishing formed surfaces*

5.3.3.1 *General*—After form removal, give each formed surface one or more of the finishes described in 5.3.3.2, 5.3.3.3, or 5.3.3.4. If Contract Documents do not specify a finish, finish surfaces as required by 5.3.3.5.

5.3.3.2 *Matching sample finish*—If required to match a sample panel furnished to Contractor, reproduce a mockup of the sample finish on an area at least 100 ft^2 in a location designated by Architect/Engineer in Contract Documents. Protect mockup from damage for duration of project. Obtain acceptance of mockup before proceeding with that finish in specified locations.

5.3.3.3 *As-cast finishes*—Use form-facing materials meeting the requirements of 2.2.1.1. Unless otherwise specified, produce as-cast formed finishes to comply with 5.3.3.3(a), 5.3.3(b), or 5.3.3.3(c).

5.3.3.3(a) *Surface finish-1.0 (SF-1.0):*

(a) No formwork facing material is specified

(b) Patch voids larger than 1-1/2 in. wide or 1/2 in. deep

(c) Remove projections larger than 1 in.

(d) Tie holes need not be patched

(e) Surface tolerance Class D as specified in ACI 117

(f) Mockup not required

5.3.3.3(b) *Surface finish-2.0 (SF-2.0):*

(a) Patch voids larger than 3/4 in. wide or 1/2 in. deep

(b) Remove projections larger than 1/4 in.

(c) Patch tie holes

(d) Surface tolerance Class B as specified in ACI 117

(e) Unless otherwise specified, provide mockup of concrete surface appearance and texture

5.3.3.3(c) *Surface finish-3.0 (SF-3.0):*

(a) Patch voids larger than 3/4 in. wide or 1/2 in. deep

(b) Remove projections larger than 1/8 in.

(c) Patch tie holes

(d) Surface tolerance Class A as specified in ACI 117

(e) Provide mockup of concrete surface appearance and texture

5.3.3.4 *Rubbed finishes*—Remove forms as early as permitted by 2.3.2 and perform necessary repairs and patching.

5.3.3.4(a) *Smooth-rubbed finish*—If specified, produce smooth-rubbed finish no later than the day following formwork removal. Wet the surface and rub it with an abrasive such as carborundum brick until uniform color and texture are produced. If insufficient cement paste can be drawn from the concrete itself by the rubbing process, use a grout made with cementitious materials from the same sources as used for in-place concrete.

5.3.3.4(b) *Grout-cleaned rubbed finish*—If grout-cleaned rubbed finish is specified, begin cleaning operations after contiguous surfaces are completed and accessible. Do not clean surfaces as Work progresses. Wet the surface and, unless otherwise specified, apply grout consisting of 1 part by volume portland cement and 1-1/2 parts of sand meeting the requirements of ASTM C144 or ASTM C404, with sufficient water to produce the consistency of thick paint. Scrub grout into voids and remove excess grout.

5.3.3.4(c) *Cork-floated finish*—If cork-floated finish is specified, remove ties, burrs, and fins. Wet the surface and, unless otherwise specified, apply stiff grout of 1 part portland cement and 1 part sand meeting the requirements of ASTM C144 or ASTM C404 to fill voids. Use sufficient water to produce a stiff consistency. Compress grout

into voids. Produce the final finish with cork float, using a swirling motion.

5.3.3.5 *Unspecified as-cast finishes*—If a surface finish is not specified, provide the following finishes:

(a) SF-1.0 on concrete surfaces not exposed to view

(b) SF-2.0 on concrete surfaces exposed to view

5.3.3.6 *Architectural finishes*—Produce architectural finishes in accordance with Section 6.

5.3.4 *Finishing unformed surfaces*

5.3.4.1 *Finisher qualifications*—Unless otherwise specified, at least one finisher or finishing supervisor shall be a certified ACI Flatwork Concrete Finisher/Technician or a certified ACI Flatwork Technician or equivalent.

5.3.4.2 *Finishes and tolerances*—Unformed surfaces shall receive the applicable finishes in 5.3.4.2(a) through 5.3.4.2(i). If finish is not specified, finish surfaces as required by 5.3.4.2(i).

If applicable, allow for the measurement of finishes of slab surfaces in accordance with ASTM E1155 and slab elevation to verify compliance with the tolerance requirements within 72 hours after slab finishing for slabs-on-ground and before stressing post-tensioning reinforcement, removing supporting formwork or shoring for elevated slabs.

5.3.4.2(a) *Scratch finish*—Place, consolidate, strike off, and level concrete; cut high spots; and fill low spots. Roughen the surface with stiff brushes or rakes before concrete becomes too stiff to brush or rake.

5.3.4.2(b) *Float finish*—Place, consolidate, strike off, and level concrete; cut high spots; and fill low spots. Do not perform further finishing operations until concrete is ready for floating. Begin floating with hand float, bladed power float equipped with float shoes, or powered disk float when bleed water sheen has disappeared and surface has stiffened sufficiently to permit operation of the specific float apparatus. Unless otherwise specified, produce a finish that will meet tolerance requirements of ACI 117 for a conventional surface.

5.3.4.2(c) *Trowel finish*—Float concrete surface, then trowel the surface. Unless otherwise specified, tolerances for concrete floors shall be for a flat surface in accordance with ACI 117. Addition of water to surface to facilitate finishing is prohibited. Do not apply hard-troweled finish to concrete with total air content greater than 3 percent.

5.3.4.2(d) *Broom or belt finish*—After concrete has received float finish, give concrete surface a coarse-scored texture by drawing a broom or burlap belt across the surface.

5.3.4.2(e) *Dry-shake finish*—If specified, blend metallic or mineral aggregate with portland cement in the proportions recommended by the aggregate manufacturer. Finishing operations shall not seal the surface before the end of bleeding to minimize potential of delamination or blistering. Float-finish concrete surface and make initial application of dry material by mechanical spreader or by broadcasting with shovels. Begin final floating after final dry-shake application. Following floating, provide a hard-troweled finish. Alternatively, if specified in Contract Documents, use bagged, premixed material applied in accordance with manufacturer's recommendations.

5.3.4.2(f) *Heavy-duty topping for two-course slabs*—Use specified materials and methods. Place and consolidate concrete for the base slab, and screed concrete to specified depth. Topping placed the same day as base slab shall be placed as soon as bleed water in the base slab disappears and surface has stiffened sufficiently to allow finishing operations. Unless otherwise specified, if topping placement is to be deferred, prepare surface to bond the base slab and topping using the following steps. Wet cure the base slab continuously for at least 3 days. Before placing the topping, remove contaminants, loose mortar, or aggregate from base slab. Dampen surface, leaving it free of standing water. Unless otherwise specified, before placing topping, scrub into slab surface a coat of portland-cement bonding grout meeting the requirements of 5.2.1.8. Do not allow grout to set or dry before topping is placed. Bonding agents other than cement grout meeting the requirements of 5.2.1.8 may be used with prior acceptance. Spread, consolidate, compact, and float topping mixture. Check for flatness of surface and complete operation with specified float, trowel, or broom finish.

5.3.4.2(g) *Topping for two-course slab not intended for heavy-duty service*—Preparation of base slab, selection of topping material, mixing, placing, consolidating, and finishing operations shall be as specified in 5.3.4.2(f), except that the aggregate need not be selected for special wear resistance.

5.3.4.2(h) *Nonslip finish*—If a nonslip finish is specified, give the surface a dry-shake application of crushed aluminum oxide, at a rate of at least 25 lb/100 ft^2, unless otherwise specified, or a broom or belt finish.

5.3.4.2(i) *Unspecified unformed surface finishes*—If finish is not specified, apply the following finishes to unformed concrete surface:

(a) Scratch finish—For surfaces intended to receive bonded cementitious or setting beds

(b) Float finish—For walks; steps; and for surfaces intended to receive waterproofing, roofing, insulation, or sand-bed terrazzo

(c) Trowel finish—For interior floors

(d) Broom finish—For parking slabs and exterior surfaces, including slabs, ramps, walkways, and steps

5.3.5 *Sawed joints*—Where saw-cut joints are required, start cutting as soon as concrete has gained sufficient strength to prevent dislodgment of coarse aggregate particles. Do not saw cut reinforcement. Unless otherwise specified, saw a continuous slot to a depth one-fourth the thickness of the slab but not less than 1 in.

5.3.6 *Curing and protection*

5.3.6.1 *Curing*—Unless otherwise specified, cure concrete in accordance with 5.3.6.2 or 5.3.6.3.

5.3.6.2 *Initial curing of unformed concrete surfaces*—If bleed water sheen is not visible on surface of concrete after strikeoff and initial bull floating, provide initial curing by means of fogging or application of evaporation retarder until final curing method is applied. Do not use fogging in cold weather concreting.

5.3.6.2(a) *Fogging*—Provide fogging equipment for complete coverage of area to be cured. Maintain visible

water sheen without accumulation of standing water on concrete surface until final setting of concrete.

5.3.6.2(b) *Evaporation retarder*—Apply in accordance with manufacturer's instructions. Do not use evaporation retarder as an aid for subsequent finishing operations and texturing.

5.3.6.3 *Final curing of unformed concrete surfaces*—Unless otherwise specified, apply one of the procedures in 5.3.6.5 after placement and finishing of concrete surfaces. Apply curing in a manner that prevents marring, marking, or discoloration of finished surface. Provide duration of curing in accordance with 5.3.6.6.

5.3.6.3(a) For concrete containing silica fume, use a curing procedure in 5.3.6.5 that supplies additional water during the entire curing period.

5.3.6.3(b) If moisture-absorbent or moisture-retaining coverings are used, apply in a manner that prevents marring, marking, or discoloration of the finished surface.

5.3.6.3(c) Do not use fogging in cold weather concreting.

5.3.6.4 *Formed concrete surfaces*—Unless otherwise specified, after formwork has been loosened or removed so that concrete surface is exposed to ambient air, continue curing by one of the methods in 5.3.6.5. Provide duration of curing in accordance with 5.3.6.6. The duration that forms remained tightly in place can be included in the duration of curing.

5.3.6.5 *Curing methods*—Unless otherwise specified, use one or more of the following methods for curing formed surfaces or as final curing for unformed surfaces:

5.3.6.5(a) *Continuous fogging*—Cure in accordance with 5.3.6.2(a), except that accumulation of standing water on concrete surface is permitted.

5.3.6.5(b) *Ponding*—Build a dike around concrete and flood surface with water. Entire surface is to remain covered with water for duration of curing period. Keep concrete surfaces continuously wet. Temperature of water used shall not be more than 20°F cooler than surface temperature of the concrete at the time the water and concrete come in contact.

5.3.6.5(c) *Continuous sprinkling*—Use either soaker hoses or lawn sprinklers. Concrete surface shall not be eroded by running water. Keep concrete surfaces continuously wet.

5.3.6.5(d) *Application of absorbent material*—Predampen absorptive materials before application. Keep concrete surfaces continuously wet. Apply additional water to absorbent materials without displacing them.

5.3.6.5(e) *Application of water-retention sheeting materials*—Cover all exposed concrete surfaces. Tape sheeting together or lap sheets, repair holes and gaps, and keep sheets in place.

5.3.6.5(f) *Application of a membrane-forming curing compound*—Apply compound in accordance with manufacturer's recommendation for specified concrete finish as soon as water sheen has disappeared from the concrete surface. For rough surfaces, such as those specified in 5.3.4.2(a), 5.3.4.2(b), and 5.3.4.2(d), apply curing compound in two applications at right angles to each other.

5.3.6.6 *Duration of curing*

5.3.6.6(a) Unless otherwise specified, continue curing measures for at least 7 days after placement. Unless otherwise specified, cure high-early-strength concrete for at least 3 days after placement.

5.3.6.6(b) Unless otherwise specified, curing measures may be terminated prior to the specified minimum duration in 5.3.6.6(a) when one of the following conditions is satisfied:

(a) Tests of at least two 6 x 12 in. or at least three 4 x 8 in. cylinders that have been field cured in accordance with ASTM C31/C31M, indicate compressive strength of at least 70 percent of f_c' when tested in accordance with ASTM C39/C39M.

(b) The compressive strength of laboratory-cured cylinders, representative of the in-place concrete, exceeds 85 percent f_c', provided the temperature of the in-place concrete has been maintained at 50°F or higher during curing.

(c) Concrete strength reaches f_c' as determined by accepted in-place test methods meeting the requirements of 2.3.4.2.

5.3.6.6(c) Unless otherwise specified, if one of the curing procedures in 5.3.6.5 is used initially, the curing procedure may be replaced by one of the other procedures after concrete is 1 day old, provided the surface of concrete does not become dry before replacement procedure is applied.

5.3.6.7 *Thermal protection against cold weather*—Maintain concrete temperature to prevent freezing of concrete and to ensure strength development.

5.3.6.7(a) Unless otherwise specified, duration of thermal protection shall be at least 3 days, or until one of the criteria of 5.3.6.6.b has been met.

5.3.6.7(b) Unless otherwise specified, remove thermal protection so that the maximum rate of decrease in temperature measured at the concrete surface shall not exceed the following:

(a) 50°F/24 hours for sections with least dimension less than 12 in.

(b) 40°F/24 hours for sections with least dimension from 12 to 36 in.

(c) 30°F/24 hours for sections with least dimension greater than 36 to 72 in.

(d) 20°F/24 hours for sections with least dimension greater than 72 in.

Maintain these rates of temperature decrease until surface temperature of the concrete is within 20°F of ambient or surrounding temperatures, at which time protection measures may be removed. Measure and record concrete temperature using an accepted method.

5.3.7 *Repair of surface defects*

5.3.7.1 *General*—Repair tie holes and other surface defects in formed finishes in accordance with the requirements of 5.3.3 unless otherwise specified. Where the concrete surface will be textured by sandblasting or bush-hammering, repair surface defects before texturing.

5.3.7.2 *Repair of tie holes*—Unless otherwise specified, patch tie holes. If portland-cement repair mortar conforming to 5.3.7.4 is used for patching, clean and dampen tie holes before applying mortar. If other materials are used, apply them in accordance with manufacturer's recommendations.

5.3.7.3 *Repair of surface defects other than tie holes*—Unless otherwise specified, repair surface defects by the following method. Outline repair area with a 1/2 in. deep saw cut and remove defective concrete down to sound concrete.

9.3.8.2(c) Fill stressing pockets with nonmetallic, nonshrink grout within 1 day after cutting prestressing steel. Grout used for pocket filling shall not contain chlorides or other chemicals known to be deleterious to prestressing steel and shall be nonreactive with prestressing steel, anchorage materials, and concrete.

SECTION 10—SHRINKAGE-COMPENSATING CONCRETE FOR INTERIOR SLABS

10.1—General

10.1.1 *Scope*—This section covers requirements for shrinkage-compensating concrete made with cementitious material conforming to ASTM C845/C845M, for constructing interior slabs as specified in Contract Documents.

10.1.2 *General requirements*—Unless otherwise specified in this section or in Contract Documents, requirements of Sections 1 through 5 are applicable for shrinkage-compensating concrete for interior slabs.

10.1.3 *Submittals*

10.1.3.1 Obtain Architect/Engineer's acceptance of required submittals before placing concrete.

10.1.3.2 Submit expansion test results determined in accordance with ASTM C878/C878M for proposed concrete mixture proportions. Include intermediate expansion data so that age at which 70 percent of 7-day laboratory expansion occurs can be determined.

10.1.3.3 Submit placing sequence that shall include sequence of placements, minimum time between placements, and layout of each placement.

10.2—Products

10.2.1 *Materials*

10.2.1.1 *Cementitious materials*—Unless otherwise specified, cementitious material shall comply with ASTM C845/C845M.

10.2.1.2 *Admixtures*—Unless otherwise specified, do not use accelerating admixtures or admixtures containing calcium chloride.

10.2.2 *Performance and design requirements*—Concrete for slabs to receive a hard-troweled finish shall not contain an air-entraining admixture or have a total air content greater than 3 percent.

10.2.2.1 *Expansion*—Unless otherwise specified, concrete expansion, determined in accordance with ASTM C878/C878M, shall be at least 0.03 percent and not more than 0.06 percent at 7 days of soaking.

10.2.2.2 *Slump*—Unless otherwise specified, slump at point of placement shall not exceed 6 in.

10.2.3 *Proportioning*—Comply with 4.2.3 and 10.2.3.1 through 10.2.3.3.

10.2.3.1 If laboratory trial mixtures are used, procedures of ASTM C192/C192M shall be modified as follows: Stop the concrete mixer after initial mixing cycle and cover mixer for 20 minutes, unless otherwise specified. After this time period, add water as necessary to produce a slump within 3/4 in. of the specified slump. Concrete shall then be mixed for an additional 2 minutes.

10.2.3.2 For proposed concrete mixture, provide laboratory test results for three expansion bars cast and tested in accordance with ASTM C878/C878M. Submit expansion test results.

10.2.3.3 *Revisions to concrete mixtures*—If concrete materials are changed or mixture proportions are revised in accordance with 4.2.3.6, evaluate the effect on expansion in accordance with ASTM C878/C878M and submit test results.

10.2.4 *Reinforcement*—Use reinforcement as specified in Contract Documents.

10.2.5 *Isolation-joint filler materials*—Unless otherwise specified, use compressible isolation-joint filler material that does not develop a stress greater than 25 psi at 50 percent strain when tested in accordance with ASTM D1621 or D3575.

10.3—Execution

10.3.1 *Reinforcement*

10.3.1.1 Unless otherwise specified, provide 1.5 in. cover from top surface for reinforced slabs-on-ground.

10.3.2 *Placing*

10.3.2.1 *Placing sequence*—Sequence of concrete placements shall be in accordance with accepted placement sequence and shall permit previous placements to have two adjacent edges free to expand.

10.3.2.2 Unless otherwise specified, time between casting adjoining sections shall be at least that required to produce 70 percent of 7-day laboratory expansion of the concrete mixture as determined in accordance with ASTM C878/C878M and as submitted in accordance with 10.1.3.2.

10.3.3 *Isolation joints*—Provide isolation joints at junctions with columns, walls, drains, or other rigid obstructions in the structure in accordance with Contract Documents.

10.3.4 *Curing*—Unless otherwise specified, water-cure shrinkage-compensating concrete for at least 7 days in accordance with 5.3.6.5(a) or 5.3.6.5(b).

SECTION 11—INDUSTRIAL FLOOR SLABS

11.1—General

11.1.1 *Scope*—This section covers requirements for concrete slabs-on-ground that are designated as industrial floor slabs. Provide materials and construct slabs at locations indicated and in accordance with Contract Documents.

11.1.2 *General requirements*—Unless otherwise specified in this section or in Contract Documents, requirements of Sections 1 through 5 are applicable for industrial floor slabs.

11.1.3 *Submittals*

11.1.3.1 Obtain acceptance of required submittals from Architect/Engineer before placing concrete.

11.1.3.2 In addition to submittal requirements of Sections 2 through 5, submit the following as specified in 11.1.3.2(a) through 11.1.3.2(e).

11.1.3.2(a) Manufacturer's data sheet for load-transfer devices at joints.

11.1.3.2(b) Manufacturer's data sheet on saw used to install contraction joints.

11.1.3.2(c) Unless otherwise specified, manufacturer's data sheet for curing cover, liquid-applied membrane-forming curing compounds, or other curing method. If curing compound is specified, submit method of removal when used in areas to receive subsequent finish flooring.

11.1.3.2(d) Plan for protecting concrete against anticipated ambient conditions during transportation, placement, finishing, and specified curing period.

11.1.3.2(e) Plan for joint layout.

11.1.3.3 In addition to submittal requirements of Section 11.1.3.2, submit 11.1.3.3(a) through 11.1.3.3(g), if specified.

11.1.3.3(a) Drying shrinkage test results, for proposed concrete mixture determined in accordance with ASTM C157/C157M, except that instead of storage for 28 days in lime-saturated water, specimens are subjected to 7 days of moist curing followed by at least 21 days of air drying, unless a longer drying period is specified in Contract Documents. The initial length of specimens used as the basis for length change shall be measured at 24 hours ± 1/2 hour upon demolding specimens and drying-shrinkage measurements shall begin at completion of 7-day moist-curing period.

11.1.3.3(b) Manufacturer's data sheet for vapor retarding sheet.

11.1.3.3(c) Manufacturer's data sheet for joint filler.

11.1.3.3(d) Manufacturer's data sheet for liquid-applied surface densifiers.

11.1.3.3(e) Manufacturer's data sheet for mineral or metallic shake hardeners.

11.1.3.3(f) Plan showing extent of each placement, placing sequence, and schedule for each placement.

11.1.3.3(g) Design of construction joint forms.

11.2—Products

11.2.1 *Materials*—Materials used for industrial slab construction shall conform to Sections 2, 3, and 4, except as modified in this section.

11.2.1.1 *Cementitious materials*—Comply with 4.2.1.1. ASTM C150/C150M Type III, or other high-early-strength hydraulic cement shall not be used.

11.2.1.2 *Aggregates*

11.2.1.2(a) Unless otherwise specified, use aggregates with a nominal maximum size of 1-1/2 in. conforming to requirements of 4.2.1.2.

11.2.1.2(b) Unless otherwise specified, use aggregate base course conforming to ASTM D2940/D2940M.

11.2.1.3 *Admixtures*

11.2.1.3(a) Unless otherwise specified, calcium chloride or admixtures containing chloride from sources other than impurities in admixture ingredients are prohibited.

11.2.1.3(b) Air-entraining admixtures are prohibited in concrete mixtures for use in slabs to receive a hard-troweled finish.

11.2.2 *Concrete mixture*—Unless otherwise specified, proportion concrete mixture to satisfy the following:

(a) Specified compressive strength of 3500 psi at 28 days

(b) Slump between 4 and 6 in.

(c) Shrinkage limit, if specified in Contract Documents

11.2.2.1 *Air content*—Concrete for slabs to receive a hard-troweled finish shall not have a total air content greater than 3 percent.

11.2.2.2 *Concrete temperature*—Unless otherwise specified, maximum temperature of concrete, as delivered, shall be 95°F.

11.2.3 *Field verification of selected mixture proportions*—Comply with 4.2.3.5 to verify the concrete mixture can be finished to achieve a hard-troweled finish.

11.2.4 *Vapor retarder*—Unless otherwise specified, vapor retarder shall conform to ASTM E1745 Class A and shall be at least 10 mil thick.

11.2.5 *Reinforcement*—If specified, use deformed reinforcing bars, tendons, or deformed or plain welded wire reinforcement in conformance with Contract Documents. Supports shall be used at a spacing to result in reinforcement placement in accordance with Contract Documents. If used, welded wire reinforcement shall have a wire spacing of at least 14 in. in both directions.

11.2.6 *Fibers*—If specified, use fibers in concrete mixture in accordance with Contract Documents.

11.2.7 *Load-transfer devices*—If required, provide load-transfer devices at joints indicated in Contract Documents.

11.2.8 *Joint filler materials*—Unless otherwise specified, use a two-component semi-rigid joint filler material. Joint filler shall have 100 percent solids, a minimum Shore A hardness of 80 when measured in accordance with ASTM D2240, and an elongation below 25 percent when measured in accordance with ASTM D638.

11.2.9 *Isolation-joint filler materials*—Unless otherwise specified, use joint material that prevents bond and allows for horizontal and vertical movement of slab relative to fixed abutting elements and penetrations. Use compressible isolation-joint filler material that does not exceed a stress of 25 psi at 50 percent strain when tested in accordance with ASTM D1621 or D3575.

11.2.10 *Curing materials*

11.2.10.1 *Curing compounds*—Membrane-forming curing compounds shall meet requirements of 5.2.1.2.

11.2.10.2 *Sheet materials*—Moisture-retaining sheet materials shall meet requirements of ASTM C171. Sheet material shall be nonstaining and absorbent.

11.2.11 *Liquid surface densifier*—If specified, use an acceptable liquid surface densifier in areas where indicated.

11.2.12 *Mineral or metallic shake surface hardeners*—If specified, use an acceptable dry-shake hardener in areas where indicated.

11.3—Execution

11.3.1 *Preparation*—Proof-roll prepared base in accordance with Contract Documents. Unless otherwise specified, compact aggregate base course to at least 95 percent of maximum density when tested in accordance with ASTM D698. Comply with requirements of 5.3.1 and verify that base surface elevation is within a tolerance of +0 in. and –1/2 in. of planned elevation. This base surface elevation tolerance shall be maintained during placement of concrete. If specified, install acceptable vapor retarder in accordance

with ASTM E1643 directly beneath slab in areas indicated in Contract Documents. Lap seams at least 6 in. and tape continuously. Repair punctures in vapor retarder.

11.3.2 *Measuring, batching, and mixing*—Comply with 4.3.1.

11.3.3 *Delivery*—Comply with 4.3.2.

11.3.4 *Concrete placement*—Comply with 5.3.2.

11.3.5 *Finishing slab surface*—Unless otherwise specified, comply with 5.3.4.2(c) and 5.3.6.2 to provide a hard-troweled finish. Water shall not be added to slab surface during finishing. If specified, apply surface hardener according to manufacturer's recommendation.

11.3.5.1 *Surface flatness and levelness*—Unless alternative values are specified, overall surface flatness shall be F_F35, and overall levelness shall be F_L25. Local area minimum values shall be F_F23 and F_L17 as determined in accordance with ASTM E1155.

11.3.5.2 Surface flatness and levelness shall be measured within 72 hours after finishing and test results submitted to Architect/Engineer within 3 days of measurement.

11.3.6 *Joints*—Construct movement joints where indicated in Contract Documents.

11.3.6.1 *Isolation joints*—Install isolation joint material to full depth of slab.

11.3.6.2 *Construction joints*—Comply with 2.2.2.5, 2.3.1.4, and 5.3.2.6. Construction joints shall be perpendicular to slab surface; include load-transfer devices, but do not include keyways. Unless otherwise specified, doweled construction joints designed to allow joint widening shall be saw cut to on-fourth slab thickness or 2 in., whichever is smaller. Align saw cut with joint. Remove concrete dust from saw-cut operation and protect joints from damage due to construction activities.

11.3.6.3 *Contraction joints*—Unless otherwise specified, saw cut all contraction joints and comply with 5.3.5. If early-entry dry-cutting saws are used, replace skid plate and blade as recommended by equipment manufacturer to minimize saw-cut raveling. Install saw cuts perpendicular to slab surface. Remove concrete dust from saw-cut operation. Protect joints from damage due to construction activities.

11.3.6.4 *Load-transfer devices*—Comply with 5.3.2.5. Install devices at slab mid-depth and secure to avoid displacement. Consolidate concrete around load-transfer devices by vibration adjacent to the devices.

11.3.7 *Curing and protection*—Comply with 5.3.6 and provide curing for at least 7 days unless otherwise specified. If a sheet material is used, apply as soon as practicable without marring finished surface. Place moisture-retaining sheet materials in a manner to prevent surface discoloration or marking. Keep slab continuously wet after final finishing is completed and during curing period. Applied water shall not decrease the slab surface temperature by more than 20°F. If a curing compound is used, including those considered self-dissipating; do not apply where subsequent finish flooring or surface densifier is to be installed unless compound is compatible with flooring system or it will be removed by method acceptable to finish flooring or surface densifier manufacturer.

11.3.8 *Liquid surface densifier*—If specified, apply liquid surface densifier in accordance with manufacturer's recommendations. If applied after curing period, remove curing cover or curing compound, allow slab surface to air-dry for at least 7 days, and apply product.

11.3.9 *Joint filling*—Unless otherwise specified, fill joints with a semi-rigid joint filler. Install joint filler full depth of saw cuts. Unless otherwise specified, do not install joint filler earlier than recommended by filler manufacturer. Joints shall be overfilled and shaved flush. During project warranty period, monitor joint filler for separation and monitor concrete deterioration along joints as joints widen. Separations shall be corrected within project warranty period.

SECTION 12—TILT-UP CONSTRUCTION

12.1—General

12.1.1 *Scope*—This section covers requirements for preparation, casting, and erection of tilt-up concrete panels as designated in Contract Documents.

12.1.2 *General requirements*—Unless otherwise specified in this section or in Contract Documents, requirements of Section 1 through 5 are applicable for tilt-up construction.

12.1.3 *Submittals*—Unless otherwise specified, submit items specified in 12.1.3.1 through 12.1.3.8.

12.1.3.1 *Bearing shims*— Manufacturer's product data sheet for bearing shims to be used.

12.1.3.2 *Coloring agents*—Data on coloring agents.

12.1.3.3 *Bond breaker*—Data on bond breaker.

12.1.3.4*Drawings*

12.1.3.4(a) *Lifting and bracing design drawings*—These panel drawings include locations for lifting inserts, brace inserts, minimum concrete strength for lifting, added reinforcement for lifting, and bracing design. Panel design shall include bracing to maintain panel tolerances until final structural connections are made. Lifting and bracing design drawings shall be signed and sealed by a licensed design engineer. If specified, submit design calculations signed and sealed by licensed design engineer.

12.1.3.4(b) *Reinforcement placing drawings*—These drawings shall include reinforcing bar sizes, locations, lengths, splices, and quantities.

12.1.3.5 *Field mockups*—If specified, field mockups shall be two panels unless noted otherwise. Each panel shall be at least 4 x 8 ft, constructed and erected using material and methods detailed in panel shop drawings. Include edge and reveal procedures, special finishes, color, repair, and aggregate sizes. Maintain field mockups until completion of Work.

12.1.3.6 *Grout*—Panel grout manufacturer's data sheet or producer's mixture proportions.

12.1.3.7 *Sandwich panel insulation system*—Details of wythe connections, and thickness and type of insulation to be used to construct insulated sandwich panels.

12.1.3.8 *Defects repair*—Methods and materials for repair of defects.

12.1.4 *Tilt-up contractor qualifications*—Provide documentation of tilt-up contractor's qualifications. Workers shall be proficient in production and erection operations and

DRAWINGS FOR THE

CELL E-2 AND OPERATIONAL INFRASTRUCTURE CONSTRUCTION

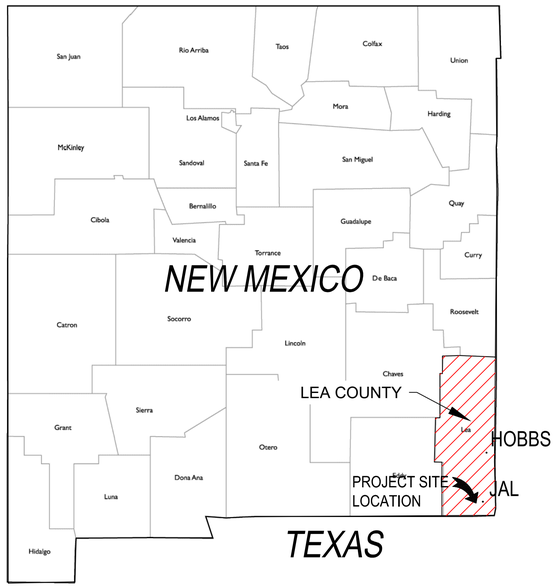
AT THE

NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY

COUNTY ROAD 2
LEA COUNTY, NEW MEXICO 88252

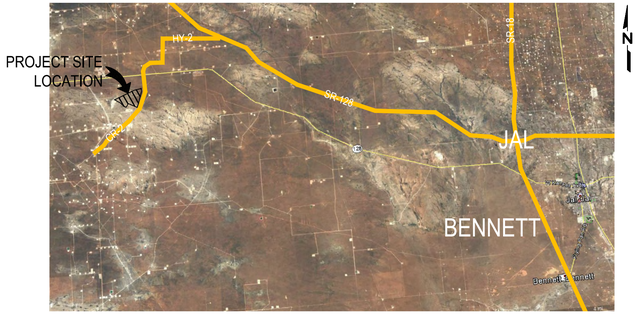
PREPARED FOR

HIGH ROLLER EPC



VICINITY MAP
N.T.S.

DRAWING NO.	DRAWING TITLE
1	COVER SHEET
2	INDEX SHEET
3	EXISTING CONDITIONS AND OVERALL SITE DEVELOPMENT PLAN
4	SITE CONSTRUCTION DEVELOPMENT PLAN
5	CELL E-2 SUBGRADE GRADING PLAN
6	SURFACE PROFILES
7	CELL E-2 CERTIFICATION AND CONTROL POINTS PLAN
8	POINTS TABLES
9	LEACHATE FORCEMAIN CONSTRUCTION PLAN
10	DETAILS
11	DETAILS
12	DETAILS



LOCATION MAP
N.T.S.

ISSUED FOR BID

Know what's below. Call before you dig.

MICHAEL P. BRADFORD
NEW MEXICO
19240
PROFESSIONAL ENGINEER

NO.	REVISION	DATE

SHEET TITLE: COVER SHEET

PROJECT TITLE: CELL E-2 AND OPERATIONAL INFRASTRUCTURE CONSTRUCTION PLANS
NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY
LEA COUNTY, NEW MEXICO

CLIENT: HIGH ROLLER EPC

SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
2970 MAPLE AVENUE, SUITE 118
TEMPE, ARIZONA 85283
(602) 840-2596

PROJ. NO. 01222034.02 | DSN. BY: MPB | DWN. BY: MPB | CHK. BY: - | ACAD FILE: F:/ENGINEERS | APP. BY: MPB

DATE: OCTOBER 2022

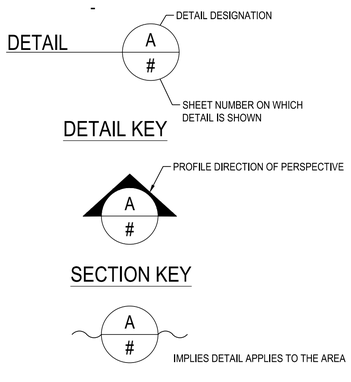
SCALE: AS SHOWN

SHEET: 1

GENERAL NOTES

1. EXISTING CONTOURS SHOWN ON THESE PLANS ARE BASED ON AN AERIAL SURVEY AND VARIOUS FIELD SURVEYS. CARE SHOULD BE TAKEN WHEN INTERPRETING CONTOURS TO VERIFY THE AREAS AND THE TRANSITIONS BETWEEN THEM.
2. EXISTING FACILITIES AND FEATURES ARE SHOWN LIGHT-LINED AND/OR SCREENED. NEW FACILITIES AND FEATURES ARE SHOWN SOLID AND HEAVY-LINED. IN GOOD FAITH EXISTING UTILITIES SHOWN WERE LOCATED BASED ON HISTORICAL SITE INFORMATION, AS-BUILT RECORDS, VISIBLE SURVEY MARKERS, AND UTILITY LOCATE INFORMATION PROVIDED BY THE OWNER. THIS DOES NOT ABSOLVE THE RESPONSIBILITY OF THE CONTRACTOR TO PERFORM AN INDEPENDENT SUBSURFACE UTILITY LOCATION VERIFICATION PRIOR TO BEGINNING EXCAVATION ACTIVITIES. DAMAGE TO ANY UTILITY KNOWN OR UNKNOWN AS INDICATED IN THESE DRAWINGS SHALL BE REPAIRED AT THE CONTRACTOR'S EXPENSE.
3. SLOPES AND GRADES ARE IN UNITS OF FT(H):FT(V) OR %, RESPECTIVELY, UNLESS OTHERWISE NOTED.
4. THESE DRAWINGS WERE PREPARED IN ACCORDANCE WITH NEW MEXICO ADMINISTRATIVE CODE 19.15.36 REGULATING SURFACE WASTE MANAGEMENT FACILITY UNDER THE GOVERNING AUTHORITY OF NEW MEXICO ENERGY, MINERALS, AND NATURAL RESOURCES DEPARTMENT - OIL CONSERVATION DIVISION; AND THE FACILITY'S OPERATING PERMIT (#NM1-66) DATED MAY 20, 2021.
5. EXISTING TOPOGRAPHIC CONTOURS SHOWN IN THESE PLANS ARE BASED ON A GROUND SURVEY PERFORMED BY SURVEYING AND MAPPING (SAM) ON NOVEMBER 30, 2018 AND AS-BUILT RECORD SURVEYS FOR CELL E-1 PERFORMED BY TRANSGLOBAL SERVICES LLC IN JUNE OF 2022. SURVEY BENCH MARKS AND CONTROL FOR THIS FACILITY ARE IN THE NAD83 STATE PLANE NEW MEXICO EAST ZONE (NM_E) HORIZONTAL COORDINATE SYSTEM AND THE NAVD88 VERTICAL DATUM AND CAN BE COORDINATED AND VERIFIED DIRECTLY BY CONTACTING SAM IN MIDLAND, TEXAS AT 432-699-0601, REFERENCE SAM JOB NUMBER 1118046564.
5. PROPERTY AND LEGAL BOUNDARY LINES SHOWN IN THESE PLANS ARE BASED ON A ALTA SURVEY PERFORMED BY SURVEYING AND MAPPING (SAM) ON IN AUGUST 2018. THE FACILITY'S PERMIT BOUNDARY SHOWN ON THESE PLANS IS AS DELINEATED IN THE APPROVED FACILITY OPERATING PERMIT (#NM1-66). FOR INFORMATION REGARDING PROPERTY AND LEGAL BOUNDARIES SHOWN CONTACT SAM IN MIDLAND, TEXAS AT 432-699-0601, REFERENCE SAM JOB NUMBER 1018044265.
6. THE EROSION AND SEDIMENT CONTROL FEATURES REQUIRED BY THESE PLANS ARE THE MINIMUM FEATURES REQUIRED. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO PLAN CONSTRUCTION STORMWATER CONTROLS TO PROTECT THE PROJECT AND WORK AREA. DAMAGE DONE TO WORK BY STORMWATER AS A RESULT OF INADEQUATE STORMWATER CONTROL PLANNING WILL BE REPAIRED/REPLACED AT THE CONTRACTOR'S EXPENSE.
7. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO PREPARE AND MAINTAIN ONSITE A CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN COMPLIANT WITH LOCAL GOVERNING REGULATIONS AND OBTAIN REQUIRED CONSTRUCTION STORMWATER CONTROL PERMITS PRIOR TO BEGINNING CONSTRUCTION ACTIVITIES.
8. IN THE CASE OF ANY DISCREPANCIES BETWEEN THESE DRAWINGS AND ASSOCIATED CONSTRUCTION SPECIFICATIONS AND CQA PLAN, CONSULT THE DESIGN THE ENGINEER OF RECORD PRIOR TO MOVING FORWARD.
9. IT IS THE CONTRACTOR'S RESPONSIBILITY TO COORDINATE CONSTRUCTION ACTIVITIES WITH LOCAL TRANSPORTATION AUTHORITIES AND OBTAIN TRAFFIC CONTROL PERMITS. CONSTRUCTION ACTIVITIES MUST ALSO BE COORDINATED WITH ADJACENT OIL AND GAS FIELD ASSOCIATED OPERATIONS. DELAYS IN CONSTRUCTION DUE TO INADEQUATE COORDINATION AND PLANNING WILL NOT BE COMPENSATED.
10. CONTRACTOR SHALL BE RESPONSIBLE FOR BRINGING TO THE OWNER AND ENGINEER'S ATTENTION ANY CONSTRUCTION ELEMENT THAT HAS NOT BEEN ADDRESSED IN THESE DRAWINGS OR SEEN TO BE DIFFERENT FROM THE LIKE ELEMENT DESCRIBED IN THESE DRAWINGS.
11. CONTRACTOR SHALL BE RESPONSIBLE FOR MAINTAINING A CLEAN WORK AREA. REMOVAL OF ALL CONSTRUCTION RELATED WASTE MATERIAL FROM THE WORK AREA SHALL BE ROUTINELY REMOVED AND DISPOSED AT A NEW MEXICO PERMITTED SOLID WASTE FACILITY, ADDITIONAL COMPENSATION WILL NOT BE GIVEN FOR WASTE REMOVAL AND DISPOSAL. ALL REMAINING CONSTRUCTION WASTE MUST BE REMOVED AT THE COMPLETION OF THE PROJECT.

SECTION/DETAIL KEY



CONTACT INFORMATION

OWNER:
NGL WASTE SERVICES, LLC (HIGH ROLLER EPC)
ATTENTION: RAVI VEMULAPALLI
1008 SOUTHVIEW CIRCLE
CENTER, TX 75935

ENGINEER:
SCS ENGINEERS
ATTENTION: MICHAEL BRADFORD, P.E. - ENGINEER OF RECORD
6100 MAPLE AVENUE
TEMPE, ARIZONA 85283

REGULATORY AUTHORITY:
STATE OF NEW MEXICO ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION
1220 SOUTH ST. FRANCIS DRIVE
SANTA FE, NEW MEXICO 87505
PHONE: (505) 476-3460

Know what's below. Call before you dig.

ISSUED FOR BID

MICHAEL P. BRADFORD
NEW MEXICO
19240
PROFESSIONAL ENGINEER

NO.	REVISION	DATE

SHEET TITLE: INDEX SHEET

PROJECT TITLE:
CELL E-2 AND OPERATIONAL INFRASTRUCTURE
CONSTRUCTION PLANS
NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY
LEA COUNTY, NEW MEXICO

CLIENT:
HIGH ROLLER EPC

SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
8799 BALBOA AVENUE, SUITE 290
SAN DIEGO, CA 92123
(858) 571-5500 FAX (562) 427-0805

PROJ. NO.	DSN. BY:	DWN. BY:	CHK. BY:	APP. BY:
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ACAD FILE: F:\ENGINEERS

DATE: OCTOBER 2022

SCALE: AS SHOWN

SHEET: 2

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

A B C D E F G H I J

EXISTING FEATURES LEGEND:

- 3300 — EXISTING GRADE CONTOURS (2' CONTOURS)
- OE — EXISTING OVERHEAD ELECTRIC
- G G G — EXISTING GAS LINES / GAS EASEMENT
- W W — EXISTING WATER LINE
- EXISTING HIGHWAY CENTERLINE
- EXISTING NMOCD PERMITTED OIL WELLS
- PARCEL LINE
- ℄ — SURVEY SECTION LINE
- FACILITY PERMIT BOUNDARY
- N: E: — PERMIT BOUNDARY CORNERS

PROPOSED FEATURES LEGEND:

- PERMITTED WASTE DISPOSAL/PHASE BOUNDARY
- WASTE DISPOSAL CELL BOUNDARY
- PROPOSED LANDFILL/OPERATIONS ROADS (FUTURE)
- APPROXIMATE LIMITS OF WORK FOR THIS PROJECT

SECTION LINE
SECTION 9 (WEST), SECTION 10 (EAST)
TOWNSHIP 25 SOUTH, RANGE 34 EAST

30-02-30458 (PLUGGED)
30-025-29127 (PLUGGED)
EXISTING STORMWATER POND
N:419295.16 E:811946.18
N:419526.18 E:813513.83
N:419281.43 E:813526.49
N:418825.22 E:813489.27
EXISTING TRUCK SCALES AND ADMIN BUILDINGS
CELL E-1 (ACTIVE)
CELL E-2 (PROPOSED)
EXISTING LEACHATE EVAPORATION POND
EXISTING CALICHE ROADWAYS
CELL W-1 (FUTURE)
CELL W-2 (FUTURE)
CELL W-3 (FUTURE)
CELL W-5 (FUTURE)
CELL W-6 (FUTURE)
CELL E-3 (FUTURE)
CELL E-4 (FUTURE)
CELL E-5 (FUTURE)
CELL E-6 (FUTURE)
EXISTING CONCRETE WASTE DRYING PADS
EXISTING CONCRETE TRUCK WASH PAD
EXISTING STORMWATER POND
BATTLE AXE ROAD (HWY 2)
N:417601.86 E:807487.96
N:417020.33 E:808329.76
N:416843.79 E:808597.23
N:416502.69 E:810363.47
N:415983.97 E:809369.36
N:415729.21 E:809851.19
N:416176.17 E:812569.06
N:415486.09 E:812251.42
30-025-20906 (PLUGGED)
30-025-43651
30-025-43650
30-025-41816
30-025-44839
30-025-44175
30-025-46453
30-025-45381

250 0 125 250
SCALE IN FEET

ISSUED FOR BID

Know what's below. Call before you dig.

MICHAEL P. BRADFORD
NEW MEXICO
19240
PROFESSIONAL ENGINEER

NO.	REVISION	DATE

SHEET TITLE: EXISTING CONDITIONS AND OVERALL SITE DEVELOPMENT PLAN

PROJECT TITLE: CELL E-2 AND OPERATIONAL INFRASTRUCTURE CONSTRUCTION PLANS
NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY
LEA COUNTY, NEW MEXICO

CLIENT: HIGH ROLLER EPC

SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
8133 MARTIN AVENUE, SUITE 118
TEMPE, ARIZONA 85283
(602) 840-2596

PROJ. NO. 01222034.02 | DSN. BY: MPB | DWN. BY: MPB | CHK. BY: - | ACAD FILE: F:/ENGINEERS | APP. BY: MPB

DATE: OCTOBER 2022

SCALE: AS SHOWN

SHEET: 3

EXISTING FEATURES LEGEND:

- EXISTING GRADE CONTOURS (2' CONTOURS)
- EXISTING OVERHEAD ELECTRIC (OHE)
- EXISTING GAS LINES / GAS EASEMENT
- EXISTING WATER LINE
- EXISTING HIGHWAY CENTERLINE
- EXISTING NMOCD PERMITTED OIL WELLS
- NGL PROPERTY LINE
- SURVEY SECTION LINE
- CP-3(#77) SURVEY CONTROL MARKERS

PROPOSED FEATURES LEGEND:

- FACILITY PERMIT BOUNDARY
- N: E: PERMIT BOUNDARY CORNERS
- PERMITTED WASTE DISPOSAL/PHASE BOUNDARY
- WASTE DISPOSAL CELL BOUNDARY
- FUTURE LANDFILL/OPERATIONS ROADS
- APPROXIMATE LIMITS OF PROPOSED WORK
- MASS EXCAVATION AREA (DWG 5)
- CALICHE/GRAVEL ROADWAY
- GEOSYNTHETIC LINED AREA

SURVEY CONTROL MARKERS

ID	NORTHING	EASTING	ELEVATION	DESCRIPTION
BM-1(#40000)	418943.826	813403.620	3339.164	IRON ROD
BM-2(#40001)	418109.185	813188.000	3338.201	IRON ROD
BM-3(#40002)	418624.839	812615.975	3340.683	IRON ROD
BM-4(#40003)	418074.073	811994.956	3338.514	IRON ROD
BM-5(#40004)	419205.100	811913.849	3343.480	IRON ROD
BM-6(#40005)	419352.152	812594.652	3340.548	IRON ROD
CP-1(#75)	419454.584	813605.233	3342.940	NME_LEA_75
CP-2(#76)	417591.176	813160.526	3336.627	NME_LEA_76
CP-3(#77)	418650.357	810938.273	3340.499	NME_LEA_77
CP-4(#78)	419310.523	812193.090	3342.395	NME_LEA_78

SECTION LINE
SECTION 9 (WEST), SECTION 10 (EAST)
TOWNSHIP 25 SOUTH, RANGE 34 EAST

GAS & OHE

30-02-30458 (PLUGGED)

EXISTING TRUCK SCALES AND SCALE HOUSE

30-025-29127 (PLUGGED)

NORTH STORMWATER POND

N:419526.18
E:813513.83

CP-1(#75)

N:419281.43
E:813526.49

CP-4(#78)

BM-6(#40005)

N:419295.16
E:811946.18

BM-5(#40004)

CELL E-1
(CONSTRUCTED)

BM-1(#40000)

N:418825.22
E:813489.27

LEACHATE EVAPORATION POND

BM-3(#40002)

CP-3(#77)

CELL E-2
(PROPOSED)
DWG 5

CELL W-1
(FUTURE)

BM-4(#40003)

BM-2(#40001)

CELL E-3
(FUTURE)

SOUTH STORMWATER POND

EXISTING DRYING PAD

EXISTING TRUCK WASH

CP-2(#76)

CELL W-2
(FUTURE)

CELL W-3
(FUTURE)

CELL W-5
(FUTURE)

CELL E-4
(FUTURE)

CELL E-5
(FUTURE)

CELL W-6
(FUTURE)

CELL E-6
(FUTURE)

N:417601.86
E:807487.96

N:417020.33
E:808329.76

N:416843.79
E:808597.23

N:416502.69
E:810363.47

N:415983.97
E:809369.36

N:415729.21
E:809851.19

N:416176.17
E:812569.06

N:415486.09
E:812251.42

30-025-20906 (PLUGGED)

30-025-43651

30-025-43650

30-025-41816

30-025-44839

30-025-44175

30-025-46453

30-025-45381

BATTLE AXE ROAD (HWY 2)

250 0 125 250
SCALE IN FEET

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MICHAEL P. BRADFORD
NEW MEXICO
19240
PROFESSIONAL ENGINEER

NO.	REVISION	DATE

SHEET TITLE: SITE CONSTRUCTION DEVELOPMENT PLAN

PROJECT TITLE: CELL E-2 AND OPERATIONAL INFRASTRUCTURE CONSTRUCTION PLANS
NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY
LEA COUNTY, NEW MEXICO

CLIENT: HIGH ROLLER EPC

SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
5780 MARC ANNE, SUITE 118
TEMPE, ARIZONA 85283
(602) 840-2596

PROJ. NO. 01222034.02 | DWN. BY: MPB | CHK. BY: - | DSN. BY: MPB | ACAD FILE: F:/ENGINEERS | APP. BY: MPB

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SHEET: 4

CELL E-1
(CONSTRUCTED)

PERIMETER BERM B/10

LEACHATE AND LEAK COLLETION TRENCH D/10

LEACHATE COLLECTION AND LEAK DETECTION SUMP
LEACHATE SUMP BOT EL=3302.70'
LEAK SUMP BOT=3300.70' G/10

LEACHATE COLLECTION AND LEAK DETECTION SUMP RISER PIPE TRENCH C/10

LEACHATE COLLECTION AND LEAK DETECTION SUMP RISER PIPE CONCRETE HEADWALL AND DISCHARGE ASSEMBLY A/11

FLOOR CELL DIVIDER BERM D/12

DAYLIGHT FROM BREAKLINE AT 3:1 MIN

CELL E-3
(FUTURE)

60 0 30 60
SCALE IN FEET

EXISTING FEATURES LEGEND:
- EXISTING GRADE CONTOURS (2' CONTOURS)
- EXISTING OVERHEAD ELECTRIC
- EXISTING GAS LINES / GAS EASEMENT
- PERMITTED FACILITY BOUNDARY
- PERMITTED WASTE LIMIT
- PERMITTED CELL BOUNDARY

PROPOSED FEATURES LEGEND:
- LINER SYSTEM ANCHOR TRENCH B/10
- FLOOR FUTURE TIE-IN/LINER TERMINATION D/12
- SIDE SLOPE FUTURE TIE-IN/LINER TERMINATION F/12
- EXISTING LINER SYSTEM EDGE / TIE-IN TO EXISTING LINER E/12
- PROJECT LIMITS/MASS EXCAVATION AND GRADING AREA
- GEOSYNTHETIC LINED AREA A/10
- CALICHE/GRAVEL ROADWAY
- GRADING BREAK LINE

NOTES:

1. PROPOSED GRADES/CONTOURS SHOWN REPRESENT THE FINISHED GRADE ELEVATION PRIOR TO PLACEMENT OF PROTECTIVE COVER MATERIAL. SEE DRAWING 7 CT FOR CERTIFICATION ELEVATIONS OF PROTECTIVE COVER LAYER
2. SEE DRAWING 7 CT FOR LINER CERTIFICATION GRID POINTS

ISSUED FOR BID

MICHAEL P. BRADFORD NEW MEXICO 19240 PROFESSIONAL ENGINEER

NO.	REVISION	DATE

SHEET TITLE: CELL E-2 SUBGRADE GRADING PLAN

PROJECT TITLE: CELL E-2 AND OPERATIONAL INFRASTRUCTURE CONSTRUCTION PLANS
NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY
LEA COUNTY, NEW MEXICO

CLIENT: HIGH ROLLER EPC

SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
6330 WEST LOOP S. SUITE 116
AUSTIN, TEXAS 78757
(512) 451-6227
TEMPE, ARIZONA 85283
(602) 840-2596

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DATE: OCTOBER 2022

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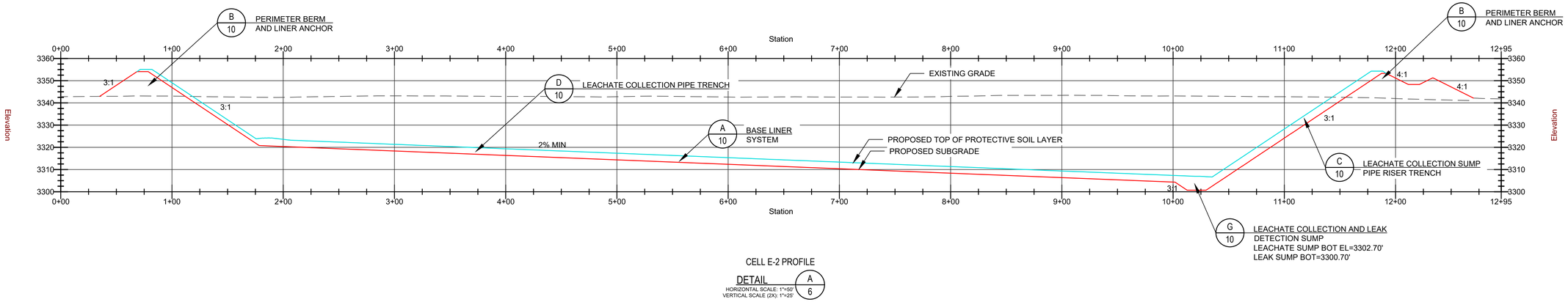
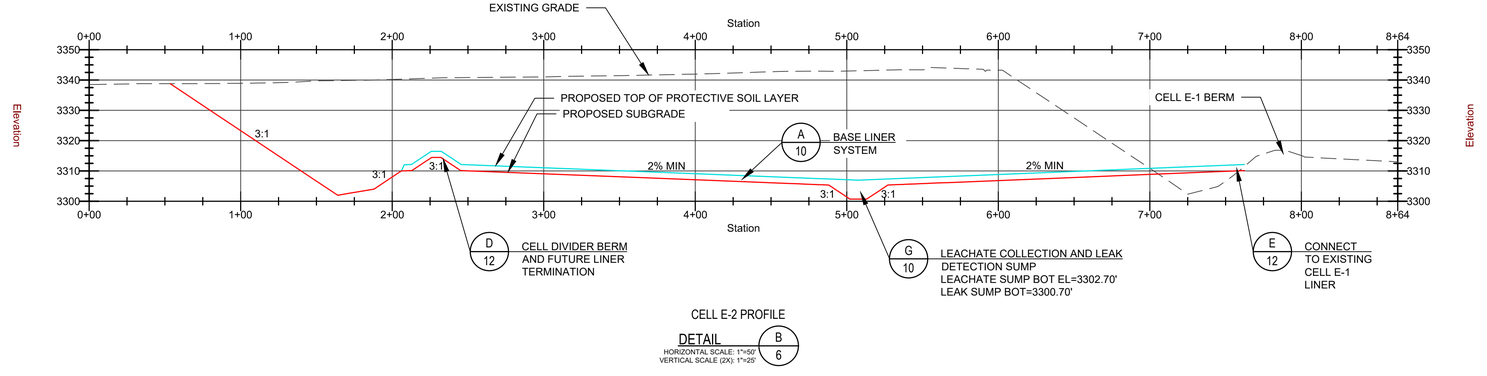
SHEET: 5



CELL E-2 PROFILE

DETAIL A/6

HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE (2X): 1"=25'



CELL E-2 PROFILE

DETAIL B/6

HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE (2X): 1"=25'

ISSUED FOR BID

Know what's below. Call before you dig.

SHEET TITLE: SURFACE PROFILES

PROJECT TITLE:
CELL E-2 AND OPERATIONAL INFRASTRUCTURE
CONSTRUCTION PLANS
NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY
LEA COUNTY, NEW MEXICO

CLIENT: HIGH ROLLER EPC

NO.	REVISION	DATE

SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
8575 W. MOHAVE, SUITE 118
TEMPE, ARIZONA 85282
(602) 840-2596

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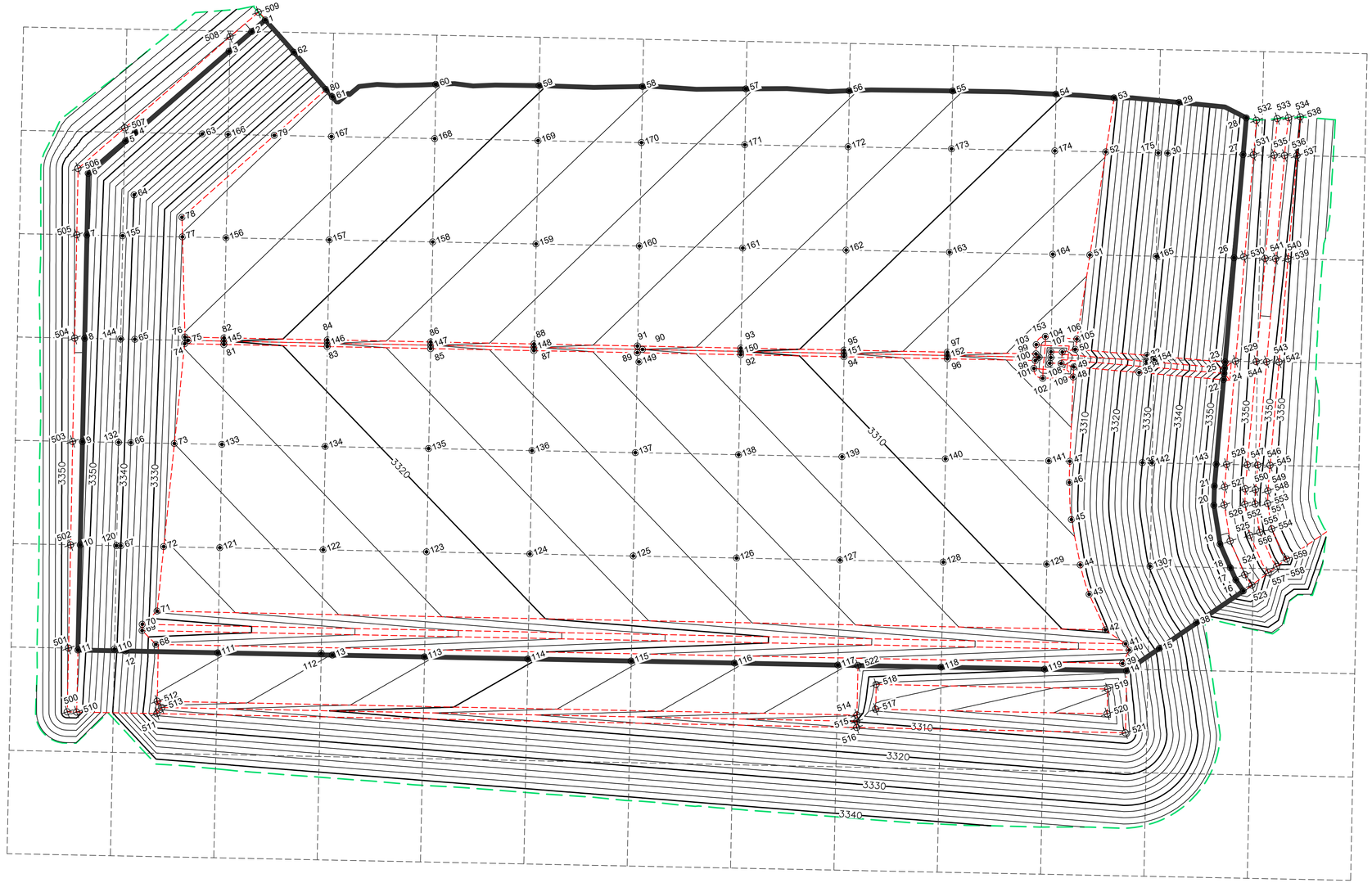
DATE: OCTOBER 2022

SCALE: AS SHOWN

SHEET: 6



ISSUED FOR BID

MICHAEL P. BRADFORD
NEW MEXICO
19240
10/28/22
PROFESSIONAL ENGINEER

NO.	REVISION	DATE

SHEET TITLE: CELL E-2 CERTIFICATION AND CONTROL POINTS PLAN

PROJECT TITLE: CELL E-2 AND OPERATIONAL INFRASTRUCTURE CONSTRUCTION PLANS NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY LEA COUNTY, NEW MEXICO

CLIENT: HIGH ROLLER EPC

SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
6100 MAPLE AVENUE, SUITE 118
TEMPE, ARIZONA 85283
(602) 840-2596

PROJ. NO. 01222034.02 | DWN. BY: MPB | ACAD FILE: F:/ENGINEERS
DSN. BY: MPB | CHK. BY: - | APP. BY: MPB

DATE: OCTOBER 2022

SCALE: AS SHOWN

SHEET: 7

nm811 Know what's below. Call before you dig.

Z:\DATA\CAD\North Ranch\CELL E-2\PLANS\007-008-CONTROL POINTS.dwg Oct 28, 2022 - 12:10pm By: 3268mpb

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

A B C D E F G H I J

CELL E-2 CERTIFICATION POINTS TABLE

ID	NORTHING	EASTING	TOP OF SUBGRADE ELEVATION	TOP OF PROTECTIVE COVER ELEVATION	DESCRIPTION
1	418920.60	811432.20	3353.92	3354.92	E2 CERT BL
2	418914.19	811416.29	3354.00	3355.00	E2 CERT BL
3	418903.33	811389.31	3354.15	3355.15	E2 CERT BL
4	418858.46	811277.82	3354.75	3355.75	E2 CERT BL
5	418853.91	811266.53	3354.81	3355.81	E2 CERT BL
6	418836.01	811222.07	3355.05	3356.03	E2 CERT BL
7	418779.97	811201.40	3354.69	3355.69	E2 CERT BL
8	418686.14	811166.81	3354.08	3355.08	E2 CERT BL
9	418592.32	811132.21	3353.48	3354.48	E2 CERT BL
10	418498.49	811097.62	3352.88	3353.88	E2 CERT BL
11	418403.12	811062.45	3352.27	3352.27	E2 LINER EDGE
12	418387.21	811105.83	3337.14	3337.14	E2 LINER EDGE
13	418318.35	811293.64	3323.96	3323.96	E2 LINER EDGE
14	418053.83	812015.10	3308.60	3308.60	E2 LINER EDGE
15	418064.02	812052.17	3321.41	3321.41	E2 LINER EDGE
16	418090.07	812147.01	3354.19	3354.19	E2 LINER EDGE
17	418102.54	812143.60	3354.15	3355.15	E2 CERT BL
18	418115.32	812142.48	3354.08	3355.11	E2 CERT BL
19	418140.33	812140.50	3354.00	3355.03	E2 CERT BL
20	418177.67	812147.00	3353.90	3354.90	E2 CERT BL
21	418195.17	812153.52	3353.84	3354.84	E2 CERT BL
22	418289.58	812195.46	3353.32	3354.32	E2 CERT BL
23	418305.30	812202.45	3353.24	3354.24	E2 CERT BL
24	418295.19	812197.96	3351.28	3354.29	E2 CERT BL
25	418299.92	812200.06	3351.28	3354.27	E2 CERT BL
26	418397.80	812243.55	3352.73	3353.73	E2 CERT BL
27	418489.39	812284.25	3352.23	3353.23	E2 CERT BL
28	418521.99	812298.73	3352.05	3353.05	E2 CERT BL
29	418557.29	812242.18	3330.00	3332.11	E2 CERT MIDSLP
30	418514.49	812215.78	3328.00	3330.11	E2 CERT MIDSLP
31	418422.69	812175.67	3328.71	3330.82	E2 CERT MIDSLP
32	418335.89	812133.19	3328.00	3330.11	E2 CERT MIDSLP
33	418330.59	812130.69	3326.00	3330.10	E2 CERT MIDSLP
34	418326.02	812128.67	3326.00	3330.12	E2 CERT MIDSLP
35	418322.74	812120.50	3326.00	3328.11	E2 CERT MIDSLP
36	418239.22	812095.10	3330.00	3332.11	E2 CERT MIDSLP
37	418138.98	812077.98	3333.15	3335.28	E2 CERT MIDSLP
38	418076.05	812094.26	3336.00	3336.46	E2 CERT MIDSLP
39	418061.81	812013.69	3308.82	3313.82	E2 CERT BL
40	418071.96	812024.03	3313.02	3315.13	E2 CERT BL
41	418078.84	812022.70	3313.09	3315.21	E2 CERT BL
42	418097.95	812008.62	3309.16	3311.27	E2 CERT BL
43	418135.61	812005.00	3308.81	3310.93	E2 CERT BL
44	418165.34	812006.09	3308.43	3310.53	E2 CERT BL
45	418209.56	812012.24	3307.74	3309.85	E2 CERT BL
46	418244.15	812022.06	3307.08	3309.19	E2 CERT BL
47	418263.39	812029.16	3306.67	3308.78	E2 CERT BL
48	418339.44	812058.82	3305.00	3307.11	E2 CERT BL
49	418348.45	812062.46	3304.84	3306.95	E2 CERT BL
50	418364.09	812069.47	3304.77	3306.88	E2 CERT BL
51	418445.85	812112.51	3306.36	3308.47	E2 CERT BL
52	418535.13	812159.52	3308.09	3310.20	E2 CERT BL
53	418581.89	812184.14	3309.00	3311.11	E2 CERT BL
54	418603.58	812132.19	3310.17	3312.17	E2 CERT BL
55	418639.15	812038.68	3312.20	3314.20	E2 CERT BL
56	418671.84	811944.17	3314.16	3316.16	E2 CERT BL
57	418706.14	811850.22	3316.16	3318.16	E2 CERT BL
58	418740.88	811756.42	3318.16	3320.16	E2 CERT BL
59	418774.21	811662.13	3320.14	3322.14	E2 CERT BL
60	418807.92	811567.98	3322.13	3324.13	E2 CERT BL
61	418829.04	811469.49	3323.84	3325.84	E2 CERT BL
62	418882.04	811448.20	3340.00	3342.11	E2 CERT MIDSLP
63	418836.10	811338.80	3340.00	3342.11	E2 CERT MIDSLP
64	418801.83	811257.23	3340.00	3342.11	E2 CERT MIDSLP
65	418669.43	811212.38	3338.00	3340.11	E2 CERT MIDSLP
66	418576.17	811176.26	3338.00	3340.11	E2 CERT MIDSLP
67	418484.97	811134.51	3340.00	3342.11	E2 CERT MIDSLP
68	418383.81	811135.45	3327.53	3329.64	E2 CERT MIDSLP
69	418400.76	811127.25	3332.12	3334.23	E2 CERT BL
70	418406.36	811129.42	3332.12	3334.23	E2 CERT BL
71	418413.82	811147.12	3327.51	3329.62	E2 CERT BL
72	418470.67	811173.49	3326.16	3328.27	E2 CERT BL
73	418561.71	811215.69	3324.00	3326.11	E2 CERT BL
74	418649.75	811256.55	3321.90	3324.01	E2 CERT BL
75	418651.65	811260.87	3320.78	3324.01	E2 CERT BL
76	418655.76	811258.88	3321.90	3324.01	E2 CERT BL
77	418748.15	811288.16	3323.92	3326.03	E2 CERT BL
78	418766.19	811293.88	3324.31	3326.42	E2 CERT BL
79	418812.10	811404.22	3324.18	3326.29	E2 CERT BL
80	418837.79	811465.96	3324.11	3326.22	E2 CERT BL
81	418636.63	811292.19	3321.14	3323.14	E2 CERT BL

CELL E-2 CERTIFICATION POINTS TABLE

ID	NORTHING	EASTING	TOP OF SUBGRADE ELEVATION	TOP OF PROTECTIVE COVER ELEVATION	DESCRIPTION
82	418642.73	811294.43	3321.14	3323.14	E2 CERT BL
83	418602.25	811386.09	3319.14	3321.14	E2 CERT BL
84	418608.31	811388.31	3319.14	3321.14	E2 CERT BL
85	418567.77	811479.96	3317.14	3319.14	E2 CERT BL
86	418573.88	811482.20	3317.14	3319.14	E2 CERT BL
87	418533.40	811573.87	3315.14	3317.14	E2 CERT BL
88	418539.46	811576.09	3315.14	3317.14	E2 CERT BL
89	418498.98	811667.76	3313.14	3315.14	E2 CERT BL
90	418500.30	811673.58	3311.98	3314.98	E2 CERT BL
91	418505.03	811669.98	3313.14	3315.14	E2 CERT BL
92	418464.55	811761.65	3311.14	3313.14	E2 CERT BL
93	418470.61	811763.87	3311.14	3313.14	E2 CERT BL
94	418430.13	811855.53	3309.14	3311.14	E2 CERT BL
95	418436.19	811857.75	3309.14	3311.14	E2 CERT BL
96	418395.71	811949.42	3307.14	3309.14	E2 CERT BL
97	418401.76	811951.64	3307.14	3309.14	E2 CERT BL
98	418366.43	812029.28	3305.44	3307.44	E2 CERT BL
99	418372.31	812031.97	3305.43	3307.43	E2 CERT BL
100	418368.20	812033.82	3304.30	3307.30	E2 CERT BL
101	418359.66	812025.65	3305.61	3307.61	E2 CERT BL
102	418347.82	812030.56	3305.63	3307.63	E2 CERT BL
103	418380.68	812035.16	3305.61	3307.61	E2 CERT BL
104	418385.24	812046.18	3305.59	3307.59	E2 CERT BL
105	418372.94	812074.12	3304.94	3307.05	E2 CERT BL
106	418365.68	812056.67	3300.70	3306.96	E2 CERT BL
107	418369.47	812046.31	3300.70	3307.19	E2 CERT BL
108	418359.44	812041.73	3300.70	3307.20	E2 CERT BL
109	418355.64	812052.09	3300.70	3306.98	E2 CERT BL
110	418392.52	811096.16	3340.79	3342.43	E2 CERT GRID
111	418356.54	811189.48	3326.18	3326.18	E2 CERT GRID
112	418323.66	811283.93	3324.22	3325.82	E2 CERT GRID
113	418287.70	811377.25	3322.18	3322.18	E2 CERT GRID
114	418253.27	811471.14	3320.18	3320.18	E2 CERT GRID
115	418218.85	811565.03	3318.18	3318.18	E2 CERT GRID
116	418184.42	811658.92	3316.18	3316.18	E2 CERT GRID
117	418150.00	811752.81	3314.18	3314.18	E2 CERT GRID
118	418115.58	811846.69	3312.18	3312.18	E2 CERT GRID
119	418081.15	811940.58	3310.18	3310.18	E2 CERT GRID
120	418486.40	811130.59	3341.39	3343.50	E2 CERT GRID
121	418451.97	811224.47	3325.07	3327.07	E2 CERT GRID
122	418417.54	811318.36	3323.07	3325.07	E2 CERT GRID
123	418383.12	811412.24	3321.07	3323.07	E2 CERT GRID
124	418348.69	811506.13	3319.07	3321.07	E2 CERT GRID
125	418314.26	811600.02	3317.08	3319.08	E2 CERT GRID
126	418279.83	811693.90	3315.08	3317.08	E2 CERT GRID
127	418245.40	811787.79	3313.08	3315.08	E2 CERT GRID
128	418210.97	811881.68	3311.08	3313.08	E2 CERT GRID
129	418176.54	811975.56	3309.08	3311.08	E2 CERT GRID
130	418142.11	812069.45	3330.30	3332.43	E2 CERT GRID
131	418107.68	812163.33	3351.59	0.00	E2 CERT GRID
132	418580.29	811165.02	3341.99	3344.10	E2 CERT GRID
133	418545.86	811258.90	3323.07	3325.07	E2 CERT GRID
134	418511.43	811352.79	3321.07	3323.07	E2 CERT GRID
135	418477.00	811446.67	3319.07	3321.07	E2 CERT GRID
136	418442.57	811540.56	3317.07	3319.07	E2 CERT GRID
137	418408.14	811634.45	3315.07	3317.07	E2 CERT GRID
138	418373.71	811728.33	3313.08	3315.08	E2 CERT GRID
139	418339.28	811822.22	3311.08	3313.08	E2 CERT GRID
140	418304.85	811916.10	3309.08	3311.08	E2 CERT GRID
141	418270.42	812009.99	3307.08	3309.08	E2 CERT GRID
142	418236.00	812103.88	3333.11	3335.22	E2 CERT GRID
143	418214.62	812162.16	3353.73	3354.73	E2 CERT GRID
144	418674.18	811199.44	3342.59	3344.70	E2 CERT GRID
145	418639.75	811293.33	3320.09	3323.08	E2 CERT GRID
146	418605.32	811387.22	3318.09	3321.08	E2 CERT GRID
147	418570.89	811481.10	3316.09	3319.08	E2 CERT GRID
148	418536.46	811574.99	3314.09	3317.08	E2 CERT GRID
149	418502.03	811668.88	3312.08	3315.08	E2 CERT GRID
150	418467.60	811762.76	3310.08	3313.08	E2 CERT GRID
151	418433.17	811856.65	3308.08	3311.08	E2 CERT GRID
152	418398.74	811950.53	3306.08	3309.08	E2 CERT GRID
153	418364.31	812044.42	3300.70	3307.08	E2 CERT GRID
154	418329.88	812138.31	3329.23	3332.50	E2 CERT GRID
155	418768.06	811233.87	3343.19	3345.30	E2 CERT GRID
156	418733.63	811327.76	3323.08	3325.08	E2 CERT GRID
157	418699.20	811421.65	3321.08	3323.08	E2 CERT GRID
158	418664.77	811515.53	3319.08	3321.08	E2 CERT GRID
159	418630.34	811609.42	3317.08	3319.08	E2 CERT GRID
160	418595.91	811703.30	3315.08	3317.08	E2 CERT GRID
161	418561.49	811797.19	3313.08	3315.08	E2 CERT GRID
162	418527.06	811891.08	3311.08	3313.08	E2 CERT GRID

CELL E-2 CERTIFICATION POINTS TABLE

ID	NORTHING	EASTING	TOP OF SUBGRADE ELEVATION	TOP OF PROTECTIVE COVER ELEVATION	DESCRIPTION
163	418492.63	811984.96	3309.08	3311.08	E2 CERT GRID
164	418458.20	812078.85	3307.07	3309.08	E2 CERT GRID
165	418423.77	812172.74	3327.67	3329.78	E2 CERT GRID
166	418827.52	811362.19	3334.34	3336.45	E2 CERT GRID
167	418793.09	811456.08	3323.08	3325.08	E2 CERT GRID
168	418758.66	811549.96	3321.08	3323.08	E2 CERT GRID
169	418724.23	811643.85	3319.08	3321.08	E2 CERT GRID
170	418689.80	811737.73	3317.08	3319.08	E2 CERT GRID
171	418655.37	811831.62	3315.08	3317.08	E2 CERT GRID
172	418620.94	811925.51	3313.08	3315.08	E2 CERT GRID
173	418586.51	812019.39	3311.08	3313.08	E2 CERT GRID
174	418552.08	812113.28	3309.07	3311.08	E2 CERT GRID
175	418517.65	812207.17	3324.95	3327.06	E2 CERT GRID

CONSTRUCTION CONTROL POINTS TABLE

ID	NORTHING	EASTING	TOP OF SUBGRADE ELEVATION	DESCRIPTION
500	418349.9359	811033.1999	3351.9095	CONST CTRL
501	418407.8211	811054.4233	3352.2803	CONST CTRL
502	418501.7093	811088.847	3352.8817	CONST CTRL
503	418595.5976	811123.2708	3353.4831	CONST CTRL
504	418689.4859	811157.6945	3354.0845	CONST CTRL
505	418783.3741	811192.1183	3354.6859	CONST CTRL
506	418843.631	811214.2113	3355.0674	CONST CTRL
507	418866.0038	811269.7909	3354.7685	CONST CTRL
508	418916.3036	811394.7486	3354.0965	CONST CTRL
509	418929.8173	811428.3198	3353.9159	CONST CTRL
510	418346.8231	811041.6898	3351.9039	CONST CTRL
511	418320.0765	811114.639	3325.3378	CONST CTRL
512	418331.3416	811118.7739	3325.7377	CONST CTRL
513	418324.1573	811120.9387	3323.2476	CONST CTRL
514	418098.2679	811754.4653	3312.1963	CONST CTRL
515	418092.6346	811752.3999	3309.7963	CONST CTRL
516	418087.0013	811750.3345	3311.7963	CONST CTRL
517	418097.7049	811773.4306	3305.4363	CONST CTRL
518	418120.2381	811781.6923	3307.4363	CONST CTRL
519	418043.1289	811992.002	3302.4763	CONST CTRL
520	418020.5957	811983.7403	3300.9563	CONST CTRL
521	417997.4995	811994.4439	3306.5963	CONST CTRL
522	418143.3343	811770.9887	3313.7963	CONST CTRL
523	418092.7112	812156.6323	3354.1953	CONST CTRL
524	418104.5729	812153.3879	3354.152	CONST CTRL
525	418139.8631	812150.6742	3354	CONST CTRL
526	418174.7638	812156.5647	3353.902	CONST CTRL
527	418191.1068	812162.6544	3353.8405	CONST CTRL
528	418211.1709	812171.5695	3353.7308	CONST CTRL
529	418302.7593	812212.265	3353.2296	CONST CTRL
530	418395.7422	812252.6017	3352.7229	CONST CTRL
531	418485.9359	812293.6559	3352.2274	CONST CTRL
532	418516.5516	812307.2594	3352.0599	CONST CTRL
533	418511.5004	812326.9004	3347.0431	CONST CTRL
534	418508.8013	812337.3955	3347.2059	CONST CTRL
535	418479.0347	812312.4749	3347.2207	CONST CTRL
536	418475.5841	812321.8844	3347.2174	CONST CTRL
537	418471.4378	812333.1911	3350.2093	CONST CTRL
538	418505.9043	812348.5557	3350.0092	CONST CTRL
539	418379.8548	812292.481	3350.7143	CONST CTRL
540	418383.9958	812281.189	3347.7185	CONST CTRL
541	418387.4464	812271.7795	3347.7219	CONST CTRL
542	418288.2666	812251.7853	3351.2155	CONST CTRL
543	418292.4075	812240.4935	3348.2196	CONST CTRL
544	418295.8581	812231.084	3348.223	CONST CTRL
545	418196.6784	812211.0895	3351.7167	CONST CTRL
546	418200.8191	812199.798	3348.7207	CONST CTRL
547	418204.2697	812190.3885	3348.7241	CONST CTRL
548	418174.0526	812201.0361	3351.8405	CONST CTRL
549	418178.9253	812190.0699	3348.8405	CONST CTRL
550	418182.9858	812180.9314	3348.8405	CONST CTRL
551	418168.9446	812175.6994	3348.902	CONST CTRL
552	418166.035	812185.2668	3348.902	CONST CTRL
553	418162.5435	812196.7476	3351.902	CONST CTRL
554	418137.9689	812192.5234	3352.027	CONST CTRL
555	418138.5115	812180.5357	3349.027	CONST CTRL
556	418138.9637	812170.5459	3349.027	CONST CTRL
557	418098.8837	812175.6385	3349.1935	CONST CTRL
558	418101.9699	812185.1416	3349.1923	CONST CTRL
559	418105.6733	812196.5454	3352.1906	CONST CTRL

ISSUED FOR BID

MICHAEL R. BRADFORD
NEW MEXICO
19240
PROFESSIONAL ENGINEER

NO.	REVISION	DATE

SHEET TITLE: POINTS TABLES

PROJECT TITLE: CELL E-2 AND OPERATIONAL INFRASTRUCTURE CONSTRUCTION PLANS
NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY
LEA COUNTY, NEW MEXICO

CLIENT: HIGH ROLLER EPC

SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
6575 WEST LOOP S, SUITE 118
BELLAIRE, TEXAS 77401
(602) 840-2596

PROJ. NO. 01222034.02 | DSN. BY: MPB | DWN. BY: MPB | CHK. BY: - | ACAD FILE: F:/ENGINEERS | APP. BY: MPB

DATE: OCTOBER 2022

SCALE: AS SHOWN

SHEET: 8

EXISTING FEATURES LEGEND:

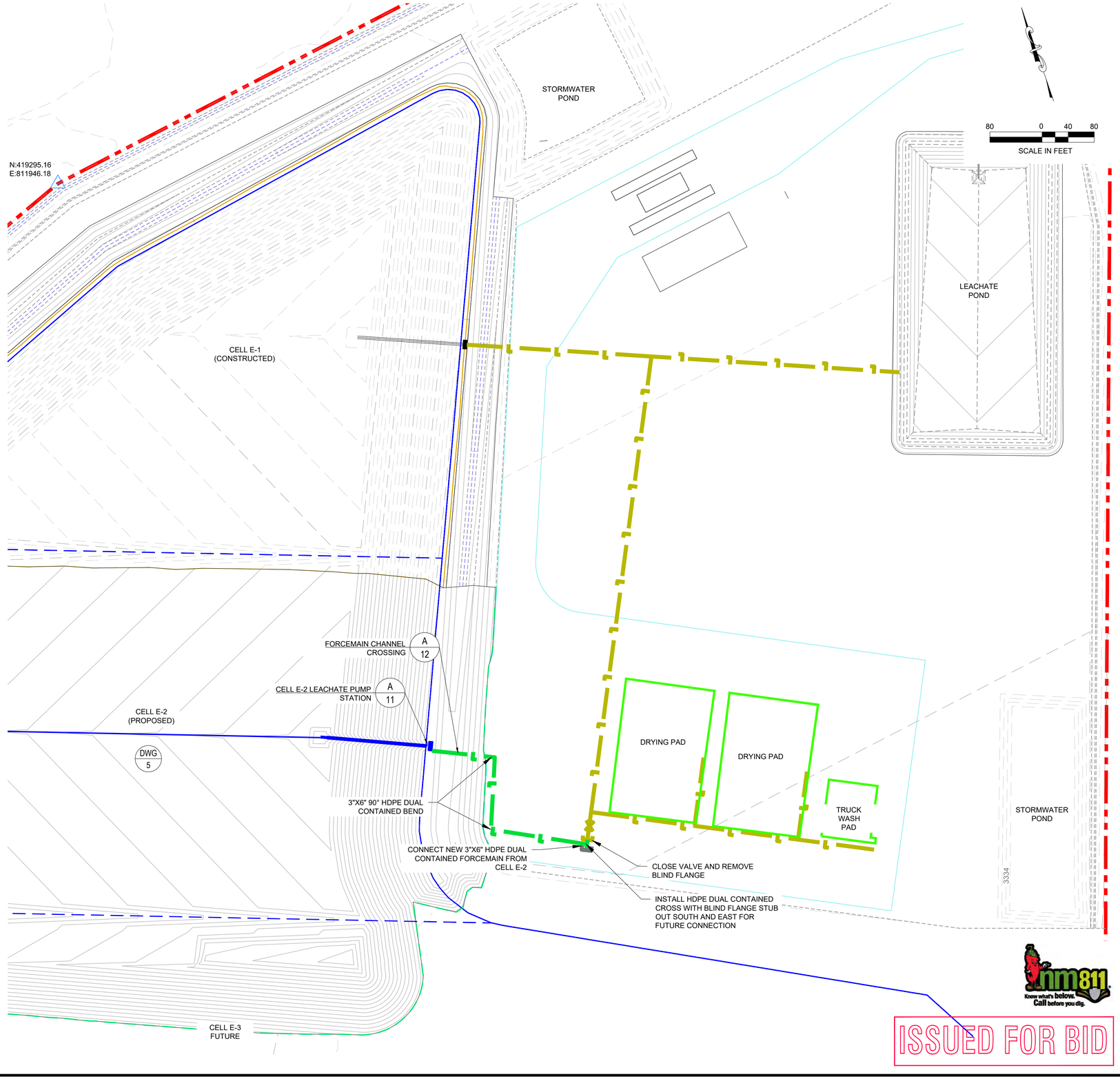
- 3300 — EXISTING GRADE CONTOURS (2' CONTOURS)
- OE — EXISTING OVERHEAD ELECTRIC
- G — G — G — EXISTING GAS LINES / GAS EASEMENT
- EXISTING FORCEMAIN INFRASTRUCTURE

PROPOSED FEATURES LEGEND:

- 3300 — 1-FT GRADING CONTOURS (CONTROL INFORMATION ON THIS SHEET)
- FACILITY PERMIT BOUNDARY
- N: E: PERMIT BOUNDARY CORNERS
- PERMITTED WASTE DISPOSAL/PHASE BOUNDARY
- WASTE DISPOSAL CELL BOUNDARY
- PROJECT LIMITS/MASS EXCAVATION AREA (APPROXIMATE)
- 3"X6" DUAL CONTAINED HDPE LEACHATE FORCEMAIN (APPROX LF AS SHOWN) — B / 12
- BLIND FLANGE FUTURE STUB

NOTES:

1. CONTRACTOR SHALL MAINTAIN A MINIMUM OFFSET OF 5-FEET FROM CONCRETE FOOTERS WITH FORCMAIN FLOWLINE.
2. FORCEMAIN ALIGNMENT SHOW IS SPECIFICALLY FOR IF THE PIPE IS BURIED DURING THIS PROJECT. PIPE WHEN BURIED MUST BE PLACED AS DETAILED TO PREVENT UNINTENTIONAL BURIAL DURING CELL CLOSURES. IF PIPE IS PLACED AT GRADE, OPERATIONS MAY ALIGN THE PIPE AS DESIRED.



ISSUED FOR BID

MICHAEL P. BRADFORD NEW MEXICO 19240 10/28/22 PROFESSIONAL ENGINEER

DATE

REVISION

NO.

SHEET TITLE: LEACHATE FORCEMAIN CONSTRUCTION PLAN

PROJECT TITLE: CELL E-2 AND OPERATIONAL INFRASTRUCTURE CONSTRUCTION PLANS NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY LEA COUNTY, NEW MEXICO

CLIENT: HIGH ROLLER EPC

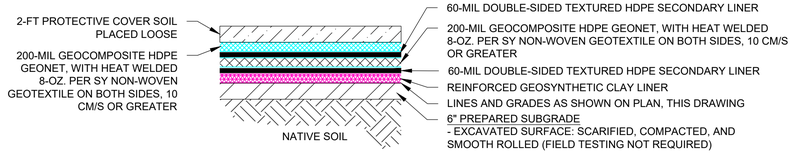
SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
8799 BALBOA AVENUE, SUITE 290
SAN DIEGO, CA 92123
(858) 571-5500 FAX. (562) 427-0805

PROJ. NO. 01222034.02 | DSN. BY: MPB | DWN. BY: MPB | CHK. BY: - | APP. BY: MPB | ACAD FILE: F:/ENGINEERS

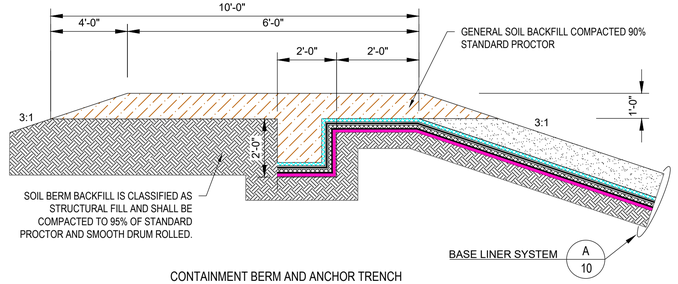
DATE: OCTOBER 2022

SCALE: AS SHOWN

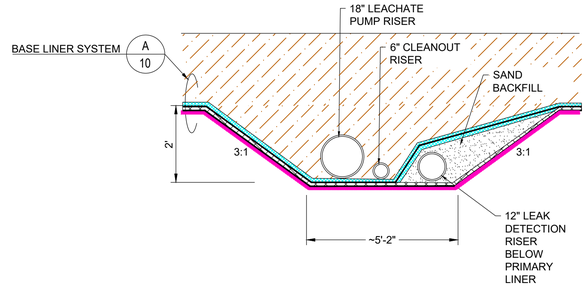
SHEET: 9



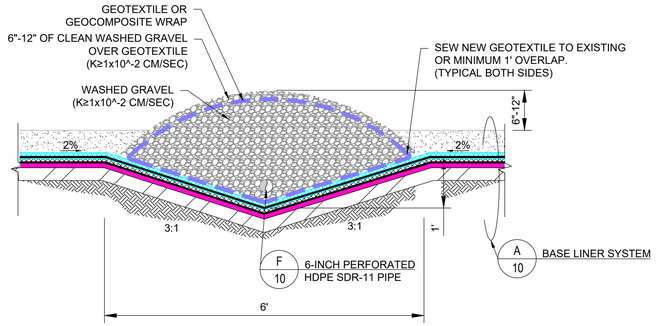
BASE LINER SYSTEM
DETAIL A/11 N.T.S.



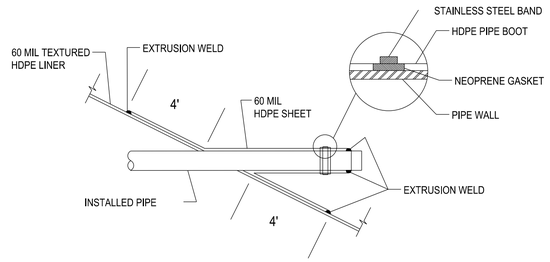
CONTAINMENT BERM AND ANCHOR TRENCH
DETAIL B/10 N.T.S.



SUMP RISER PIPE TRENCH
DETAIL C/10 N.T.S.

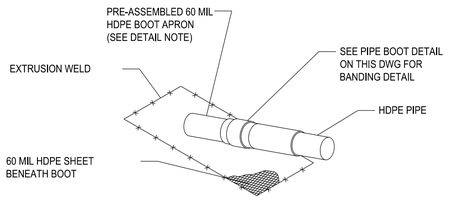


LEACHATE COLLECTION PIPE AND TRENCH
DETAIL D/10 N.T.S.

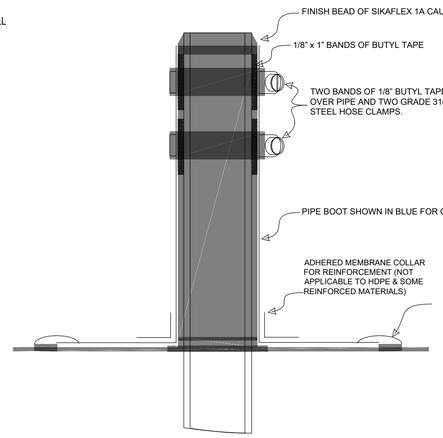


SLOPED SIDE WALL HDPE LINER PIPE BOOT DETAIL – PROFILE VIEW

NOTE:
CONTRACTOR SHALL PROVIDE PRE-ASSEMBLED AND TESTED/ CERTIFIED PIPE BOOTS FOR EACH PIPE PENETRATION AS PER THE SPECIFICATIONS

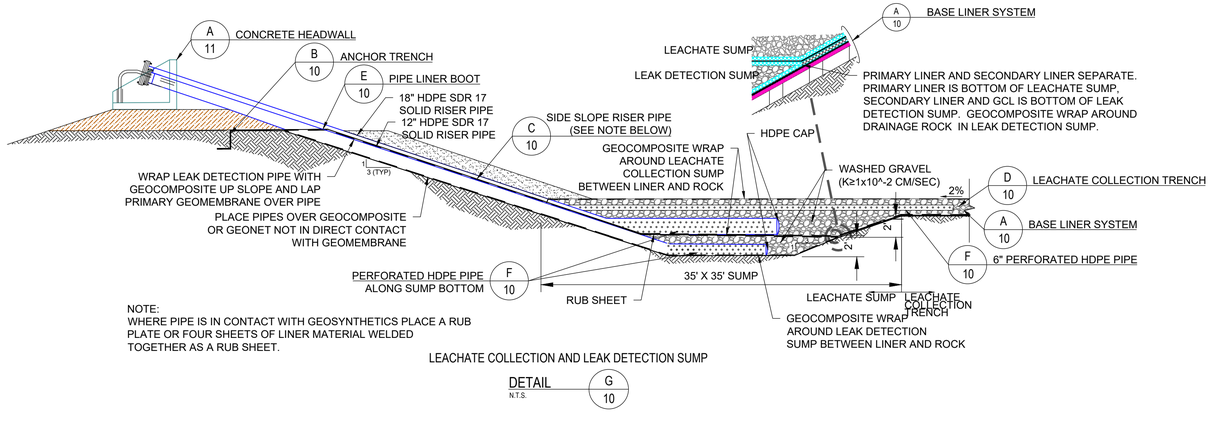


SLOPED SIDE WALL PIPE BOOT DETAIL – ISOMETRIC VIEW



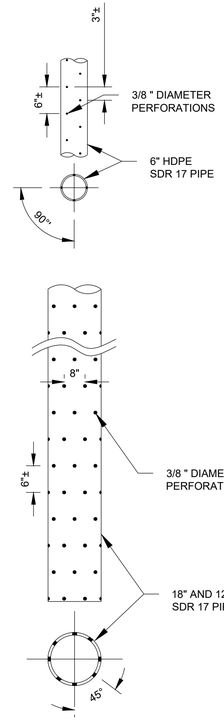
VERTICAL WALL PIPE BOOT DETAIL – PROFILE VIEW

LINER PIPE BOOT
DETAIL E/10 N.T.S.



NOTE:
WHERE PIPE IS IN CONTACT WITH GEOSYNTHETICS PLACE A RUB PLATE OR FOUR SHEETS OF LINER MATERIAL WELDED TOGETHER AS A RUB SHEET.

LEACHATE COLLECTION AND LEAK DETECTION SUMP
DETAIL G/10 N.T.S.



NOTE:
PERFORATIONS BUILT TO MANUFACTURER STANDARD.

PIPE PERFORATIONS
DETAIL F/10 N.T.S.

MICHAEL P. BRADFORD
NEW MEXICO
19240
10/28/22
PROFESSIONAL ENGINEER

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CELL E-2 AND OPERATIONAL INFRASTRUCTURE CONSTRUCTION PLANS
NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY
LEA COUNTY, NEW MEXICO

CLIENT:

SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
6060 N. CENTRAL EXPWY, SUITE 118
DALLAS, TEXAS 75206
(214) 373-8300

PROJ. NO. 01222034.02 | DSN. BY: MPB | DWN. BY: MPB | CHK. BY: - | ACAD FILE: F:/ENGINEERS | APP. BY: MPB

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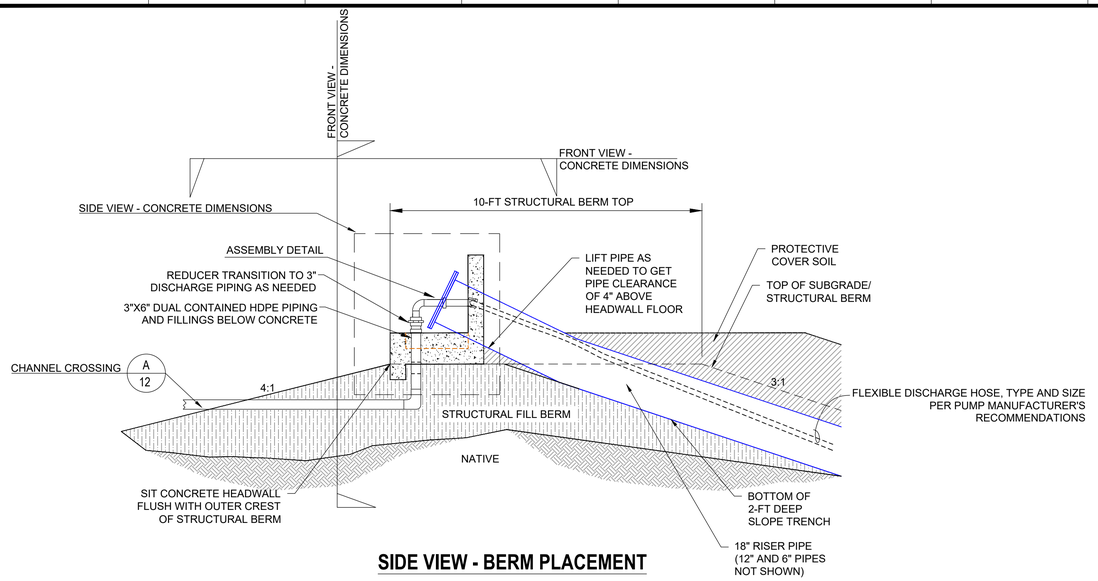
SCALE: AS SHOWN

SHEET: 10

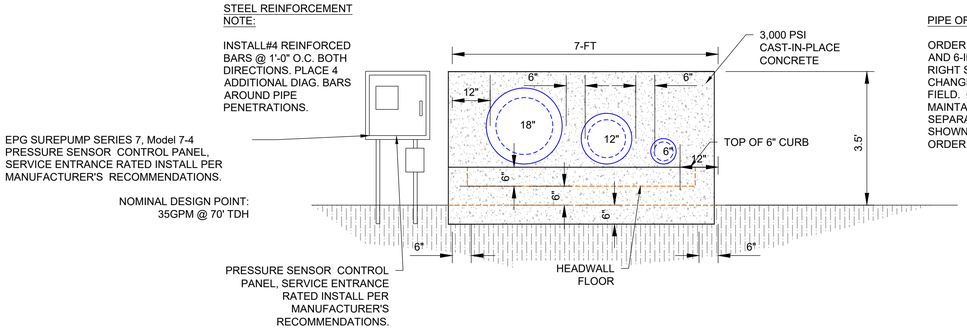
ISSUED FOR BID



SIDE VIEW - BERM PLACEMENT

STEEL REINFORCEMENT NOTE:

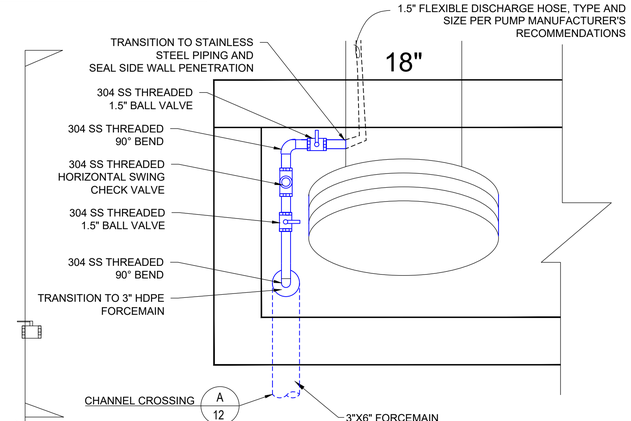
INSTALL#4 REINFORCED BARS @ 1'-0" O.C. BOTH DIRECTIONS. PLACE 4 ADDITIONAL DIAG. BARS AROUND PIPE PENETRATIONS.



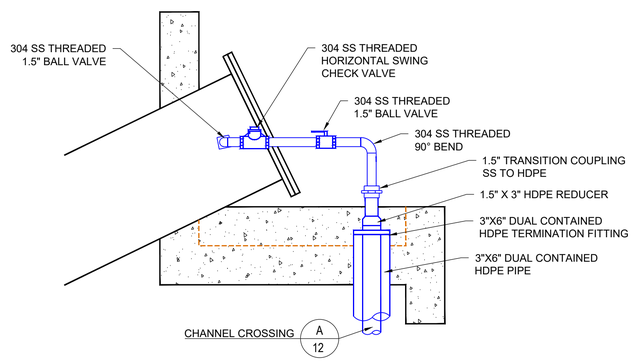
FRONT VIEW - CONCRETE DIMENSIONS

PIPE ORIENTATION NOTE:

ORDER OF 18-INCH, 12-INCH AND 6-INCH RISERS LEFT TO RIGHT SHOWN CAN BE CHANGED AS NEEDED IN FIELD. CONTRACTOR TO MAINTAIN FLANGE TO FLANGE SEPARATION DISTANCES SHOWN REGARDLESS OF ORDER.



ASSMBLY DETAIL - TOP VIEW



ASSMBLY DETAIL - SIDE VIEW

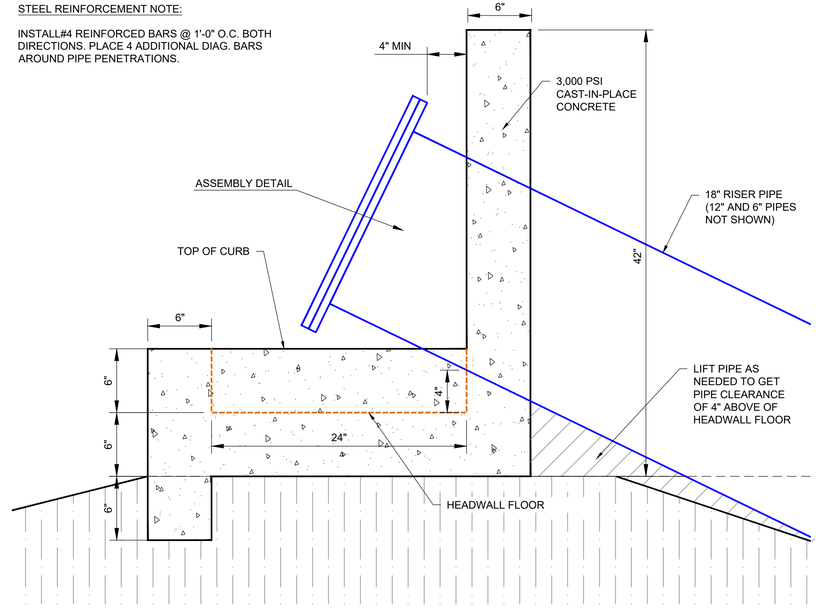
NOTES:
1. ELECTRICAL AND POWER CONNECTIONS TO BE PROVIDED BY OTHERS.
2. CAP ALL RISER PIPE ENDS WITH HDPE FLANGED ADAPTOR WITH D.I. BACKUP RING AND BLIND FLANGE150LB BOLT PATTERN AND STAINLESS STEEL BOLTS AND NUTS.
3. DISCHARGE ASSEMBLY PIPING TO BE 1.5-INCH 304 STAINLESS STEEL THREADED.

LEACHATE PUMP RISER HEADWALL AND DISCHARGE ASSEMBLY

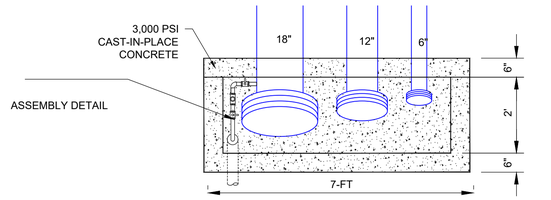
DETAIL A 11 N.T.S.

STEEL REINFORCEMENT NOTE:

INSTALL#4 REINFORCED BARS @ 1'-0" O.C. BOTH DIRECTIONS. PLACE 4 ADDITIONAL DIAG. BARS AROUND PIPE PENETRATIONS.



SIDE VIEW - CONCRETE DIMENSIONS



PIPE ORIENTATION NOTE:

ORDER OF 18-INCH, 12-INCH AND 6-INCH RISERS LEFT TO RIGHT SHOWN CAN BE CHANGED AS NEEDED IN FIELD. CONTRACTOR TO MAINTAIN FLANGE TO FLANGE SEPARATION DISTANCES SHOWN REGARDLESS OF ORDER.

TOP VIEW - CONCRETE DIMENSIONS

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NORTH RANCH SURFACE WASTE MANAGEMENT FACILITY
LEA COUNTY, NEW MEXICO

CLIENT:

SCS ENGINEERS
ENVIRONMENTAL CONSULTANTS
6060 N. 44TH STREET, SUITE 118
PHOENIX, ARIZONA 85253
(602) 840-2596

ACAD FILE: F:\ENGINEERS
DWN. BY: MPB
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DSN. BY: MPB

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SHEET: 11

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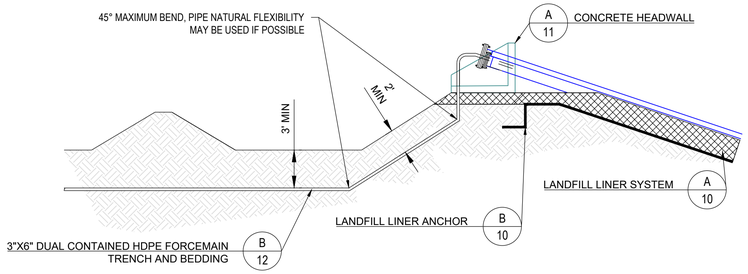
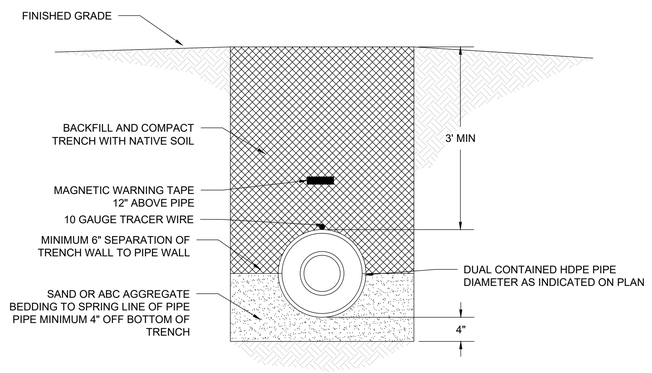


FORCEMAIN CHANNEL CROSSING

DETAIL A/12

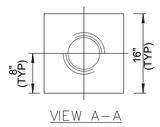
SCALE: NOT TO SCALE



TYPICAL BURIED FORCEMAIN TRENCH AND BEDDING

DETAIL B/12

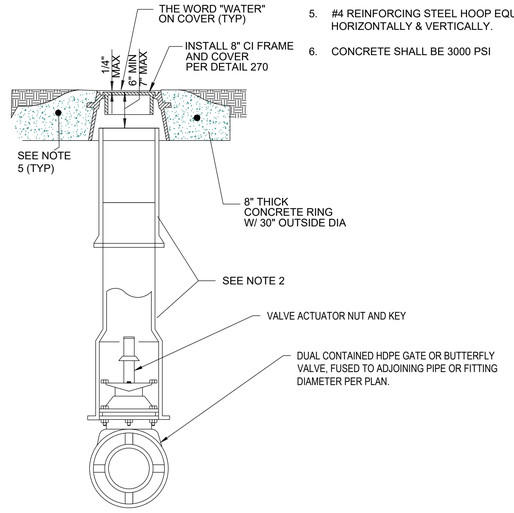
SCALE: NOT TO SCALE



VIEW A–A

NOTES:

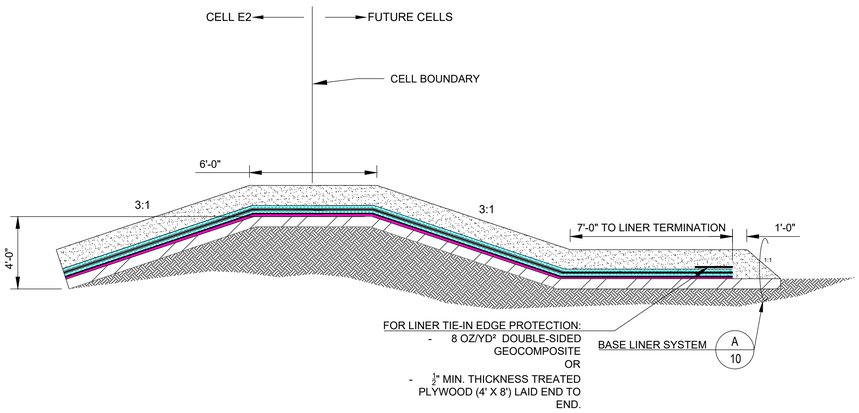
1. VALVE BOX SHALL BE ADJUSTED TO THE FINISHED GRADE PRIOR TO PLACEMENT OF CONCRETE.
2. USE DEEP SKIRTED LID (4" OR MORE) TYPE, SLIDING ADJUSTABLE CAST IRON VALVE BOX C.I. MIN 30,000 P.S.I.
3. GROUND BELOW THE CONCRETE RISER PAD TO BE COMPACTED 95% MAXIMUM DENSITY.
4. CUT RISER PIPE TO LENGTH IN FIELD.
5. #4 REINFORCING STEEL HOOP EQUALLY CENTERED HORIZONTALLY & VERTICALLY.
6. CONCRETE SHALL BE 3000 PSI



TYPICAL VALVE BOX AND COVER

DETAIL C/12

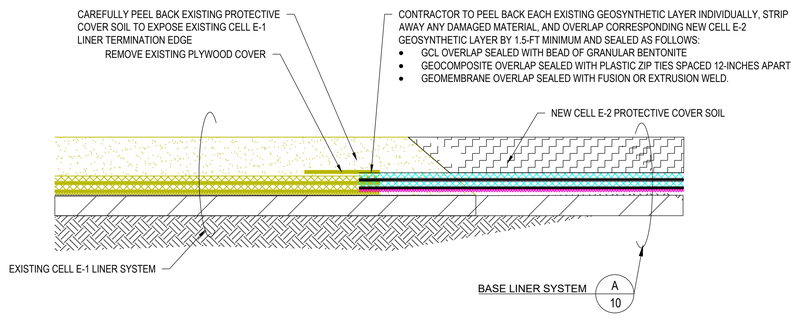
SCALE: NOT TO SCALE



FLOOR CELL DIVIDER BERM AND LINER TERMINATION

DETAIL D/12

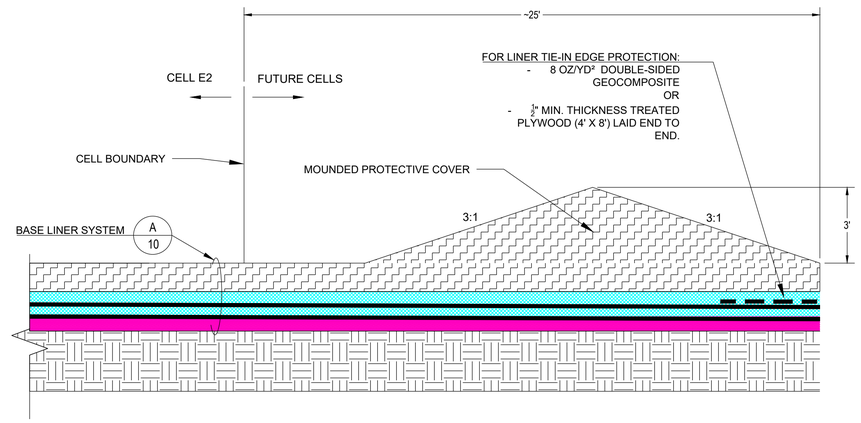
N.T.S.



EXISTING LINER TIE IN DETAIL

DETAIL E/12

N.T.S.



SIDE SLOPE CELL DIVIDER BERM AND LINER TERMINATION

DETAIL F/12

N.T.S.

nm811 Know what's below. Call before you dig.

ISSUED FOR BID

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8575 W. SAM HOUSTON PKWY. SUITE 118
TEMPE, ARIZONA 85253
(602) 840-2596

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01222034.02	MPB	MPB	-	F:\ENGINEERS	MPB

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SCALE: AS SHOWN

SHEET: 12

District I
1625 N. French Dr., Hobbs, NM 88240
Phone:(575) 393-6161 Fax:(575) 393-0720
District II
811 S. First St., Artesia, NM 88210
Phone:(575) 748-1283 Fax:(575) 748-9720
District III
1000 Rio Brazos Rd., Aztec, NM 87410
Phone:(505) 334-6178 Fax:(505) 334-6170
District IV
1220 S. St Francis Dr., Santa Fe, NM 87505
Phone:(505) 476-3470 Fax:(505) 476-3462

State of New Mexico
Energy, Minerals and Natural Resources
Oil Conservation Division
1220 S. St Francis Dr.
Santa Fe, NM 87505

CONDITIONS

Action 162477

CONDITIONS

Operator:	OGRID:
NGL Waste Services, LLC 1008 Southview Circle Center, TX 75935	329268
	Action Number: 162477
	Action Type: [C-137] Non-Fee SWMF Submittal (SWMF NON-FEE SUBMITTAL)

CONDITIONS

Created By	Condition	Condition Date
bjones	OCD has completed the review the Construction Plans for Cell E-2 and have accepted the submittal into the administrative record.	11/30/2022