National Nuclear Security Administration

DEPARTMENT OF ENERGY
National Nuclear Security Administration
Los Alamos Site Office
Los Alamos, New Mexico 87544

JUN 3 0 2005

Mr. James Bearzi, Chief
NMED/Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Dear Mr. Bearzi:

Enclosed are two hard copies and one electronic copy of the Remedy Design Work Plan for the Los Alamos Site Office, TA-73 Airport Landfill. This work plan replaces the previous Phase II Work Plan delivered to NMED in April 2004, and this previous work plan is hereby rescinded. The concrete hangar foundations shown in design drawings represent the maximum extent of cover penetration that may be required for Los Alamos County airport hangar foundations. Several other options that may provide the required supports with less extensive penetration of the MatCon surface are being considered in collaboration with Los Alamos County. If another option is selected, errata sheets for the revised drawings will be submitted during the review period. Finally, all the design drawings have been stamped with "NOT FOR CONSTRUCTION'. Once all review comments have been received, final design documents will be issued without this stamp.

On December 22, 2004, NMED granted DOE's second extension request for response to NMED's approval with modifications (September 2, 2004) for the previous Phase II Work Plan for the Los Alamos Airport Landfills. DOE had requested the extension to respond to modifications #1 and #4. of NMED's approval letter. DOE also requested the extension to prepare an Environmental Assessment to consider remedy alternatives and to perform an impact analysis. All requested information was due NMED no later than June 30, 2005.

In view of our new Remedy Design Work Plan, DOE withdraws its responses to modifications #1 and #4 of NMED's approval letter. DOE no longer seeks clarification of these two modifications. With regard to remedy alternatives and impact analysis, DOE provided the Airport Landfill Environmental Assessment (EA) and Finding of No Significant Impact to NMED via a transmittal letter sent to NMED Secretary Ron Curry on May 26, 2005. The NEPA finding was based on the consideration that there are no significant impacts to the environment or to human health expected as a result of implementation of our new proposed action at LANL. As a result of the EA and stakeholder input from Los Alamos County, the New Mexico Department of Transportation, the Federal Aviation Administration, and local Pilots Association, DOE proposes the enclosed new Remedy Design Work Plan for NMED's consideration as a best solution for the Los Alamos Airport Landfills.

Sincerely,

David R. Gregory
Federal Project Manager

ES: 2BE-003

Enclosures

JUN 30 2005

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NW-ID-2004-031
Revision 1

REMEDY DESIGN WORK PLAN FOR THE LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILL

June 2005

Prepared for:

U. S. Department of Energy, National Nuclear Security Administration
Los Alamos Site Office
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DOCUMENT APPROVAL PAGE

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Approval Signatures

Name	Signature	Date	Title
Doug Jorgensen	Original signature on file	05/24/05	North Wind Inc. Project Manager
Robert Enz	Original signature on file	05/24/05	U.S. Department of Energy, LASO

Revision Log

Revision	Date	Reason for Revision
Draft	03/30/04	Not applicable; first draft of document
Revision 0	04/15/04	Document revised to incorporate DOE/LASO comments of 04/05/04.
Revision 1	5/31/05	Document revised to reflect scope change per DOE revised Statement of Work. Primary revisions include addition of design history and reference to the change in design.

CONTENTS

ATTACHMENTS

1.0 INTRODUCTION

This Remedy Design Work Plan describes the final remedy that the U.S. Department of Energy (DOE) will implement at the Los Alamos Site Office (LASO) Technical Area (TA)-73 Airport Landfill and Debris Disposal Area (DDA) project, henceforth referred to as the Airport Landfill project. This revision of the Remedy Design Work Plan (Revision 1) was prepared to address stakeholder requests that the original design (Revision 0) be modified to better accommodate aircraft parking. The revised project scope includes a Modified Asphalt Technology for Waste Containment (MatCon™) asphalt surface over the flat portion of the landfill, a gas venting layer under the MatCon™ surface, and a retaining wall along the base of the east slope. In addition, airport improvements will be made to the west end of the main landfill, including hangar pads and aircraft tie-downs. All requirements for the final remedy identified by the New Mexico Environment Department (NMED), as well as other applicable requirements and stakeholder requests, are met by this design. The design of the DDA cover was not affected by the revised scope.

This document is in compliance with specific guidance in Sections III.M, VI.K, and VII.E of the Compliance Order on Consent (NMED 2005).

1.1 Contents of Remedy Design Work Plan

The contents of the Remedy Design Work Plan are prescribed in the NMED conditional approval letter of the Voluntary Corrective Measure (VCM) Plan (NMED 2003). The conditional approval letter is referenced by Section VI.L of the NMED Order of November 26, 2002 (NMED 2002). The conditional approval letter prescribes the following elements of the Remedy Design Work Plan:

- Detailed engineering design (Section 2.0),
- Construction or implementation details (Section 3.0),
- Vapor monitoring system design and plan (Section 5.0),
- Demonstration of cover performance over the life of the cover (Section 6.0),
- Schedule for cover maintenance (Section 7.0),
- Closure and post-closure care for the landfill once construction of the cover is complete (Section 8.0), and
- Explanation as to why certain ground water monitoring data referenced in the VCM Plan were not reported (Section 9.0).

This Remedy Design Work Plan is organized by sections corresponding to the above elements (corresponding sections in parentheses). For some elements, North Wind Inc. (NWI) has prepared a plan that addresses the specific element, and that plan is referenced in the appropriate section and as an attachment. For the remaining elements, descriptive text is provided to address the particular element.

1.2 Scope of Document

The Remedy Design Work Plan applies to the construction and post-closure care and monitoring of the landfill cover at the Airport Landfill project. The construction phase is defined as the time period from mobilization to demobilization. The post-closure phase is defined as 30 years after closure (i.e., completion of construction of the landfill cover).

1.3 Site Description and Background

A detailed site description and operational history are documented in the Los Alamos National Laboratory (LANL) VCM Plan (LANL 2002). The Airport Landfill project consists of two solid waste management units (SWMUs), 73-001(a) and 73-001(d). SWMU 73-001(a), main landfill, and SWMU 73-001(d), DDA, are inactive units and both are listed in Table A within Module VIII of LANL's Hazardous Waste Facility Permit (LANL 1996). Both SWMUs are located within TA-73 on DOE property, as shown in Figure 1.3-1 (see Section 13). The main landfill is east of the existing airport hangars and the DDA is east of the end of the runway. Figure 1.3-2 (see Section 13) shows the location of the SWMUs in TA-73.

In 1943, the DOE began using the hanging valley north of the airport runway as the main landfill. Garbage was collected twice a week from the LANL and town site and burned on the edge of the hanging valley. Heavy equipment was then used to push the burned residues and ash into whichever landfill disposal area was being used at the time. This intentional burning ceased in 1965 when Los Alamos County (LAC) assumed operation of the landfill. The county continued to operate the landfill until June 30, 1973.

The DDA was used from 1984 to 1986 to bury debris excavated from the western portion of the main landfill. This material was excavated and replaced with clean fill to prepare the western portion of the landfill for the construction of airplane hangars and tie-down areas. Since the wastes placed in the DDA came from the main landfill, both areas contained similar types of debris. In 1986, the DDA landfill was covered with soil and hydroseeded.

2.0 DETAILED ENGINEERING DESIGN

This section describes the TA-73 closure requirements, the basis for the revision of the Remedy Design Work Plan, and summarizes the significant features of the revised design.

2.1 Closure Requirements

The preferred final TA-73 Airport Landfill remedy was described by NMED in the VCM Plan Conditional Approval Letter (NMED 2003) as:

> "…an engineered alternative earthen cover (cap) or RCRA Subtitle C equivalent cover, as long as the cover construction will perform equivalent to or better than a standard RCRA Subtitle C prescriptive cover outlined in 40 CFR 265 Subpart N, incorporated by 20.4.1.600 NMAC".

The functional requirements cited in 40 *Code of Federal Regulations* (CFR) 265.310(a)(1-5) include:

1. Provide long-term minimization of migration of liquids through the closed landfill,
2. Function with minimum maintenance,
3. Promote drainage and minimize erosion or abrasion of the cover,
4. Accommodate settling and subsidence so that the cover's integrity is maintained, and
5. Have a permeability less than or equal to the permeability of any bottom liner or natural subsoils present.

In accordance with DOE Order 5480.4, "Environmental Protection, Safety, and Health Protection Standards" (DOE 1993), other federal, State of New Mexico, and LAC regulations were reviewed to identify the mandatory environmental protection, safety, and health requirements. Table 2.2-1 (see Section 12) lists the regulatory requirements applicable to the design and closure of the landfill and the DDA, including the 40 CFR 265.310 requirements.

2.2 Basis for Revised Design

The Phase II Work Plan, Revision 0 (North Wind 2004), proposed a vegetated earthen cover that met the *Resource Conservation and Recovery Act* (RCRA) Subtitle C functional requirements identified in 40 CFR 265.310 for the unlined TA-73 Airport Landfill. NMED approved the design with stipulations in September 2004 (NMED 2004). Following submittal of the Phase II Work Plan (Revision 0), LAC officially notified DOE of their concerns with the proposed remediation on the airport landfill (September 16, 2004). The primary issue of concern was that the submitted design did not account for or accommodate airport expansion plans.

On October 7, 2004, DOE requested from NMED an extension for response to comments on the Phase II Work Plan. NMED granted this extension on October 20, 2004, with a due date of December 31, 2004 for receipt of comment response.

Alternatives to the Revision 0 design for the main landfill were tentatively evaluated and costed during the remaining calendar year of 2004. On December 20, 2004, DOE requested a second extension for response to comments and to prepare an Environmental Assessment (EA) on reasonable alternatives for remediation of the airport landfill and to perform impact analysis. NMED granted this second extension with a new due date for response to comments scheduled for June 30, 2005. The preparation of the EA was initiated at this time.

The EA for the remediation of the LAC Airport Landfill was completed on March 29, 2005 (DOE 2005a) and released for public comment on April 4, 2005. The EA provided interested parties several alternatives to remediation of the landfill and provided sufficient evidence and analysis for determining the significance of impacts from the corrective measures alternatives. The federal decision to be made in the EA process was to determine whether to prepare an Environmental Impact Statement (EIS) based on the significance of the environmental impacts. This process also provides a vehicle for stakeholders to share their ideas concerning the proposed corrective measures alternatives with DOE officials.

Stakeholder comments were received from the Federal Aviation Administration (FAA), NMED, Aircraft Owners and Pilots Association, and San Ildefonso Pueblo. The comments consisted of statements and questions concerning duration of the corrective measures, environmental justice, administrative authority language, incorrect names, and a request for removal of a cumulative impact section sentence. Additions, deletions, and appropriate changes were made to the draft EA in response to these comments. Based on stakeholder input and evaluation results of the EA, a Finding of No Significant Impact (FONSI) for this site was prepared and signed by DOE officials in May 2005 (DOE 2005b).

Based on stakeholder input and future use considerations of the main landfill area, Alternative 1 (as described in the EA) was determined to be the preferred alternative for design and construction. Alternative 1 involves leaving waste in place at the main landfill, relocating waste from the east slope to the main landfill surface, installing a gas collection system below a MatCon^{TM} cover (proprietary formulation of asphalt) over the landfill, constructing a retaining wall at the base of the east slope, and covering the DDA as previously described in the original design. The remaining east slope and north slopes will have infiltration barriers and rock armor finishes. In addition, airport improvements will be made to the west end of the main landfill, including hanger pads and aircraft tie-downs. This alternative meets 40 CFR 265.310 functional requirements for the TA-73 Airport Landfill closure and is the preferred alternative of stakeholders. This alternative is the basis for design for Revision 1 of the Remedy Design Work Plan.

Landfill cover requirements cited in 40 CFR 265.310 are assessed, with respect to the MatCon^{TM} cover, in Table 2.2-2 (see Section 12). MatCon^{TM} paving was evaluated by the EPA SITE Program and was determined to be able to achieve as-built hydraulic conductivities of less than 1E-08 cm/sec, "which exceeds the requirement of less than 1E-07 cm/sec established for RCRA Subtitle C hazardous waste landfill covers…" (EPA 2003). The referenced Subtitle C permeability requirement is for lined landfills, based on requirements that a) the landfill cover "...have a permeability less than or equal to the permeability of any bottom liner or natural subsoils present" (40 CFR 265.310(1)(5); and b) the lower component of the landfill liner "...must be constructed of at least 3 ft of compacted soil material with a hydraulic conductivity of no more than 1E-07 cm/sec (40 CFR 264.301(c)(1)(i))."

2.3 Final Design

The final design package, which includes specifications, drawings, and engineering calculations, is included as Attachment A. The final design specifications and drawings will incorporate NMED review comments of the draft final design package and represents the final specifications directing construction of the landfill cover.

3.0 CONSTRUCTION OR IMPLEMENTATION DETAILS

The Construction Plan for the LASO TA-73 Airport Landfill (North Wind 2005a) is included as Attachment B and describes methods and protocols that NWI will use to manage construction activities at the Airport Landfill project. The Construction Plan summarizes planned construction activities and shows how specific construction activities will be completed in accordance with final design specifications and drawings.

The Construction Plan provides construction management protocol, including key personnel responsibilities, reporting requirements, and a detailed construction schedule. The Construction Plan also provides a detailed description of construction activities, which include:

- Procurement of materials and services;
- Mobilization activities, which include assembling construction documents, conducting a construction readiness assessment, building access roads, installing temporary field trailers, initial surveying of the DDA and main landfill, mobilizing heavy equipment to the site, and locating underground utilities;
- Site preparation activities, which include installing perimeter fencing, installing storm water run-off and erosion controls, abandoning existing monitoring wells within the footprint of the main landfill, and abandoning and/or relocating existing utilities;
- Construction of the DDA, which includes a pre-construction survey, rough regrading, adding topsoil (as needed) to bring final topsoil to 12 in. over the entire DDA footprint, and surveying the final grade;
- Construction of the east and north slope of the main landfill, which includes salvaging existing soil for use as subgrade, a pre-excavation survey, relocating existing municipal landfill waste, establishing the subgrade, adding the infiltration layer, adding geotextile and rock armor (riprap) over the slopes, adding a retaining wall at the toe of the east slope, and a survey of the final grade;
- Construction of the approved cover over the main landfill, which also includes stripping and stockpiling soil cover, relocating waste, backfilling soil, compaction and contouring of area, placement of gas collection layer aggregate and piping, and placement of MatCon™ asphalt surface. Construction will additionally include installation of hanger pads and aircraft tie-downs on the MatCon™ surface;
- Revegetation of the DDA;
- DOE inspection and acceptance; and
- Demobilization.

The Construction Plan also provides meetings and inspections criteria; quality controls; health and safety controls; operation, maintenance, and monitoring requirements; and training and certification requirements.

Quality control (QC) of constructed landfill components is an important element of the Airport Landfill project. The Construction Quality Control Plan (CQCP) for the TA-73 Airport Landfill (North Wind 2005b) provides QC requirements for construction activities, including testing, in progress inspections, and hold points critical between phases of the construction. The CQCP is included as Attachment C.

4.0 WASTE MANAGEMENT PLAN

The Waste Management Plan (WMP) for the LASO TA-73 Airport Landfill (North Wind 2005c) describes methods that NWI will use to manage waste generated during execution of the Airport Landfill project. The WMP, included as Attachment D, describes waste management goals, pollution prevention and waste minimization techniques, methods for managing nonhazardous waste streams and petroleum-contaminated soil, training requirements, and spill notification and reporting protocols.

5.0 VAPOR MONITORING SYSTEM DESIGN AND PLAN

Based on the proposed design and construction of the MatCon™ surface over the main landfill surface and the future construction of airplane hangers on the MatCon™, a gas collection system with surface venting will be a installed as a component of the design to ensure mitigation of any possible methane gas generation within the hanger structures, and to prevent exceedences of 25% of the lower explosive limit (LEL) at the property boundary. Vapor monitoring is not required and will not be performed.

The gas collection system is included in the design package and includes specifications for a minimum of 6 in. of coarse base aggregate overlying woven geotextile, perforated piping within the aggregate, and gas vent locations to the surface.

6.0 DEMONSTRATION OF COVER PERFORMANCE

The Post-closure Care and Monitoring Plan (PCMP) for the TA-73 Airport Landfill (North Wind 2005d) is included as Attachment E and identifies post-closure care and monitoring requirements for the landfill and describes activities to meet those requirements. The PCMP applies to operation and maintenance of the cover integrity.

The PCMP identifies regulatory requirements for post-closure care and monitoring; post-closure monitoring and maintenance methods for the cover system, storm water control system, survey benchmarks, and access roads; record-keeping and reporting requirements; and describes an inspection schedule for years one through five of the post-closure period.

7.0 SCHEDULE FOR COVER MAINTENANCE

The schedule for cover maintenance is provided in the PCMP (Attachment E). Inspections for years one through five of the post-closure period are tentatively scheduled for the first 2 weeks of June each year so that the condition of vegetation in the DDA can be inspected and corrected, as needed, early in the growing season. All other deficiencies should be corrected at the earliest opportunity and before the end of the calendar year in order to be completed during the reporting period.

8.0 CLOSURE AND POST-CLOSURE CARE

Methods for closure and post-closure care are provided in the PCMP (Attachment D). Monitoring for cover integrity will include inspections of the cover and maintenance and repair of deficiencies. No frequency is specified in the requirements; however, annual inspections are specified in this plan. An inspection report will be completed for each inspection. The following subsections describe inspection and maintenance tasks.

8.1 Cover System

Annual cover inspections will include site walkovers looking for and documenting erosional damage and cracks, gaps at seals between asphalt and concrete, animal burrows, subsidences, and condition of vegetation. The PCMP provides methods for repairing these conditions, if warranted.

8.2 Storm Water Control System

Annual storm water control system inspections will include all areas of the site, as described for post-construction in the Storm Water Pollution Prevention Plan (SWPPP) for the TA-73 Airport Landfill (North Wind 2005e). Inspectors will look for evidence of, or the potential for, pollutants entering the storm water conveyance system. Discharge locations identified in the site plans will be inspected to determine whether erosion controls are effective in preventing significant impact to Pueblo Canyon.

8.3 Survey Benchmarks

Annual inspections will include locating and documenting the condition of permanent survey benchmarks. Benchmarks will be maintained in a clearly visible condition.

9.0 VOLUNTARY CORRECTIVE MEASURE PLAN GROUND WATER MONITORING DATA

In the VCM Plan conditional approval letter (NMED 2003), NMED inquired as to why certain monitoring well sampling data were collected and results not reported. The comment was in regard to Section 2.3.2.1, "Monitoring Well Sampling" of the VCM Plan (LANL 2002), which states:

> "…therefore, the data are of little or no use when evaluating the effectiveness of the run-on controls, and the monitoring well sampling results are not presented in this plan."

LANL's response to the inquiry was that the above referenced data will be provided to NMED in the Remedy Design Work Plan. The following information (Rust 2004), provided by NWI, responds to NMED's inquiry and is included to satisfy LANL's commitment that the explanation will be included in the Remedy Design Work Plan:

> "The pore water sampling from the existing monitoring wells that was attempted during the supplemental sampling campaign executed in 2001 failed to generate meaningful data. All wells were sampled in an attempt to collect pore water to verify the effectiveness of run on controls and to assess the moisture content within the landfill after 2 years of storm water diversion. Unfortunately, inadequate pore water was collected from any of the monitoring wells for meaningful analysis. It is believed that this is due to the ongoing drought conditions, which has resulted in inadequate landfill moisture to sustain water in the subsurface, coupled with the installation of the aforementioned storm water controls to divert runoff that formerly drained onto the landfill."

10.0 SUPPORTING PROJECT DOCUMENTS

As discussed previously, this Remedy Design Work Plan is the primary scoping document for the Airport Landfill project. However, other plans and procedures have been prepared to direct and manage activities for both the planning and construction phases of the project. The following subsections provide a brief overview of these documents.

10.1 Project Quality Plan

The Project Quality Plan (PQP) for the LASO TA-73 Airport Landfill (North Wind 2005f) describes how NWI will implement a quality assurance (QA) program for the Airport Landfill project that complies with the applicable requirements of DOE Order 414.1A, "Quality Assurance" (DOE 2001) and 10 CFR 830.120, Subpart A, "Quality Assurance Requirements."

The PQP conforms to the 10 QA criteria, as stated in DOE Order 414.1A, which include (1) program description, (2) personnel training and qualification, (3) quality improvement, (4) documents and records, (5) work processes, (6) design, (7) procurement, (8) inspection and acceptance testing, (9) management assessment, and (10) independent assessment.

10.2 Health and Safety Plan

The Health and Safety Plan (HASP) for the LASO TA-73 Airport Landfill (North Wind 2005g) establishes the procedures and requirements that will be used to eliminate or minimize health and safety hazards to personnel conducting construction tasks at the Airport Landfill project. The objective of the HASP is to meet the regulatory requirements of the Occupational Safety and Health Administration standard, 29 CFR 1926.65, "Hazardous Waste Operations and Emergency Response." The HASP governs all work at the project sites that is performed by NWI, subcontractors, and any other personnel who enter the project site.

The HASP identifies anticipated site hazards and appropriate mitigation measures, exposure monitoring and sampling protocol, accident and exposure prevention, personal protective equipment, required personnel training, site control and security measures, occupational medical surveillance, key site personnel responsibilities, emergency response plan, decontamination procedures, and record-keeping requirements.

10.3 Project Management Plan

The Project Management Plan (PMP) for the LASO TA-73 Airport Landfill (North Wind 2005h) describes the management structure and processes that NWI will use to manage the Airport Landfill project. The PMP identifies key positions and associated responsibilities, availability and allocation or resources, management controls, contract administration, reporting protocol, project deliverables, a summary of the corporate QA program, and training and certification requirements. The project baseline schedule and work breakdown structure are also found in the PMP.

10.4 Storm Water Pollution Prevention Plan

The SWPPP (North Wind 2005e) has been prepared for the construction and post-construction phases of the final design remedy cover at the Airport Landfill project. The SWPPP complies with the terms of the "Final National Pollutant Discharge Elimination System General Permit for Storm Water Discharges from Construction Activities" (FR 2003). The SWPPP also complies with applicable DOE and State of New Mexico regulations.

The primary purpose of the SWPPP is to provide a framework for reducing soil erosion and minimizing pollutants in storm water during construction of the final design remedy cover at the Airport Landfill.

10.5 Implementing Procedures

As described in the PQP (North Wind 2005f), NWI corporate QA procedures will be implemented during the Airport Landfill project. In addition, several project-specific Project Work Instructions (PWIs) have been developed. The PWIs include:

- PWI-4201-001, Project Files,
- PWI-4201-002, Field Activities Documentation,
- PWI-4201-004, Readiness Assessment, and
- PWI-4201-005, Field Change.

11.0 PROGRESS REPORTS

Progress reports for the Airport Landfill project shall be submitted to NMED on a monthly basis, during construction of the landfill covers. Reports shall include work completed during the reporting period, a summary of issues or delays and actions taken to mitigate issues or delays, work planned to be completed in the next reporting period, and copies of any sampling results or waste disposal records generated. Reports shall be submitted at the end of each month following receipt of a construction notice to proceed.

12.0 TABLES

Table 2.2-1 Regulatory Requirements for Airport Landfill Closure Design

Disposal Facility Component	Federal		State of New Mexico or Los Alamos County		Stakeholder Requests		Minimum Applicable Technical Requirement	Additional Design Basis
	Technical Requirement	Citation	Technical Requirement	Citation			Citation	
Final Cover System Geometry	Regrading requires a maximum 7-foot horizontal: 1-foot vertical (7:1) slope beyond 125-feet setback from runway centerline	14 CFR 77.25	None Identified	None Identified	- Provide paved surface for parking aircraft - 0.5-2% slopes - Tie (grade) into existing tarmac	DOE/EA-1515	14 CFR 77.25 DOE/EA-1515	Slope stability calculations; hangar foundation and tie-down design
Final Cover Requirements and Construction	Notice of Construction near airport	14 CFR 77.11	Obtain written approval from Los Alamos County Building Inspector and Airport Manager prior to construction “in or about” existing hangar or building	LAC 4-149 (Ord. No. 85-238)	None Identified	None Identified	14 CFR 77.11 LAC 4-149	None Identified
			Submit form 7460-1, “Notice of Proposed Construction or Alteration”	14 CFR 77	None Identified	None Identified	14 CFR 77	None Identified
			Obtain permit from Los Alamos County Engineer to excavate in public place	LAC 34-32	None Identified	None Identified	LAC 34-32	None Identified
			Excavation may take place during the hours 7:00 a.m. and 6:00 p.m. only	LAC 34-54	None Identified	None Identified	LAC 34-54	None Identified
			Noise must not exceed 65 dBA, unless apply for special permit	LAC 18-73	None Identified	None Identified	LAC 18-73	Evaluate equipment to determine need for special permit
	Required Construction Quality Assurance Program	40 CFR 265.19	None Identified	None Identified	None Identified	None Identified	40 CFR 265.19	Required by Scope of Work
	Must provide minimization of liquids	40 CFR 265.310	40 CFR 265 requirements incorporated by reference	NMAC 20.4.1.600	None Identified	None Identified	40 CFR 265.310 (NMAC 20.4.1.600)	None Identified
	Minimum maintenance	40 CFR 265.310	40 CFR 265 requirements incorporated by reference	NMAC 20.4.1.600	None Identified	None Identified	40 CFR 265.310 (NMAC 20.4.1.600)	None Identified

Table 2.2-1. (continued).

Disposal Facility Component	Federal		State of New Mexico or Los Alamos County		Stakeholder Requests		Minimum Applicable Technical Requirement	Additional Design Basis
	Technical Requirement	Citation	Technical Requirement	Citation			Citation	
Final Cover Requirements and Construction (cont.)	Promote drainage and minimize erosion	40 CFR 265.310	40 CFR 265 requirements incorporated by reference	NMAC 20.4.1.600	None Identified	None Identified	40 CFR 265.310 (NMAC 20.4.1.600)	None Identified
	Accommodate settling and subsidence	40 CFR 265.310	40 CFR 265 requirements incorporated by reference	NMAC 20.4.1.600	- Meet all strength requirements of Los Alamos Airport	DOE/EA-1515	40 CFR 265.310 (NMAC 20.4.1.600)	Slope stability and settlement calculations
	Permeability less than natural subsoils or bottom liner	40 CFR 265.310	40 CFR 265 requirements incorporated by reference	NMAC 20.4.1.600	None Identified	None Identified	40 CFR 265.310 (NMAC 20.4.1.600)	None Identified
	- Preventing 25 year storm flow - Collect and control 24-hour/25-year volume BMPs in Stormwater Control Plan	40 CFR 122 40 CFR 265.301	40 CFR 265 requirements incorporated by reference	NMAC 20.4.1.600	Collect and control 6-hour/100-year volume	Kyle Zimmerman, L.A. Engineer, personal communication with North Wind, 2005.	40 CFR 122 40 CFR 265.301 (NMAC 20.4.1.600) Kyle Zimmerman, L.A. Engineer, personal communication with North Wind, 2005.	- Applies during construction - Applies to relocated waste and/or period during closure when interim cover is removed - Applies to airport improvements
Gas Collection System	Exempt from emission requirements for MSW landfills because not active after Nov. 8, 1987	40 CFR 51, 52, and 60	Exempt from emission requirements for MSW landfills because not active after Nov. 8, 1987	NMAC 20.2.64.7A	Collect and vent landfill gas under sealed surface to prevent exceedences at property boundary and/or prevent accumulation in structures	DOE/EA-1515	DOE/EA-1515	None Identified
Facility Surface Water Drainage and Sediment Control	- Designed to minimize water contact with waste - Surface features direct surface water drainage away from facility to not result in erosion	40 CFR 122	None Identified	None Identified	None Identified	None Identified	40 CFR 122	- Owner/operator will apply for NPDES permit for post-closure use -Applies to both landfill and DDA during construction

Table 2.2-1. (continued).

Disposal Facility Component	Federal		State of New Mexico or Los Alamos County		Stakeholder Requests		Minimum Applicable Technical Requirement	Additional Design Basis
	Technical Requirement	**Citation**	**Technical Requirement**	**Citation**			**Citation**	
Facility Surface Water Drainage and Sediment Control (cont.)	- Meet NPDES requirements Storm Water Pollution Prevention Plan - Prevent 25-year storm flow	40 CFR 122	None Identified	None Identified	Kyle Zimmerman, L.A. Engineer, personal communication with North Wind, 2005.	Kyle Zimmerman, L.A. Engineer, personal communication with North Wind, 2005.	40 CFR 122 Kyle Zimmerman, L.A. Engineer, personal communication with North Wind, 2005.	- Owner/operator will apply for NPDES permit for post-closure use - Applies only to relocated waste and/or period during closure when interim cover is removed - Applies to airport improvements
Disposal Facility Releases	Cover or manage to control wind dispersal of particulate matter	40 CFR 265.301	Excavated material must be maintained to minimize disruption of traffic and to keep dirt or dust from spreading or flying 40 CFR 265 requirements incorporated by reference	LAC 34-46 NMAC 20.4.600	None Identified	None Identified	40 CFR 265.301 LAC 34-46 NMAC 20.4.600	Applies only to relocated waste and/or period during closure when interim cover is removed; ensure windblown material does not interfere with flight line
Support Facilities								
Borrow Facilities	- BMPs in Stormwater Control Plan - Minimal clearing for grading - Detain run-off and trap sediment - Surface features direct surface water drainage away from facility	40 CFR 122	None Identified	None Identified	None Identified	None Identified	40 CFR 122	Assume that borrow material will be purchased from vendor; therefore, requirements will be responsibility of vendor
	- Comply with truck height and weight restrictions during hauling - Comply with Motor Carrier Safety	23 CFR 658 49 CFR 40, 325, 350, 355-399	Comply with height and weight of vehicles and loads	NMAC 18.19.8 LAC 38-688 to 673	None Identified	None Identified	23 CFR 658 49 CFR 40, 325, 350, 355-399 NMAC 18.19.8 LAC 38-668 to 673	None Identified

Table 2.2-1. (continued).

Disposal Facility Component	Federal		State of New Mexico or Los Alamos County		Stakeholder Requests		Minimum Applicable Technical Requirement	Additional Design Basis
	Technical Requirement	**Citation**	**Technical Requirement**	**Citation**			**Citation**	
Safety and Security								
Sanitary Sewer	Provide toilet and hand washing facilities for workers	29 CFR 1926	None Identified	None Identified	None Identified	None Identified	29 CFR 1926	Assume temporary facilities
Fencing	None Identified	None Identified	Have worksites fenced or maintained in a manner to safeguard property and public	LAC 10-75	None Identified	None Identified	LAC 10-75	None Identified
	Cover or manage to control wind dispersal of particulate matter	40 CFR 265.301	40 CFR requirements incorporated by reference	NMAC 20.4.1.600	None Identified	None Identified	40 CFR 265.301 NMAC 20.4.1.600	Applies only to relocated waste and/or period during closure when interim cover is removed ; ensure windblown material does not interfere with flight line
Post Closure Monitoring	- Begin after closure for 30 yrs - Maintain effectiveness of final cover, including run-on/run-off controls	40 CFR 265, 117 40 CFR 265, 310	40 CFR requirements incorporated by reference	NMAC 20.4.1.600	None Identified	None Identified	40 CFR 265.117 40 CFR 265.310 NMAC 20.4.1.600	No post-closure air or GW monitoring required
	Closure and post-closure plans are required	40 CFR 265.112, 118	40 CFR requirements incorporated by reference	NMAC 20.4.1.600	None Identified	None Identified	40 CFR 265.112, 118 NMAC 20.4.1.600	None Identified
	Certification of closure report within 60 days of closure	40 CFR 265.115	None Identified	None Identified	None Identified	None Identified	40 CFR 265.115 NMAC 20.4.1.600	None Identified
	Complete closure activities within 180 days	40 CFR 265.113	40 CFR requirements incorporated by reference	NMAC 20.4.1.600	None Identified	None Identified	40 CFR 265.311 (NMAC 20.4.1.600)	None Identified
	GW must be protected GW monitoring program Evaluate vegetation	40 CFR 265.92 - 99	40 CFR requirements incorporated by reference	NMAC 20.4.1.600	None Identified	None Identified	40 CFR 265.92-99 (NMAC 20.4.1.600)	No GW monitoring required. Per DOE Scope of Work

Table 2.2-1. (continued).

Disposal Facility Component	Federal		State of New Mexico or Los Alamos County		Stakeholder Requests	Minimum Applicable Technical Requirement	Additional Design Basis
	Technical Requirement	Citation	Technical Requirement	Citation		Citation	

NOTE: DOE Order 5480.4 (DOE 1993) is incorporated by reference. Order 5480.4 requirements include (1) specify and provide requirements for the application of the mandatory ES&H standards applicable to all DOE and DOE contractor operations, (2) provide listing of reference ES&H standards, and (3) identify the sources of the mandatory and reference ES&H standards.

BMP = Best management practice
CFR = *Code of Federal Regulations*
cm/sec = Centimeters per second
dBA = Decibel Adjusted
DDA = Debris Disposal Area
DOE = U.S. Department of Energy
EA = Environmental Assessment
ES&H = Environmental safety and health
GW = Groundwater
LAC = *Los Alamos County Code*
MSW = Municipal solid waste
NMAC = *New Mexico Administrative Code*
NPDES = National Pollutant Discharge Elimination System

Table 2.2-2. Comparison of proposed MatCon™ cover performance to RCRA Subtitle C requirements (40 CFR 265.310a).

Number	RCRA Subtitle C Closure Cover Requirement	Extent to Which the Proposed Cover Does or Does Not Meet the Requirement
1	Provide long-term minimization of migration of liquids through the closed landfill	*Meets the requirement*. As-built permeability of less than 1E-07 cm/sec effectively minimizes migration of precipitation.
2	Function with minimum maintenance	*Meets the requirement*. Asphalt surface is easily inspected and repaired and is compatible with end use as airport parking.
3	Promote drainage and minimize erosion or abrasion of the cover	*Meets the requirement*. Paved surface is sloped at 2% nominal to promote drainage and minimize erosion/abrasion.
4	Accommodate settling and subsidence so that the cover's integrity is maintained	*Meets the requirement*. MatCon™ can tolerate three times more deflection without cracking than standard asphalt and can bridge voids without failing.
5	Have a permeability less than or equal to the permeability of any bottom liner or natural subsoils present	*Meets the requirement*. The landfill is not lined and is entirely underlain by the Bandelier Tuff. Demonstrated as-built permeability of MatCon™ is less than 1E-08 cm/sec, which is lower than required for RCRA Subtitle C covers over lined landfills; and is much less than the permeability of the underlying Bandelier tuff, which ranges from 1E-03 to 1E-05 cm/sec (D.B. Stephens & Associates, Inc., 1993; Rogers and Gallaher 1995).

13.0 FIGURES

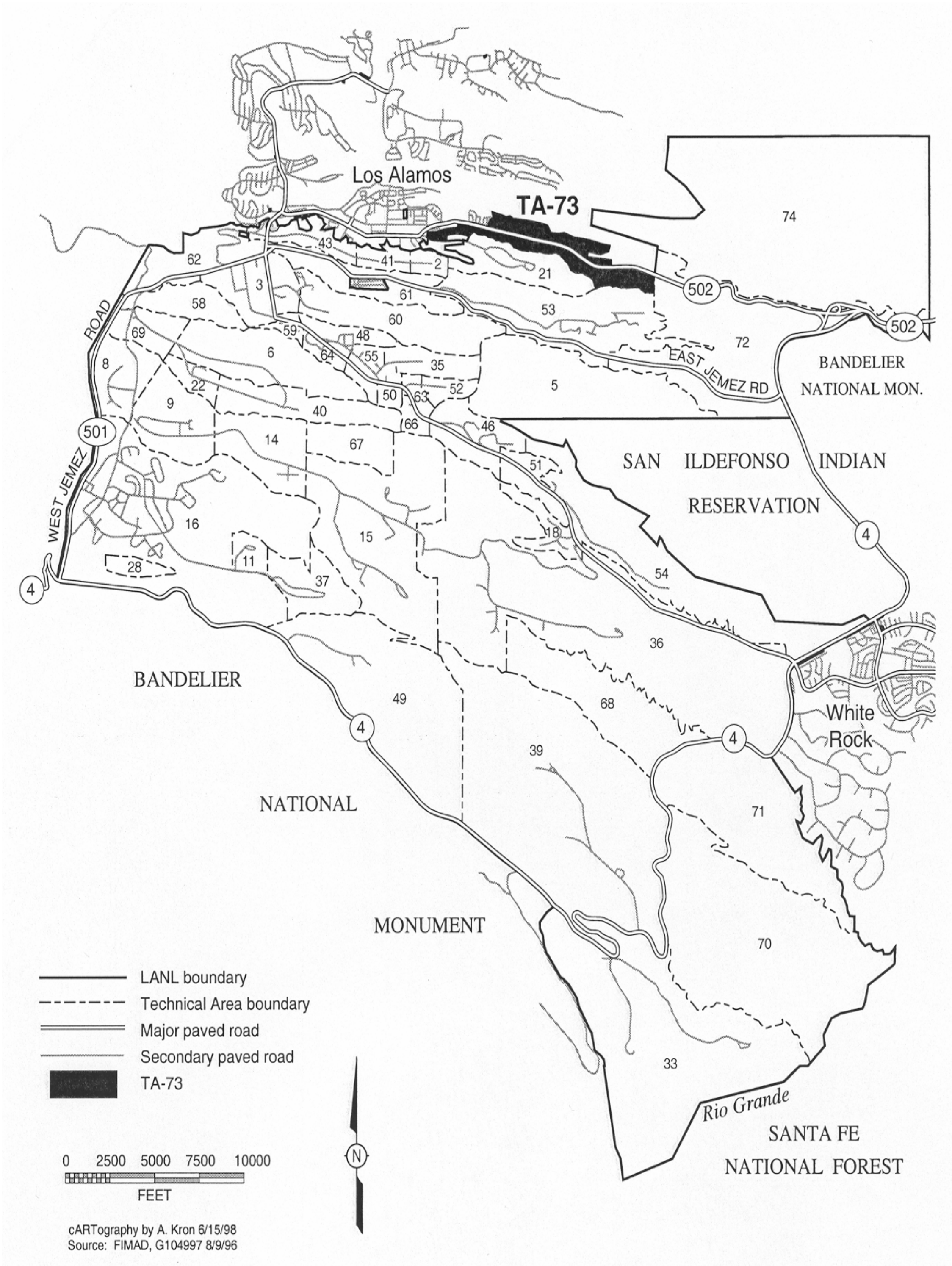

Figure 1.3-1. Location of TA-73

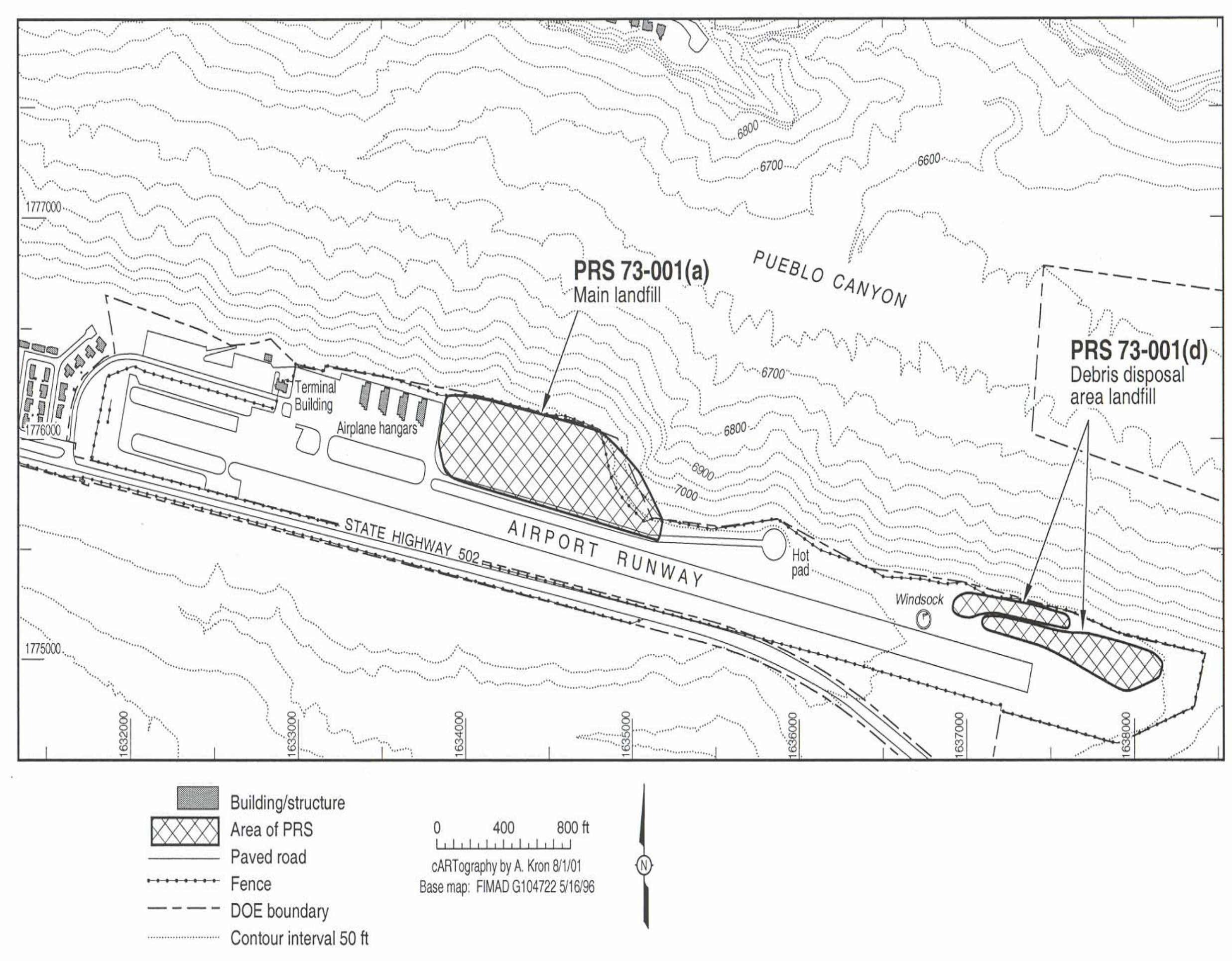

Figure 1.3-2. Location of the main landfill and debris disposal area at TA-73 (LANL 2002)
Note: "PRS" has changed to "SWMU"

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PWI-4201-001, Project Files

PWI-4201-002, Field Activities Documentation

PWI-4201-004, Readiness Assessment

PWI-4201-005, Field Change

15.0 ACRONYMS

BMP	Best Management Practice
CFR	*Code of Federal Regulations*
CQCP	Construction Quality Control Plan
DDA	Debris Disposal Area
DOE	U.S. Department of Energy
EA	Environmental Assessment
EIS	Environmental Impact Statement
FAA	Federal Aviation Administration
FONSI	Finding of No Significant Import
HASP	Health and Safety Plan
LAC	Los Alamos County
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office
LEL	Lower explosive limit
MatCon™	Modified Asphalt Technology for Waste Containment
NMED	New Mexico Environment Department
NWI	North Wind Inc.
PCMP	Post-closure Care and Monitoring Plan
PMP	Project Management Plan
PQP	Project Quality Plan
PWI	Project Work Instruction
QA	Quality assurance
QC	Quality control
RCRA	*Resource Conservation and Recovery Act*
SWMU	Solid Waste Management Unit
SWPPP	Storm Water Pollution and Prevention Plan
TA	Technical Area
VCM	Voluntary Corrective Measure
WMP	Waste Management Plan

Attachment A
Final Design Package
(Specifications, Drawings, and Calculations)

Revision 1

CONSTRUCTION DRAWINGS
FOR THE LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILL

June 2005

Prepared for:

U. S. Department of Energy, National Nuclear Security Administration
Los Alamos Site Office
528 35th Street
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Prepared by:

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1425 Higham Street
Idaho Falls, Idaho 83402

NW-ID-2004-039
Revision 1

CONSTRUCTION SPECIFICATIONS FOR THE LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILL

June 2005

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NW-ID-2004-040
Revision 1

ENGINEERING CALCULATIONS FOR THE LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILL

June 2005

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Attachment B
Construction Plan for the LASO TA-73 Airport Landfill

NW-ID-2004-001
Revision 2

CONSTRUCTION PLAN FOR THE LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILL

June 2005

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DOCUMENT APPROVAL PAGE

Document Number: NW-ID-2004-001 Revision: 2

Document Title: Construction Plan for the Los Alamos Site Office TA-73 Airport Landfill

Approval Signatures

Name	Signature	Date	Title
Doug Jorgensen	Original signature on file	05/24/05	North Wind Project Manager
Robert Enz	Original signature on file	05/24/05	U.S. Department of Energy, LASO

Revision Log

Revision	Date	Reason for Revision
Draft	02/12/04	Not applicable; first draft of document
Revision 0	03/15/04	Document revised to reflect DOE-LASO comments of 03/01/04.
Revision 1	04/15/04	Document revised to correct minor formatting errors, further define construction traffic control measures in Section 9.9, and append a detailed construction schedule in Appendix B.
Revision 2	05/31/05	Document revised to reflect additional dust control measures (Section 11.6) and airport coordination (Section 11.8). Document revised to reflect scope change per DOE revised SOW.

CONTENTS

APPENDICES

1.0 INTRODUCTION

This Construction Plan describes methods and protocols that North Wind Inc. (NWI) will use to manage construction activities at the U.S. Department of Energy (DOE) Los Alamos Site Office (LASO) Technical Area (TA)-73 Airport Landfill, henceforth referred to as the Airport Landfill project. The Construction Plan provides background information and a summary of planned construction activities. The plan also describes operation, maintenance, and monitoring requirements during the construction and post-construction phases, and the training and certification requirements.

2.0 SITE DESCRIPTION AND OPERATIONAL HISTORY

The site description and operational history are documented in the Los Alamos National Laboratory (LANL) Voluntary Corrective Measure Plan (LANL 2002).

The Airport Landfill consists of two solid waste management units (SWMUs), 73-001(a) and 73-001(d). SWMU 73-001(a) is an inactive municipal landfill, hereinafter referred to as the main landfill. SWMU 73-001(d) is an inactive debris disposal area (DDA), hereinafter referred to as the DDA. Both SWMUs are inactive and are located within TA-73 on DOE property adjacent to the Los Alamos Airport, as shown in Figure 2.1-1 (see Section 12). The main landfill is east of the existing airport hangars and the DDA is north and east of the end of the runway. Figure 2.1-2 (see Section 12) shows the location of the SWMUs in TA-73.

In 1943, DOE began using the hanging valley north of the airport runway as the main landfill. Garbage was collected twice a week from LANL and Los Alamos and burned on the edge of the hanging valley. Heavy equipment was then used to push the burned residues and ash into whichever landfill disposal area was being used at the time. This intentional burning ceased in 1965 when Los Alamos County (LAC) assumed operation of the landfill. The county continued to operate the landfill until June 30, 1973.

The DDA was used from 1984 to 1986 to bury debris excavated from the western portion of the main landfill. This material was excavated and replaced with clean fill to prepare the western portion of the landfill for the construction of airplane hangars and tie-down areas. Since the wastes placed in the DDA came from the main landfill, both areas contained similar types of debris. In 1986, the DDA was covered with soil and hydroseeded.

3.0 SCOPE OF WORK

The project consists of designing and constructing an appropriate cover over the main landfill and repairing the existing soil cover over the DDA. Construction activities on the main landfill are complicated by the steep embankments on the north and east sides of the debris area and its proximity to the active county airport. Construction activities will include redistribution of waste; building retaining walls at the base of the east slope; installation of a gas collection system below a Modified Asphalt Technology for Waste Containment (MatCon^{TM}) asphalt surface, which includes fill and grading to accommodate future airport expansion; and construction of high strength concrete pads to serve as foundations for future airport hangars and aircraft tie-downs. Final design drawings and specifications for both the main landfill and DDA are provided in the Remedy Design Work Plan for LASO TA-73 Airport Landfill (North Wind 2005a).

4.0 CONSTRUCTION MANAGEMENT

This section describes construction management protocols that will be employed to ensure that activities described in the Work Plan are completed safely, within budget, and on schedule. Additional project management information is provided in the Project Management Plan (PMP) for the LASO TA-73 Airport Landfill (North Wind 2005b).

4.1 Project Organization

NWI is the prime contractor for this project. Weston Solutions, Inc. (WESTON), a NWI subcontractor, is a significant partner on the project providing design and field quality control (QC) support. Although not subcontracted to NWI, a number of specialty vendors will be contracted by DOE and will be overseen by NWI to ensure that their components are installed according to the approved design (e.g., it is assumed that Wilder Construction Company will install the proprietary low permeability MatCon™ cover). The DOE-LASO Environmental Management Program is the customer for the project. Further details regarding the project organization are provided in the PMP (North Wind 2005b).

4.2 Training and Certification

Training and certification of key personnel will be commensurate with assigned tasks. In general, training will be conducted according to the PMP (North Wind 2005b), Project Quality Plan (PQP) for the LASO TA-73 Airport Landfill (North Wind 2005c), and the Health and Safety Plan (HASP) for the LASO TA-73 Airport Landfill (North Wind 2005d). At a minimum, project personnel completing construction activities will be required to read and understand the project documents, including the Work Plan and related documents, and will comply with training requirements of the HASP.

During construction, the Project Manager (PM) may identify additional training and/or certification necessary for the successful completion of the project. This training may take the form of on-the-job training, additional required reading, documented classroom learning, or hands-on demonstration of required skills.

All required training will be documented and tracked as provided in Quality Assurance Procedure (QAP)-10-021, Indoctrination and Training. The following subsections describe training and certifications necessary to perform key functional activities.

4.2.1. Site Access

All personnel entering the site are required to receive DOE “Get Employee Trained” training.

4.2.2. Heavy Equipment Operation

Personnel operating heavy equipment will have demonstrated ability in the operation of the particular equipment and will demonstrate proficiency to the satisfaction of the Construction Manager (CM). Truck drivers transporting landfill material (e.g., borrow soil) will have a Commercial Driver’s License.

4.2.3. Health and Safety

The NWI Corporate Health and Safety Director will be a Certified Industrial Hygienist. Site health and safety officer(s), managers, and site workers will be trained and certified commensurate with activities and associated hazards. Health and safety training and certifications will be specified in the HASP (North Wind 2005d).

4.2.4. Measuring and Test Equipment

NWI personnel who use measuring and test equipment (M&TE) will comply with QAP-10-121, Control of Measuring and Test Equipment, and will be trained to use the particular device. This may be formal classroom training or may consist of documented on-the-job training. M&TE users will ensure that equipment is calibrated to nationally recognized standards (e.g., National Institute for Standards and Technology) and that calibration is current. If no nationally recognized standards exist, the basis for calibration will be documented. M&TE users also ensure equipment is of the proper type, range, accuracy, and that it is uniquely identified and traceable to its calibration date. Geotechnical laboratory personnel will comply with requirements of their company quality program.

4.2.5. Surveyors and Engineers

Surveyors and engineers will be licensed in the State of New Mexico. The Construction Quality Control Plan (CQCP) for the LASO TA-73 Airport Landfill (North Wind 2005e) provides additional details.

4.2.6. Auditing

NWI personnel conducting internal audits or field surveillances will be trained in accordance with QAP-10-022, Certification of Personnel, and QAP-10-181, Quality Audits.

4.3 Reporting

The CM will provide weekly updates on construction progress to the PM using progress reports from the Site Superintendent (SS). The update will detail construction progress and activities for the week, description of any nonconformances, weekly crew size, possible health or safety concerns, and other significant work tasks during the week. The PM will forward this information to the DOE-LASO Contracting Office Representative (COR) following receipt of the update. Additional reporting details are found in the PMP (North Wind 2005b).

4.4 Schedule

The construction schedule is provided in Appendix B.

5.0 CONSTRUCTION ACTIVITIES

The following subsections describe construction activities at the main landfill and DDA. This narrative provides a description of how the final remedy will be implemented at the Airport Landfill. Detailed requirements of the work are defined in the specifications and drawings of the Work Plan (North Wind 2005a). In the case of any discrepancies, the drawings take precedence over the specifications, and specifications take precedence over the project documents. The only exception is the HASP (North Wind 2005d). Requirements of the HASP shall be implemented without modification regardless of information provided in specifications, drawings, or other documents.

5.1 Procurement

General methods for procurement of materials and services are addressed in the PQP (North Wind 2005c), including methods for procuring quality-affecting materials and services. Purchase order documents and subcontracts will be prepared for each vendor supplying materials and for subcontractors supplying services, with the terms of the purchase clearly defined. Delivery of materials and services will be scheduled based on project sequence to minimize storage and risk of loss or damage.

Materials to be purchased include, but are not limited to, riprap, aggregates, concrete, low permeability soils, and geotextiles. Material specifications and QC requirements are provided in the CQCP (North Wind 2005e) and the Construction Specifications for LASO TA-73 Airport Landfill (North Wind 2005f).

Services to be subcontracted by NWI include design and field QC services to be provided by WESTON and geotechnical testing services to be provided by a local laboratory. Local suppliers will also be retained (as necessary) for equipment rentals, surveying, electrical and plumbing work, equipment maintenance, fencing, hydroseeding, construction waste disposal, and other miscellaneous services.

5.2 Mobilization

Mobilization activities include transporting required equipment and personnel, construction of access roads, installation of field trailers, locating underground utilities, and taking delivery of initial materials.

5.2.1. Assemble Construction Documents

A complete set of project documents, including the Work Plan and related documents, will be kept in the office trailer for planning and scheduling. Another set will be provided to the SS for his working use. A set of final construction drawings will be located in the office trailer so that changes can be readily red-lined to facilitate development of as-built drawings. The project schedule will be displayed on the wall for quick reference and weekly progress tracking. Project documents will be controlled in accordance with NWI QAP-10-061, Document Control. Forms and records generated during the course of the project will be completed, filed, and managed as described in the QAP-16, Control of Quality Records.

5.2.2. Conduct Construction Readiness Assessment

A construction readiness assessment will be conducted in accordance with Project Work Instruction (PWI)-4201-004, Readiness Assessment. A readiness checklist will be completed that provides formal documentation that the project is ready to start, and may be modified to account for the final design requirements. At a minimum, the checklist will include:

- Safety basis documented,
- Notice to Proceed (NTP) issued,
- Plans and procedures prepared, issued, and available onsite,
- Training conducted and documented,
- Equipment procured, inspected, and approved for use,
- Permits obtained,
- Underground utility survey completed and utilities marked,
- Support facilities installed and useable,
- All stakeholders notified, including LAC Airport,
- Security measures (including signage) implemented,
- Subcontractors procured and available, as required,
- Storm Water Pollution and Prevention Plan for LASO TA-73 Airport Landfill (SWPPP) (North Wind 2005g) implemented, including filing of Notice of Intent with the U.S. Environmental Protection Agency (EPA),
- Material storage area developed,
- Project record keeping system in place,
- Initial site photographs taken, and
- Required wage and employment signage posted.

5.2.3. Conduct Pre-construction Meeting

Prior to the start of construction activities, a meeting will be conducted with site workers to review the project objectives and requirements, workmanship standards, and site-specific safety requirements.

Non-routine workers such as truck drivers and day laborers will not attend this pre-construction meeting. Instead, they will be provided with a safety briefing to address potential hazards that they may be exposed to as described in the HASP (North Wind 2005d). At a minimum, the pre-construction meeting will address the following topics:

- Introduction of project team,
- Organization chart and lines of authority and communication,
- Project scope and objectives,
- Identification of subcontractors and suppliers,
- Use of equipment and facilities,
- Project schedule and work hours,
- Reporting and record keeping requirements,
- Correspondence, including oral versus written protocol,
- Project plans and specifications, and location of documents,
- Workmanship standards,
- Site access and security procedures, particularly regarding Los Alamos Airport,
- Job safety and health, including required training,
- Quality assurance/quality control (QA/QC) procedures,
- Equipment maintenance and daily checks,
- Material handling, delivery, and storage, and
- Temporary utilities, communications, and housekeeping.

5.2.4. Construct Access Roads

Access roads will be constructed according to Specification 02500, "Gravel Roads" (North Wind 2005f). Primary haul routes to the DDA and main landfill will be established by improving the spur road off of NM 502, as shown in final design drawings. The spur road is accessed through an existing gate at the east end of the runway. This access road will be improved (as necessary) by clearing brush and vegetation to native soils (as required) and adding appropriate road base. After the base course is finished, a gravel surface will be applied. This road will be built with one lane but will include turn-outs for two-way traffic. The access road will be left in place after landfill construction activities for airport use and future maintenance work. Traffic control associated with use of the access road for delivery of borrow material is discussed in Section 11.9.

5.2.5. Install Temporary Field Trailers

Two temporary field trailers and a tool van will be installed at the project staging area located at the northwest corner of the site near the east hangar. One trailer will be designated as the field office and will have adequate desk space for three people. This trailer will also be used to file project documents, including records. The second trailer will be designated as a lunch/break room and will be used for safety and progress meetings with the crew. The tool van will be used for storage of hand tools, safety equipment, and other miscellaneous equipment.

Temporary electrical utilities will be run to both trailers and phone line(s) will be installed to the office trailer. Drinking water and potable hand washing water will be available in both trailers.

5.2.6. Survey DDA and Main Landfill

A New Mexico licensed surveyor will be subcontracted for all surveying. Control points will be established from local elevation and coordinate datum. These controls will be permanent monuments used throughout construction and post-construction for any needed topographic, radial stakeout, and benchmark elevations. Monuments will be protected against damage, defacing, or loss. All surveying will be conducted per Specification 02005, “Surveying.”

A topographic map will be developed prior to construction. Baseline cross-sections identified on the grading plan will be marked on a 50-ft grid interval. Cut/fill and finished grade stakes will be placed and referenced to the grid. Intermediate grade checks between grid points may be performed, as needed. Initial staking will include angle points for fence relocation at the northeast end of the main landfill and centerline cut and fills for proposed access routes.

5.2.7. Mobilize Heavy Equipment to Site

Equipment will be unloaded in the staging area, east of the hangars and asphalt tarmac. Off-road equipment will be delivered to the site by transport, and U.S. Department of Transportation (DOT)-compliant equipment will be driven to the site. At a minimum, the following equipment is expected to be used during construction activities:

- D-7 or D-8 dozer (2 units),
- 4,000-gal water truck,
- 5- to 7-cubic yard (cy) front-end loader,
- 65,000-lb tracked excavator,
- Grader,
- Roller Compactor,
- 10-ton smooth drum vibratory roller, and
- Harrow rake or disker.

When in use, heavy equipment will be inspected initially and then on a daily basis thereafter.

5.2.8. Identify Underground Utilities

Underground utilities will be located by contacting New Mexico One Call Systems Inc. at 1-800-321-2537 at least five (5) days prior to excavation. The utility survey area will include proposed excavation areas with a 200-ft buffer, and will be marked on the ground with white paint or stakes. Utilities identified within the survey area will be marked on the ground with the colors noted below, as recommended by One Call Systems. Utilities will then be exposed at 100-ft intervals throughout the survey area by potholing with hand shovels or a hydraulic unit. To avoid confusion and misidentification, the following colors are reserved and are not to be used for other activities (i.e., surveying):

- Blue – water,
- Green – sewer,
- Orange – communications,
- Red – electric, and
- Yellow – gas.

The location of identified utilities will be transferred to a site base map and utility markings will be repainted as necessary. These measures will protect against the need for re-surveying if the initial markings are obliterated during construction.

5.3 Site Preparation

The following sections identify activities that will be performed before excavation activities commence at the main landfill or DDA.

5.3.1. Install Fencing

A new section of perimeter chain link fence will be installed along and outside the toe of the east slope and along a portion of the north side of the main landfill, as described in the project drawings. Fencing will be installed by a subcontractor, as specified in Specification 02980, “Chain Link Fence.”

After the new fence is installed, the existing fence through the middle of the east slope will be removed. Any fencing in the construction area temporarily opened will be closed and secured at the end of the workday. These measures will ensure site security and help control access to the airport at all times. The removed fencing material will be recycled or sold for salvage, if possible.

5.3.2. Install Storm Water Controls

Prior to earth-disturbing activities at the DDA or main landfill, erosion and runoff controls identified in the SWPPP (North Wind 2005g) and final design documents will be installed. This will include, as necessary, installation of silt fences, drainage channels and check dams, sediment traps, inlet filters, culverts, and berms. All storm water controls will be installed according to Specification 02930, “Erosion and Sediment Control.”

Silt fences will be installed by anchoring the bottom of the silt fence in a trench dug with a small trencher and then backfilling the trench. Drainage channels will be constructed with a dozer or grader blade and compacted with the wheeled loader. Check dams and sediment traps will be installed with a small backhoe excavator. An excavator will dig inlet filter and culvert beds to grade and the components will be installed by heavy equipment. Berms will be constructed using imported gravel material and compacted by wheel rolling or tamping.

5.3.3. Abandon Monitoring Wells

Some of the existing soil gas monitoring wells in the main landfill will be abandoned. Well casings will be stripped of any readily removable instrumentation and tubing prior to closure. If any stainless steel vapor port tubing must be abandoned, the tubing will be cut off 3 to 4 ft below grade and the top few inches bent over to pinch the tubing closed. Casings will be sounded with a tag line (assuming that no instrumentation remains in the well) and the amount of bentonite required for backfill will be estimated based on well diameter and depth. Well casings will be backfilled with bentonite powder or chips to displace any methane that may be present. As the well is backfilled, the depth of the well will be continually sounded with the tag line to verify that bridging is not occurring. If bridging becomes an issue, a tremie pipe may be used.

After backfilling, the casing will be cut off approximately 3 to 4 ft below final grade. Approximately 1 ft of bentonite will be placed over the cut-off casing and the remaining excavation will be backfilled with soil.

Appropriate health and safety monitoring will be conducted during abandonment to detect the presence of possibly flammable gases (e.g., methane). If such gases are present, they will be allowed to fully vent before cutting off the casing. A hot work permit will be obtained prior to using gas cutting torches.

5.3.4. Abandon/Relocate Utilities

It may be necessary to abandon or relocate some existing utilities. The utility owner will be contacted and details will be discussed for the desired relocation or abandonment. Procedures to abandon or relocate the utility will be defined and approved prior to performing the work. A formal request will be made for the utility to be shut down before excavation.

The relocated utility will be replaced according to the utility owner's installation specifications, as appropriate. The HASP (North Wind 2005d) provides health and safety precautions if an unidentified utility is cut or ruptured.

5.4 Construction of DDA

The DDA will be constructed to include a minimum of 12 in. of topsoil over existing waste, a final grade of about 3% for promote runoff, and vegetation with native plants. Previously completed penetration testing identified the depth to waste and amount of cover soil required to meet the 12-in. minimum. This approach minimized disturbance to portions of the DDA with adequate soil cover, and will minimize costs for imported soil and preserve existing vegetation.

5.4.1. Pre-Construction Survey

Based on results of penetration testing, grade control and final fill elevations at the DDA will be laid out on 50-ft grids or smaller based on the size of the area requiring topsoil. Intermittent grade checks may be performed, as necessary. Surveying will be conducted per Specification 02005, "Surveying."

5.4.2. Rough Regrade

Brush or trees will be grubbed only from those areas requiring additional topsoil and will be chipped onsite and stockpiled for mixing with topsoil. A dozer will be used to shape portions of the DDA to achieve the required slope. Shaping will be limited to filling depressions and voids and establishing a surface that can be driven on by belly dump trucks delivering topsoil.

5.4.3. Add Topsoil

Topsoil for the DDA final cover will be delivered on site by truck, and the topsoil will be dumped where needed. To the extent possible, trucks will not be driven on exposed waste or on undisturbed areas of the DDA. Topsoil will be watered and leveled by a dozer to the required elevation. The final contour will be graded with a dozer or motor patrol, filling voids and feathering edges of material to match existing contours.

5.4.4. Revegetation

Revegetation of the DDA will proceed per Specification 02932, "Seeding, Mulching, and Restoration." Hydroseeding is preferred because of the short duration of the project and the large area to be revegetated. Temporary erosion controls will be implemented so that the seed, fertilizer, and mulch can be applied to the DDA under one mobilization. Compacted or tracked topsoil will be loosened before hydroseeding. All areas of the project are accessible to typical hydroseeding equipment capable of spraying over 100 ft from the truck and through the use of hoses to access any remote locations. Completely covering the disturbed areas with a tackifier and hydroseed will help with dust control until vegetation has been established. A temporary sprinkling system or watering by truck may be required until vegetation has been established.

5.4.5. Survey Final Grade

Final DDA grades will be surveyed to confirm that the final elevation matches design specifications and to provide measurements for as-built records. All surveying will be conducted per Specification 02005, "Surveying."

5.5 Construction of East and North Slope of Main Landfill

Construction of the east and north slopes of the main landfill generally consists of salvaging existing soil cover, excavating existing landfill waste to establish a nominal 3H:1V to 4H:1V grade, constructing retaining walls on the east slope, installing a low permeability soil layer, installing geotextile, and applying a riprap armor cover.

5.5.1. Pre-Excavation Survey

The east and north slopes of the main landfill will be slope-staked to delineate the limits of earthwork and breakpoints for the toe, benches, and top of cuts. Reference stakes will be set to allow the operators to monitor and control the grades during excavation. All surveying will be conducted per Specification 02005, “Surveying.”

5.5.2. Salvage Soil

Existing soil will be salvaged to the extent possible from the main landfill slopes as well as the central portion of the landfill. Cover soil from the northern half of the main landfill and the east slope will be removed by dozing into an elongated pile or windrow extending east to west, approximately in the center of the landfill. Once the northern half is brought to grade with the relocated waste, the salvaged soil can be readily dozed over the debris and incorporated into the final cover. A similar process will be used on the southern half of the main landfill.

5.5.3. Relocate Waste

Excavation at the main landfill will be conducted in accordance with Part 3.01 of Specification 02200, “Earthwork,” and Specification 02266, “Landfill Waste Placement Procedures.” The excavation and relocation of landfill waste will be completed with a combination of dozers, loaders, and excavators. Dozers will excavate in layers and establish the proper slope. A berm will always result on the outside face of the slope, which will act as a catch for rolling debris or rock. As waste is excavated, it will be pushed to the lip of the slope(s). From there, another dozer will push the waste to its final destination. The exception is waste destined for the western portions of the landfill (i.e., more than about 300 ft from the top cuts of the slopes), which will be shuttled with a loader.

An excavator will be used to excavate the lowest portions of the east slope to establish grades for the retaining wall construction. Limited portions of the north slope may also require use of the excavator. The excavated debris will be lifted up the slope as far as possible with the excavator and then dozers will move the material to the top of the landfill and set it aside for other equipment to take to the fill locations.

Waste will be relocated first to the northern half of the main landfill, where it will be covered with salvaged soil. After the northern half is filled and covered, existing cover soil will be salvaged from the southern half of the main landfill and the process repeated.

During waste excavation and relocation, dust control will be provided continuously with the water truck. Portions of the slope that cannot be reached by the water truck will be sprayed manually with a hose from the truck. Some types of relocated municipal solid waste (e.g., paper products, loose plastic, and ash) may be an airborne nuisance during windy conditions. Other waste may be considered hazardous to the general public. These materials will be contained by covering them with soil, rock, matting, or other suitable means (i.e., salvaged chain link fence). The CM will determine when and if these controls are necessary.

5.5.4. Construct Retaining Walls

The retaining walls will be constructed according to Specification 03300, “Cast-in-Place Concrete” and Specification 02273, “Mechanically Stabilized Earth Retaining Walls.” An access ramp will be constructed to provide access to the toe area of the slope for the excavator. The excavator will then be used to create the subgrades for construction of retaining wall number one (concrete gravity wall).

Once retaining wall number one has been poured, forms removed, and the concrete has cured to specification, the area up-slope from the retaining wall will be backfilled with select fill and compacted with a small roller or manual compactor. This area then serves as the bench upon which the number two retaining wall will be constructed.

Once retaining wall number two has been constructed, the area behind the top of retaining wall number two will serve as a bench for the construction of retaining walls numbers three and four. Retaining walls numbers three and four are much shorter in length and will be constructed above the north and south ends, respectively, of retaining wall number two.

5.5.5. Establish Subgrade and Survey

The subgrade will be prepared in accordance with Part 3.02.B of Specification 02200, “Earthwork.” Subgrading will be completed with the dozer to create the rough template for the two proposed benches and to better define the required 4H:1V slope, as detailed in the design drawings. Salvage soil or other material will be added to provide a subgrade suitable for installation of the cover layers.

Once debris is excavated from the east and north slopes, surveys of the slope faces will be completed for as-built records and to support eventual cover depth. Elevation and the limits of the debris will be documented by the surveyor.

5.5.6. Install Infiltration Layer

The infiltration layer will be applied to the north and east slopes of the landfill. The infiltration layer consists of a nominal 18 in. of low permeability soil. The infiltration layer will be constructed in two lifts in accordance with Specification 02200, “Earthwork.” Material for the first lift will be delivered and dumped at the top of the slopes and a dozer will push it downward onto the slopes. Once roughed into place over the entire slopes, compaction will be obtained with a sheepsfoot roller pulled behind a dozer. Water will be applied with a hose and nozzle capable of spraying from the top of the slopes to the toe.

After compaction, lifts will be scarified to a depth of several inches, with an appropriate attachment (e.g., harrow rake or disker) pulled by a dozer. Scarification provides a good binding surface between lifts and also provides a good binding surface for the geotextile.

5.5.7. Add Geotextile and Riprap

Geotextile will be installed over the infiltration layer as a protective liner between the infiltration layer and riprap per Specification 06020, “Geotextiles.” After the geotextile is placed, riprap will be installed in accordance with Parts 2.01 and 3.01 of Specification 02270, “Channel Protection.” Riprap will be placed starting at the top of the MSE retaining wall and proceeding upslope to the interface of the MatCon™ cover. The riprap will be lightly compacted with dozer tracks. It is anticipated that minimal dust control will be required for the riprap placement.

5.5.8. Survey Final Grade

Final grades will be surveyed to confirm that final east and north slope elevations match the design specifications and provide measurements for as-built records. All surveying will be conducted per Specification 02005, “Surveying.”

5.6 Construction of Main Landfill Cover

The main landfill cover will consist of compacted structural fill, an aggregate base course, gas collection system, and MatCon™ pavement. The following subsections provide details regarding the main landfill cover construction.

5.6.1. Establish Subgrade and Survey

Prior to placing any structural fill, the subgrade will be prepared in accordance with Part 3.02.B of Specification 02200, “Earthwork.” Vegetation, root matter, and topsoil will be removed and all areas will be proof-rolled on-grade using a heavy-duty roller. If needed, additional salvage soil or other suitable material will be added over the top of the main landfill to provide a subgrade suitable for installation of the structural fill. Subgrading will be completed with the dozer to create the rough template for the variable top slope, as detailed in the design drawings.

After the subgrade is established, surveys of the main landfill will be completed for as-built records and to support eventual cover depth. Elevation and the limits of the debris will be documented by the surveyor. Grade hubs will be placed on a 50-ft grid pattern to achieve lift elevation.

5.6.2. Install Structural Fill Layer

Structural fill material will be placed on the subgrade on the slopes and top of the main landfill as necessary to support construction of the cover systems. Placement shall be in accordance with Part D of Specification 02200, "Earthwork."

The structural fill will initially be placed at the east end of the landfill and pushed onto the landfill with a dozer, working the material to the west. The structural fill layer will be constructed with multiple lifts to accomplish required density. As the materials are being placed and compacted to the west, the trucks will also continue to move west with each delivery. This procedure will keep the trucks on clean compacted structural fill at all times. In general, after the first lift is placed, the procedure will be reversed and the material will be worked from west to east using the procedure described above.

As the material is being worked, water will be added by the water truck to control dust and achieve required moisture before compaction. Compaction will be obtained with a vibratory roller. Moisture conditioning and compaction testing will be an ongoing process during each lift.

5.6.3. Install Aggregate Layer and Off-Gas Collection System

Following acceptance testing of the structural fill layer, a woven geotextile fabric will be placed on the compacted structural fill. A 6-in. thick (nominal) aggregate base course will then be placed on the geotextile. The off-gas collection system will be constructed within the aggregate base course. The off-gas collection system will consist of a series of 4-in. perforated high-density polyethylene (HDPE) pipes. The perforated piping will run north-south and will connect to a manifold on the north side of the top of the landfill. The manifold then vents to the surface in the northeast corner of the landfill. Installation of the off-gas collection system will be performed in accordance with Specification 02730, "Gas Collection System."

5.6.4. Install Storm Drain System

Prior to placement of the interim cover (salvage topsoil), the concrete storm drain system (Specification 02720, "Storm Drain System") will be installed. The series of concrete inlets, manholes, pipes, and cover will be installed utilizing precast materials to the extent possible. Field conditions will be verified prior to ordering precast elements. An excavator and loader will be used for trench excavation, granular material bedding placement, concrete material placement, and backfill. The manholes and pipe will be handled with appropriate attachments and sling devices to prevent damage to the precast material while lifting and setting. Pipe grades and location of associated structures will be checked prior to backfill.

Trench excavation and backfill with be completed as specified in Section 02200, "Earthwork," with trench walls conforming to OSHA trenching standards. Trench shoring or side sloping will be implemented, as appropriate, with field verified grade lines. Manhole structures will be placed on a firm crushed rock base, as referenced in Section 02200.

Construction of the storm drain system will occur after the site surface water controls are in place. As the drain system is built, adjustments and/or tie-ins to the site runoff controls will be made so as not to jeopardize the effectiveness of site runoff controls. Silt screens will be placed around new inlets to avoid excess sediment into the new piping. The system outlets will be placed on competent rock to minimize erosion, as referenced in the design drawings, Sheet 2003 (North Wind 2005a, Attachment A).

5.6.5. Construct Aircraft Hanger Pad

To support operations at the Los Alamos Airport, an approximately 190 ft $\times$ 48 ft concrete hangar pad will be constructed on the western portion of the new landfill cover. The pad will consist of a steel, reinforced concrete slab poured in place on the off-gas collection layer as subgrade. The slab will have two (2) layers of reinforcing in consideration of the potential for differential settlement. The hangar pad will be constructed and installed in accordance with Specification 03300, "Cast-in-Place Concrete."

Typical aircraft tie-downs to be constructed are shown in Drawing 2024, Hanger Layout, as shown in Attachment A of the Remedy Design Work Plan (North Wind 2005a).

5.6.6. Install MatCon™ Cover

The MatCon™ system is an advanced modified asphalt technology that combines a proprietary binder with specified aggregates. The MatCon™ cover provides a durable surface that is usable by the Los Alamos Airport and still meets permeability requirements for the remedy. Standard asphalt paving techniques are used to install the cover. The MatCon™ cover will be installed in accordance with Specification 02511, "Hot Mix Asphalt."

6.0 ACCEPTANCE TESTS

Acceptance testing prior to, during, and after construction of each feature of work is described in the CQCP (North Wind 2005e). A dedicated Quality Control Field Engineer (QCFE) will inspect all aspects of the construction to ensure conformance with approved drawings and specifications. The QCFE will also oversee quantitative testing to be performed by a subcontracted geotechnical laboratory. Preliminary real-time test results will be provided to the SS before proceeding to the next activity to minimize the need for rework.

Critical tests include density measurements of the earthen layers per Specification 02200, "Earthwork;" standard concrete tests for the aircraft hanger per Specification 03300, "Cast-in-Place Concrete;" and compaction, thickness, and permeability of the MatCon™ cover per Specification 02511, "Hot Mix Asphalt."

At the completion of construction, DOE will perform the final inspection and acceptance of the project. NWI will submit a written document stating that the work was performed to project specifications and is ready for a final inspection. Following the inspection, any nonconforming or variant items will be promptly remedied and the final acceptance will then be requested.

7.0 DEMOBILIZATION

Demobilization consists of removing temporary facilities and utilities. Equipment will be transported offsite and the staging area will be dismantled. All trash and construction debris will be disposed of. Temporary fencing, cones, lighting, or other controls will be removed.

8.0 MEETINGS AND INSPECTIONS

A weekly job site meeting will be scheduled at a recurring day and time so all those involved can schedule accordingly. The meeting will update the past week's progress, planned events for the current week, current issues, health and safety issues, and overall schedule status. Attendees will vary depending on ongoing activities but will generally include a DOE representative, CM, Superintendent, and subcontractor personnel. Meeting minutes will be recorded and distributed.

Site inspections may be initiated by DOE, QA/QC needs, HASP (North Wind 2005d) enforcement, or other conditions. Inspections will occur on a random schedule or may occur at decision or hold points. Requirements for site access by non-project personnel (i.e., independent inspectors) are described in the HASP. At a minimum, inspectors and site visitors will be logged in by the SS, briefed on health and safety issues and protocol (e.g., daily tailgate safety briefing), and will be issued appropriate safety gear, as required.

Installed items that may potentially be suspect/counterfeit items (S/CI) will be inspected in accordance with the PQP (North Wind 2005c) and DOE Guide 440.1-6, "Implementation Guide for Use with Suspect/Counterfeit Items Requirements of DOE O 440.1, Worker Protection Management; 10 *Code of Federal Regulations* (CFR) 830.120; and DOE 5700.6c, Quality Assurance" (DOE 1997). In addition, items used during construction activities that may cause injury or fatalities if failure occurs (e.g., ratchet straps/tie down assemblies, fasteners, bridal slings, or hoisting slings) will also be inspected on a regular basis in accordance with the PQP and DOE Guide 440.1-6.

9.0 QUALITY CONTROLS

Quality controls specific to construction activities are addressed in the CQCP (North Wind 2005e). The PQP (North Wind 2005c) provides overall project QA methods.

10.0 HEALTH AND SAFETY CONTROLS

Health and safety controls and emergency procedures are addressed in the HASP (North Wind 2005d).

11.0 OPERATION, MAINTENANCE, AND MONITORING REQUIREMENTS

This section addresses operation, maintenance, and monitoring (OMM) activities to be performed during construction and/or post-construction phases. The construction phase, which is the time period from mobilization of construction equipment to demobilization, will last approximately 6 months. The post-construction phase is the time period from demobilization to final stabilization. For this project, final stabilization is defined as placement of the riprap slope on the east and north edge of the main landfill, completion of the MatCon™ installation on the main landfill, and the point of time at which the DDA has achieved at least 70% vegetation.

Upon final stabilization, a Notice of Termination (NOT) will be filed with the EPA. This phase, while uncertain due to inability to forecast 70% vegetation, is expected to last 6 to 12 months. After final stabilization has occurred, this contract is considered complete and post-closure care and monitoring will be the responsibility of DOE. OMM during post-closure is addressed in the Post-closure Care and Monitoring Plan (PCMP) for the LASO TA-73 Airport Landfill (North Wind 2005h). The post-closure period begins at filing of the NOT and lasts for up to 30 years.

Overall project requirements, including requirements for OMM during construction and post-construction phases, are defined in the Design Basis Document for LASO TA-73 Airport Landfill (North Wind 2004). In order to meet those requirements during construction and post-construction phases, some OMM activities have been addressed in the following documents:

- The CQCP (North Wind 2005e) for inspection and testing of construction materials and procedures,
- The SWPPP (North Wind 2005g) for runoff controls, maintenance of the vegetated cover, and protection of archaeological resources,
- The ancillary National Environmental Policy Act of 1969 (NEPA) documentation for protection of protected species, and
- The HASP (North Wind 2005d) for protection of human health and monitoring of soil gas releases during construction, including methane.

Additional OMM requirements not specified in the above documents that apply to the construction and post-construction phases have been identified. These requirements, including citations for regulatory requirements, are listed below.

11.1 Fire Prevention

“Provide adequate means to prevent and extinguish fires (*New Mexico Administrative Code* [NMAC] 20.9.1.400.B.7).”

All vehicles working on the construction site will be required to have fire extinguishers in the cab or elsewhere on the vehicle.

11.2 Sanitary Facilities

“Provide toilet and hand washing facilities for workers (29 CFR 1926).”

Facilities will be provided in the staging area, located near the office trailer at the northwest corner of the main landfill.

11.3 Access Roads

“Maintain access roads (NMAC 20.9.1.400.B.9).”

All access roads required for OMM will be maintained as needed.

11.4 Noise Levels

“Noise may not exceed 65 dBA during construction (LAC 18-73).”

Noise levels at the landfill during construction will be lower than for airport operations, based on published noise levels for planned construction equipment and aircraft using the airport. Noise will be mitigated to the extent feasible by minimizing operational duration of high-noise level equipment. Noise levels will be addressed in an environmental assessment conducted by DOE.

11.5 Work Hours

“Excavation may take place only during the hours from 7 AM to 6 PM (LAC-34-54).”

Excavation of waste will be limited to these hours.

11.6 Dust Control

“Excavated material must be maintained to minimize disruption of traffic and to keep dirt or dust from spreading or flying (LAC-34-46).”

Dust will be continually monitored (visually) during earth moving activities. Monitoring locations will include a background location upwind of the site and at several locations downwind of areas that could potentially be a source of excessive dust. If visual obscurity exceeds 25% above background levels, as measured by a Ringelmann Smoke Chart or equivalent method, dust-creating activities will be suspended until visual obscurity falls below 25% above background levels. In general, dust-creating activities will not recommence until at least 2 hours have passed, in which visibility has not been obscured by 25%. However, if the cause of the dust is clearly identified and mitigated, activities may recommence within this 2-hour window at the discretion of the SS. An example would be excessive dust caused by a malfunctioning water truck. Upon the repair of the water truck and successful resumption of watering, activities could recommence.

Dust will be controlled by frequent watering and/or tacking compounds. Dirt access roads, disturbed areas, and material stockpiles will be watered at a frequency determined by the SS, dependent on weather conditions, area of disturbance, traffic patterns, and nature of soil. Water will be applied to maintain air quality such that the soil is wet but not saturated or muddy. At a minimum, watering will occur whenever dust and suspended sediment exceeds the action level described above, threatens air quality, or becomes a public nuisance. Prior to clearing and grubbing, portions of the landfill and DDA may also be watered to prevent generating excess dust.

Airborne ash may be a particular concern due to aesthetics and potential for contamination. In addition to the water controls described above, tacking agent(s) will be readily available to apply as needed to control blowing ash.

During construction, a water truck will be used to control dust on excavations and access roads and to condition fill material before compaction. The truck will be equipped to apply a front spray, back spray, and/or a pumped hose and nozzle spray. Water is available from a hydrant at the northwest corner of the hangar facilities. The hydrant will be fitted with a metering device to measure volume used. Access roads will be gravel surfaced and sprayed as necessary to prevent visible dust. During the peak of soil delivery, the supplier may be required to assist with dust control of the haul routes.

11.7 Site Security

“Prevent unauthorized entry by 24-hour surveillance system, fencing, or signage during construction (NMAC 20.9.1.400.B.4; 40 CFR 265.14); have worksites fenced or maintained in a manner to safeguard property and the public (LAC 10-75).”

Fencing and signage will be maintained during construction. Temporary fences will be used in areas where permanent fences must be removed to complete construction. Any area where fencing and signage must be removed will be guarded until replaced. All personnel entering the site are required to receive DOE “Get Employee Trained” training.

A gate across the DDA access spur from State Highway 502 will be staffed by a laborer for security when trucks are hauling materials to the site. The monitor will open the gate and notify site workers of incoming loads for logistical and safety purposes.

Additional site security information is provided in the HASP (North Wind 2005d).

11.8 Airport Coordination

Construction activities will be conducted inside the fence line of the Los Alamos Airport, which has an active runway and taxiway, storage of aircraft on the tarmac, and in hangers. Construction activities will be coordinated with airport operations personnel and any operations that may effect runway operations, reduce the tarmac footprint for aircraft storage, or remove or open fence areas or gates will be communicated during the pre-job briefing with airport personnel. The SS will continue to provide updates to the airport operations personnel during the course of the project.

Although the construction plans for activities in the DDA and main landfill areas are not anticipated to impact active runway operations, the following practices will be followed to reduce hazards to aircraft and construction personnel:

- A construction fence or high visibility rope and barricades will be used to delineate construction work zones and as temporary fencing.
- Airport boundary security fence and gates will be maintained. Temporary gates will be equipped with hardware that will allow them to be locked and secured during nonworking hours.
- Vehicle and equipment operators will be briefed during the pre-job briefing on established traffic routes, prohibited driving areas of the airport, and other relevant airport safety information. This information will be updated and communicated at the daily construction briefing when changes to established routes or other pertinent information need to be communicated to project personnel.
- Radio communication between the SS and airport operations personnel will be established (as required airport operations), if necessary, as directed by airport personnel. All site activities shall be suspended to accommodate air traffic.
- Vehicle and equipment operators will be monitored by the Site Safety Officer (SSO) and SS to ensure compliance with established vehicle traffic routes and requirements.

Other applicable requirements from the DOT and Federal Aviation Administration (FAA), Advisor Circular, AC No. 150/5370-2E, “Operational Safety on Airports during Construction” (FAA 2003) will be complied with site documents. Additional information is provided in the HASP (North Wind 2005d).

11.9 Construction Traffic Control

Traffic control will be established prior to start of construction. Elements of the traffic control will include the following:

- A Traffic Control Plan will be prepared,
- A Traffic Permit will be prepared for approval by the LAC and the New Mexico DOT,

- Flaggers and signs will be in place along State Highway 502. This work will be subcontracted to qualified companies that provide such services,
- Inspection records for delivery truck brakes will be requested from the borrow source supplier, and
- Truck routes will be approved as part of the Traffic Permit.

Large commercial vehicles (i.e., industrial haul and water trucks) and equipment will be used for hauling of fill materials and other supplies. Designated traffic lanes and routes will be established for this equipment when operating on the project site. Established vehicle traffic lanes and routes will be clearly communicated to all personnel and drivers during the pre-job briefing and will be marked and delineated where feasible to prevent inadvertent entry or crossing by personnel or other equipment.

Entry to and exit from the airport landfill site will be controlled. Only established and approved gates will be used. A spur from the State Highway 502 gate adjacent to the DDA area will be used to facilitate fill material delivery. The spur will be marked, required signs posted, and flagger control used in accordance with the “Manual on Uniform Traffic Control Devices” (DOT 2003) and LAC requirements.

Highway signs will be erected on State Highway 502 at the ingress/egress to the main landfill and DDA, in accordance with Traffic Control Devices Manual (DOT 2003). The signs will warn approaching traffic of construction activities. A minimum of two flagmen will be posted at the DDA ingress/egress to control traffic. The need for flagmen at the main landfill will be assessed in consultation with airport personnel. The flagmen will have two-way radio contact (or alternate electronic devices) with the SS.

Heavy truck traffic delivering borrow source material will be limited to the hours of 9 a.m. through 3 p.m. Monday through Friday. If congestion on State Highway 502 becomes a problem during the week, truck deliveries may be scheduled for the weekend. Trucks will arrive in a convoy of about ten (10) trucks, and the lead truck will radio the SS ahead of arrival to ensure flagmen are on the scene.

Additional information is provided in the HASP (North Wind 2005d).

11.10 Housekeeping

“Control litter, disease vectors and odors (NMAC 20.9.1.400.B.12).”

Wind dispersal and odors will be controlled through dust control measures described in Section 9.6. Disease vectors (e.g., birds and rodents) will be controlled if needed; however, due to the relatively brief duration of waste excavation and relocation, this will likely not be needed.

In general, litter on the site will be controlled by minimizing exposed debris that may become airborne. This will be accomplished by placing an interim soil cover on emplaced debris immediately after compaction, and by covering debris exposed on the working face of excavations with a woven geotextile or a plastic mesh material, as necessary, to prevent airborne litter from leaving the site.

If wind velocities exceed sustained 35 miles per hour (mph), as measured by a handheld monitor or similar instrument, any litter-handling or litter-exposing operations will cease. This does not apply to litter that is too heavy to become airborne (e.g., concrete, scrap metal, or wood). Operations may resume when wind velocity decreases below sustained 35 mph. This work will not resume under any circumstances if airborne litter is observed leaving the site. If this occurs, the litter control methods discussed above will be initiated to cover exposed waste that may become airborne.

Good housekeeping at the construction site will be practiced at all times to prevent accumulation of litter. Paper products, lunch trash, rubbish, construction solid waste, and other nonhazardous materials will be placed in a closed dumpster or rolloff box and will be emptied as needed by a local contractor. The SS will inspect the site daily for litter. Loose incidental trash will be picked up and thrown away. Any exposed waste with the potential to become airborne will be covered at the end of each work day.

12.0 FIGURES

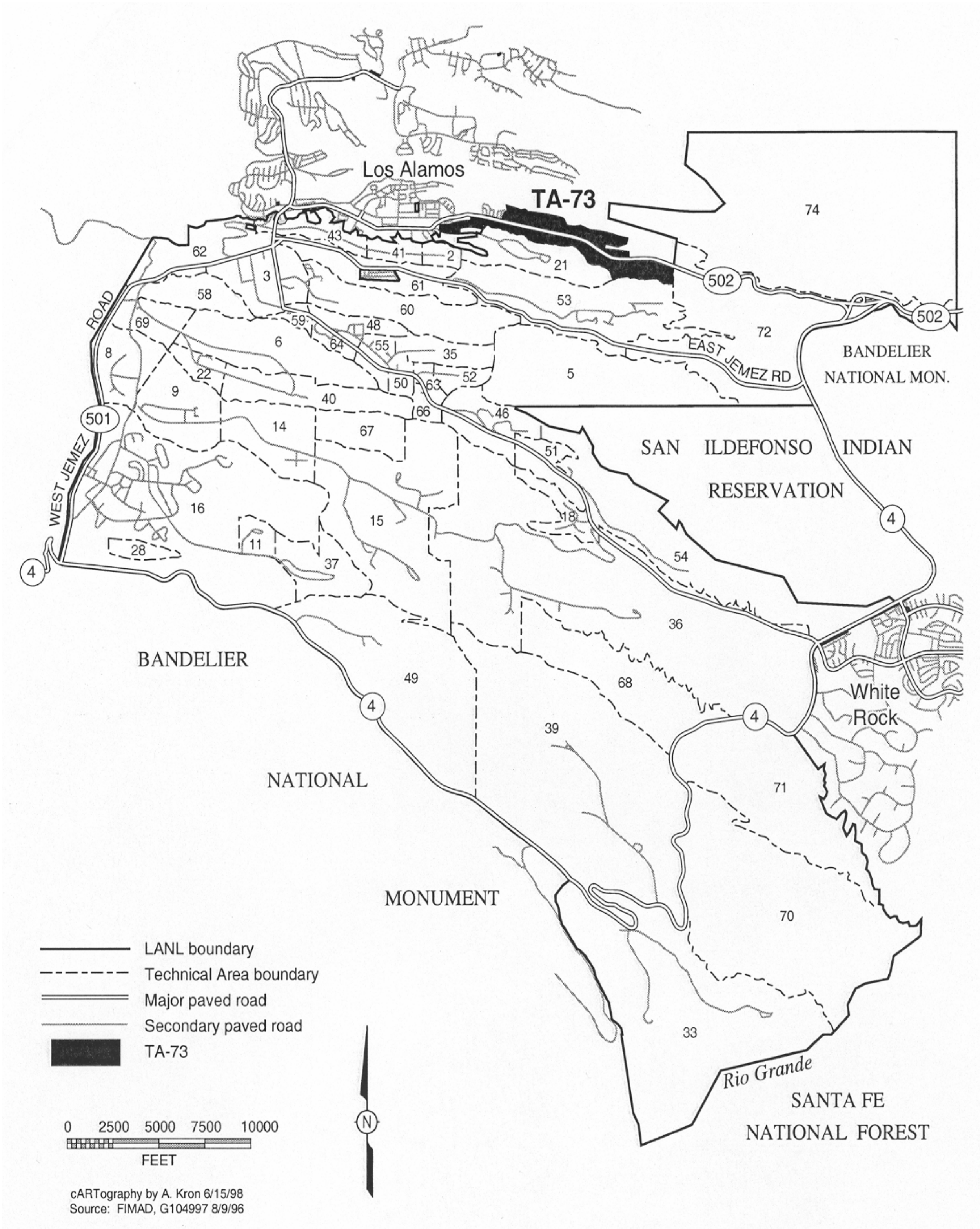

Figure 2.1-1. Location of TA-73

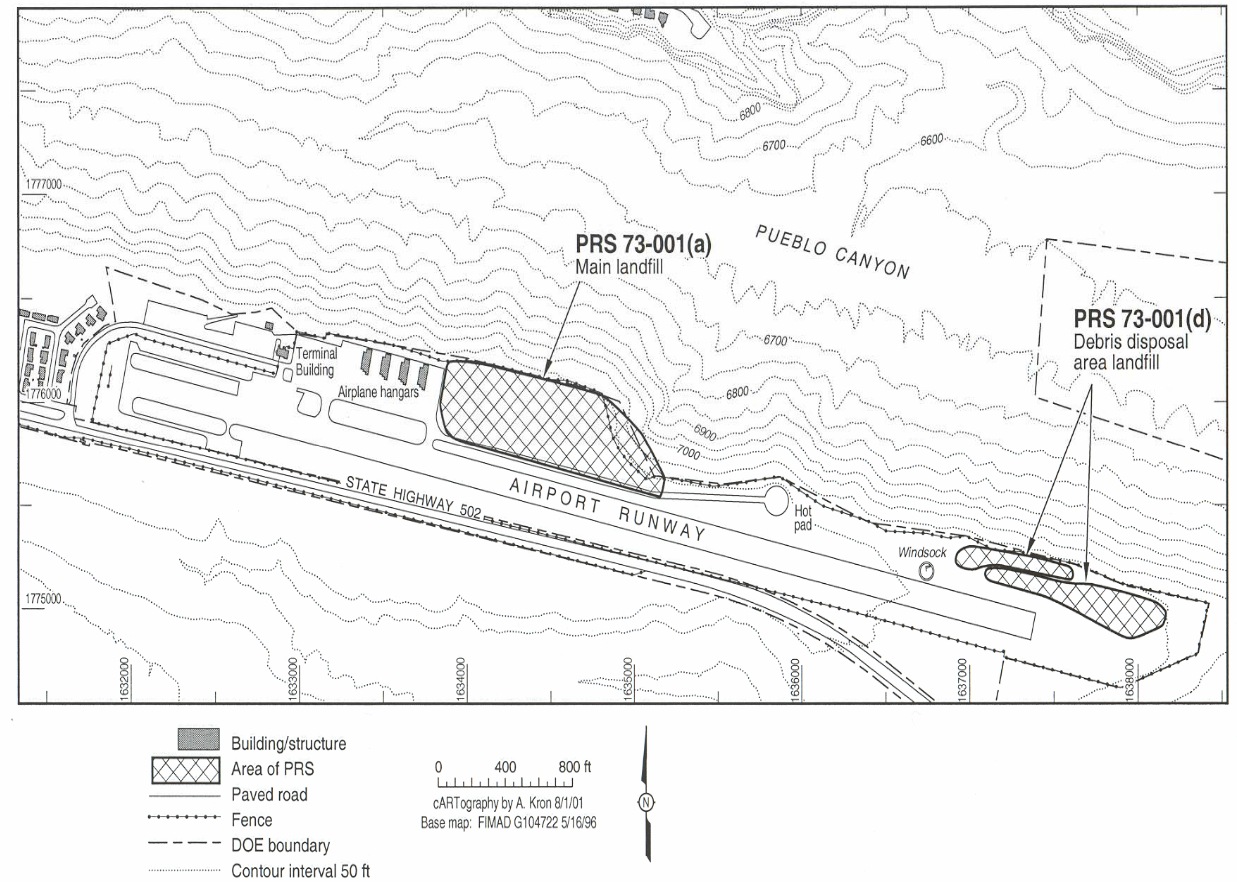

Figure 2.1-2. Location of the main landfill and debris disposal area (LANL 2002)
Note: "PRS" has changed to "SWMU"

13.0 REFERENCES

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29 CFR 1926, 2002, Title 29, "Labor," Part 1926, "Safety and Health Regulations for Construction," *Code of Federal Regulations*, Office of the Federal Register, April 15, 2002.

40 CFR 265.14, 2002, Title 40, "Protection of Environment," Part 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Section 265.14, "Security," *Code of Federal Regulations*, Office of the Federal Register.

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The following are NWI quality documents that are controlled in accordance with QAP-10-171, Records Control. The latest revision applies:

PWI-4201-004, Readiness Assessment

QAP-10-021, Indoctrination and Training

QAP-10-022, Certification of Personnel

QAP-10-061, Document Control

QAP-10-121, Control of Measuring and Test Equipment

QAP-10-181, Quality Audits

QAP-16, Control of Quality Records

Appendix A

Acronyms

Appendix A

Acronyms

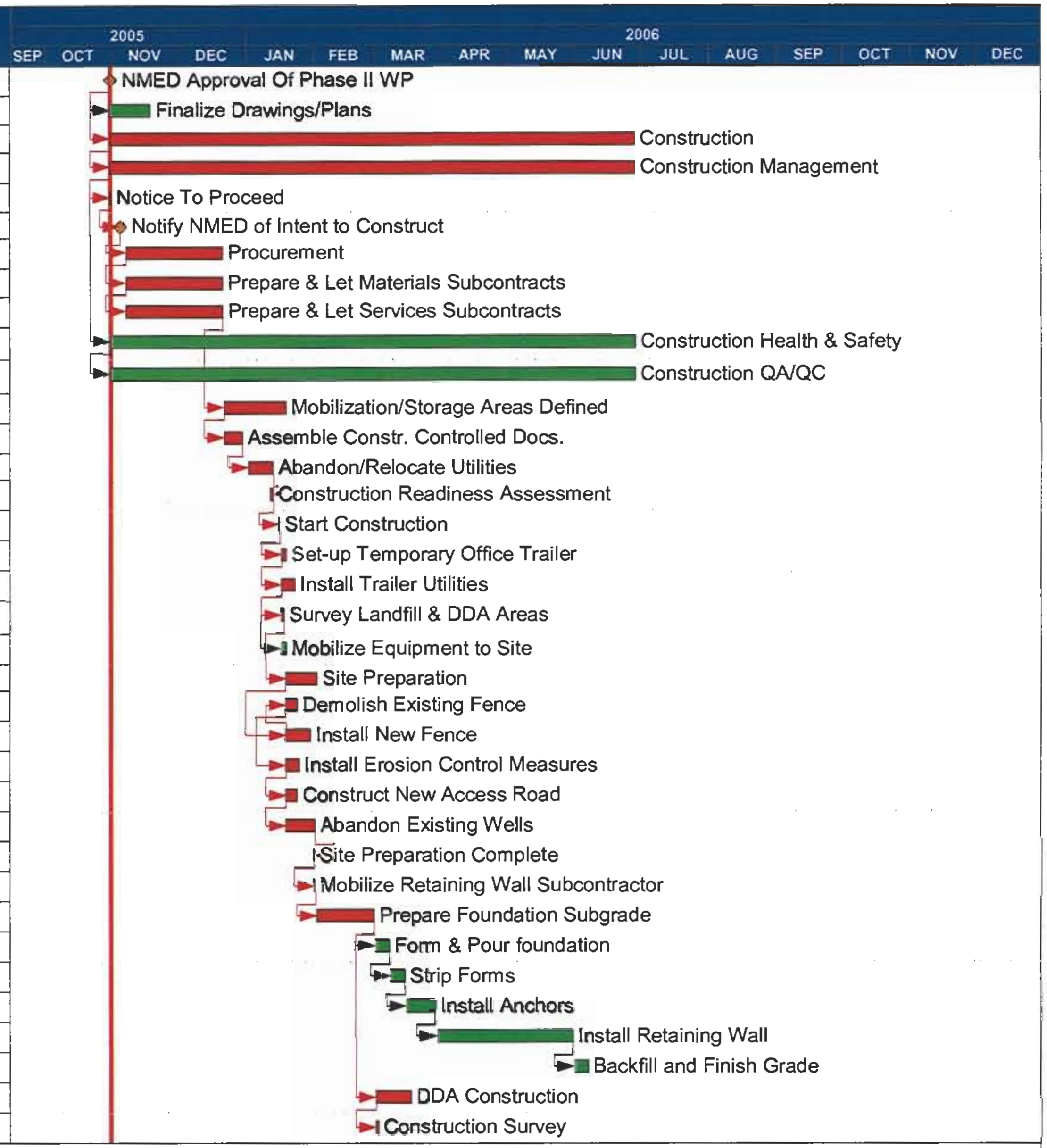
CFR	*Code of Federal Regulations*
CM	Construction Manager
CO	Contracting Officer
COR	Contracting Office Representative
CQCP	Construction Quality Control Plan
cy	Cubic yard(s)
DDA	Debris Disposal Area
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
HASP	Health and Safety Plan
HDPE	high-density polyethylene
ISM	Integrated Safety Management
LAC	Los Alamos County
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office
M&TE	Measuring and test equipment
MatCon™	Modified Asphalt Technology for Waste Containment
mph	miles per hour
NEPA	National Environmental Policy Act of 1969
NMAC	*New Mexico Administrative Code*
NWI	North Wind Inc.
NOT	Notice of Termination
NTP	Notice to Proceed

OMM	Operation, maintenance, and monitoring
PCMP	Post-closure Care and Monitoring Plan
PM	Project Manager
PMP	Project Management Plan
PQP	Project Quality Plan
PWI	Project Work Instruction
QA	Quality assurance
QAP	Quality Assurance Procedure
QA/QC	Quality assurance/quality control
QC	Quality control
QCFE	Quality Control Field Engineer
S/CI	Suspect/counterfeit item
SOW	Statement of Work
SS	Site Superintendent
SSO	Site Safety Officer
SWMU	Solid Waste Management Unit
SWPPP	Storm Water Pollution Prevention Plan
TA	Technical Area
WESTON	Weston Solutions, Inc.

Appendix B

Construction Schedule

Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish
3.0	NMED Approval Of Phase II WP	0	0	31OCT05	
3.1	Finalize Drawings/Plans	1d	15d	31OCT05	18NOV05
4.0	Construction	173d	173d	31OCT05 *	28JUN06
4.1.	Construction Management	173d	173d	31OCT05	28JUN06
4.1.1	Notice To Proceed	1d	1d	31OCT05	31OCT05
4.1.2	Notify NMED of Intent to Construct	0	0		04NOV05
4.1.3	Procurement	33d	33d	07NOV05	21DEC05
4.1.4	Prepare & Let Materials	33d	33d	07NOV05	21DEC05
4.1.5	Prepare & Let Services	33d	33d	07NOV05	21DEC05
4.2	Construction Health & Safety	173d	173d	31OCT05	28JUN06
4.3	Construction QA/QC	173d	173d	31OCT05	28JUN06
4.4	Mobilization/Storage Areas Defined	21d	21d	22DEC05	19JAN06
4.4.1	Assemble Constr. Controlled Docs.	7d	7d	22DEC05	30DEC05
4.4.2	Abandon/Relocate Utilities	10d	10d	02JAN06	13JAN06
4.4.3	Construction Readiness	2d	2d	12JAN06	13JAN06
4.4.4	Start Construction	1d	1d	16JAN06	16JAN06
4.4.5	Set-up Temporary Office Trailer	3d	3d	17JAN06	19JAN06
4.4.6	Install Trailer Utilities	5d	5d	17JAN06	23JAN06
4.4.7	Survey Landfill & DDA Areas	2d	2d	17JAN06	18JAN06
4.4.8	Mobilize Equipment to Site	3d	3d	17JAN06	19JAN06
4.5	Site Preparation	11d	11d	19JAN06	02FEB06
4.5.1	Demolish Existing Fence	4d	4d	19JAN06	24JAN06
4.5.2	Install New Fence	8d	8d	19JAN06	30JAN06
4.5.3	Install Erosion Control Measures	5d	5d	19JAN06	25JAN06
4.5.4	Construct New Access Road	4d	4d	19JAN06	24JAN06
4.5.5	Abandon Existing Wells	10d	10d	19JAN06	01FEB06
4.5.6	Site Preparation Complete	1d	1d	01FEB06	01FEB06
4.5.7	Mobilize Retaining Wall	1d	1d	01FEB06	01FEB06
4.5.8	Prepare Foundation Subgrade	19d	19d	02FEB06	28FEB06
4.5.81	Form & Pour foundation	5d	5d	01MAR06	07MAR06
4.5.82	Strip Forms	5d	5d	08MAR06	14MAR06
4.5.83	Install Anchors	10d	10d	15MAR06	28MAR06
4.5.84	Install Retaining Wall	45d	45d	29MAR06	30MAY06
4.5.85	Backfill and Finish Grade	5d	5d	31MAY06	06JUN06
4.6	DDA Construction	13d	13d	01MAR06	17MAR06
4.6.1	Construction Survey	2d	2d	01MAR06	02MAR06



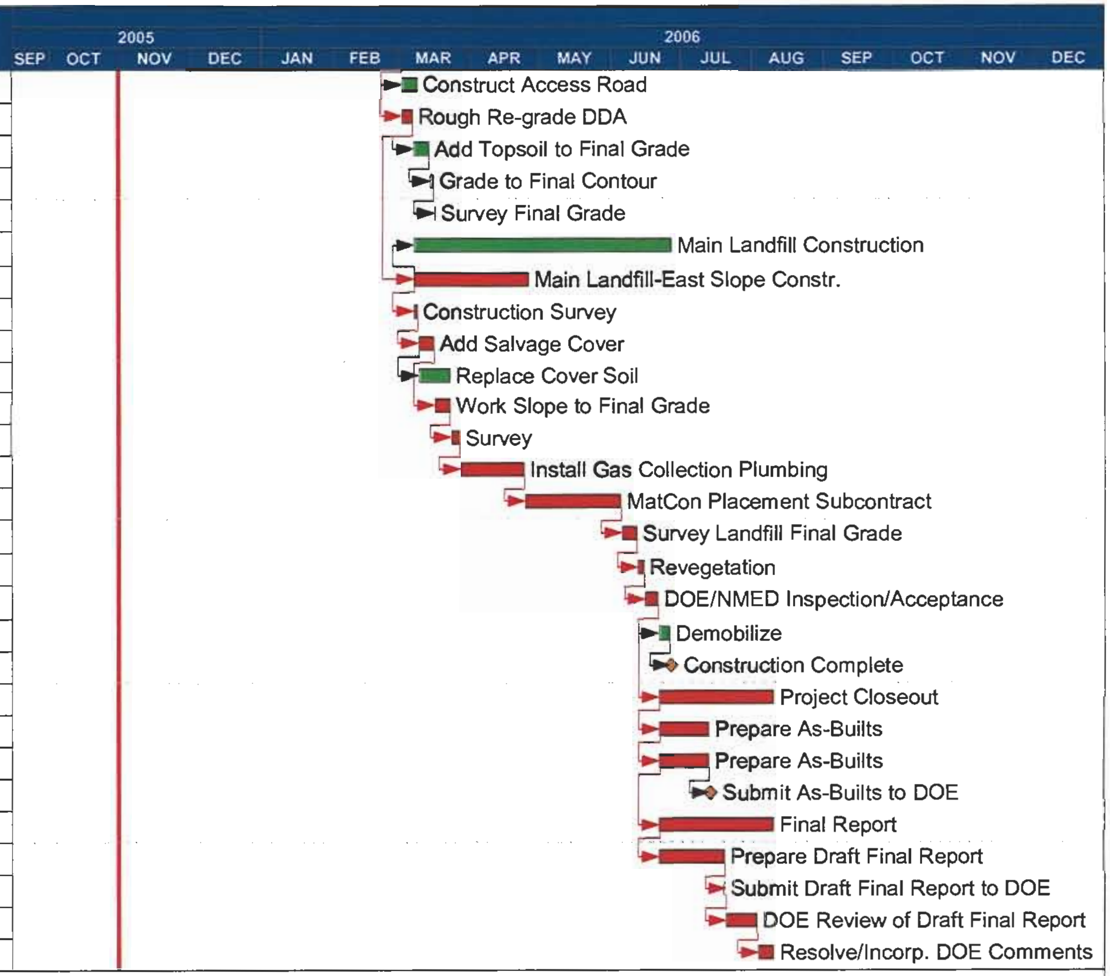
Start date	**31OCT05**
Finish date	**10AUG06**
Data date	**31OCT05**
Run date	**23JUN05**
Page number	**1A**

Los Alamos Site Office
TA-73 Airport Landfill Project -Construction Schedule

North Wind, Inc.

Early bar
Progress bar
Critical bar
Summary bar
Start milestone point
Finish milestone point

Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish
4.6.2	Construct Access Road	5d	5d	03MAR06	09MAR06
4.6.3	Rough Re-grade DDA	3d	3d	03MAR06	07MAR06
4.6.4	Add Topsoil to Final Grade	5d	5d	08MAR06	14MAR06
4.6.5	Grade to Final Contour	2d	2d	15MAR06	16MAR06
4.6.6	Survey Final Grade	1d	1d	17MAR06	17MAR06
4.7	Main Landfill Construction	80d	80d	08MAR06	27JUN06
4.7.1	Main Landfill-East Slope Constr.	36d	36d	08MAR06	26APR06
4.7.1.1	Construction Survey	2d	2d	08MAR06	09MAR06
4.7.1.2	Add Salvage Cover	35d	5d	10MAR06	16MAR06
4.7.1.21	Replace Cover Soil	1d	10d	10MAR06	23MAR06
4.7.1.3	Work Slope to Final Grade	20d	5d	17MAR06	23MAR06
4.7.1.5	Survey	2d	2d	24MAR06	27MAR06
4.7.1.6	Install Gas Collection Plumbing	5d	20d	28MAR06	24APR06
4.7.2.	MatCon Placement Subcontract	30d	30d	25APR06	05JUN06
4.7.2.8	Survey Landfill Final Grade	5d	5d	06JUN06	12JUN06
4.8	Revegetation	3d	3d	13JUN06	15JUN06
4.8.1	DOE/NMED Inspection/Acceptance	4d	4d	16JUN06	21JUN06
4.9	Demobilize	3d	3d	22JUN06	26JUN06
4.9.1	Construction Complete	0	0	27JUN06	
5.0	Project Closeout	35d	35d	22JUN06 *	10AUG06
5.1	Prepare As-Builts	15d	15d	22JUN06	13JUL06
5.1.1	Prepare As-Builts	15d	15d	22JUN06	13JUL06
5.1.2	Submit As-Builts to DOE	0	0	14JUL06	
5.2.	Final Report	35d	35d	22JUN06 *	10AUG06
5.2.1	Prepare Draft Final Report	20d	20d	22JUN06	20JUL06
5.2.2	Submit Draft Final Report to DOE	0	0	21JUL06	20JUL06
5.2.3	DOE Review of Draft Final Report	10d	10d	21JUL06	03AUG06
5.2.4	Resolve/Incorp. DOE Comments	5d	5d	04AUG06	10AUG06



Start date	31OCT05
Finish date	10AUG06
Data date	31OCT05
Run date	23JUN05
Page number	2A

Los Alamos Site Office
TA-73 Airport Landfill Project -Construction Schedule

North Wind, Inc.

- Early bar
- Progress bar
- Critical bar
- Summary bar
- Start milestone point
- Finish milestone point

Attachment C
Construction Quality Control Plan
for the LASO TA-73 Airport Landfill

NW-ID-2004-016
Revision 2

CONSTRUCTION QUALITY CONTROL PLAN FOR THE LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILL

June 2005

Prepared for:

U. S. Department of Energy, National Nuclear Security Administration
Los Alamos Site Office
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Los Alamos, New Mexico 87544

Prepared by:

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DOCUMENT APPROVAL PAGE

Document Number: NW-ID-2004-016 Revision: 2

Document Title: Construction Quality Control Plan for the Los Alamos Site Office TA-73 Airport Landfill

Approval Signatures

Name	Signature	Date	Title
Doug Jorgensen	Original signature on file	05/24/05	Project Manager
Leslie Diggins	Original signature on file	05/24/05	Corporate Quality Assurance Manager

Revision Log

Revision	Date	Reason for Revision
Draft	02/12/04	Not applicable; first draft of document
Revision 0	03/15/04	Document revised to ensure consistency with final construction specifications. DOE-LASO had no comment on the draft of this document.
Revision 1	04/06/04	Document revised to correct minor formatting errors and add discussion of identification and mitigation of potential suspect/counterfeit items (Section 7.0)
Revision 2	05/31/05	Document revised to reflect scope change per DOE revised SOW. Primary revisions include rewrite of Section 5, Landfill Cover Construction to reflect new design elements.

CONTENTS

APPENDICES

1.0 INTRODUCTION

This Construction Quality Control Plan (CQCP) provides the quality control (QC) requirements, in accordance with NWI-QAM-01-001, North Wind Inc. (NWI) Quality Assurance Manual, for construction activities at the U.S. Department of Energy (DOE) Los Alamos Site Office (LASO) Technical Area (TA)-73 Airport Landfill, henceforth referred to as the Airport Landfill project.

The CQCP provides the minimum inspection, testing (i.e., methods and frequency), materials, installation, and documentation requirements to ensure that design specifications for the Airport Landfill project are met or exceeded during construction. Protocols for reporting test results, certifying compliance with specifications and drawings, correcting construction deficiencies, and documenting such corrections are also provided.

1.1 Site Description and Background

A complete site description and project background are provided in the Remedy Design Work Plan for LASO TA-73 Airport Landfill (North Wind 2005a). Figure 1.1-1 (see Section 9) shows the general location of the work area in relation to Los Alamos. Figure 1.1-2 (see Section 9) shows the main landfill east of the existing airport hangars and the Debris Disposal Area (DDA) north and east of the end of the runway.

1.2 Document Scope

The construction quality control (CQC) activities described in this document will assure compliance with approved construction specifications and drawings. These design elements have been prepared by Weston Solutions, Inc. (WESTON) in an iterative process. The process began with a conceptual design presented in the Design Basis Document for LASO TA-73 Airport Landfill (North Wind 2004) and culminated with a final design approved by DOE and the New Mexico Environmental Department (NMED). The final design package includes specifications and drawings. As such, the CQCP extensively references the final construction specifications. Reference shall be by the specification number and title (e.g., Specification 01010, “Summary of Work”), as discussed in Construction Specifications for LASO TA-73 Airport Landfill (North Wind 2005b). Construction specifications take precedence over construction drawings, which in turn take precedence over project scoping plans.

1.3 Document Interfaces

The Remedy Design Work Plan (North Wind 2005a) is the primary scoping document for the project. The Remedy Design Work Plan includes by reference or incorporation:

- Final construction specifications, drawings, and engineering calculations,
- Construction Plan for the Los Alamos Site Office TA-73 Airport Landfill (North Wind 2005c),
- This CQCP,
- Waste Management Plan (WMP) for the LASO TA-73 Airport Landfill (North Wind 2005d), and
- Post-closure Care and Monitoring Plan (PCMP) for the LASO TA-73 Airport Landfill (North Wind 2005e).

In addition to the Remedy Design Work Plan, the following project plans direct or implement CQC activities and will be available onsite and followed during construction:

- Project Quality Plan (PQP)—Overall project quality assurance (QA) is managed according to the Project Quality Plan for the LASO TA-73 Airport Landfill (North Wind 2005f). The PQP establishes an audit schedule, defines methods to qualify subcontractor QA programs, and discusses the protocol for nonconformance reporting and resolution.

- Project Management Plan (PMP)—The PMP for LASO TA-73 Airport Landfill (North Wind 2005g) describes the overall management structure and methods for the project. The PMP defines meeting and reporting protocols, provides overall organizational structure, and defines methods for procurement of materials and services.

- Storm Water Pollution Prevention Plan (SWPPP)—The SWPPP for LASO TA-73 Airport Landfill (North Wind 2005h) describes storm water runoff and erosion controls that will be implemented.

- Health and Safety Plan (HASP)—The HASP for the LASO TA-73 Airport Landfill (North Wind 2005i) provides controls for the use of field test equipment (e.g., nuclear density gauge).

2.0 QUALITY CONTROL PROGRAM

The objective of this QC program is to create a plan-execute check system to ensure that all activities are performed in accordance with project requirements and in conformance to the approved project guidance documents. Primary QC activities and objectives include:

- Collecting and analyzing off-site borrow source material to assure that these materials comply with respective specifications.

- Verifying that man-made materials (e.g., geotextiles, Modified Asphalt Technology for Waste Containment [MatCon™], silt fences, and chain link fence) installed during construction of the final remedy comply with specifications.

- Field-testing installed components of the landfill cover for appropriate parameters (e.g., moisture content and compaction).

- Verifying that landfill cover components (e.g., soils, riprap, geotextiles, MatCon™ cover) and ancillary components (e.g., storm water runoff and erosion control devices and fencing) are properly installed, maintained, and inspected in compliance with approved specifications.

The QC process encompasses a review of each specific feature of work by a designated Quality Control Field Engineer (QCFE). The QCFE will perform these duties whether a government representative is present or not. All QC activities will be summarized in PQP-4201-001, PQPF-4201-001.4, Daily Quality Control Reports (DQCRs). An example of the DQCR is provided in Appendix B.

Specific features of work for this project are listed in Table 2.0-1 (see Section 8).

3.0 ORGANIZATIONAL STRUCTURE AND RESPONSIBILITIES

The project organization structure and responsibilities are described in PQP-4201-001. Specific responsibilities for implementing this CQCP are described in the following sections.

3.1 Construction Manager

The Construction Manager (CM) has overall responsibility for implementing the CQC program. The CM has the sole authority to direct and manage personnel and equipment to accomplish this task. The CM will have sufficient educational, technical, and administrative experience to fulfill this role. The CM will be cognizant of specific construction practices relating to construction, observation, testing procedures, documentation procedures, and construction-level specifications, permit requirements, and regulations applicable to the Airport Landfill project. The CM reports to the Project Manager (PM) and directs the Site Superintendent (SS).

3.2 Site Superintendent

The NWI SS is responsible for daily work activities and directly manages field construction crews and support staff. This is a full-time, onsite position. The primary responsibility of the SS is to ensure that all aspects of the project are conducted in accordance with the final construction specifications, construction drawings, and project scoping documents, using necessary and industry-accepted construction procedures. Additional QC responsibilities tasked to the SS include:

- Ensures adequate quantities or required materials are available and schedules the delivery of these materials,
- Ensures equipment (e.g., heavy equipment and onsite testing devices) is available and functional to obtain required results and meet project specifications,
- Visually inspects delivered offsite borrow source material for undesired elements (i.e., large rocks or debris),
- Obtains material certifications (e.g., seed tags, geotextile, and fencing certifications) and provides these certifications to the QCFE,
- Inspects construction activities, including installation of landfill cover components, to verify they are performed in compliance with specifications,
- Ensures soil layers are not placed, spread, or compacted during unfavorable weather conditions,
- Performs or oversees intermittent grade checks, by visual means or survey, to control cut and fill operations,
- Checks survey data for consistency, completeness, and accuracy (to the extent possible),
- Works with the QCFE and CM to resolve nonconformances,
- Inspects subgrade for loose or unstable areas, and
- Manages and maintains project documents and records in accordance with Section 6.0.

The SS reports to the CM and directs field personnel and subcontractors. The SS interfaces with the QCFE and provides access, equipment, materials, and other support as needed to enable the QCFE to complete required tasks.

3.3 Quality Control Field Engineer

The QCFE is responsible for conducting CQC activities in accordance with this document, the PQP (North Wind 2005f), Project Work Instructions (PWIs), the project work plan, and supporting documents. The QCFE will be onsite as needed during construction of the landfill cover. The QCFE will have sufficient practical, technical, and managerial experience to successfully complete assigned CQC activities and will have a working knowledge of permit requirements, specifications, and implementing project plans. The QCFE will be under the direct supervision of a Professional Engineer registered in the State of New Mexico in civil or geotechnical engineering.

The primary task assigned to the QCFE is verifying that the various components of the landfill cover are installed according to specifications. This verification will be documented at hold points with Incremental Certification Reports (ICRs) and other documents, as described in Section 6. Additional CQC tasks assigned to the QCFE include:

- Pre-qualifies offsite borrow material to ensure the material is compliant with specifications,
- Oversees field tests to ensure that soil layers are properly installed and compacted,
- Periodically monitors the loading of offsite borrow material to ensure it was excavated from a pre-qualified location,
- Checks delivered material against certifications to ensure the materials conform to specifications,
- Verifies that the equipment used in CQC field testing meets the test requirements (including calibration) and that testing is completed according to standardized procedures,
- Recommends acceptance or rejection of work items, particularly with regard to installation of soil layers,
- Documents CQC activities, including daily and monthly summary CQC reports, and
- Prepares ICRs.

The QCFE will be responsible for obtaining laboratory test results and field test data and for reviewing these data for conformance to the specifications, drawings, and the CQCP. A copy of these data will be provided to the SS and/or CM.

The QCFE reports to the SS on a daily basis. The QCFE interfaces with the NWI PM and the Corporate Quality Assurance Manager to report and resolve nonconformances. The QCFE also directs the Geotechnical Testing Laboratory (GTL) staff on issues related to sample collection and analysis and data reporting.

3.4 Geotechnical Testing Laboratory

A GTL will be subcontracted for sample analysis and data reporting, as described in Section 3.0. GTL personnel will collect samples for as-delivered testing and will operate field test equipment (e.g., nuclear density gauge).

3.5 Project Meetings

The SS and QCFE will communicate on a regular basis to ensure the requirements in this CQCP, supporting documents listed in Section 1.3, and construction specifications are being met. This will be accomplished through meetings held during the progress of the work. The meetings will be documented and the documentation will be managed as described in Section 6.0. Additional pre-construction and progress meeting requirements are discussed in the Construction Plan (North Wind 2005c) and the PMP (North Wind 2005g).

4.0 PRECONSTRUCTION AND SITE PREPARATION

Preconstruction, mobilization, and site preparation activities are detailed in the Construction Plan (North Wind 2005c). The following subsections provide CQC information relating to preconstruction and site preparation activities.

4.1 Construct Access Roads

Access roads to the main landfill and DDA will be constructed in accordance with Specification 02500, “Gravel Roads.” No CQC activities are required.

4.2 Survey Debris Disposal Area and Main Landfill

Surveying will be conducted in accordance with Specification 02005, “Surveying.” Survey work will be performed under the direction of a Land Surveyor registered in the State of New Mexico. The QCFE will check survey data for consistency and accuracy, to the extent possible.

4.3 Install Perimeter Fencing

Chain link perimeter fencing will be installed in accordance with Specification 02980, “Chain Link Fence.” The SS will obtain material certifications for delivered fencing and the QCFE will check the certifications against the specification to ensure compliance. The QCFE will also periodically spot-check rolls of fencing against the certification to ensure the proper material was delivered.

4.4 Install Storm Water Controls

Storm water runoff and erosion controls will be installed, maintained, and inspected in accordance with the SWPPP (North Wind 2005h) and the following final construction specifications:

- Specification 02720, “Storm Drain System,”
- Specification 02750, “Stormwater Management and Discharge,” and
- Specification 02930, “Erosion and Sediment Control.”

The SS will verify that the erosion control materials listed in the above references are available on site and will obtain manufacturer certifications for silt fence, storm drain system components, and other erosion control materials. The QCFE will check the certifications against the specification to ensure compliance.

4.5 Materials Testing

All soil and aggregate materials are required to be tested and approved for use prior to placement. These materials may be obtained from onsite or offsite sources. The GTL will test representative samples of all materials prior to use to verify acceptance criteria. Prior to use, the QCFE will review applicable test data to ensure material is acceptable for use and properly documented. Parts 1.04 and 2 of Specification 02200, “Earthwork” provide specifications for the following material types to be used:

- Structural Fill Soil,
- Infiltration Soil,
- Topsoil, and
- Aggregate Bedding.

Concrete materials used in construction of the retaining wall and hangar pad are also required to be tested and approved prior to installation. The GTL will test representative samples of all concrete materials during installation to verify acceptance criteria. As soon as test results become available, the QCFE will review applicable test data to ensure the material is acceptable for use and properly documented. Specification 03300, “Cast-in-Place Concrete” and Specification 03400, “Precast Concrete,” provide specifications for the following concrete structures to be used:

- Airport hangar pad,
- Retaining wall, and
- Manholes, storm drain structures, etc.

Part 1.03 of Specification 01400, “Quality Control,” provides additional guidance for certification of materials.

5.0 LANDFILL COVER CONSTRUCTION

Landfill cover construction activities are detailed in the Construction Plan (North Wind 2005c). The following subsections provide appropriate CQC information relating to cover construction at the main landfill and the DDA.

5.1 Repair Debris Disposal Area Cover

The existing soil cover over the DDA will be repaired to ensure that there is a minimum 12 in. soil cover over existing waste, a final grade of approximately 3% to promote runoff, and re-vegetation with native plants. The only testing required for this activity is mechanical penetration tests to identify the depth to waste and amount of new cover soil required. Cover restoration will proceed as specified in Specification 02932, “Seeding, Mulching, and Restoration.”

5.1.1 Pre-use Inspection

Seed certifications will be reviewed by the QCFE prior to placement of the seed to verify compliance with the specification document.

5.1.2 Field Testing

There is no field testing required.

5.1.3 Hold Point

Upon completion of the DDA restoration work, the QCFE will inspect the site, soil certification, seed certification, and survey data to verify compliance with construction specifications and drawings. The QCFE will accept or reject the DDA cover by written notification to the SS via an ICR. If rejected, work will not proceed on the landfill cover until the DDA cover has been repaired or re-installed.

5.2 Excavate at Main Landfill

Excavation at the main landfill will be conducted in accordance with Part 3.01 of Specification 02200, “Earthwork,” and Specification 02266, “Landfill Waste Placement Procedures.” This activity consists of relocating existing landfill waste from the east and north slopes to obtain an approximate grade of 4H:1V. Bedrock will not be excavated. The excavated waste will be relocated to fill areas on the flat portion (top cap) of the landfill.

Waste will be emplaced in fill areas at the direction of the SS (no required lift thickness) and will be compacted by dozer tracking only. The QCFE will visually confirm that dozer tracking has adequately prepared a uniform and firm base for construction of the landfill cover. There are no other required QC tests for waste excavation.

5.3 Subgrade Preparation

Prior to placing any structural fill, the subgrade will be prepared in accordance with Part 3.02.B of Specification 02200, "Earthwork." The SS shall ensure that vegetation, root matter, and topsoil have been removed and all areas have been proof-rolled on-grade using a heavy-duty roller. The QCFE shall visually inspect the entire area to identify any loose or unstable zones requiring additional work. Areas of the subgrade that cannot be sufficiently compacted will be undercut and proof-rolled until sufficiently stable, as determined by the QCFE. There are no other QC checks required for this activity.

5.4 Construction of Retaining Wall

Retaining walls will be built on the north east face of the landfill. The retaining walls will be constructed according to Specification 03300, "Cast-in-Place Concrete" and Specification 02273, "Mechanically Stabilized Earth Retaining Walls."

5.4.1 Pre-use Inspection

Any prefabricated components of the concrete or mechanically stabilized earth (MSE) retaining walls (e.g., footings, concrete pads, and soil anchors) will be certified by the manufacturer prior to shipment. The SS will acquire certifications for all components and the QCFE will review all certifications to verify compliance with design specifications.

5.4.2 Field Testing

Field testing will be required during construction of the concrete gravity retaining wall and the MSE retaining walls. GTL personnel will test concrete during placement to document that the material, as placed, meets or exceeds construction specifications. Structural fill emplaced behind the MSE walls will also be tested by GTL personnel to verify density and to ensure suitability for fastening of the soil anchors.

5.4.3 Hold Point

After the retaining walls have been constructed, they will be inspected by the QCFE to verify compliance with all construction specifications and drawings. Based on this visual observation and evaluation of field test results, the QCFE will accept or reject the retaining walls by written notification to the SS via an ICR. If rejected, work will not proceed on the landfill cover until the retaining wall(s) have been repaired or re-installed.

5.5 Placement of Structural Fill

Structural fill material will be placed on the subgrade on the slopes and top of the main landfill as necessary to support construction of the cover systems. Placement shall be in accordance with Part D of Specification 02200, "Earthwork." The following CQC controls will be applied.

5.5.1 Pre-use Inspection

Before use, all structural fill shall be tested and approved for use as described in Section 5.5. Rejected material will not be used.

5.5.2 Field Testing

Compacted lift(s) will be tested by GTL personnel under the supervision of the QCFE for the parameters shown in Table 02200-2 of Specification 02200, "Earthwork." The actual number and locations of the moisture-density tests shall be determined and documented by the QCFE. Damage to the structural fill resulting from field tests shall be repaired with granular or powdered sodium bentonite.

5.5.3 Hold Point

After the structural fill has been placed, it will be inspected by the QCFE for loose or unstable areas. Based on this visual observation and analysis of survey data and field test results, the QCFE will accept or reject the structural fill by written notification to the SS via an ICR. If rejected, work will not proceed on the landfill cover until the fill has been repaired or re-installed.

5.6 Installation of Infiltration Layer

The infiltration layer will be applied to the north and east slopes of the landfill. The infiltration layer consists of imported low permeability soil. The infiltration layer will be constructed with two nominal 9-in. lifts in accordance with Specification 02200, "Earthwork."

5.6.1 Pre-use Inspection

Prior to delivery of infiltration soil material to the site, the GTL shall test the material to verify that it meets or exceeds requirements of Section 2.01.B of Specification 02200, "Earthwork."

5.6.2 Field Testing

Once the infiltration soil is roughed into place over the entire slopes, compaction will be obtained with a sheepsfoot roller pulled behind a dozer. Water will be applied with a hose and nozzle capable of spraying from the top of the slopes to the toe. GTL personnel shall test the material to verify moisture-density requirements of Section 3.02.E of Specification 02200, "Earthwork."

5.6.3 Hold Point

After compaction, the infiltration layer will be inspected by the QCFE to verify conformance with specifications. Based on a visual observation, review of GTL test data, and material certifications, the QCFE will accept or reject the infiltration layer by written notification to the SS via an ICR. If rejected, work will not proceed on the landfill cover until the layer has been repaired or re-installed.

5.7 Installation of Geotextile

Geotextile will be added over the entire surfaces of the slope faces as a protective liner between the infiltration layer and riprap. Geotextiles will be installed in accordance with Construction Specification 06020, "Geotextiles."

5.7.1 Pre-use Inspection

Prior to delivery of the geotextile to the landfill site, the SS will obtain product specifications from the supplier. The QCFE will review the supplier data to verify that the material meets requirements of the specification document.

5.7.2 Field Testing

No field testing for the geotextile is required.

5.7.3 Hold Point

After the geotextile is installed, it will be inspected by the QCFE to verify compliance with the specification document. Based on a visual observation and review of manufacturer specifications for the material, the QCFE will accept or reject the geotextile by written notification to the SS via an ICR. If rejected, work will not proceed until the cover system has been repaired or re-installed.

5.8 Installation of Riprap

Riprap will be installed in accordance with Parts 2.01 and 3.01 of Specification 02270, "Channel Protection." Riprap will be placed starting at the toe top of the MSE retaining wall of the slope and proceeding upslope to the interface of the MatCon™ cover. The QCFE shall visually inspect riprap materials as they are being placed to ensure that the materials comply with the construction specifications.

5.8.1 Hold Point

After riprap has been installed, it will be inspected by the QCFE to ensure uniform coverage and conformance with specifications. Based on this visual observation, the QCFE will accept or reject riprap emplacement by written notification to the SS via an ICR. If rejected, work will not proceed on the landfill cover until the riprap has been repaired or re-installed.

5.9 Installation of Gas Venting System

The gas venting system will be installed in accordance with Specification 02730, "Gas Collection System." Perforated piping will be installed in a bed of coarse aggregate, as specified.

5.9.1 Hold Point

After the gravel layer and piping are installed, they will be inspected by the QCFE to verify compliance with the specification document. Based on a visual observation, the QCFE will accept or reject the gas venting system by written notification to the SS via an ICR. If rejected, work will not proceed on the landfill cover until the gas venting system has been repaired or re-installed.

5.10 Construction of Hanger Pad

To support operations at the Los Alamos Airport, an approximately 190 ft × 48 ft concrete hangar pad will be constructed on the western portion of the new landfill cover. The pad will consist of a steel reinforced concrete slab poured in place on the off-gas collection layer as subgrade. The slab will have two (2) layers of reinforcing in consideration of the potential for differential settlement. QC activities associated with construction of the pad are critical to meet not only the needs of the airport but also to ensure that objectives of the remedial action are accomplished. The hangar pad will be constructed and installed in accordance with Specification 03300, "Case-in-Place Concrete."

5.10.1 Pre-use Inspection

Prior to placement of the hangar pad, the QCFE will verify that the gas collection system has been installed and approved.

5.10.2 Field Testing

GTL personnel will perform standard concrete tests during installation to document conformance with the construction specification.

5.10.3 Hold Point

After the hangar pad has been installed, it will be inspected by the QCFE to verify that it meets all associated design specifications. Based on this visual observation and analysis of GTL data, the QCFE will accept or reject the hangar pad by written notification to the SS via an ICR. If rejected, work will not proceed on the landfill cover until the pad has been repaired or re-installed.

5.11 Installation of Modified Asphalt Technology for Waste Containment™ Cover

The MatCon™ system is an advanced modified asphalt technology that combines a proprietary binder with specified aggregates. The MatCon™ cover provides a durable surface that is usable by the Los Alamos Airport and still meets permeability requirements for the remedy. The MatCon™ cover will be installed in accordance with Specification 02511, "Hot Mix Asphalt."

5.11.1 Pre-use Inspection

The materials used in the MatCon™ product are subject to strict QC requirements to ensure long-term performance of the cover. The specific ingredients and process are proprietary and as such, no pre-use testing is required. However, the SS will obtain and the QCFE will review manufacturer certifications of all materials prior to delivery to the landfill site.

5.11.2 Field Testing

The MatCon™ cover will be tested by the vendor to document achieved compaction and thickness parameters. These data will be obtained by the SS and reviewed by the QCFE. In addition, GTL personnel shall conduct post placement permeability tests to verify compliance with remedial action objectives. Permeability testing will include the seal between the MatCon™ and the hangar pad as well as the general cover surface.

5.11.3 Hold Point

After the MatCon™ cover is installed, it will be inspected by the QCFE to verify compliance with the Construction Specifications (North Wind 2005b). Based on a visual observation and review of vendor supplied data, as well as GTL data, the QCFE will accept or reject the cover by written notification to the SS via an ICR. If rejected, work will not proceed until the cover system has been repaired or re-installed.

5.12 Seeding, Mulching, and Restoration

Seeding, mulching, and restoration of the DDA will be conducted in compliance with Specification 02932, "Seeding, Mulching, and Restoration." Vegetation is an important storm water runoff and erosion control and as such, additional information is provided in the SWPPP (North Wind 2005h).

6.0 DOCUMENTATION

The SS will verify that CQC records generated during construction are managed according to PWI-4201-001, Project Files, and Quality Assurance Procedure (QAP)-10-171, Records Control. Copies of relevant CQC documentation, including project scoping plans listed in Section 1.3 that affect CQC activities, as well as other project plans listed in the PMP (North Wind 2005g), shall be maintained at the field office.

A set of final construction drawings will be located in the office trailer for red-lining changes for constructing as-built drawings. The project schedule will be displayed on the wall for quick reference and weekly progress tracking. The Construction Plan (North Wind 2005c) provides additional documentation requirements.

6.1 Nonconformances and Field Changes

A nonconformance is a deficiency in characteristics, documentation, or procedures that renders the quality of an item or activity unacceptable or indeterminate. If a deficiency cannot be repaired or replaced to the satisfaction of the QCFE within the guidelines established by this CQCP, then such a deficiency will be considered a nonconformance. During the course of construction, site personnel (particularly the QCFE and SS) may identify nonconformances. Nonconformances will be documented according to QAP-10-161, Corrective, Preventive, and Improvement Actions; QAP-10-151, Control of Nonconforming Items; and PQP-4201-001.

Nonconforming items will be reported to the NWI PM and the Corporate Quality Assurance Manager who work cooperatively to prepare a Nonconformance Report (NCR). The NCR will document the nonconformance, the root cause, and corrective actions taken (or to be taken) to prevent reoccurrence of the nonconformance.

Field changes to project documents may be required based on actual site conditions, unforeseeable circumstances, or client-initiated change control. Field changes will be identified and documented in accordance with PWI-4201-005, Field Change.

6.2 Field Logbooks

The SS and QCFE will maintain separate field logbooks in accordance with PWI-4201-002, Field Activities Documentation. In addition to the requirements stated in PWI-4201-002, field logbooks will contain the information necessary for the reporting requirements listed in Section 6.3.

6.3 Reporting

The PMP (North Wind 2005g) provides overall direction for reporting. Other reports will be prepared as described in the following subsections.

6.3.1 Daily Quality Control Reports

DQCRs and monthly summary reports will be prepared by the QCFE with input from the SS, as required. The reports will be submitted to the SS and PM. An example of the DQCR form is provided in Appendix B. The monthly reports provide a summary of the DQCRs. At a minimum, the daily report will include the following items (as applicable):

- Date and project name,
- Description of areas of work observed and/or tested,
- Weather conditions,
- Work locations,
- Equipment and personnel used,
- Arrival and departure times and times of work interruption,
- Summary of completed field testing,
- Description of receipt of offsite materials,
- Copies of ICRs completed that day, as applicable,
- Decisions made regarding acceptance of specific portions of work and/or remedial actions implemented in cases of sub-standard quality,
- Identification of work that the QCFE believes should be accepted, rejected, or uncovered for observation, or that may require special testing, inspection, or approval,
- Analysis and interpretation of GTL data and field test results,
- Description of nonconformances identified, and
- General description of photographs taken.

6.3.2 Incremental Certification Reports

The QCFE will prepare and submit ICRs that certify key components of the landfill cover have been installed in accordance with this CQCP and the final construction specifications and drawings. ICRs will be submitted at the CQC hold points identified throughout this document. The QCFE will submit the ICRs to the SS as they are completed. ICRs will also be included in monthly reports. At a minimum, the ICRs will include the following:

- General summary of work to include, but not limited to, construction activities, observations, problems and corrective actions, and deviations from design,
- Interpretation of the GTL data, survey data, and field test results as they relate to acceptability of delivered materials or proper placement and compaction of soil lifts; raw data may be included in the ICR, as appropriate,
- Manufacturers' certification(s) of materials used in the construction,
- Surface acceptance forms,
- Project photographs, with dates and captions,
- Field directives specific to installation, including design and field change notices,
- NCRs, as applicable, and
- DOE change orders specific to the installation.

6.4 Equipment Calibration

A nuclear density gauge will be used for field testing in accordance with QAP-10-121, Control of Measuring and Test Equipment. The QCFE (or designee) will review initial equipment calibration records (supplied by the instrument manufacturer) to confirm that they meet the project specifications or applicable American Society for Testing and Materials standards. In addition, the QCFE (or designee) will perform and document daily count checks and other daily instrument checks per the manufacturer's instructions. These performance check records will be filed onsite and furnished to the SS, as requested.

The nuclear density gauge contains an internal radioactive source; therefore, health and safety requirements relative to the radioactive source are applicable. The HASP (North Wind 2005i) provides additional details.

7.0 SUSPECT/COUNTERFEIT ITEMS

Installed items that may potentially be suspect/counterfeit items will be inspected in accordance with PQP-4201-001; QAP-10-081, Product Identification and Traceability; QAP-10-101, Inspection; QAP-10-111, Test Control; and DOE Guide 440.1-6, Implementation Guide for Use with Suspect/Counterfeit Items Requirements of DOE O 440.1, Worker Protection Management; 10 CFR 830.120, Nuclear Safety Management; and DOE 5700.6c, Quality Assurance (DOE 1997). In addition, items used during construction activities that may cause injury or fatalities if failure occurs (e.g., ratchet straps/tie down assemblies, fasteners, bridal slings, or hoisting slings) will also be inspected on a regular basis in accordance with the above documents.

8.0 TABLES

Table 2.0-1. Features of Work

No.	Item
1	Repair debris disposal area cover
2	Excavate at main landfill
3	Subgrade preparation
4	Construction of retaining wall
5	Placement of structural fill
6	Installation of infiltration layer
7	Installation of geotextile
8	Installation of riprap
9	Installation of gas venting system
10	Construction of hangar pad
11	Installation of MatCon™ cover

9.0 FIGURES

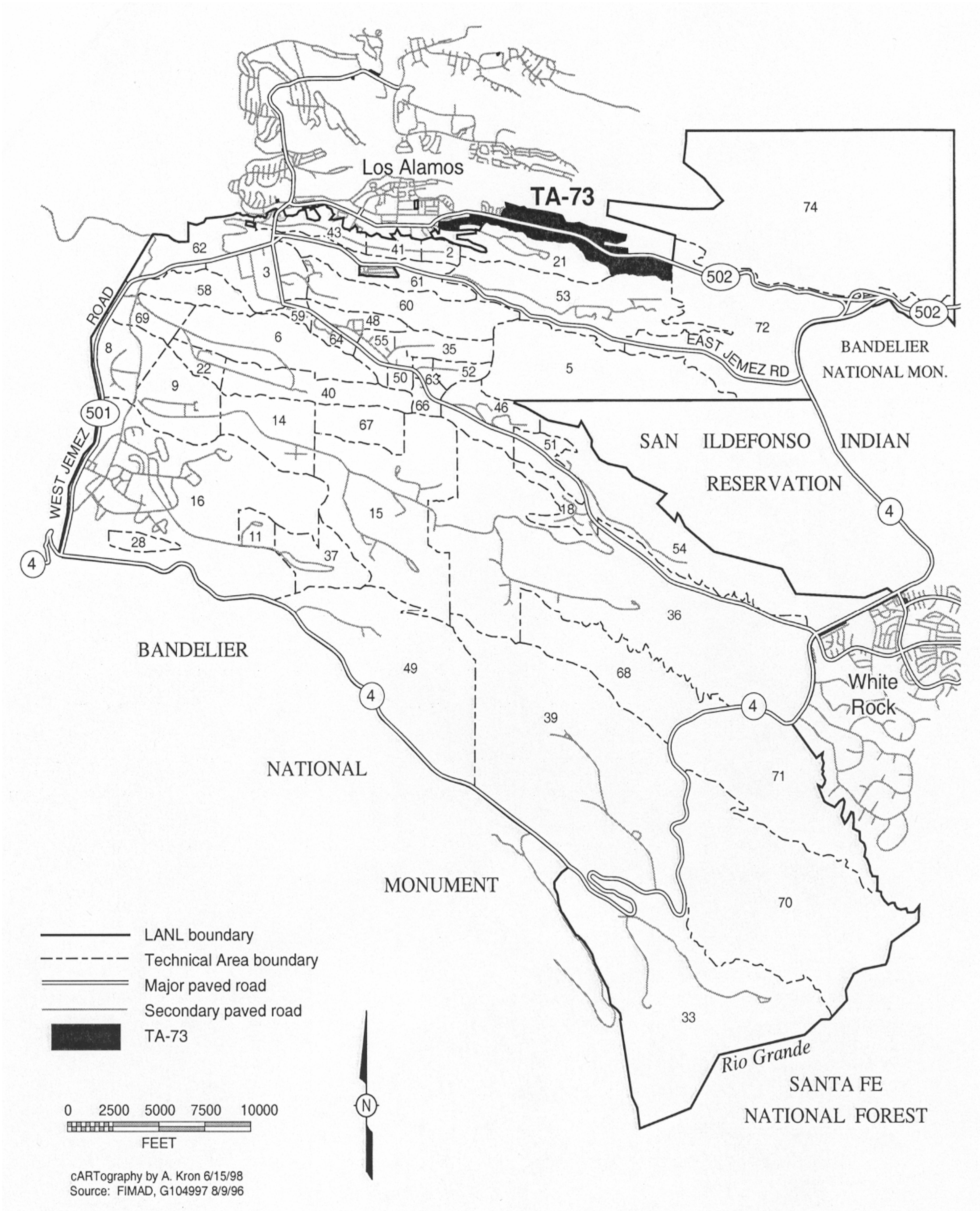

Figure 1.1-1. Location of the work site at Los Alamos National Laboratory

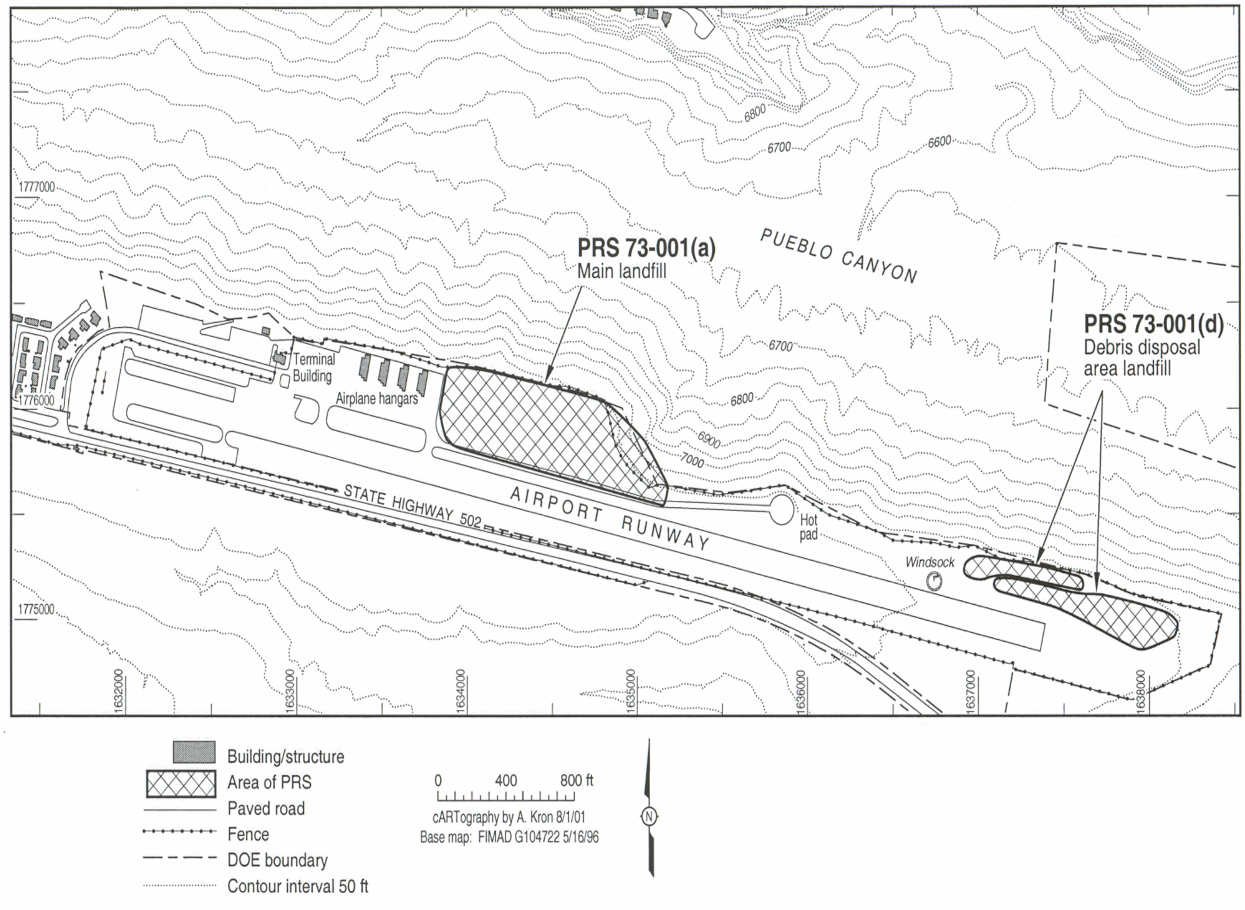

Figure 1.1-2. Location of main landfill and debris disposal area (LANL 2002)
Note: “PRS” has changed to “SWMU”

10.0 REFERENCES

DOE, 1997, Implementation Guide for Use with Suspect/Counterfeit Item Requirements of DOE O 440.1, Worker Protection Management, 10 CFR 830.120; and DOE 5700.6C, Quality Assurance. U.S. Department of Energy Guide 440.1-6, prepared by the Office of Environment Safety and Health, U.S. Government Printing Office, Washington, D.C. June.

North Wind, 2004, "Design Basis Document for Los Alamos Site Office TA-73 Airport Landfill," Revision 1, NW-ID-2004-042, North Wind Inc., Idaho Falls, Idaho, April 2004.

North Wind, 2005a, "Remedy Design Work Plan for Los Alamos Site Office TA-73 Airport Landfill," Revision 1, NW-ID-2004-031, North Wind, Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005b, "Construction Specifications for Los Alamos Site Office TA 73 Airport Landfill, 906 Design Submittal," Draft Final, NW-ID-2004-039, North Wind Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005c, "Construction Plan for the Los Alamos Site Office TA-73 Airport Landfill, Revision 2, NW-ID-2004-001, North Wind Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005d, "Waste Management Plan for the Los Alamos Site Office TA-73 Airport Landfill," Revision 1, NW-ID-2004-006, North Wind, Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005e, "Post-closure Care and Monitoring Plan for Los Alamos Site Office TA-73 Airport Landfill," Revision 1, NW-ID-2004-027, North Wind Inc., Idaho Falls, Idaho, June 2005.

North Wind 2005f, "Project Quality Plan for the Los Alamos Site Office TA-73 Airport Landfill, Revision 2, NW-ID-2003-071, North Wind, Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005g, "Project Management Plan for Los Alamos Site Office TA-73 Airport Landfill," Revision 2, NW-ID-2003-073, North Wind Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005h, "Storm Water Pollution and Prevention Plan for Los Alamos Site Office TA-73 Airport Landfill," Revision 1, NW-ID-2004-005, North Wind Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005i, "Health and Safety Plan for Los Alamos Site Office TA-73 Airport Landfill," Revision 0, NW-ID-2004-017, North Wind Inc., Idaho Falls, Idaho, June 2005.

The following are NWI quality documents that are controlled in accordance with QAP-10-171, Records Control. The latest revision applies:

NWI-QAM-01-001, North Wind, Inc., Quality Assurance Manual

QAP-10-081, Product Identification and Traceability

QAP-10-101, Inspection

QAP-10-111, Test Control

QAP-10-121, Control of Measuring and Test Equipment

QAP-10-151, Control of Nonconforming Items

QAP-10-161, Corrective, Preventive, and Improvement Actions

QAP-10-171, Records Control

PQP-4201-001, Project Quality Plan for Los Alamos Site Office TA-73 Airport Landfill

PWI-4201-001, Project Files

PWI-4201-002, Field Activities Documentation

PWI-4201-005, Field Change

Appendix A

Acronyms

Appendix A
Acronyms

CM	Construction Manager
CQC	Construction Quality Control
CQCP	Construction Quality Control Plan
DDA	Debris Disposal Area
DOE	U.S. Department of Energy
DQCR	Daily Quality Control Report
GTL	Geotechnical Testing Laboratory
HASP	Health and Safety Plan
ICR	Incremental Certification Report
LASO	Los Alamos Site Office
MatCon™	Modified Asphalt Technology for Waste Containment
MSE	mechanically stabilized earth
NCR	Nonconformance Report
NMED	New Mexico Environmental Department
NWI	North Wind Inc.
PCMP	Post-closure Care and Monitoring Plan
PM	Project Manager
PMP	Project Management Plan
PQP	Project Quality Plan
PWI	Project Work Instruction
QA	Quality Assurance
QAP	Quality Assurance Procedure
QC	Quality Control
QCFE	Quality Control Field Engineer
SS	Site Superintendent
SWPPP	Storm Water Pollution Prevention Plan
TA	Technical Area
WESTON	Weston Solutions, Inc.
WMP	Waste Management Plan

Appendix B

Example of PQPF-4201-001.1, Daily Quality Control Report

Example of PQPF-4201-001.4, Daily Quality Control Report

North Wind

Daily Quality Control Report

Page 1 of 2

______________________ Contract Number / Task Order Number

______________________ Project Title / NWI Project No.

______________________ CQC Report Number

______________________ Date or Time Period

______________________ Location and Team

Weather Conditions:

Temp Low __________ Temp High __________

Wind Speed __________ Conditions __________

______________________ Contractor

Quality Control Inspections Performed This Date (Include inspections, results, deficiencies observed, and corrective action)

Preparatory ☐ see attached checklist

Initial ☐ see attached checklist

Follow-Up ☐

Was the construction deficiency tracking list updated this date? Yes ☐ No ☐

Field Sampling and Testing

Has field testing been performed this date? Yes ☐ No ☐

Type of test	Method/Matrix	Results

Have Data Quality Objectives been achieved? Yes ☐ No ☐

Have Samples Been Collected for Laboratory Analysis Yes ☐ No ☐

Type of Test	EPA Test Method/Matrix	Quantity of Samples

Have required amount of QC trip blanks and rinsates been achieved? Yes ☐ No ☐

Have appropriate QC laboratory tests been ordered? (matrix spikes, method blanks, surrogates, reference standards, etc.) Yes ☐ No ☐

Have QA and QC samples been collected in the specified quantity? Yes ☐ No ☐

Have samples been properly labeled and packaged? Yes ☐ No ☐

Health and Safety

Worker protection levels this date: Level A ☐ Level B ☐ Level C ☐ Level D ☐

Was any work activity conducted within a confined space? Yes ☐ No ☐

Was any work activity conducted within an area determined to be immediately dangerous to life and health? Yes ☐ No ☐

Were approved decontamination procedures used on workers and equipments as required? Yes ☐ No ☐

Was a Job Safety Meeting held this date? Yes ☐ No ☐

Were there any lost time accidents this date? **(If YES, attach copy of completed accident report)** Yes ☐ No ☐

Was hazardous waste/material released into the environment? Yes ☐ No ☐

Safety comments: (Include any infractions of approved safety plan, and include instructions from Government personnel. Specify corrective action taken.)

Work Activities Performed This Date

Reference (DFW #/Tech Spec #)	Activity & Location	Quantity	Subcontractor

EXAMPLE

PQPF-5004-001.4 Rev. 0

Attachment D
Waste Management Plan
for the LASO TA-73 Airport Landfill

NW-ID-2004-006
Revision 1

WASTE MANAGEMENT PLAN
FOR THE LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILL

June 2005

Prepared for:

U. S. Department of Energy, National Nuclear Security Administration
Los Alamos Site Office
528 35th Street
Los Alamos, New Mexico 87544

Prepared by:

North Wind Inc.
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DOCUMENT APPROVAL PAGE

Document Number: NW-ID-2004-006 Revision: 1

Document Title: Waste Management Plan for the Los Alamos Site Office TA-73 Airport Landfill

Approval Signatures

Name	Signature	Date	Title
Doug Jorgensen	Original signature on file	05/24/05	North Wind Project Manager
Robert Enz	Original signature on file	05/24/05	U.S. Department of Energy, LASO

Revision Log

Revision	Date	Reason for Revision
Draft	02/07/04	Not applicable; first draft of document
Revision 0	03/15/04	Document revised to incorporate DOE/LASO comments of 02/26/04.
Revision 1	05/31/05	Document revised to reflect scope change per DOE revised SOW.

CONTENTS

APPENDICES

1.0 INTRODUCTION

This Waste Management Plan (WMP) describes methods that North Wind Inc. (NWI) will use to manage investigation-derived waste (IDW) generated during execution of the U.S. Department of Energy (DOE) Los Alamos Site Office (LASO) Technical Area (TA)-73 Airport Landfill and Debris Disposal Area (DDA) project, henceforth referred to as the Airport Landfill project.

As described in the DOE Savannah River Operations Office Statement of Work (SOW) for the Airport Landfill (DOE 2003), the Airport Landfill project mission consists of designing and constructing an earthen evapotranspiration cover over Solid Waste Management Unit (SWMU) 73-001(a) and recontouring and reseeding SWMU 73-001(d). SWMU 73-001(a) is an inactive municipal landfill, hereinafter referred to as the main landfill. SWMU 73-001(d) is an inactive debris disposal area, hereinafter referred to as the DDA. Due to stakeholder concerns, DOE has revised the scope for the main landfill. This scope revision calls for a Modified Asphalt Technology for Waste Containment (MatCon™) asphalt surface over the flat portion of the landfill, a gas venting layer under the MatCon™ surface, and a retaining wall along the base of the east slope. In addition, certain airport improvements will be made along the west end of the main landfill, which may include hangar footings and aircraft tie-downs. The design of the DDA cover was not affected by the revised scope.

The site description and operational history are documented in the Los Alamos National Laboratory (LANL) Voluntary Corrective Measure (VCM) Plan (LANL 2002).

1.1 Document Contents

Section 1.0 is an introduction and discusses supporting documents, site description and background, and the scope of the WMP. Section 2.0 presents the waste management goals of the project. Section 3.0 provides methods for pollution prevention and waste minimization. Section 4.0 describes management of nonhazardous waste streams and Section 5.0 describes management of petroleum-contaminated soil (PCS). Section 6.0 discusses training objectives and methods, and Section 7.0 provides references cited in this plan.

1.2 Document Interfaces

This WMP implements and interfaces with the following project documents, as described below:

- Project Quality Plan (PQP) for the LASO TA-73 Airport Landfill (North Wind 2005a),
- Project Management Plan (PMP) for the LASO TA-73 Airport Landfill (North Wind 2005b),
- Storm Water Pollution Prevention Plan (SWPPP) for the LASO TA-73 Airport Landfill (North Wind 2005c),
- Construction Plan for the LASO TA-73 Airport Landfill (North Wind 2005d), and
- Health and Safety Plan (HASP) for the LASO TA-73 Airport Landfill (North Wind 2005e).

1.2.1. Project Quality Plan

The PQP (North Wind 2005a) describes how NWI will implement a quality assurance (QA) program that complies with applicable DOE and federal regulations.

1.2.2. Project Management Plan

The PMP (North Wind 2005b) describes the management structure and processes that NWI will use to manage the project.

1.2.3. Storm Water Pollution Prevention Plan

The SWPPP (North Wind 2005c) addresses storm water discharges associated with construction and post-construction activities and describes how the project will comply with the terms and conditions of the "National Pollutant Discharge Elimination System General Permit for Storm Water Discharges from Construction Activities" (FR 2003).

1.2.4. Construction Plan

The Construction Plan (North Wind 2005d) directs, schedules, and controls construction-related activities. The Construction Plan identifies the work force, materials, hardware, other resource requirements, and subcontractor requirements.

1.2.5. Health and Safety Plan

The HASP (North Wind 2005e) addresses construction activities as they relate to the DOE integrated safety management system, safe work practices, hazard identification and mitigation, occurrence reporting methods, and required training. The HASP was prepared in accordance with applicable safety standards and regulations.

1.3 Site Description and Background

The Airport Landfill consists of two SWMUs: 73-001(a), main landfill, and 73-001(d), DDA. Both are inactive SWMUs and are listed in Table A within Module VIII of LANL's Hazardous Waste Facility Permit (LANL 1996). Both SWMUs are located within TA-73 on DOE property, as shown in Figure 1.3-1 (see Section 7). The main landfill is east of the existing airport hangars and the DDA is east of the end of the runway. Figure 1.3-2 (see Section 7) shows the location of the SWMUs in TA-73.

In 1943, the DOE began using the hanging valley north of the airport runway as the main landfill. Garbage was collected twice a week from the LANL and town site and burned on the edge of the hanging valley. Heavy equipment was then used to push the burned residues and ash into whichever landfill disposal area was being used at the time. This intentional burning ceased in 1965 when Los Alamos County assumed operation of the landfill. The county continued to operate the landfill until June 30, 1973.

The DDA was used from 1984 to 1986 to bury debris excavated from the western portion of the main landfill. This material was excavated and replaced with clean fill to prepare the western portion of the landfill for the construction of airplane hangars and tie-down areas. Since the wastes placed in the DDA came from the main landfill, both areas contain similar types of debris. In 1986, the DDA landfill was covered with soil and hydroseeded.

1.4 Scope of Waste Management Plan

This WMP describes methods to manage IDW and does not pertain to existing landfill waste that may be potentially contaminated or hazardous. Specifically, the WMP addresses management of nonhazardous waste streams and management of PCS, which may be generated as the result of leaks from heavy equipment or fuel spills during refueling activities.

The design for construction of the cover over the main landfill involves exposing and relocating landfill waste from the north and east slopes to obtain an acceptable grade for slope stability. A cover will then be constructed over the main landfill. The site background and process knowledge presented in the RCRA Facility Investigation (RFI) Report for Potential Release Sites 73-001(a,b,c,d) and 73-004(d), Airport Landfill Areas (LANL 1998) strongly indicate that only municipal landfill waste (i.e., nonhazardous waste) was disposed of at the main landfill. Thus, contaminated or hazardous waste is not expected to be encountered during waste relocation activities.

Certain waste streams (i.e., personal protective equipment [PPE] and wash fluids) would be considered potentially contaminated waste only by virtue of contact with potentially contaminated media (i.e., relocated landfill waste). In the unlikely event that hazardous waste is exposed during relocation, best management practices (BMPs) will be used to avoid contact. These BMPs are identified in the HASP (North Wind 2005e) and may include identification criteria, waste segregation, access controls, and immediate covering with soil. Implementing these BMPs will eliminate the potential to contaminate IDW and create a hazardous waste stream.

2.0 WASTE MANAGEMENT GOALS

The two primary waste management goals for the Airport Landfill project are as follows:

1. Minimize, substitute, or eliminate IDW as much as possible, then;
2. Collect, store, and dispose of any remaining IDW in a manner protective of human health and the environment.

These goals will be accomplished by using pollution prevention and waste minimization practices to the greatest extent possible. Remaining IDW will be managed consistent with the final remedy and by assessing the risk posed by managing the waste onsite based on site access controls and anticipated contaminant concentrations.

3.0 POLLUTION PREVENTION AND WASTE MINIMIZATION

This section describes pollution prevention techniques and methods to minimize generation of IDW. These practices will reduce the need for special storage or disposal requirements that may result in substantial additional costs yet provide little or no reduction in risk to human health and the environment. Additional information is provided in the SWPPP (North Wind 2005c).

3.1 Material Handling

A designated materials storage area will be established to prevent storm water from coming into contact with potential pollutants and reduce material loss from blowing wind. Construction materials (i.e., seed or fertilizer) will be stored in closed bins or placed on pallets and covered with heavy mil plastic or tarpaulins. Petroleum products will be stored in an approved cabinet or container. Materials will be stacked according to directions to avoid damage and possible spillage. Transfer of material from its original container to a secondary container will be avoided to the extent possible to minimize spillage.

3.2 Equipment Inspection and Maintenance

Vehicles and heavy equipment will be monitored daily before use for proper operation and to detect leaking fluids. If fluid leaks or conditions conducive to fluid leaks are detected, the vehicle will either be removed from the site, parked over heavy mil plastic, or a drip plan will be placed under the vehicle. The leak will be corrected before the vehicle is placed back into service. When not in use, heavy equipment will be parked at the construction parking lot. Regular maintenance of heavy equipment will minimize the potential for spills or leaks. A service truck will be used to maintain and service heavy equipment. This activity will occur at a designated area.

Drip pans will be the primary tool for containing leaks. Drip pans will be placed under leaking vehicles until the vehicle can be removed from the site or repaired. Drip pans will be emptied into a composite container, either at the end of each day or as needed. The Construction Manager (CM) (or designee) will ensure drip pans are emptied at a frequency sufficient to eliminate the possibility of spillage. The frequency of emptying the pan will depend on the volume of the leak and the potential for the drip pan to lose its contents by inadvertent tipping, high winds, or other means.

Disposition of any collected liquids may be assigned to the waste management subcontractor or, if properly segregated and documented, may be disposed of at an appropriately licensed facility.

3.3 Spill Prevention

To avoid fuel spills during refueling, an assigned individual will always be present during refueling and will be aware of the location and operation of the shut-off valve of the fuel tanker. Small equipment (i.e., generators or pumps) will be placed over bermed heavy mil plastic. If refueling spills or leaks occur, the bermed plastic will contain the pollutants until proper cleanup and disposal. Drip pans may also be used for refueling or for placement under equipment that is leaking or has the potential to leak. If used, drip pans will be managed as described in Section 3.2.

A spill kit containing a first aid kit, airhorn, PPE for cleanup activities, shovel, leather gloves, and appropriate absorbents (e.g., pillows, tubes, sand or vermiculite, pads, and paper towels) will be readily available to control and contain spills. Site personnel will be trained in the use of the spill kit and in spill notification procedures.

3.4 Product Substitution

To the extent possible, potentially hazardous materials will be substituted for less hazardous or non-hazardous products.

3.5 Recycling

A recycling station will be established onsite that may include recycling of aluminum cans, office paper products, packaging material (e.g., shrink-wrap and corrugated cardboard), plastic containers (e.g., 5-gal containers for motor oil or hydraulic fluid), and glass. The final selection of materials to be recycled will be made based on information from local recyclers or Los Alamos County. Since “curbside” recycling is not anticipated, the CM, or designee, will ensure that collected material will be transported to the recycling center.

3.6 Salvage

Salvage opportunities for this project include:

- Chippings – cleared and grubbed vegetation from the DDA will be chipped and tilled into the topsoil prior to revegetation of this area. Cleared and grubbed vegetation from the main landfill will be chipped and disposed of in a suitable off-site landfill or used to augment topsoils in the DDA.
- Wood pallets – wood pallets used for storage of delivered materials will be reused during the project to the extent possible. After construction is complete, wood pallets may be returned to their source, if possible, or may be disposed of as construction debris.
- Straw bales – straw bales used for storm water management controls will be broken apart and spread over the revegetated portions of the DDA as mulch.

- Chain link fence – a portion of the existing perimeter chain link fence along the east slope of the main landfill will be removed to allow construction access. To the extent possible, dictated by the construction schedule and cost constraints, undamaged fencing will be re-used at the toe of the east slope where new fencing is required. Fencing that cannot be re-used will be recycled or sold for salvage.

4.0 NONHAZARDOUS WASTE STREAM MANAGEMENT

Management of IDW will be based on field observations, process knowledge, and BMPs. Management of IDW will be consistent with the final remedy (landfill caps) for the site, thus avoiding the need for separate treatment and/or disposal arrangements. Pollution prevention and waste minimization practices will be used to the greatest extent possible to reduce the amount of nonhazardous IDW generated during the course of the Airport Landfill project.

4.1 Nonhazardous Waste Streams

Nonhazardous IDW generated during construction activities will include the following:

- PPE,
- Wash fluids,
- Construction debris, and
- Sanitary waste.

4.1.1. Personal Protective Equipment

PPE consists of over-garment coveralls (e.g., Tyvek or cotton coveralls), nitrile gloves, and respirator cartridges. Levels of PPE usage are addressed in the HASP (North Wind 2005e). Used PPE will be containerized in clear plastic bags, securely sealed, and labeled with the date of generation, the location (e.g., DDA or main landfill), generator contact information, and the words “Used PPE.” The bags will be disposed of daily in the site dumpster or rolloff box and a local contractor will be used to empty the dumpster on a regular basis.

4.1.2. Wash Fluids

Wash fluids consist of water only (no soap) used to wash dirt and mud from heavy equipment and project vehicles. Washing will occur at the wash station, which will be constructed over gravel at a flat area. Wash fluids will be allowed to evaporate or infiltrate into the ground (i.e., return to the source). If considerable amounts of wash fluid are generated, it may be desirable to pump and containerize the water for secondary use as dust control.

4.1.3. Construction Debris

Construction debris includes excess or damaged wood, matting, geotextiles, fencing, empty material containers, or other construction supplies. To the extent possible, this debris will be recycled or salvaged. Remaining debris will be containerized in a rolloff box or similar device as soon as practicable after accumulation and will be regularly removed by a local contractor.

4.1.4. Sanitary Waste

Sanitary waste for this project includes paper products, lunch trash, and used office supplies. Sanitary waste will be generated mostly at the field trailers, and good housekeeping will be practiced such that sanitary waste does not accumulate or is left uncovered. Sanitary waste will be containerized in plastic bags and will be frequently disposed of in the site dumpster.

4.2 Recordkeeping

It is not necessary to record disposition of nonhazardous IDW destined for disposal at the county municipal landfill (e.g., construction debris, PPE, and sanitary waste). General waste management activities will be documented in the field logbook in accordance with Project Work Instruction (PWI)-4201-002, Field Activities Documentation.

5.0 MANAGEMENT OF PETROLEUM-CONTAMINATED SOIL

Based on process knowledge of site conditions and BMPs described in the HASP and scope of this Waste Management Plan, PCS may be generated as a waste stream during construction activities at the Airport Landfill project as the result of a fuel spill or leaking heavy equipment. This waste stream would consist of soil contaminated by leaking or spilled diesel fuel, gasoline, and/or hydraulic fluid during refueling or operation and maintenance of heavy equipment.

Methods for contaminated soil containment and cleanup, reporting, recordkeeping, and disposition are provided in the following subsections.

5.1 Cleanup and Containerizing Petroleum-Contaminated Soil

The source of the leak or spill will be corrected, if it can be performed safely. The leak or spill will then be contained using pillows or tubes, temporary earth berms, or other methods. The contaminated soil and residual petroleum hydrocarbon fluids will be cleaned up, preferably with heavy equipment, to avoid site worker exposure and possible contamination of PPE. If this is not possible, shovels or scoops will be used. Excess fluid will be removed from absorbents, pillows, tubes, and other solid material used during cleanup.

The following items will be available onsite for cleanup activities:

- Several unused open-top 55-gal drums, with ring sealers,
- Clear, heavy mil plastic bags, preferably drum liners,
- Wooden pallets for drum storage, and
- Toolkit containing drum wrenches, drum web, grease pencils for drum marking, and tamper-indicating devices.

Used absorbents will be containerized in clear plastic bags labeled with the date, location (i.e., main landfill or DDA), and contents and will be placed in the site dumpster for ultimate disposal at an off-site landfill. The contaminated soil will be containerized in unused 55-gal drum(s) lined with drum liners. The drum(s) will be labeled with the following information: (This information can be written directly on the drum with a grease pencil or can be written on a large adhesive label in thick indelible ink.)

- Date of containment,
- Drum number (sequential beginning with “1”),
- The words “Hydrocarbon Waste,” and
- The name and phone number of the project CM or Project Manager (PM).

The drum(s) will be sealed with tamper-indicating devices and placed on wooden pallets at or near the project staging area or at a location where they are not likely to be damaged or disturbed.

5.2 Disposition of Petroleum-Contaminated Soil

A turnkey waste management subcontractor will be retained for final disposition of PCS. The waste management subcontractor will be contacted as soon as possible after the soil has been containerized but no later than 45 days after cleanup. The subcontractor will perform required sampling and analysis and will remove the soil for remediation or disposal, as dictated by sampling results. Multiple spills shall not be co-mingled.

A waste manifest and waste profile will be prepared to meet the specifications of the waste management subcontractor. Material safety data sheets (MSDS) will be used to provide information on the chemical and physical properties of the contaminated media.

5.3 Recordkeeping of Petroleum-Contaminated Soil Cleanup

Containment and cleanup activities will be documented in the field logbook, according to PWI-4201-002, Field Activities Documentation, by the person performing the activity or a person with firsthand knowledge of the event. A detailed description of the spill will be documented to include (at a minimum) the information presented in Section 5.4. If notification is required, the logbook will also contain the name and phone number of the person contacted and the date and time of notification.

5.4 Notification of Spills or Unauthorized Discharges

The Site Supervisor (SS) shall report all spills or unauthorized discharges, regardless of amount, to the following entities:

- North Wind PM: (208) 557-7864
  (208) 520-1097 (alternate phone number)

- North Wind CM: (208) 783-1069
  (208) 818-1713 (alternate phone number)

- LANL Office of Emergency Management Response: (505) 667-6211.

This notification will occur as soon as possible after the discharge but in no event more than 24 hours after the discharge. The following information will be reported:

- The name, address, and telephone number of the person or persons in charge of the facility, as well as the owner or operator of the facility,
- The name and address of the facility,
- The date, time, location, and duration of the discharge,
- The source and cause of discharge,
- A description of the discharge, including its chemical composition,
- The estimated volume of the discharge, and
- Actions taken to mitigate immediate damage from the discharge.

6.0 TRAINING

Training requirements are specified in the HASP (North Wind 2005e). Specific to waste management activities, site personnel will be trained in waste containment and cleanup procedures, use of the spill kit, emergency notification, and BMPs for avoiding contact with potentially hazardous waste. Training will be provided initially and then at specified refresher intervals, as determined by the CM.

7.0 FIGURES

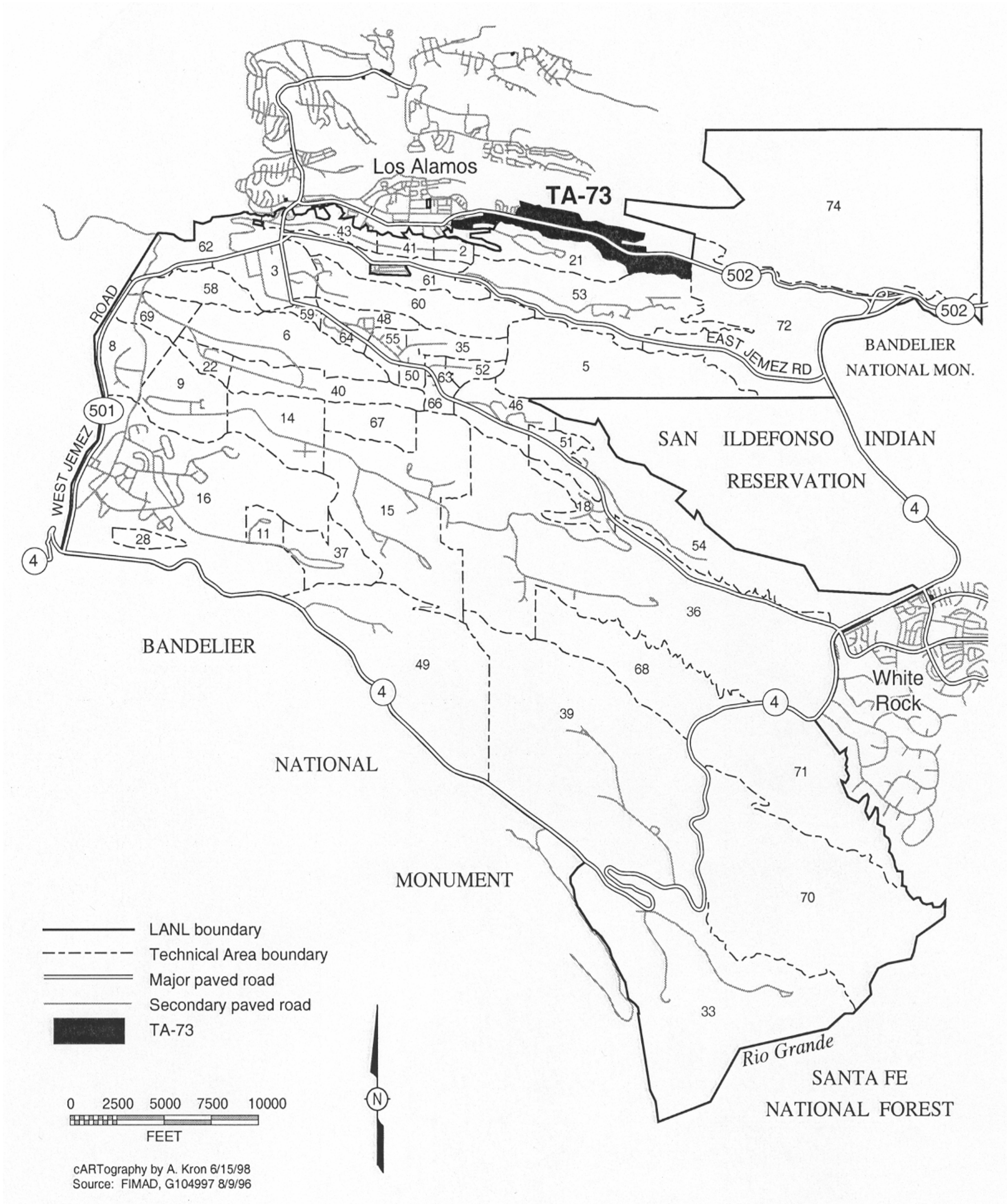

Figure 1.3-1. Location of TA-73 at Los Alamos National Laboratory

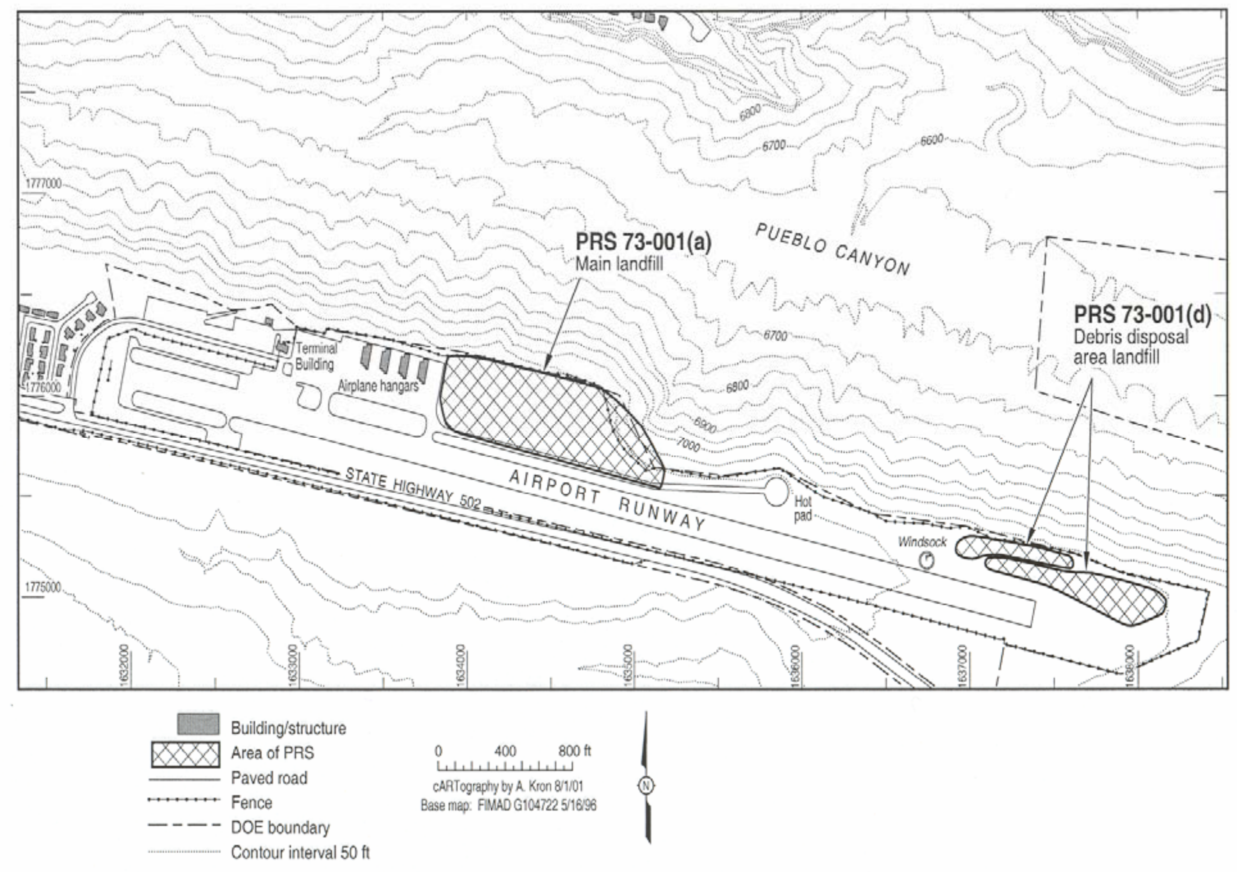

Figure 1.3-2. Location of Potential Release Sites at TA-73 (LANL 2002)
Note: "PRS" has changed to "SWMU"

8.0 REFERENCES

DOE, 2003, "National Nuclear Security Administration Los Alamos Site Office Statement of Work for the 'Airport Landfill'," Savannah River Operations Office, U.S. Department of Energy, Aiken, South Carolina, November 2003.

FR, 2003, Part 68 FR 39087, "Final National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges From Construction Activities," Volume 68, Number 126, pages 39087-39091, *Federal Register*, Government Printing Office, Washington D.C., July 1, 2003.

LANL, 1996, "LANL HSWA Module VIII Permit, 1996 Revision (guidance)," Los Alamos National Laboratory, Los Alamos, New Mexico (57486), January 1996.

LANL, 1998, "RFI Report for Potential Release Sites 73-001(a,b,c,d) and 73-004(d), Airport Landfill Areas," Vol. 1, 2, and 3, Los Alamos National Laboratory report LA-UR-98-3824, Los Alamos National Laboratory, Los Alamos, New Mexico (63070), November 1, 1998.

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North Wind, 2005a, "Project Quality Plan for the Los Alamos Site Office TA-73 Airport Landfill," Revision 1, NW-ID-2003-071, North Wind, Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005b, "Project Management Plan for the Los Alamos Site Office TA-73 Airport Landfill," Revision 1, NW-ID-2003-073, North Wind Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005c, "Storm Water Pollution Prevention Plan for the Los Alamos Site Office TA-73 Airport Landfill," Revision 1, NW-ID-2004-005, North Wind, Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005d, "Construction Plan for the Los Alamos Site Office TA-73 Airport Landfill," Revision 2, NW-ID-2004-001, North Wind, Inc., Idaho Falls, Idaho, June 2005.

North Wind, 2005e, "Health and Safety Plan for the Los Alamos Site Office TA-73 Airport Landfill," Revision 1, NW-ID-2004-017, North Wind, Inc., Idaho Falls, Idaho, June 2005.

The following are NWI quality documents that are controlled in accordance with QAP-10-171, Records Control. The latest revision applies.

PWI-4201-002, Field Activities Documentation

Appendix A

Acronyms

Appendix A

Acronyms

BMP	Best management practice
CM	Construction Manager
DDA	Debris Disposal Area
DOE	U.S. Department of Energy
HASP	Health and Safety Plan
IDW	Investigation-derived waste
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office
MatCon™	Modified Asphalt Technology for Waste Containment
MSDS	Material Safety Data Sheets
NWI	North Wind Inc.
PCS	Petroleum-contaminated soil
PM	Project Manager
PMP	Project Management Plan
PPE	Personal protective equipment
PQP	Project Quality Plan
PWI	Project Work Instruction
QA	Quality assurance
RFI	RCRA Facility Investigation
SOW	Statement of Work
SS	Site Supervisor
SWMU	Solid Waste Management Unit
SWPPP	Storm Water Pollution Prevention Plan
TA	Technical Area
VCM	Voluntary Corrective Measure
WMP	Waste Management Plan

Attachment E
Post-closure Care and Monitoring Plan
for the LASO TA-73 Airport Landfill

NW-ID-2004-027
Revision 1

POST-CLOSURE CARE AND MONITORING PLAN FOR THE LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILL

June 2005

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DOCUMENT APPROVAL PAGE

Document Number: NW-ID-2004-027 Revision: 1

Document Title: Post-closure Care and Monitoring Plan for the Los Alamos Site Office TA-73 Airport Landfill

Approval Signatures

Name	Signature	Date	Title
Doug Jorgensen	Original signature on file	05/24/05	North Wind Inc. Project Manager
Robert Enz	Original signature on file	05/24/05	U.S. Department of Energy, LASO

Revision Log

Revision	Date	Reason for Revision
Draft	03/30/04	Not applicable; first draft of document
Revision 0	04/15/04	Document revised to incorporate DOE/LASO comments of 04/05/04.
Revision 1	05/31/05	Document revised to reflect scope change per DOE revised SOW. Primary revisions made to Section 2.

CONTENTS

APPENDICES

1.0 INTRODUCTION

This Post-closure Care and Monitoring Plan (PCMP) addresses post-closure care and monitoring for the U.S. Department of Energy (DOE) Los Alamos Site Office (LASO) Technical Area (TA)-73 Airport Landfill, hereinafter referred to as the Airport Landfill project. This PCMP identifies post-closure care and monitoring requirements for the landfill and describes activities to meet those requirements. A tentative inspection and reporting schedule is also identified.

Background information for the Airport Landfill project is provided in the Los Alamos National Laboratory (LANL) *Resource Conservation and Recovery Act* (RCRA) facility investigation (RFI) Report for Potential Release Sites 73-001(a,b,c,d) and 73-004(d), Airport Landfill Areas (LANL 1998). The closure cover design and supporting information are provided in the Remedy Design Work Plan for the LASO TA-73 Airport Landfill (North Wind 2005a).

2.0 REQUIREMENTS

The Airport Landfill project consists of designing and constructing an RCRA Subtitle D cover over the main landfill and re-contouring and reseeding of the Debris Disposal Area (DDA). The design history and regulatory requirements for this project are outlined in the Remedy Design Work Plan.

As described in the Remedy Design Work Plan, and previously in the Environmental Assessment (DOE 2005) for this project, the final remedy involves leaving waste in place at the main landfill; installing a gas collection system below a Modified Asphalt Technology for Waste Containment (MatCon™) (proprietary formulation of asphalt) surface over the landfill; and constructing a retaining wall at the toe of the east slope. The remaining slopes will contain infiltration barriers with riprap completions. In addition, certain airport improvements will be made along the west end of the main landfill, including hanger pads and aircraft tie-downs. The cover for the DDA will consist of re-grading the DDA surface with a uniform 12 in. of native soil cover, followed by revegetation of the disturbed surfaces.

Details of the landfill design can be located in the construction drawings, specifications, and calculations included as Attachment A of the Remedy Design Work Plan.

The PCMP requirements identified in the Design Basis Document for LASO TA-73 Airport Landfill (North Wind 2004) are summarized in Table 2.0-1 (see Section 6) and discussed in this section. NMAC 20.9.1.500.B states that the owner/operator must:

> "…submit a PCMP which shall include, but not be limited to, maintenance of cover integrity, maintenance, and operation of the leachate collection system and operation of the methane and ground water monitoring systems."

NMAC 20.9.1.500.B.2.b states that:

> "Reports of monitoring performance and data collected shall be submitted to the 'NMED' Secretary within 45 days from the end of each calendar year."

Post-closure monitoring, to establish compliance with the 1E-05 cm/sec performance standard, is not required under RCRA regulations. As discussed in the Construction Quality Control Plan (CQCP) for the LASO TA-73 Airport Landfill (North Wind 2005b), quality control testing and inspections will be performed on the various landfill cover components, particularly the low-permeability infiltration layer, to assure that the infiltration layer is installed and compacted to meet the 1E-05 cm/sec performance standard. In addition, samples will be collected from the infiltration layer material at the offsite borrow source and analyzed to ensure the material meets the performance standard before delivery to the site.

The Post-closure Plan, prepared under 40 *Code of Federal Regulations* (CFR) 265.118, “Post-closure Plan; Amendment of Plan,” must include:

- A description of planned groundwater monitoring activities,
- A description of planned maintenance activities, and
- The name, address, and telephone numbers of the person(s) or office to contact during the post-closure period.

The scope of the activities addressed under the RCRA Subtitle C Post-closure Care Plan for an interim status unpermitted landfill are defined in 40 CFR 265.310, “Closure and Post-closure Care,” which states that after closure, the owner or operator must:

- Maintain the integrity and effectiveness of the final cover, including making repairs to the cover (as necessary) to correct the effects of settling, subsidence, erosion, or other events,
- Maintain and monitor the leak detection system,
- Maintain and monitor the groundwater monitoring system,
- Prevent run-on and run-off from eroding or otherwise damaging the final cover, and
- Protect and maintain surveyed benchmarks used in complying with §265.309.

The TA-73 landfill does not include a leachate collection system; therefore, this requirement (NMAC 20.9.1.500.B) does not apply.

The TA-73 landfill does not have dedicated groundwater monitoring wells because the depth to groundwater is over 1,200 ft; therefore, this requirement does not apply.

The requirement for methane monitoring (NMAC 20.9.1.500.B) does not apply because (1) the landfill was not active after November 8, 1987; and (2) engineering calculations, prepared by North Wind Inc. (NWI), indicate that gas concentrations will not exceed 25% of the lower explosive limit (LEL) for methane at the property boundary. Vapor monitoring is therefore not required. However, a methane collection and venting system will be implemented to allow any methane that is present to escape to the atmosphere and to ensure no methane generation is experienced in enclosed aircraft hangers.

3.0 POST-CLOSURE MONITORING AND MAINTENANCE

Post-closure monitoring for cover integrity will include inspections of the cover and maintenance and repair of deficiencies. Frequency requirements are specified in this plan. An inspection report, which will be completed for each inspection, will contain (at a minimum) the following information:

- Name of inspector and inspection date and time,
- Weather information at the time of the inspection,
- Condition of the cover system (including MatCon™ asphalt surface, riprap surface, and soil surface), retaining walls, storm water control features, and survey benchmarks,
- Incidents of noncompliance with the “Final National Pollutant Discharge Elimination System General Permit for Storm Water Discharges from Construction Activities” (FR 2003) or the Storm Water Pollution Prevention Plan (SWPPP) for the LASO TA-73 Airport Landfill (North Wind 2005c); noncompliances, if any, will be identified during the inspections mandated by the SWPPP,

- Location(s) of discharges of sediment or other pollutants from the site,
- Corrective actions required, and
- Signature of inspector.

Inspection records and documentation of corrective actions will be retained in the project file and provided with the annual report. Inspection and maintenance tasks are described below.

3.1 Cover System

Cover system inspections will include site walkovers to investigate and document the existing conditions and any deficiencies that are present. Inspection scheduling and specific deficiency remedies will be conducted as described below. Areas other than the MatCon™ asphalt surface and the retaining walls shall be inspected at least annually and more frequently, as directed by the Contractor Professional Engineer (PE) registered in the State of New Mexico, if substantial deficiencies exist. MatCon™ asphalt surface and retaining walls shall be inspected as directed in Sections 3.1.5 and 3.4.

3.1.1. Erosional Damage and Cracks

Rill erosion and/or cracking result in loss of topsoil from the cover and potential damage to the underlying low-permeability soil layer. The inspector will look for run-off rills on the DDA cover system. Cracks and/or rills deeper than approximately four (4) in. will be filled and compacted using topsoil and equipment appropriate to the scale of the erosional features and as per construction Specification 02200, “Earthwork” (North Wind 2005d). Excessive compaction shall not be used unless repair of the underlying low-permeability soil layer is required.

3.1.2. Animal Burrows

Animal burrows can breach the cover, allowing exposure of waste and possibly preferential flow pathways through the cover to develop, resulting in increased infiltration. All animal burrows greater than approximately four (4) in. in depth shall be filled and compacted using topsoil and equipment appropriate to the scale of the erosional features and as per construction Specification 02200, “Earthwork.” Excessive compaction will not be used unless repair of the underlying low-permeability soil layer is required.

3.1.3. Subsidences

Subsidence of underlying waste can result in depressions in the surface cover, allowing for ponding and increased infiltration of water. All subsidences within the DDA cover system greater than approximately one (1) ft in depth, relative to the surrounding grade, shall be filled and compacted (as per construction Specification 02200, “Earthwork”) using topsoil and equipment appropriate to the scale of the subsidence feature. Additionally, all subsidence within the riprap cover system greater than one (1) ft in depth, relative to the surrounding grade, shall be filled using riprap and equipment appropriate to the scale of the subsidence feature. Excessive compaction will not be used unless repair of the underlying low-permeability soil layer is required.

3.1.4. Condition of Vegetation

The condition of surficial vegetation shall be noted. Areas greater than approximately 10,000 ft^2 lacking vegetation shall be reseeded, fertilized, and/or watered as needed to reestablish vegetation, as per construction Specification 02932, “Seeding, Mulching and Restoration” (North Wind 2005d).

3.1.5. MatCon™ Asphalt Surface

The MatCon™ asphalt surface shall be inspected and evaluated in accordance with the MatCon™ Operation and Maintenance Plan prepared by the MatCon™ subcontractor. In general, the MatCon™ subcontractor representatives will make annual inspections and evaluations for the first five (5) years. The owner/operator will be required to make monthly inspections and submit the results to the MatCon™ subcontractor and to the PE. During the construction process, MatCon™ subcontractor representatives will instruct the owner/operator on the proper inspection techniques and documentation.

3.2 Storm Water Control System

Annual storm water control system inspections will include all areas of the site, as described in the SWPPP (North Wind 2005c). Inspectors will look for evidence of, or the potential for, pollutants entering the storm water conveyance system. Discharge locations identified in the site plans will be inspected to determine whether erosion controls are effective in preventing significant impact to Pueblo Canyon.

Qualified personnel knowledgeable in the principles and practice of erosion and sediment controls will perform inspections and maintenance for the following:

- **Condition of sediment basins**—inspect for fill height of sediments, presence of vegetation or debris, condition of berms and outlets, etc. The basins and outlets will be maintained by removing excess sediment and/or debris as needed to maintain proper function. Berms will be repaired as needed to maintain storage capacity of the basin.

- **Condition of outlet chutes, perimeter drains/berms, terrace drains, culverts, and drop inlets**—inspect for presence of sediments, breaches in berms, presence of vegetation or debris, etc. Sediments, vegetation, or debris retarding storm water runoff will be removed as needed. Breaches in berms or chutes will be repaired using the appropriate materials.

Inspection records and documentation of corrective actions will be retained in the project file and provided with the annual report.

3.3 Survey Benchmarks

Annual inspections will include locating and documenting the condition of the permanent survey benchmark. Benchmarks will be maintained in a clearly visible condition.

3.4 Retaining Walls

Visual inspections will be performed for both the concrete and mechanically stabilized earth (MSE) walls.

The monitoring schedule for the retaining walls during the post-closure period shall be as follows:

- Every six (6) months for the first two (2) years after construction of the walls, and

- At the end of the two (2)-year period, the need for any additional inspections and their frequency will be determined by the PE based on the results and conclusions of the inspections.

The inspector shall perform the following tasks:

- Investigate for any cracks that may have developed in the concrete wall. Digital photos shall be taken to illustrate the extent of the crack(s). Measurements of the location and depth of the crack(s) shall be determined and documented.

- Investigate for any separation, rotation, or other movement of the MSE walls. Document location and take digital photo of extent of movement.

- Document any soil erosion or other evidence of water damage in the vicinity of retaining walls.

3.5 Methane Venting System

Annual inspections of the above-ground portion of the methane venting system will include looking for and documenting any deficiencies that would limit or prevent the system from functioning in accordance with the design.

4.0 RECORD-KEEPING AND REPORTING

A project file containing records of all inspections and maintenance performed will be maintained by DOE-LASO. An annual report, including inspection and maintenance records for the preceding year, will be prepared and provided to the New Mexico Environmental Department (NMED) Secretary within 45 days from the end of each calendar year.

The name, address, and telephone number for the individual to contact during the post-closure period is as follows:

Robert Enz
DOE-LASO Project Manager
528 35th Street
Los Alamos, NM 87544
(505) 667-7640

5.0 SCHEDULE

All cover system deficiencies should be inspected (according to this plan) and corrected at the earliest opportunity, and before the end of the calendar year, in order to be completed during the reporting period.

The inspection and evaluation schedule for the MatCon™ asphalt surface shall be in accordance with the MatCon™ Operation and Maintenance Plan, to be prepared by the MatCon™ subcontractor.

6.0 TABLES

Table 2.0-1. Summary of Post-closure Care and Monitoring Requirements

Citation	Requirement	Method of Compliance
NMAC 20 9.1.500 NMAC 20.4.1.600 (40 CFR 265.118)	PCMP	PCMP
NMAC 20 9.1.500 NMAC 20.4.1.600 (40 CFR 265.310)	Maintain cover integrity	Inspection and maintenance of cover system in accordance with this plan
NMAC 20 9.1.500 NMAC 20.4.1.600 (40 CFR 265.310)	Maintain and operate leachate collection system	Leachate collection system not required
NMAC 20 9.1.500 NMAC 20.4.1.600 (40 CFR 265.310)	Maintain and operate methane collection/monitoring system	Implementation of methane collection and monitoring system not required
NMAC 20 9.1.500	Groundwater monitoring	Groundwater monitoring not required
NMAC 20 9.1.500	Reporting	Annual monitoring report
NMAC 20.4.1.600 (40 CFR 265.310)	Prevent run-on and run-off from eroding or otherwise damaging the final cover	Inspection and maintenance of surface water controls as per this plan
NMAC 20.4.1.600 (40 CFR 265.310)	Protect and maintain surveyed benchmarks	Annual inspection and maintenance of survey benchmarks
DOE-LASO and Los Alamos County requirements	Maintain access roads to main landfill and Debris Disposal Area	No permanent access roads are needed to meet applicable landfill closure requirements; therefore, access roads are not included in the PCMP

CFR = Code of Federal Regulations
NMAC = New Mexico Administrative Code
PCMP = Post-closure Care and Monitoring Plan

7.0 REFERENCES

40 CFR 265.118, 2003, “Post-closure Plan; Amendment of Plan,” *Code of Federal Regulations,* published by the U.S. Government Printing Office, Washington, D.C., January 1, 2003.

40 CFR 265.309, 2003, “Surveying and Recordkeeping,” *Code of Federal Regulations,* published by the U.S. Government Printing Office, Washington, D.C., January 1, 2003.

40 CFR 265.310, 2003, “Closure and Post-closure Care,” *Code of Federal Regulations,* published by the U.S. Government Printing Office, Washington, D.C., January 1, 2003.

DOE, 2005, “National Nuclear Security Administration Los Alamos Site Office Environmental Assessment for Proposed Closure of the Airport Landfills Within Technical Area 73 at Los Alamos National Laboratory, Los Alamos, New Mexico,” DOE/EA-1515, U.S. Department of Energy, May 2005.

FR, 2003, FR-39087, Part 68, “Final National Pollutant Discharge Elimination System General Permit for Storm Water Discharges from Construction Activities,” *Federal Register,* Vol. 68, Number 126, pp. 39087– 39091, published by the U.S. Government Printing Office, Washington, D.C., July 1, 2003.

LANL, 1998, “RFI Report for Potential Release Sites 73-001(a,b,c,d) and 73-004(d), Airport Landfill Areas,” Vol. 1, 2, and 3, Los Alamos National Laboratory (LANL) report LA-UR-98-3824, 63070, Los Alamos, New Mexico, November 1, 1998.

NMAC 20.9.1.500, 2001, “Closure and Post-closure Requirements,” *New Mexico Administrative Code,* published by the Commission of Public Records, Administrative Law Division, Santa Fe, New Mexico, November 27, 2001.

NMAC 20.4.1.600, 2003, “Adoption of 40 CFR Part 265,” *New Mexico Administrative Code,* published by the Commission of Public Records, Administrative Law Division, Santa Fe, New Mexico, October 1, 2003.

North Wind, 2004, “Design Basis Document for Los Alamos Site Office TA-73 Airport Landfill,” Revision 1, NWI-ID-2004-042, North Wind Inc., Idaho Falls, ID, April 2004.

North Wind, 2005a, “Remedy Design Work Plan for the Los Alamos Site Office TA-73 Airport Landfill,” Revision 1, NWI-ID-2004-031, North Wind Inc., Idaho Falls, ID, June 2005.

North Wind, 2005b, “Construction Quality Control Plan for the Los Alamos Site Office TA-73 Airport Landfill,” Revision 2, NWI-ID-2004-016, North Wind Inc., Idaho Falls, ID, June 2005.

North Wind, 2005c, “Storm Water Pollution Prevention Plan for the Los Alamos Site Office TA-73 Airport Landfill,” Revision 2, NWI-ID-2004-005, North Wind Inc., Idaho Falls, ID, June 2005.

North Wind, 2005d, “Construction Specifications for Los Alamos Site Office TA 73 Airport Landfill, 906 Design Submittal,” Draft Final, NW-ID-2004-039, North Wind Inc., Idaho Falls, Idaho, June 2005.

Appendix A

Acronyms

Appendix A

Acronyms

CFR	*Code of Federal Regulations*
CQCP	Construction Quality Control Plan
DDA	Debris Disposal Area
DOE	U.S. Department of Energy
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office
LEL	Lower explosive limit
MatCon™	Modified Asphalt Technology for Waste Containment
MSE	mechanically stabilized earth
NMAC	*New Mexico Administrative Code*
NMED	New Mexico Environmental Department
NWI	North Wind Inc.
PCMP	Post-closure Care and Monitoring Plan
PE	Professional Engineer
RCRA	*Resource Conservation and Recovery Act*
RFI	RCRA facility investigation
SWPPP	Storm Water Pollution Prevention Plan
TA	Technical Area

NW-ID-2004-039
Final, Revision 1

CONSTRUCTION SPECIFICATIONS FOR LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILL

100% Design Submittal Final

June 2005

Prepared for:

North Wind, Inc.
545 Shoup Avenue, Suite 200
Idaho Falls, Idaho 83402

Prepared by:

Weston Solutions, Inc.
6565 Americas Parkway N.E., Suite 200
Albuquerque, New Mexico 87110

TABLE OF CONTENTS

DIVISION 1

GENERAL REQUIREMENTS

SECTION 01010

SUMMARY OF WORK

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. This Project is located at the Los Alamos County Airport, located in Los Alamos, NM. North Wind, Inc. has been contracted by the U.S. Department of Energy (DOE) Los Alamos Site Office (LASO) to design and construct a cover system for the Technical Area (TA)-73 Airport Landfill that is compliant with New Mexico Solid Waste Management Regulations (20 *New Mexico Administrative Code* [NMAC] 9.1). On April 1, 2003, the New Mexico Environment Department (NMED) granted conditional approval of the Voluntary Corrective Measures (VCM) Plan for an engineered alternative earthen final cover (NMED 2003).

B. Potential release sites (PRSs) 73-001(a)-99 Airport Landfill (main landfill) and 73-001(b)-99 Debris Disposal Area (DDA) are inactive PRSs and are listed in Table A within Module VIII of Los Alamos National Laboratory (LANL) Hazardous Waste Facility Permit (LANL 1996, 57486.1). Both landfill areas are located within TA-73 on DOE property, immediately north of the Los Alamos County Airport runway, between the runway and the edge of the mesa. The airport is currently operating under the management of Los Alamos County under lease from the DOE.

C. The main landfill area consists of a natural hanging valley into which municipal and LANL sanitary waste was disposed of for approximately 30 years. The west and south sides of the main landfill coincide approximately with the edges of the asphalt tie-down area and the asphalt taxiway to the hot pad, respectively. The north side extends approximately to the chain link security fence along the north side of the airport. To the east, the landfill extends to the end of the hanging valley.

D. The DDA lies east of the main landfill and consists of two roughly parallel trenches excavated to a maximum depth of approximately 35 feet (ft). To the west, the trenches extend to within approximately 150 ft of the windsock. To the east, the trenches extend approximately 800 ft beyond the end of the runway.

E. The main landfill covers a surface area of approximately 11.5 acres (AC). The DDA covers a surface area of approximately 5 AC.

F. Access to PRSs 73-001(a)-99 and 73-001(b)-99 is controlled by a perimeter fence around the entire airport. Access to the tarmac is limited to private airplane owners, operators, passengers, and other individuals with legitimate reasons to be there.

G. The work generally consists of the construction of a cap or cover over the existing 11.5-AC landfill. Waste from the east slope will be pulled back and relocated in order to reduce the excessively steep sideslope and to construct retaining walls. Waste will be excavated from the north slope to achieve an effective inclination of no steeper than 3H:1V. Waste will be excavated from the east slope to achieve an effective inclination of no steeper than 4H:1V except that steeper temporary slopes will be excavated to facilitate the construction of the retaining walls. The proposed cover configuration is an 18-inch (in.) infiltration layer and a 6-in. rock layer on the north and east sideslopes and an asphalt cap (MatCon™) over the flattop area. The purpose of the cover is to minimize moisture percolation through the landfill refuse and to prevent or reduce leaching and downward migration of contaminants. The work at the DDA consists of recontouring to provide a uniform cover thickness and reseeding. Both sites shall be graded to facilitate drainage and minimize erosion.

H. The work to be performed as described in this section is for the Contractor's general information only and is not intended to be a complete list of the work for this project. It is the Contractor's responsibility to determine the full scope of work required to complete this project on time, within budget, and in compliance with the Contract Documents. The scope of work is indicated by the requirements of each Specification.

I. The work includes, but is not limited to:

1. Construction of facilities and access roads as required for access to the sites.
2. Construction of erosion and sedimentation controls necessary for construction and post-construction.
3. Excavation and relocation of waste material from the north and east slopes of the main landfill and establishment of final grades.
4. Installation of a rock armor or other suitable material over the east and north slopes of the main landfill.
5. Construction of retaining walls at the toe of and on the east slope.
6. Construction of the MatCon™ cap on the flat portion of the main landfill.
7. Regrade the DDA to eliminate low spots and establish proper drainage.
8. Add topsoil to the DDA as needed to bring the topsoil thickness over the entire footprint to 12 in.
9. Revegetate denuded and/or disturbed areas at the main landfill and DDA.

J. The Contractor shall use the design documents, to include but not be limited to these Specifications and the Construction Drawings, to construct closure covers at the airport landfills.

K. The Contractor will coordinate work to minimize impacts to airport operations.

L. The Contractor is responsible for operating and maintaining all equipment, materials, systems, structures, and other physical features located within the designated construction boundary in a neat, safe, functional, and protected condition for the duration of the project. This responsibility pertains to all items located on the project site prior to start of the work, items brought onto the site by the Contractor, and items under construction.

1.02 DEFINITIONS

A. The Owner shall mean DOE.

B. The Contractor shall mean North Wind, Inc. Contractor responsibilities are specified in the North Wind, Inc. Project Management Plan for the LASO TA-73 Airport Landfill (PMP), Document number NW-ID-2003-073. Contractor personnel include Project Manager, Construction Manager, and Site Superintendent (SS).

C. The Engineer shall mean the Engineer of Record from Weston Solutions, Inc. The Engineer of Record shall be a Professional Engineer registered in the State of New Mexico in civil engineering. The Engineer of Record may designate someone to act on his behalf (including a North Wind employee), under his supervision. Weston Solutions, Inc. responsibilities are specified in the PMP.

D. The Subcontractor shall mean any individual or company contracted by the Contractor to provide services or perform work associated with the project.

E. The term “airport landfills” refers to both the inactive landfill and the DDA.

F. Where “as shown,” “as detailed,” “as noted,” “as indicated,” or words of like meaning are used in the Contractor documents, it shall be understood that reference is being made to the drawings unless otherwise noted.

PART 2 MATERIALS

Not Applicable

PART 3 EXECUTION

3.01 SPECIFICATIONS

The priority of Contract Documents is Specifications to Drawings to Project Scoping Plans. This flow-down means that the Specifications take precedence over the Drawings which take precedence over the ancillary Project Scoping Plans.

3.02 DRAWINGS

A. An index of Project drawings is shown on the Drawings.

B. Dimensions shown on the Drawings take precedence over scaled dimensions. Large-scale details have precedence over smaller scale.

REFERENCES

Los Alamos National Laboratory (LANL), January 1996. “LANL HSWA Module VIII Permit, 1996 Revision (guidance),” Los Alamos, New Mexico. (LANL 1996, 57486)

Los Alamos National Laboratory (LANL), October 2002. “Voluntary Corrective Measure Plan for Potential Release Sites 73-001(a)-99 and 73-001(b)-99,” Los Alamos National Laboratory document LA-UR-02-4433, Los Alamos, New Mexico. (LANL 2002, ER2002-0359).

New Mexico Environment Department (NMED), April 2003, “Conditional Approval of Voluntary Corrective Measures (VCM) Plan for Potential Release Sites (PRSs) 73-001(a)-99 and 73-001(b)-99,” letter from Vickie Maranville, NMED HWB, to Pete Nanos, Director and Everett Trollinger, Project Manager. (NMED 2003)

END OF SECTION

SECTION 01015

GENERAL CONDUCT OF WORK

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Coordination of Work.

B. Handling and Storage.

C. Referenced Standards.

1.02 RELATED SECTIONS AND REQUIREMENTS

A. Division 1 - General Requirements

B. Waste Management Plan for LASO TA-73 Airport Landfill (WMP), March, 2004

C. Construction Plan for LASO TA-73 Airport Landfill, March, 2004

1.03 COORDINATION OF WORK

A. The Contractor shall be responsible for the coordination of all work so that the Project can be completed within the time stipulated in the Contract. It is the Contractor's responsibility to review coordination of all work in detail with the Engineer and his other Contractors as necessary to avoid any misunderstanding.

B. The Contractor's Project Manager will serve as the point of contact for all communication.

C. The Contractor shall supervise and direct all work required under this Contract. The Contractor shall be solely responsible for the construction methodology, controls, techniques, sequences, procedures, or construction safety, except as required in Contract documents or in cases where written direction to the Contractor overrides the Contractor's choice. Major changes to the engineering design must be approved by the Engineer and the Owner.

D. The Contractor will restrict/control access to the site for construction personnel, equipment, and materials to the access-control points at the site.

1.04 HANDLING AND STORAGE

A. The Contractor shall, at the Contractor's expense, handle, haul, and distribute all materials and all surplus supplies on the different portions of the Work as necessary. Contractor shall provide suitable and adequate storage room for materials and equipment during the progress of the Work and be responsible for loss of, or damage to, materials and equipment furnished by the Contractor, until the final acceptance of the Work.

B. All excavated materials, construction equipment, materials and equipment to be incorporated in the Work shall be placed so as not to contaminate, damage, or delay the Work and so that free access can be had at all times to this project, and any other project, and to all installations in the vicinity of the Work.

1.05 REFERENCED STANDARDS

A. Referenced standards used throughout the Contract Documents to specify the quality of materials or workmanship shall refer to the latest edition of such standards that is accepted by the authority having jurisdiction, except where a specific edition is indicated in the Contract Documents.

1.06 WASTE MANAGEMENT

A. It is anticipated that the Contractor will encounter contamination while performing the work. Refer to the WMP for additional information and requirements.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01090

ABBREVIATIONS

PART 1 GENERAL

1.01 ABBREVIATIONS

A. Abbreviations used in these Contract Documents shall refer to and designate the following, as applicable:

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
AOS	Apparent opening size
ASTM	American Society for Testing and Materials
BFM	Bonded Fiber Matrix
CA	Construction area
C_c	Coefficient of Gradation
CFR	*Code of Federal Regulations*
CLFMI	Chain Link Fence Manufacturers Institute
COR	Contracting Office Representative
CQCP	Construction Quality Control Plan
C_u	Uniformity Coefficient
CWA	Controlled Work Area
DDA	Debris Disposal Area
DOE	United States Department of Energy
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FOD	Foreign objects debris
FS	Federal Specifications
GTL	Geotechnical testing laboratory
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office
MatCon™	asphalt capping material
MARV	minimum average roll value
NMAC	*New Mexico Administrative Code*
NMDOT	New Mexico Department of Transportation
NMED	New Mexico Environment Department
NSA	National Stone Association
OFZ	Obstacle-free zone
OGBC	Open graded base course
OSHA	Occupational Safety and Health Act
PLS	Pure live seed
PMP	Project Management Plan
PPE	Personal protective equipment
PQAP	Project Quality Assurance Plan
PRS	Potential release site
PVC	Polyvinyl chloride
QA	Quality assurance
QC	quality control
RA	Restricted area
SS	Site Superintendent
SSO	Site Safety Officer
SWPPP	Storm Water Pollution Prevention Plan

TA	Technical Area
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
UV	Ultraviolet
WMP	Waste Management Plan
VCM	Voluntary Corrective Measure

UNITS OF MEASURE

AC	Acre
cm/sec	Centimeters per second
CY	Cubic yard(s)
dBA	Decibel A-weighted
F	Fahrenheit
ft	Foot (feet)
in.	Inch(es)
lb	Pound(s)
mph	Miles per hour
pcf	Pounds per cubic foot
psi	Pounds per square inch
ft^2	Square foot (feet)

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01200

PROJECT MEETINGS

PART 1 GENERAL

1.01 WEEKLY MEETINGS

A. Weekly job meetings shall be conducted with the Engineer, Contractor and other designated parties to evaluate progress on the project to date. These meetings shall be held at Site Trailer at a scheduled time convenient to all parties.

B. It may periodically become necessary to have special meetings to resolve project conflicts in which all parties shall be required to attend.

C. Other items to be reviewed during weekly job meetings are:

1. Health and safety Issues.
2. Project schedule.
3. Coordinate construction activities with operational personnel.
4. Manpower requirements, etc.
5. Coordinate projected progress with other Prime Contractors, as applicable.
6. Review submittal schedules, expedite as required to maintain schedule.
7. Maintaining of quality and work standards.
8. Review any changes for:
    a. Effect on Construction Schedule.
    b. Cost Reductions.
9. Review next week's work items.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01310

CONSTRUCTION SCHEDULES

PART 1 GENERAL

1.01 SECTION INCLUDES

A. General Requirements.

B. Form of Schedules.

C. Content of Schedules.

D. Updating.

E. Submittals.

F. Distribution.

G. Coordination.

1.02 RELATED SECTIONS AND REQUIREMENTS

A. Division 1 - General Requirements.

B. Construction Plan for LASO TA-73 Airport Landfill, June 2005

1.03 GENERAL REQUIREMENTS

A. The construction schedule for the entire work is provided in the Contractor's Construction Plan for LASO TA-73 Airport Landfill. The construction schedule shall be revised monthly, or more frequently if directed by Engineer. based on the progress of work.

1.04 FORM OF SCHEDULES

A. Contractor will prepare manually or in computer generated format, a Work Breakdown Structure and Gantt schedule analysis. Exact format to be approved by the Engineer in accordance with 1.07 of this section.

B. Reproducible sheets at 11-in. x 17-in. shall be provided to the Engineer.

1.05 CONTENT OF SCHEDULES

A. Complete sequence of construction by activity.

1. Shop Drawings, Sealants, Concrete Mix Designs, Asphalt Mix Designs, Product Data, Samples and Guarantees.

2. Selection of finishes.

3. Product fabrication and delivery dates.

4. Dates for beginning, and completion of, each construction activity, specifically:

a. Mobilization

b. Site preparation

c. Waste Relocation and rough regrade

d. Retaining wall construction

e. Landfill cover installation

e. Acceptance Testing

f. Revegetation

g. Demobilization

5. Date(s) for final inspection and acceptance.

B. Identify Work of separate stages, or separate phases, or other logically grouped activities.

C. Projected percentage of completion for each item of Work as of first week of each month.

D. Provide subschedules as necessary to define critical portions of entire schedule.

E. Assign to each scheduled major activity a sum of money, the total of which shall equal the approved contract price.

1.06 UPDATING

A. Show all changes occurring since previous submission of updated schedule.

B. Indicate progress of each activity, show completion dates.

C. Include:

1. Major changes in scope.

2. Activities modified since previous updating.

3. Revised projections due to changes.

4. Other identifiable changes.

D. Provide narrative report, if necessary, to include:

1. Discussion of problem areas, including current and anticipated delay factors and their impact.

2. Corrective action taken, or proposed, and its effect.

3. Effect of change in schedules of other contractors.

4. Description of revisions:

a. Effect on schedule due to change of scope.

b. Revisions in duration of activities.

c. Other changes that may affect schedule.

1.07 SUBMITTALS

A. Submit initial schedules within ten (10) days after the date of contract execution.

1. The Engineer will review schedules and return review copy within ten (10) days after receipt.

2. If required, resubmit within seven (7) days after return of review copy.

B. Submit monthly updated schedule accurately depicting progress to first week of each month.

1.08 COORDINATION

A. Schedules of subcontractors will be available for inspection at the Engineer's request.

B. Contractor shall coordinate schedules with schedules of subcontractors.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01330

SURVEY DATA

PART 1 GENERAL

1.01 LINES, GRADES, AND MEASUREMENTS

A. The Contractor shall make all measurements and check all dimensions necessary for the proper construction of the Work called for by the Drawings and Specifications. During the execution of the Work, the Contractor shall make all necessary measurements to prevent misfitting in said work, and shall be responsible therefore and for the accurate construction of the Work.

1.02 DIMENSIONS OF EXISTING FEATURES

A. The dimensions and locations of existing structures, topography, and drainage swales are of critical importance in the installation or connection of new work, the Contractor shall verify such dimensions and locations in the field before the construction or fabrication of any structure, material or equipment.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01340

SHOP DRAWINGS, SAMPLES, AS-BUILTS, AND OTHER SUBMITTALS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. General Instruction.

B. Samples.

C. Shop Drawings.

D. Product Data.

1.02 RELATED SECTIONS AND REQUIREMENTS

A. Division 1 - General Requirements.

B. Construction Plan for LASO TA-73 Airport Landfill, June 2005.

C. Health and Safety Plan for LASO TA-73 Airport Landfill (HASP), June 2005

1.03 GENERAL INSTRUCTIONS

A. Within ten working days after the formal execution of the contract, the Contractor shall submit a Submittal Schedule to the Engineer. The Submittal Schedule shall be a sub-schedule to the Construction Schedule required under Section 01310 Subpart 1.05D, and shall include dates for submittal, approval, fabrication as appropriate, and delivery of the Work. This schedule shall also list samples and other submittals as planned by the Contractor and as required by the Contract Documents. The Engineer will review the schedule in accordance with the provisions of Section 01310 and return either approved or modified copies to the Contractor. Once accepted by the Engineer, the schedule shall be followed throughout the project unless superseded by a new schedule accepted by the parties involved. The Engineer will require ten working days to properly review this schedule. The Engineer will add or delete submittals required for review.

B. Information submitted as a separate submittal or as part of another submittal that has not been listed on the schedule as a required submittal will be scanned briefly by the Engineer. Such extraneous and unrequired information will be marked as "NO ACTION TAKEN" and returned.

C. When Shop Drawings are required by the various technical specification sections or elsewhere in the Contract Documents, the names and addresses of the proposed manufacturers (if different from those listed in the Contract Documents) shall be submitted prior to the submittal of the Shop Drawings so that the Engineer may consider and approve or disapprove the manufacturer and/or the supplier as to his or their ability to furnish a product meeting the requirements of the Contract Documents. This preliminary submittal is subject to final approval of the particular material or equipment. As requested, the Contractor or equipment supplier shall also submit data relating to the materials and equipment he proposes to incorporate into the work, in sufficient detail to enable the Engineer to identify the particular product in question and to form an opinion as to its conformity to the contract requirements. Such data shall be submitted in a manner similar to that specified for Shop Drawings.

D. The normal time allowed for review of Shop Drawings, and other submittals, is two calendar weeks after receipt of the submittal by the Engineer, or other party responsible for the review. Requirements for shorter review periods must be presented in writing by the Contractor.

E. Submittals shall be approved by the Contractor, as shown by the Contractor's approval marked on each copy. Submittals shall not be accepted from subcontractors, suppliers, manufacturers, or representatives. Submittals shall be identified by reference to Contract document number, drawing number, equipment number and specification section number, equipment or material schedule, or room numbers, as appropriate. Submittals shall be numbered consecutively by the Contractor, or equipment supplier, as appropriate. Resubmissions shall use the same number with a suffix added to identify each resubmission (i.e., "A" shall identify the first resubmission).

F. Minimum sheet size: 8-1/2-in. x 11-in.

G. Number of submittals required:

1. Shop Drawings: Submit the number of opaque reproductions, which the Contractor requires, plus four copies which will be retained.

2. As-Built Drawings: Submit one electronic version in AutoCAD 2004 or more recent version and one hard copy suitable for reproduction.

3. Product Data: Submit the number of copies which the Contractor requires, plus four copies which will be retained.

4. Samples: Submit the number stated in each specification section.

5. Certificates: Submit three copies which will be retained.

H. Submittals shall contain:

1. The date of submission and the dates of any previous submissions.

2. The Project title and number.

3. Contract identification.

4. The names of:

   a. Contractor.
   b. Supplier.
   c. Manufacturer.

5. Identification of the product, with the specification section number and other appropriate information.

6. Field dimensions, clearly identified as such.

7. Relation to adjacent or critical features of the work or materials.

8. Applicable standards, such as American Society for Testing and Materials (ASTM) or Federal Specification (FS) numbers.

9. Identification of deviations from Contract Documents.

10. Identification of revisions on resubmittals.

11. 8 in. x 3 in. blank spaces for Contractor and the Engineer's review stamps.

12. Contractor's stamp, initialed or signed, certifying to review of submittal, verification of products, field measurements and field construction criteria, and coordination of the information within the submittal with requirements of the work and of Contract Documents.

1.04 SCHEDULE OF VALUES

A. For all lump sum work, the Contractor shall submit a Schedule of Values.

B. The Schedule of Values shall be submitted to the Engineer within five (5) days after the Notice-to-Proceed.

C. The Schedule of Values shall be subject to the review and approval of the Engineer.

D. The Schedule of Values shall identify all the major elements of the work and the cost of each element. The total scheduled cost shall equal the contract price.

E. The Schedule of Values shall identify costs for all: mobilization, demobilization, and site preparation; establishment, maintenance and removal of erosion and sedimentation control; construction schedule preparation and updating; as-built documents, as well as: construction activities, generally broken down by structure, location, and specific location.

F. The approved Schedule of Values will form the basis for the values assigned to scheduled activities established in Section 01310.

1.05 SAMPLES

A. If the Engineer so requires, either prior to beginning or during the progress of the work, the Contractor or equipment supplier shall submit samples of materials for such special tests as may be necessary to demonstrate that they conform to the Specifications. Such samples, including concrete test cylinders, shall be furnished, taken, stored, packed, and shipped as directed, at the expense of the Contractor. Except as otherwise specified, the Contractor shall make arrangements for, and pay for, the actual tests.

B. All samples shall be packed so as to reach their destination in good condition, and shall be labeled to indicate the material represented, the name of the building or work and location for which the material is intended, and the name of the Contractor or equipment supplier submitting the sample.

C. To ensure consideration of samples, the Contractor or equipment supplier shall notify the Engineer in writing that the samples have been shipped and shall properly describe the samples in the letter. In no case shall the letter of notification be enclosed with the samples.

D. The Contractor or equipment supplier shall submit data and samples, or place his orders, sufficiently early to permit consideration, inspection, testing, and approval before the materials and equipment are needed for incorporation in the work.

E. When required, the Contractor or equipment supplier shall furnish to the Engineer triplicate copies of manufacturer's attesting to the accuracy of shop or Mill tests (or reports from independent testing laboratories) relative to materials, equipment performance ratings, and concrete data.

F. The materials and equipment used on the Work shall correspond with the samples submitted.

1.06 SHOP DRAWINGS

A. The Contractor or equipment supplier, as appropriate, shall submit for approval at least four (4) print copies (plus any additional copies required by the Contractor or subcontractors or equipment suppliers) of Shop Drawings of materials fabricated especially for this contract, and of equipment and materials for which such drawings are specifically requested in the Contract Documents. One copy, plus any additional copies provided, will be reviewed, stamped, and returned to the Contractor.

B. Such drawings shall show the principal dimensions, weights, structural and operating features, performance characteristics and capacities, wiring and piping diagrams, space required, clearances required, type and/or brand of finish or shop coat, grease fittings, etc., depending on the subject of the drawings. Show location, size, dimensions and embedment depth for anchor bolts. List special tools required to operate, and maintain equipment. Describe tool's purpose. When it is customary to do so, when the dimensions are of particular importance, or when so specified, the drawings shall be certified by the manufacturer or fabricator as correct for this contract.

C. The Contractor or equipment supplier shall be responsible for the prompt submission of all Shop Drawings in accordance with the Shop Drawing Schedule so that there shall be no delay to the work due to the absence or lateness of such drawings.

D. No material shall be purchased or fabricated especially for this Contract until the required Shop Drawings have been submitted and reviewed as conforming to the Contract requirements. All materials and work involved in the construction shall then be as represented by said drawings.

E. Only Shop Drawings which have been checked and corrected by the fabricator should be submitted to the Contractor by the Contractor’s subcontractors and vendors. Prior to submitting Shop Drawings to the Engineer, the Contractor shall check thoroughly all such drawings so that the subject matter thereof conforms to the Drawings and Specifications in all respects. Shop Drawings which are correct shall be marked with the date, checker's name and indication of the Contractor's approval, and then shall be submitted to the Engineer; other drawings shall be returned to the fabricator or subcontractor for correction.

F. The Engineer review of Shop Drawings will follow a general check made to ascertain conformance with the design concept and functional results of the Project and compliance with the information given in the Contract Documents. The Contractor shall be responsible for dimensions to be confirmed and correlated at the job site and for coordination of the work of all trades. The Contractor, or equipment supplier if appropriate, shall also be responsible for information that pertains solely to the fabrication processes or to techniques of construction.

G. The Engineer classifications are as follows:

APPROVED	(___)
APPROVED AS CORRECTED	(___)
REVISE AND RESUBMIT	(___)
REJECTED	(___)
NO ACTION TAKEN	(___)

H. The Contractor or equipment supplier shall make any corrections required by the Engineer and shall return the required number of corrected copies of Shop Drawings until approved.

I. At the time of each submission or resubmission, the Contractor or equipment supplier shall direct specific attention, in writing, to deviations that the Shop Drawings or samples may have from the requirements of the Contract Documents or corrections required by the Engineer on previous submissions.

J. The Contractor's stamp of approval on Shop Drawings and samples shall constitute a representation to the Engineer that the Contractor has either determined and verified all quantities, dimensions, field construction criteria, materials, catalog numbers and similar data (or he assumes full responsibility for doing so) and that the Contractor has reviewed or coordinated each Shop Drawing and sample with the requirements of the Contract Documents. Submittals received without this information will be returned without being reviewed by the Engineer.

K. The approval of Shop Drawings and samples shall not relieve the Contractor or equipment supplier from responsibility for any deviations from the requirements of the Contract Documents, unless the Engineer has been notified, in writing, and has given written approval to such deviation, nor shall any approval by the Engineer relieve the Contractor or equipment supplier from responsibility for errors and omissions in Shop Drawings.

1.07 PRODUCT DATA

A. Product data may be submitted instead of Shop Drawings when the information required for Shop Drawings is contained in Manufacturer's standard literature.

B. Manufacturer's standard catalog data, schematic drawings and diagrams:

1. Mark each copy to identify pertinent products or models.

2. Modify drawings and diagrams to delete information which is not applicable to the work.

3. Supplement standard information to provide information specifically applicable to the work.

1.08 CERTIFICATES

A. Types of certificates required are specified in respective Specification Sections.

B. Shop tests: Provide Manufacturer's sworn reports for actual product to be incorporated in the work.

C. Laboratory tests: Provide independent testing laboratory reports for actual product to be incorporated in the work.

D. Certificates of compliance: Provide Manufacturer's sworn statement or independent testing laboratory's report for products similar to those to be incorporated in the work with information indicating compliance with specifications. Test used to show compliance shall have been made within one year of the date of submission, unless approved otherwise by the Engineer.

E. Certified drawings: Provide certified drawings from the manufacturer as required in each specification section.

F. Refer to Section 01400 for certification requirements relative to an alternative to on-site sampling and testing.

1.09 AS-BUILT DOCUMENTS

A. The Site Superintendent will keep a record of all changes approved by the owner and all field changes, including changes to lines and grades.

B. The Contractor shall maintain one current record hard copy of all Specifications, Drawings, Addenda, Change Orders and Shop Drawings at the site. The documents shall be kept current, in good order, an annotated to show all changes made during the construction process and be clearly marked “AS-BUILT Documents.” These As-Built documents shall be available for review by the Engineer during all normal working hours.

C. The Contractor shall submit to the Engineer, within 10 days after the completion of contract, one set of the above “AS-BUILT” documents containing all changes, additions or deviations from the original set of Documents that have been incorporated into the Work. The Contractor is responsible for the accuracy of these AS-BUILT documents.

D. The Engineer, within 15 days after receipt of the As-Built documents will produce a final electronic version of the As-Built documents provided by the contractor. The electronic version will be in AutoCAD 2004 or more recent version.

E. The Contractor shall include As-Built Documents in the submitted Schedule of Values.

1.10 PROGRESS PHOTOGRAPHS

A. The Contractor shall take progress photographs throughout the duration of the contract. Photographs shall be taken at weekly intervals or as may be specifically directed by the Owner.

B. Digital photographs shall be taken of each process to document status, progress, and quality. Selected color prints (4 per 8.5 x 11 page) shall be provided with monthly progress reports. Additional color prints shall be provided to the Engineer upon request.

C. Each digital photograph shall contain the date taken and formatted on an electronic file to contain a description, indicating the location, direction, and what is shown.

1.11 HASP

A. Refer to the HASP for requirements regarding environmental health and safety.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01400

QUALITY CONTROL

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The Contractor is responsible for quality control and shall establish and maintain an effective Project Quality Assurance Plan for LASO TA-73 Airport Landfill (PQAP).

B. The Construction Quality Control Plan for LASO TA-73 Airport Landfill (CQCP) shall cover all construction operations, both on site and off site and shall be keyed to the proposed construction sequence.

1.02 RELATED SECTIONS AND REQUIREMENTS

A. PQAP, November 2003.

B. CQCP, June 2005.

1.03 MATERIALS CERTIFICATION

A. For certain products, assemblies, and materials, in lieu of on-site sampling and testing procedures, the Engineer will accept from the Contractor the manufacturer's certification, with respect to the product(s) involved, upon the conditions set forth in the following paragraphs:

1. Certification shall state that the named product conforms to the Specifications and that representative samples have been sampled and tested as specified.

2. Certification shall be accompanied with a certified copy of the test results.

3. The certification shall give name and address of the manufacturer and the testing agency, the date of test, and shall set forth the means of identification which will permit field determination of the products delivered to the project as being one product covered by the certification.

4. The certification shall be duplicated with one (1) copy sent with shipment of the covered product to the Contractor and one (1) copy sent to the Engineer.

5. The Contractor shall be responsible for any additional costs for certification and for any costs of sampling and testing.

6. The Engineer reserves the right to require samples and test products to assure compliance with pertinent requirements with respect to fire certification of the products by the manufacturer thereof.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

A. The Contractor's approved PQAP and CQCP defines the minimum construction requirements to be implemented to ensure that the approved design requirements are met or exceeded. The quality assurance (QA) team will report to the Contractor's Project Manager on behalf of the Owner.

END OF SECTION

SECTION 01500

TEMPORARY FACILITIES

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. This section covers the installation, maintenance, and operation of all temporary facilities and controls at the site necessary to support the Contractor operations during the course of the Contract. These temporary facilities and controls will be removed at Contract completion, and include, but are not limited to, office trailers, haul roads, drain facilities, decontamination pads, staging areas, access controls, lighting, utilities, and janitorial services.

1.02 PROJECT SIGNS

A. The Contractor shall erect a Project sign board near the Highway 502 entrance to the site. The information on the sign board shall be protected from the weather elements and the information shall be legible at all times. The sign shall be installed at a location approved by the Engineer..

1. The Project sign shall be constructed of sturdy and moisture-resistant material.

2. The following information shall be displayed in painted black lettering, clearly visible from 100 ft:

U.S. DEPARTMENT OF ENERGY
LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILL CLOSURE

B. The Contractor shall construct and install a Project Information Board at the entrance to the Temporary Facilities Area.

1. The Project sign shall be constructed of sturdy and moisture-resistant material.

2. The following information shall be displayed in painted black lettering,
   a. Caution: Construction Area.
   b. A list containing the following telephone numbers:
      (1) 911 or other local emergency telephone numbers.
      (2) Location of nearest telephone.
      (3) DOE-LASO Security telephone number.
      (4) DOE Contracting Office Representative (COR) name and telephone number.
      (5) Contractor Project Manager name and telephone number.
   c. Primary and alternative site evacuation routes.
   d. Hospital/emergency route map with written instructions and the route highlighted.
   e. DOE “Whistle Blower Protection Notification” with applicable DOE name and telephone number (provided by DOE).
   f. Davis-Bacon wages for Los Alamos County, NM.
   g. Map showing site contamination.
   h. Equal Employment Opportunity poster.
   i. Occupational Safety and Health Administration (OSHA) poster.
   j. DOE Poster—Contractor Employee Occupational or Health Complaint form (provided by DOE).

1.03 PRECAUTIONS AGAINST WEATHER

A. During adverse weather conditions and against the possibility thereof, the Contractor shall take all necessary precautions so that the Work shall be properly done and be satisfactory in all respects. When required, protection shall be provided by use of tarpaulins, wood and building paper shelters, or other approved means.

B. During cold weather (below 40^{o} degrees Fahrenheit [F]), materials shall be preheated, if required, and the materials and adjacent structure into which they are to be incorporated shall be made and kept sufficiently warm so that a proper bond will take place and a proper curing, aging, or drying will result. Protected spaces shall be artificially heated by approved means which shall result in a moist or dry atmosphere according to the particular requirements of the work being protected. Ingredients for concrete and mortar shall be sufficiently heated so that the mixture shall be warm throughout when used.

1.04 TEMPORARY HEAT

A. If temporary heat is required for the protection of the Work, the Contractor shall provide and install heating apparatus, shall provide adequate and proper fuel, and shall maintain fires as required. Temporary heating apparatus shall be installed and operated in such manner that the finished work will not be damaged thereby. Temporary heating apparatus shall be of the types approved by local codes and ordinances governing the Work.

1.05 WATER SUPPLY

A. Water necessary for operations and fire protection will be obtained from the hydrant shown on the Drawings. The Contractor shall make all arrangements necessary to obtain water.

1.06 ELECTRICAL ENERGY

A. Suitable electrical power necessary to perform the work shall be obtained from sources at the airport, by the Contractor.

B. There shall be sufficient electric lighting, provided by the Contractor, so that all work may be properly conducted when there is not sufficient daylight in the work area.

C. The Contractor shall assume all risks of loss or damage of any kind to any vehicles, machinery, equipment, materials or supplies which it shall provide in doing the work.

1.07 SANITARY FACILITIES

A. The Contractor shall provide adequate sanitary conveniences meeting governing local and state codes and regulations for the use of those employed on the work site. Such conveniences shall be made available when the first employees arrive on the work site and shall be constructed and maintained in suitable numbers and at such points and in such manner as may be required or approved.

B. The Contractor shall maintain the sanitary facilities in a satisfactory and sanitary condition at all times and shall enforce their use. The Contractor shall rigorously prohibit the committing of nuisances on the site of the Work, on the lands of the Government, or on adjacent property.

1.08 ACCESS/CONTAMINATION CONTROL

A. As construction progresses, the Contractor shall maintain contamination control boundaries between clean areas and areas of contamination.

B. Install access-control fencing to restrict, reduce, or eliminate access by the public. Fence type(s) shall be as indicated on the drawings.

C. Contamination-control fencing around contaminated areas shall be, at a minimum, colored, plastic, safety fencing or approved equal 4-ft high. Posts and fabric shall be secure and tight at all times.

D. The Contractor shall maintain site perimeter fences, gates and signs to prevent intrusion by the general public. Maintenance includes keeping fences taut, performing all minor repairs that do not require additional materials, and placement of signs.

E. If the Contractor uncovers any archaeological or historical artifacts or bones of unknown origins during the term of the Contract, the Contractor shall immediately halt operations in the vicinity of such a discovery and immediately notify the Owner. Further work in these areas shall not resume without written authorization from the Owner.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01560

TEMPORARY CONTROLS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Safety and Protection.

B. Protection of the Public.

C. Site Control and Security.

D. Maintenance of Existing Operations.

E. Maintenance of Traffic.

F. Protection of Natural Water Courses.

G. Removal of Debris During Construction.

H. Final Cleaning.

I. Dust Control.

J. Noise Control.

K. Environmental Control.

1.02 RELATED SECTIONS AND REQUIREMENTS

A. Division 1 - General Requirements.

B. WMP.

C. HASP.

D. Storm Water Pollution Prevention Plan for LASO TA-73 Airport Landfill (SWPPP), June 2005.

E. Construction Plan for LASO TA-73 Airport Landfill.

1.03 SAFETY AND PROTECTION

A. Contractor shall be responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the work. The Contractor shall take all necessary precautions for the safety of, and shall provide the necessary protection to prevent damage, injury or loss to:

1. All employees on the work and other persons who may be affected thereby. Refer to the HASP for site safety and health procedures.

2. All the work and all materials or equipment to be incorporated therein, and any adjacent materials, equipment, or facilities, including that in storage on or off the site.

B. The Contractor shall notify owners of adjacent utilities when implementation of the work may affect them. All damage, injury or loss to any property referred to in paragraph 1.03 A.2 above caused, directly or indirectly, in whole or in part, by Contractor, any subcontractor or anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, shall be remedied by the Contractor at the Contractor's expense.

C. The Contractor shall not load or permit any part of any structure to be loaded with a weight that would endanger its safety.

D. The Contractor shall provide protection of the work from freezing and other elements, which would be harmful to it. The Contractor shall furnish heat or protective shelters or temporary buildings as required for the protection of the work.

E. The Contractor shall take all necessary precautions for the safety of employees on the work, and shall comply with all applicable provisions of Federal, state, and local safety laws and building codes, and Project requirements in order to prevent accidents or injury to persons on, about, or adjacent to the premises where the work is being performed. The Contractor shall erect and properly maintain at all times, as required by the Project and by the conditions and progress of the work, all necessary safeguards and barricades for the protection of employees on the work and the safety of others employed near the work and the public, and shall post danger signs and warning lights warning against the hazards created by dangerous features of the construction including, but not limited to, protruding nails, excavations, scaffolding, stairways, and falling materials.

F. The Contractor shall designate a responsible member of its organization on the work whose duty shall be the prevention of accidents. The name and position of the person so designated shall be reported in writing to the Owner.

G. The Contractor shall immediately report in writing to the Owner, giving full details, all serious accidents which arise out of or in connection with the performance of the work, whether on or adjacent to the site, which cause death, personal injury, or property damage. In addition, if death or serious injury or substantial property damage is caused, the accident shall be reported immediately by telephone or messenger to the Owner. If a claim is made or suit is filed by anyone against the Contractor or any subcontractor on account of any accident, the Contractor shall promptly report the facts in writing to the Owner, giving full details of the claim.

H. The Contractor shall assume all risks of loss or damage of any kind to any vehicles, machinery, equipment, materials, or supplies which it shall provide in doing the work.

I. The Contractor shall take all precautions to prevent damage to the work by the elements, storms, or by water entering the site of the work directly or through the ground. In case of damage by the elements, storm, or water, the Contractor shall make repairs or replacements or rebuild such parts of the work as the Engineer may require in order that the work may be completed by the Contract Documents. If Contractor believes that additional work done by the Contractor, which arose from causes beyond the Contractor's control, entitles him to an increase in the Contract Price or an extension of the Contract Time, he may make a claim thereof as provided herein.

J. The Contractor shall comply with all insurance requirements stated in the Contract Documents.

K. It is anticipated that the Contractor may encounter contamination while performing the work; refer to the WMP and the HASP for additional information and requirements.

1.04 PROTECTION OF THE PUBLIC

A. The Contractor shall conduct work so as to interfere as little as possible with the operating personnel of the site or those persons that may have business at the site. Wherever necessary or required, and at the Contractor's own expense, the Contractor shall maintain fences, furnish full-time or part-time watchmen, guards, and like protective personnel, maintain lights, and take such additional precautions as may be necessary to protect life and property.

1.05 SITE CONTROL AND SECURITY

A. Site control and security will be maintained at the airport project site during all activities to prevent unauthorized personnel from entering the work area and to maintain airport perimeter security requirements. Entry into and exit out of the airport and construction areas (CA) will be controlled through the appropriate use of barriers, signs, and other measures in accordance with *Code of Federal Regulations* (CFR) 29 CFR 1910.144, "Safety Color Code for Marking Physical Hazards" (CFR 2003e) and 29 CFR 1910.145, "Specifications for Accident Prevention Signs and Tags" (CFR 2003f).

B. Signs that are routinely lost because of high winds and will be replaced as soon as possible the next working day following discovery.

C. Three types of site control designations (areas) will be used to meet Hazardous Waste Operations and Emergency Response (HAZWOPER), construction, and Federal Aviation Administration (FAA) site control requirements. These areas based on the potential hazards, complexity of work tasks, duration of project tasks, location and number of non-project personnel near the project area, and to prevent entry of personnel and equipment into the obstacle-free zone (OFZ). Radiologically controlled areas are not anticipated but could be established if radioactive materials or article are encountered. The three areas are

- CAs (general CA boundary)
- Controlled work area (CWA) (established for higher hazard tasks within the CA)
- Restricted area (RA) (OFZ and other areas where entry is not permitted)

D. The existing airport perimeter fence and gates provide general security and access control. This fence will be maintained during all construction activities and access to the project CA will be controlled. Only authorized project personnel and authorized visitors (visitors must have official business on site, receive HASP orientation briefing, and have proper personal protective equipment [PPE] for the area they will access) will be allowed access to the CA. Project construction and administrative areas (field trailer) will be delineated and posted to prevent inadvertent entry by persons conducting normal airport operations or maintenance tasks.

E. All personnel are required to sign in and out of the site access log located in the field trailer.

F. Where warranted, designated traffic routes may also be established. These areas also will be posted to prevent inadvertent entry by unauthorized personnel. Project personnel will also be prohibited from entering airport operational areas (not turned over for construction activities) to minimize the impact on airport operations and to reduce the likelihood of distributing foreign objects debris (FOD) on the tarmac and taxiway.

G. The CAs at the site will be the primary activity locations (main landfill and DDA). The CA boundary will be delineated using the existing airport perimeter fence and other temporary construction fencing where deemed appropriate. All areas beyond the construction field trailer will be considered a CA for site control purposes (whether delineated and posted or not) and all training, badging, and PPE requirements apply. The primary access points to the CA will be clearly posted with “Construction Area” or similar caution signs. Only authorized personnel may enter the CA..

H. CWAs will be established to alert personnel within the CA of tasks or activities with increased hazards and to limit the number of workers and equipment in these areas. CWAs will also be used when there is a potential for exposure to site contaminants beyond the immediate work area. CWAs will control the flow of equipment and personnel through the use of established entry/exit points and traffic lanes. The boundary of the CWA may be marked with a combination of stanchions or posts and delineated with rope or ribbon and include warning signs or other demarcation. Only the minimum number of personnel required to safely perform the project tasks will be allowed into the CWA. All personnel who enter the CWA will have adequate training and wear the appropriate level of PPE for the degree and type of hazards present.

I. RAs will be established to prevent access to certain areas during the course of the project. Examples of RAs include the OFZ around the active runway, the area within 6 ft of the unprotected edge of the east slope above the Pueblo Canyon wall, and other areas designated throughout the course of the project. Entry into RAs is prohibited without authorization from the Site Safety Officer (SSO), SS, and Construction Manager. Entry will not be authorized without a compelling reason and only after other options not requiring entry have been considered and deemed not feasible by the SSO, SS and Construction Manager. If the OFZ must be entered, then coordination with airport operations personnel prior to entry is also required.

J. Additional PPE, communications equipment, and materials may be required for entry into RAs. A separate personnel control log will be maintained by the SS for entry into RAs and access will be limited to only essential personnel. Name of individuals entering along with time of entry and exit will be documented. The two-person rule (buddy system) will be required for all RA with the second person positioned immediately outside the RA and entering only when required.

1.06 MAINTENANCE OF THE EXISTING OPERATIONS

A. Airport surfaces shall be swept and washed as needed.

B. The Contractor must plan and implement construction activities to ensure daily airport operations are not impacted. Operation of the other facilities cannot be interrupted, stopped, or rerouted, unless approved by the Los Alamos County Airport Manager.

C. Failure of the Contractor to comply with the requirements of this Paragraph 1.05 will be considered a sufficient cause for the Owner to shut down the work. The Contractor will not be entitled to any extra compensation resulting from such a shutdown.

1.07 MAINTENANCE OF TRAFFIC

A. The Contractor shall carry on all work so that other site traffic will have access to all existing gravel roads, driveways, and facilities.

1.08 PROTECTION OF NATURAL WATERCOURSES

A. The Contractor shall use all care possible to prevent sedimentation and other pollution of waters during construction. Prohibited practices include, but are not limited to:

1. Dumping of soil material into streams or on stream.

2. Operating of equipment in streams.

3. Pumping of silt-laden water from trenches, containment sumps, or other excavations into streams.

4. Disposing of debris in streams and surrounding areas.

B. All erosion and sediment control work shall comply with Section 02930 of these Specifications, the Contractor's approved SWPPP and all applicable requirements of governing authorities having jurisdiction. The Contractor shall provide the necessary strawbales, silt sacks, silt fence, and/or other temporary erosion-control measures to contain all work activities. The Engineer may require additional erosion control measures should conditions warrant.

C. Erosion control measures shall be established at the beginning of construction and maintained during the entire period of construction. On-site areas that are subject to severe erosion, and off-site areas that are especially vulnerable to damage from erosion and/or sedimentation are to be identified by the Contractor and will receive special attention.

D. All land-disturbing activities are to be planned and conducted so as to minimize the size of the area to be exposed at any one time and to minimize the length of the time of exposure.

E. Surface water runoff originating upgrade of exposed areas should be controlled to reduce erosion and sediment loss during the period of exposure.

F. All land-disturbing activities are to be planned and conducted so as to minimize off-site sedimentation damage.

1.09 REMOVAL OF DEBRIS DURING CONSTRUCTION

A. During its progress, the work and the adjacent areas affected thereby, shall be kept clean and all rubbish, surplus materials, and unneeded construction equipment shall be properly removed and all damage repaired at the expense of the Contractor.

B. Airport taxiways and runways shall be kept free of debris. They will be swept or washed free of debris, as needed.

C. Where materials or debris has washed or flowed into or has been placed in watercourses, ditches, gutters, drains, catch basins, or elsewhere as a result of the Contractor's operations, such material or debris shall be entirely removed and properly disposed of during progress of the work, and the watercourses, ditches, gutters, drains, catch basins, and other facilities kept in neat, clean and functioning conditions.

1.10 FINAL CLEANING

A. On or before the completion of the work, the Contractor shall, unless otherwise directed in writing by the Owner, tear down and remove all temporary buildings and structures built by him; shall remove all temporary works, tools, and machinery or other construction equipment furnished by him; shall remove, acceptably disinfect, and cover all organic material and material containing organic matter in, under, and around privies, houses, and other buildings used by him; shall remove all rubbish from any grounds which he has occupied; and shall leave the roads and all parts of the premises and adjacent property affected by the Contractor's operations in a neat and satisfactory condition.

B. The Contractor shall restore or replace, subject to the approval of the Owner, any property damaged by the Contractor's work, equipment, or employees, to a condition at least equal to that existing immediately prior to the beginning of operations. Suitable materials, equipment, and methods shall be used for such restoration as approved by the Owner, or as required elsewhere in the Contract Documents.

1.11 DUST CONTROL

A. During the progress of the work, the Contractor shall conduct operations and maintain the area of activities so as to minimize the creation and dispersion of dust.

B. The Contractor shall control dust within the construction boundaries shown on the Drawings. Dust suppression shall include all roadways, stockpiles, and other areas.

C. Dust suppression activities shall be conducted as necessary.

D. The Contractor shall take necessary measures to eliminate dust. Visible dust is not allowed. The Contractor may use techniques that include, but are not limited to the use of a water truck and other methods described in the Contractor's Construction Plan to control dust on excavations and access roads.

E. Water for dust control sprinkling shall be clean, free of salt, oil, and other injurious materials.

1.12 NOISE CONTROL

A. Noise may not exceed 65 decibel A-weighted (dBA) at the site boundary during construction.

B. All work that would generate noise that could affect adjacent facilities is to be conducted during hours as designated by the Owner.

C. The Contractor is to review any excessively noisy activities with the Owner in sufficient time to permit a complete evaluation of the effects of such noise on the operations at the site and on adjacent facilities before the work is started.

1.13 ENVIRONMENTAL CONTROL

A. The Contractor is responsible for controlling all emissions into the environment in order to comply with all regulatory requirements.

B. Any accidental emissions must be reported in accordance with the WMP.

1.14 CONTAMINATED MATERIAL SPILLS

A. To avoid fuel spills during refueling, an assigned individual will always be present during refueling, and will be aware of the location and operation of the shut-off valve of the fuel tanker. Small equipment such as generators or pumps will be placed over bermed heavy mil plastic. If refueling spills or leaks occur, the bermed plastic will contain the pollutants until proper cleanup and disposal. Drip pans may also be used for refueling, or for placement under equipment that is leaking or has the potential to leak.

B. A spill kit containing a first aid kit, airhorn, PPE for cleanup activities, shovel, leather gloves, and appropriate absorbents (e.g., pillows, tubes, sand or vermiculite, pads, paper towels, etc.) will be readily available to control and contain spills. Site personnel will be trained in the use of the spill kit and in spill notification procedures.

C. Spills of non-petroleum products (e.g., fertilizers) will be minimized by proper handling of containers. To the extent possible, transfer of material from large storage containers to small application containers will occur at the materials storage area.

D. The SS shall report all spills or unauthorized discharges, regardless of amount, to the Contractor's Project Manager, the Contractor's Construction Manager, and the LANL Office of Emergency Management Response (S-8). Refer to the WMP for notification phone numbers. This notification will occur as soon as possible after the discharge, but in no event more that 24 hours after the discharge. The following information will be reported:

- The name, address, and telephone number of the person or persons in charge of the facility, as well as the owner or operator of the facility
- The name and address of the facility
- The date, time, location, and duration of the discharge
- The source and cause of discharge
- A description of the discharge, including its chemical composition
- The estimated volume of the discharge
- Actions taken to mitigate immediate damage from the discharge

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01600

MATERIALS AND EQUIPMENT, PRODUCT OPTIONS, AND SUBSTITUTIONS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. General Material and Equipment Requirements.

B. Procedures for Substitutions.

1.02 RELATED SECTIONS AND REQUIREMENTS

A. Division 1 - General Requirements.

1.03 GENERAL MATERIAL AND EQUIPMENT REQUIREMENTS

A. Unless otherwise indicated on the Drawings or Specifications, only new materials and equipment shall be incorporated in the work. All materials and equipment furnished by the Contractor, or equipment supplier as appropriate, to be incorporated in the work shall be subject to the inspection and approval of the Engineer. No material shall be processed for, fabricated for, or delivered to the work without prior approval of the Engineer.

B. For the purpose of indicating the standards of type, quality, design, and performance of materials and equipment to be provided under this contract, various materials and equipment are named in the Contract Documents, as commercial brands or equal.

C. The manufacturer(s) named are listed as the approved vendor, or equipment supplier if appropriate, in preparing the Bid. The list is based on the Engineer’s knowledge of or experience with the various manufacturers and does not represent that the manufacturers listed will meet the detailed requirements of the Specification. It is the responsibility of the Contractor, or equipment supplier if appropriate, in preparing the Bid to inform and be satisfied that the manufacturer selected for each item of equipment or material will meet the detailed requirements of the Contract Documents, whether the manufacturer selected is one of the named manufacturers or not.

1.04 PRODUCT OPTIONS AND SUBSTITUTIONS

A. The Contract Documents have been prepared using particular items of equipment and material in order to provide a complete set of plans and specifications. These are the materials and manufacturer that will not be substituted unless approved by the Engineer. As-Built drawings shall be maintained by the installing contractor showing the materials actually installed.

B. The following procedures will be followed relative to substitutions:

1. The General Contractor as part of the Bid shall submit a list of requested and approved substitutions which shall be accompanied by the following information:

a. Catalog cuts of the proposed equipment.

b. Other drawings and manufacturer's information as necessary to fully describe the equipment or material as intended for its specific use in this project.

c. For major equipment that is an integral part of the process, the submittal shall include a letter from the manufacturer certifying that the recommended substitution will meet the performance requirements for that piece of equipment.

d. Identification of changes required in the installation of the substituted equipment or material compared to the information presented in the Contract Documents.

2. The Engineer shall briefly review the requested substitution and determine the acceptability of the substituted equipment or material. This brief review will not relieve the Contractor of the responsibility for the proper functioning of the equipment or material. The Engineer will retain the right of final decision as to the acceptability of the substitution.

3. Substitutions cannot be made after the contract has been awarded without approval of the Engineer.

4. The Contractor will maintain accurate "As-Built" drawings showing the equipment or materials as actually installed.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01700

CONTRACT CLOSEOUT

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Closeout Procedures.

B. Final Cleaning.

C. Project Record Documents.

D. Warranties.

1.02 RELATED SECTIONS

A. Division 1 - General Requirements.

B. PMP.

1.03 CLOSEOUT PROCEDURES

A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and that Work is complete in accordance with Contract Documents and ready for inspection by the Owner.

B. Submit final Application for Payment identifying total adjusted Contract Sum, previous payments, and sum remaining due.

1.04 FINAL CLEANING

A. Execute final cleaning prior to final inspection.

B. Clean interior and exterior surfaces exposed to view.

C. Clean site, sweep paved areas, rake clean landscaped surfaces.

D. Remove waste and surplus materials, rubbish, and construction facilities from the site.

1.05 PROJECT RECORD DOCUMENTS

A. Maintain on-site, one set of the following record documents; record actual revisions to the Work:

1. Contract Drawings.
2. Specifications.
3. Written or verbal instructions.
4. Modifications to the Contract.
5. Reviewed shop drawings, product data, and samples.

B. Store Record Documents separate from documents used for construction.

C. Record information concurrent with construction progress.

D. Specifications: Legibly mark and record at each product section description of actual products installed, including the following:

1. Manufacturer's name and product model and number.

2. Product substitutions or alternates utilized.

3. Changes made by Addenda and Modifications.

E. Record Documents, As-Built Drawings, and Shop Drawings: Legibly mark each item to record actual construction including:

1. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the Work.

2. Field changes of dimension and detail.

3. Details not on original Contract Drawings.

F. Submit documents to the Owner with claim for final Application for Payment.

1.06 WARRANTIES

A. Provide notarized copies.

B. Execute and assemble documents from Subcontractors, suppliers, and manufacturers.

C. Provide Table of Contents and assemble in a ring binder with durable plastic cover.

D. Submit prior to final Application for Payment.

E. For items of Work delayed beyond date of Substantial Completion, provide updated submittal within 10 days after acceptance, listing date of acceptance as start of warranty period.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

DIVISION 2

SITE WORK

SECTION 02005

SURVEYING

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The work to be performed under this section shall include:

1. Project as-built surveys as required herein and elsewhere in the Technical Specification.

2. Surveys during the life of the project as directed by the Engineer, and surveys required to measure the quantities of completed work for determining the value of partial payments as described in other sections of these Specifications.

3. Pre-construction and construction topographic surveys.

B. The survey work shall be performed under the direction of a Land Surveyor registered in the State of New Mexico who shall be subcontracted by the Contractor for the life of the Contract to perform the QA survey work to be performed under this item. The Contractor's QA Surveyor shall be independent from the Contractor and approved by the Engineer. Topographic, cross-sectional, and grade verification surveys will include the development by the QA Surveyor of topographic drawings for the use by the Engineer in verifying field conditions, measurement of quantities, and adjusting the design as necessary.

1.02 RELATED SECTIONS AND REQUIREMNTS

A. CQCP.

B. Construction Plan for LASO TA-73 Airport Landfill.

1.03 SUBMITTALS

A. Prior to commencement of work under this item, the Contractor shall submit the name, address, and telephone number of the QA Surveyor that will perform this work on the Project.

B. The Contractor shall organize the placement of the components of the landfill cover systems into manageable areas of work. The Contractor shall submit to the Engineer the pre-construction surveys before commencing excavation, fill placement, or cover system work. Additional topographic surveys of the completed work shall be submitted with each payment request and shall be a condition precedent to the Engineer's approval of the Contractor's request for partial payment. Topographic surveys and as-built surveys to be developed include the following:

1. Pre-construction topographic survey plan shall depict the existing conditions within the limits of work prior to earth disturbance at both the DDA and main landfill.

2. The Contractor, at a minimum, shall also prepare construction topographic and as-built surveys for each of the following surfaces as shown on the Contract Drawings and described in the Technical Specifications.

(a) Existing topography of the main landfill, including locations and elevations of any existing structure on the landfill.

(b) Subgrade surface after removal of existing interim cover material (main landfill).

(c) Subgrade surface on east slope of landfill clearly showing the areal extent of resistant material (bedrock). To be submitted immediately upon removal of waste from the slope.

(d) The top surface of the relocated interim cover material (main landfill).

(e) The top surface of the infiltration layer (main landfill)

(f) Top surface of the aggregate base course.

(g) The final grade surface (main landfill and DDA).

(h) Horizontal alignment and top and bottom of all retaining walls.

3. The Contractor shall, at a minimum, prepare construction topographic surveys for other areas within the limit of work (but beyond the landfill surface) for each of the following surfaces as shown on the Drawings and described in the Technical Specifications:

(a) The final grades of all permanent stormwater management structures (to include all related pipe locations, sizes, and invert elevations).

4. The coordinate system requirements for deliverables are North American Datum 83 and North American Vertical Datum 088.

5. All topographic survey plans shall be prepared at a scale of 1 in. = 30 ft with a 2- ft contour interval applying National Map Standards, unless otherwise directed by the Engineer.

D. The Contractor shall compile all topographic surveys performed for work during the course of the Contract into composite plans for the respective surfaces of each area surveyed. The composite plans shall be prepared at a scale of 1 in. = 30 ft with 2-ft contour intervals (with spot elevations at all tops and toes of slopes) and shall be submitted to the Engineer no later than 15 working days after the scheduled completion date for the Construction.

E. For all work under this item, the Contractor shall submit disk copies of the topographic survey plans in AutoCAD 2004 (or latest version) format with executable files along with two (2) prints for each survey plan required.

F. The Engineer reserves the right to require the submittal of copies of any or all survey field notes from the Contractor.

G. Tolerance on construction shall be ±0.15 ft every 100 ft with no compounding of tolerance except for asphalt and concrete surface which shall have a tolerance of ±0.10 ft every 100 ft with no compounding of tolerance . All minimum and maximum slopes shall be maintained.

PART 2 MATERIALS

Not Applicable.

PART 3 EXECUTION

3.01 SURVEYING

A. The Contractor shall locate, protect, and verify survey control points established from local elevation and coordinate datum prior to starting site work and preserve these points during construction. These controls will be permanent monuments used throughout construction and post-construction for any needed topographic, radial stakeout, and benchmark elevations. The Contractor shall promptly report to the Engineer lost, relocated or destroyed control points. The Contractor shall maintain complete and accurate field notes for all control points and survey points as work progresses.

B. The Contractor shall perform and update the as-built surveys throughout the life of the Contract as necessary and at the end of the project.

C. For all survey work, survey points shall be obtained using a 50-ft grid. Additional points shall be surveyed at toe and top of slopes and as necessary to provide accurate topography in areas where slopes vary between the above noted grid points. All point elevations shall be accurate to a tenth of a foot. All pipe invert elevations shall be accurate to a hundredth of a foot.

D. Initial Staking will include angle points for fence relocation at the northeast end of the main landfill and centerline cut and fills for proposed access routes.

E. Upon completion of survey work the Contractor shall submit to the Engineer the deliverables (including plans, drawings, electronic disks, and survey notes), in accordance with subsection 1.02.

F. All deliverables under this item shall be signed and sealed by the QA Surveyor.

END OF SECTION

SECTION 02100

CLEARING AND STRIPPING

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The work to be performed under this Section includes all requirements for the clearing and stripping of all areas within the Contract Limit of Work in accordance with the Documents.

1.02 DEFINITIONS

A. Clearing is the removal from the ground surface and disposal, within the contract limit of disturbance, of brush, shrubs, other vegetation, rubbish, and debris (natural and man-made).

B. Stripping is the removal and stockpiling, within the contract limit of disturbance or as provided for by the Engineer, of all topsoils and cover soils that are above the limits of waste including matted roots, and organic materials.

PART 2 MATERIALS

Not Applicable.

PART 3 EXECUTION

3.01 GENERAL

A. Do not start earthwork operations in areas where clearing and stripping is not complete. Comply with erosion, sediment control, and storm management measures specified in the SWPPP and Section 02930 (Erosion and Sediment Control).

3.02 CLEARING

A. Clear all items to the limits necessary to perform construction activities and shred all cleared and grubbed material for use in topsoil applications. The Contractor is responsible to dispose of cleared and grubbed materials in accordance with State and Federal guidelines.

B. Burning of any material shall not be permitted on the Site.

3.03 STRIPPING

A. Cut existing vegetation on the main landfill as close to the existing ground surface as possible. Remove material from the ground surface and use it as mulch for temporary stabilization.

B. Disk the first 6 to 8 in. of cover soils, including stubble vegetation. Thoroughly mix the soils with the vegetative matter.

C. Remove the completed disked material and stockpile as topsoil.

D. Do not over excavate the topsoil material.

E. Assure the topsoil is segregated from the waste and cover soils.

END OF SECTION

SECTION 02200

EARTHWORK

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The work to be performed under this section includes requirements for excavation; subgrade preparation; placement and compaction of structural fill and other soil or aggregate materials, including low-permeability soil; grading; items associated with the backfilling of pipe/utility trenches; filling for roads, channels, etc. as required; and performing laboratory and field testing of earthwork materials, as shown on the Drawings or as directed by the Engineer. The work shall also include completing up to 5 geotechnical test borings along the alignment of Wall No.1.

1.02 RELATED SECTIONS AND REFERENCES

A. Section 02100 – Clearing and Stripping

B. Section 02270 – Channel Protection

C. Section 02750 – Stormwater Management and Discharge

D. Section 02930 – Erosion and Sediment Control

E. SWPPP, June 2005.

F. CQCP, June 2005.

G. Construction Plan for LASO TA-73 Airport Landfill, June 2005.

H. New Mexico Department of Transportation (NMDOT) Specifications for Highway and Bridge Construction, 2000 Edition.

1.03 DEFINITIONS

A. Definitions pertinent to the earthwork requirements of this project include:

1. <u>Existing/Relocated Interim Cover Material</u> – on-site soil suitable for backfilling pipe trenches and associated in-line structures and for use in backfilling areas from which waste was removed.

2. <u>Structural fill</u> – suitable imported soil/aggregate used for wall backfill.

3. <u>Common borrow</u> – suitable soils meeting the material requirements specified herein and provided from locations within the limits of the site property. Common borrow, to the greatest extent practicable, within the limits of construction methods, engineering judgment and design and in accordance with these Specifications shall be used for site construction.

4. <u>Foreign borrow</u> – suitable material meeting the material requirements specified herein and provided from sources outside the limits of the site property. Foreign borrow will be used to supplement common borrow material as needed.

5. Infiltration layer soils – defined as foreign borrow, suitable material meeting the requirements specified herein, and infiltration layer soil for use within the main landfill cover system shall be common borrow, environmentally-clean and free of organic material, frozen material, wood, or foreign trash, or other objectionable materials which may be decomposable, compressible, or which cannot be properly compacted, shall not contain recycled materials.

6. Topsoil – suitable material meeting the material requirements specified herein; and provided from sources within or outside the limits of the site property.

7. Unsuitable material – unsuitable material not meeting the requirements set forth herein for fill materials or as otherwise determined by the Engineer to be inappropriate and/or unacceptable for use. Unsuitable material shall be disposed of by the Contractor in the main landfill.

8. Environmentally-clean – soil purchased from commercially available sources shall be certified to be free of chemical contaminants by the seller. The Engineer reserves the right to require additional chemical testing by the Contractor, at no cost to the Engineer, of proposed foreign borrow material to verify its environmental cleanliness should the borrow site history suggest the possible presence of contamination. The Engineer also reserves the right to inspect the foreign borrow site at any time prior to or during construction activities.

9. Noncalcareous – soil or aggregate that, when tested in accordance with ASTM D3042 for soils and ASTM D4373 for aggregates, possesses no more than a 5% loss of weight (dry basis) for aggregates or a maximum carbonate content of 15%.

10. Subgrade – excavation bottom or existing grade, as specified herein, prepared to receive soil fill or aggregate materials.

1.04 QUALITY CONTROL

A. General

1. Unless otherwise indicated, all laboratory and field testing shall be performed by an independent geotechnical testing laboratory (GTL) employed by the Contractor, with test materials furnished by the Contractor under the direction of the Engineer. The GTL proposed by the Contractor shall be reviewed and approved by the Engineer. The laboratory shall, at a minimum, be in compliance with ASTM D3740 Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rocks as Used in Engineering Design and Construction.

2. The Contractor shall test materials as set forth in the applicable referenced sections and as required herein.

B. Preconstruction Material Testing Requirements

1. The Contractor shall arrange for an inspection by the Engineer of each proposed foreign and common borrow source prior to the commencement of earthwork operations. During said inspection, the Contractor shall provide any equipment necessary to excavate test pits throughout the limits of the proposed source so as to provide the Engineer with a thorough inspection of the type(s) and uniformity of material(s) throughout the proposed source. Upon the Engineer's visual inspection and preliminary acceptance of a proposed borrow source, the Contractor shall collect representative samples of the borrow soils for

subsequent geotechnical testing in accordance with Table 02200-1 and as directed by the Engineer.

2. The Contractor is required to submit representative samples of each proposed foreign and common borrow material to the GTL at the minimum frequencies specified in Table 02200-1. The physical property tests shall be completed for each sample and the material approved prior to use of the material at the site. The Contractor shall complete all testing on infiltration layer materials prior to delivery to the site at the frequency specified in Table 02200-1. Infiltration layer material must be pre-approved prior to delivery to the site. Additional quality control testing will be performed on samples of delivered material. If, during the course of construction, an alternative borrow source is used, the material must be pre-approved by the Engineer in accordance with the requirements of this Specification prior to delivery to the site.

3. When a material is approved for use as infiltration layer soil, additional testing shall be performed in accordance with Table 02200-1 to correlate acceptable in-place compactive effort and moisture content to required permeability properties. The resulting lab data shall be used to develop a window within which the degree of compaction and moisture content of the tested in-place soil should fall. By doing so, a reasonable level of assurance can be expected that permeability of the in-place soil will meet the regulatory requirements for hydraulic conductivity.

4. The results of this preconstruction testing program shall be submitted to the Engineer for approval at least two (2) weeks before use of these soils at the site. These test results may be applied toward the test frequency requirements. Physical specimens of all proposed foreign borrow materials shall also be submitted to the Engineer, if requested. The Engineer shall have the authority to reject any and all soils that are believed to be inappropriate for earthwork construction.

5. The frequency of conformance testing of each approved soil material shall be in accordance with Table 02200-1 or at anytime that a significant change in physical properties of the proposed fill materials is observed by the GTL or the Engineer. The results of this on-going conformance testing shall be reviewed and approved by the Engineer prior to use of that material for which the testing was completed.

Table 02200-1
Material Quality Control
*Minimum Preconstruction Testing Requirements

Property	Test Method	Fill Materials[3] Frequency	Infiltration Layer Frequency	Topsoil Frequency
Particle Size Analysis w/Hydrometer[1]	ASTM D421/D422	10,000CY	5,000CY	5,000 CY
Atterberg Limits	ASTM D4318	10,000 CY	5,000CY	---------
Organic Content	ASTM D2974	10,000 CY	---------	5,000 CY
Moisture Content	ASTM D2216	10,000 CY	5,000CY	5,000 CY
Standard Proctor Compaction	ASTM D698	10,000 CY	5,000CY	---------
Permeability[2]	ASTM D5084	---------	5,000CY	---------
pH	ASTM D4972	---------	---------	5,000 CY
Nitrogen (TKN)	EPA 351.3	---------	---------	5,000 CY
Phosphorus, Orthophosphate (as P)	EPA 9056A	---------	---------	5,000 CY

[1]Provide USCS designations for Structural Fill/Common Borrow/Foreign Borrow and Infiltration Layer samples and USDA classification for topsoil samples.
[2]Permeability tests for infiltration layer soil shall be conducted on remolded samples compacted to 95% degree of compaction as determined from ASTM D698 within -1% to +2% of optimum moisture content. The permeability test shall be performed under a confining stress of between 0.5 and 2.0 psi, with the lowest value being preferred and a hydraulic gradient of 1.0.
[3]Fill materials include Structural Fill, Common Borrow and Foreign Borrow.
[4]Testing frequency requirements for imported materials obtained from a NMDOT certified source may be reduced by the Engineer based on review of historical records for material produced by the source.

Preconstruction
Minimum Testing Acceptance Criteria

Property	Test Method	Fill Materials[1]	Infiltration Layer	Topsoil
Particle Size Analysis w/Hydrometer	ASTM D421/D422	See 2.01.A.2.e	---------	---------
Atterberg Limits	ASTM D4318	LL ≤ 40; PI ≤ 12	---------	---------
Organic Content	ASTM D2974	≤ 6%	---------	> 5%
Standard Proctor Compaction	ASTM D698	Dry density [2] ≥ 105 pcf	---------	---------
Permeability	ASTM D5084	---------	K $\leq 1 \times 10^{-5}$ cm/s	---------
pH	ASTM D4972	---------	---------	5.5 – 7.6
USDA Classification	Via ASTM D421/D422	---------	---------	Sandy loam, loam, silty loam, sandy clay loam
Nitrogen (TKN)	EPA 351.3	---------	---------	None; used to guide amendment
Phosphorus, Orthophosphate (as P)	EPA 9056A	---------	---------	None; used to guide amendment

[1]Fill materials include Structural Fill, Common Borrow and Foreign Borrow.
[2]Maximum dry density for structural fill used behind retaining walls shall be at least 110 pcf.

C. Field Quality Control Testing Requirements

1. The Contractor shall provide all horizontal and vertical controls necessary for all earthworks as well as associated grid layout and staking using benchmarks and monuments, if any, shown on the Drawings and required by these Specifications.

2. Placing soil material and performing earthworks will be subject to periodic QA inspection by the Engineer. The GTL shall provide continuous quality control (QC) inspection including field moisture and density tests during the compaction of each lift of soil in accordance with Table 02200-2. The Contractor shall also provide labor and equipment to prepare smooth surface spot locations as designated by the independent GTL or the Engineer on which to perform field tests.

Table 02200-2
Field Quality Control
Minimum Testing Requirements

Property	Test Method	Fill Materials[1] Frequency	Infiltration Layer Frequency
Field Dry Density	ASTM D2922	10,000 SF	2/Ac/Lift
Field Moisture Content	ASTM D3017	10,000 SF	2/Ac/Lift
Particle Size Analysis (Sieve only)	ASTM D421/422	---------	2500 CY
Standard Proctor	ASTM D698	---------	5000 CY

[1]Fill materials include Structural Fill, Common Borrow and Foreign Borrow.

Field Quality Control
Minimum Testing Acceptance Criteria

Property	Test Method	Fill Materials[1]	Infiltration Layer
Field Dry Density	ASTM D2922	98% Standard Proctor	95% Standard Proctor[1]
Field Moisture Content	ASTM D3017	± 3% Optimum	-1 to +2% Optimum[1]
Particle Size Analysis (Sieve Only)	ASTM D421/422	---------	Range to be determined[2]

[1]Fill materials include Structural Fill, Common Borrow and Foreign Borrow.
[2]Acceptable range will be established upon completion of preconstruction testing.

3. Following the placement and compaction of each lift of soil, said lift shall be tested to determine the in-place compacted dry density and moisture content of the in-place soils, and to determine conformance of these data with the project specifications, before subsequent lifts are placed. The testing results from the infiltration layer shall also show that in-place density and moisture content fall within the permeability window determined for the infiltration layer soils as described in Subsection 1.04.B.3. Tests outside of the window shall be considered failing unless otherwise approved by the Engineer. Deficient areas shall be recompacted in accordance with approved techniques as stated herein.

   The GTL shall perform in-place field density and moisture tests of each compacted lift in accordance with the following approved methods:

   a. ASTM D2922 and D3017 (Moisture Content and Density of Soil and Soil-Aggregate in Place by Nuclear Methods). The direct transmission method shall be used unless otherwise directed by the Engineer.

4. For each placed lift, one field moisture-density test shall be performed by the GTL for each 100 lineal ft of trench backfill and narrow above-grade fills, for every 10,000 square feet (ft^2) of structural fill/common fill soil and 2 every AC of infiltration layer soil placed and compacted. The field moisture-density testing frequency shall be increased, if deemed necessary by the Engineer.

5. Any test resulting in penetration of the infiltration soil layer shall be repaired using granular or powdered bentonite.

1.05 SUBMITTALS

A. Delivery Tickets

1. Delivery tickets showing the following information with each load of foreign borrow fill material used shall be submitted to the SS:

   a. Location of borrow source.

   b. Name and location of supplier.

   c. Type and amount of material delivered.

B. Certified Test Reports

1. The Contractor shall submit to the Engineer the source, estimated quantity, and testing results of all soil material to be used. Acceptance of the soil material from any location shall not be construed as approval of an entire location, but only insofar as the soil material continues to meet the Specification requirements.

2. The Contractor shall submit two (2) certified copies of each report of laboratory test results to the Engineer at least two (2) weeks before use of any soil materials.

3. The Contractor shall submit Certificates of Compliance in accordance with Section 01340 for soil and aggregate materials stating that the materials are environmentally-clean and satisfy all material requirements of these Specifications.

PART 2 MATERIALS

2.01 SOIL MATERIALS

A. Existing/Relocated Interim Cover Material

1. Existing/Relocated Interim Cover Material shall be approved common or foreign borrow material consisting of soil having a uniform mixture of durable natural materials. Common borrow generated by site excavation activities required to achieve design subgrade elevations shall be used as fill to the maximum extent possible.

2. Fill soil generated from site excavation activities shall be environmentally-clean, and free of frozen material, wood, trash, or other objectionable materials which may be decomposable, compressible or which cannot be properly compacted, shall not contain any recycled materials, and:

   a. Shall classify as SC, SM, SW, ML, CL, or CL-ML according to the Unified Soil Classification System (USCS), unless otherwise specified herein or approved by the Engineer for use to construct a specific work element. Fill shall not be gap-graded or uniformly graded, as determined by the Engineer.

b. Liquid limit shall not exceed 40 and plasticity index shall not exceed 12.

c. Material shall have a uniformity coefficient, (C_u) greater than 6.

d. Material shall have a coefficient of gradation, (C_c) between 1 and 3.

e. Material shall not contain particles larger than:

- 2 in. for trench backfill.
- 1 in. for the 12-in. lift of fill soil adjacent to any geosynthetic materials.
- 4 in. for fill used in embankment or other fills.

f. Material shall have a maximum dry density of not less than 105 pounds per cubic foot (pcf) as determined by ASTM D698.

3. Common borrow shall be screened and otherwise processed by the Contractor as required to achieve the maximum particle size specified.

4. Fill shall have physical properties which permit its ready spreading and compacting and minimize particle segregation.

5. Snow, ice, and frozen soil shall be strictly excluded from structural fill materials.

6. The moisture content of soils being placed as fill shall be near optimum conditions so as to provide the specified compaction and ensure a stable embankment.

7. Recycled materials shall be unacceptable for use as fill.

8. Foreign borrow may be used to augment common borrow providing the requirements specified herein are satisfied.

B. Infiltration Layer

1. Infiltration Layer soil for use within the main landfill cover system shall be foreign borrow, environmentally-clean and free of organic material, frozen material, wood, or foreign trash, or other objectionable materials which may be decomposable, compressible, or which cannot be properly compacted, shall not contain recycled materials, and shall satisfy the following:

a. Maximum particle size of 1.5 in.

b. Maximum permeability of $1x10^{-5}$ centimeters per second (cm/sec) when compacted to at least 95% of its maximum dry density (ASTM D698) at a moisture content between -1% and +2% wet of its optimum moisture content under a confining stress of 2 psi, unless otherwise approved by the Engineer. (Permeability testing shall be completed under the lowest normal stress that can be reliability maintained by the laboratory test apparatus.)

C. Topsoil

1. Topsoil shall be sandy loam, silty loam, or sandy clay loam as classified by the United States Department of Agriculture (USDA). Gradation analysis (sieve and hydrometer; ASTM D421/422) shall be completed to allow proper USDA classification of the material. Topsoil shall be fertile and friable surface soil of good and uniform quality. Topsoil shall not contain subsoil materials. Topsoil shall be free of refuse, hard clods, woody vegetation, stiff clay, construction debris, boulders, stones larger than 2 in., hydrocarbons, petroleum materials or chemicals toxic to plants, other miscellaneous or otherwise unstable or undesirable materials, and other deleterious inclusions. Testing of topsoil shall be at the frequencies shown on Table 02200-1.

2. Topsoil shall have a minimum organic content of 1% by weight. The organic content of soils shall be determined by the Engineer-approved laboratory utilizing the method described in the ASTM D2974.

3. Topsoil shall have a pH value within a range of 5.5 to 7.6.

4. Apply slow release fertilizers to minimize deficiencies in topsoil, based on prequalification testing results. Organic fertilizers such as Biosol Mix, Biosol, Osmocote, composted manure or other products approved by the Engineer or his designee may be used. If composted manure is to be applied, test the nutrient content and interpret before it is used. If wood chips are used, chips shall have a relatively large surface area to volume ratio to be more easily broken down in the soil. Incorporate wood chips at low rates (0.5 ton/ AC) in order to assure the Carbon to Nitrogen ratio in soil is at favorable conditions for plant germination and growth. If higher rates are used, add nitrogen fertilizer to assure nutrient availability to plants.

2.02 BEDDING MATERIALS

A. Aggregate Bedding for gas collection pipes located within the limit of waste and below the paved surface shall meet the requirements for Aggregate Base Course.

B. Bedding for gas collection pipes located within the limit of waste but beyond the paved surface shall meet the requirements for Infiltration Layer material.

C. Aggregate Bedding for storm drain pipes and precast and cast-in-place concrete structures shall be noncalcareous aggregate meeting the requirements of NMDOT Section 304.21 for Class OGBC (open-graded base course) unless otherwise recommended by the manufacturer. Slag will not be permitted.

2.03 AGGREGATE BASE COURSE

A. Aggregate base course shall be noncalcareous aggregate meeting the requirements of NMDOT Section 304.21 for Class I Base Course or as otherwise may be required to satisfy the design requirements for the support of the MatCon™ pavement.

2.04 STRUCTURAL FILL

A. Structural Fill used as backfill for the reinforced concrete wall (Wall No.1) shall be noncalcareous aggregate meeting the requirements of NMDOT Section 304.21 for Class I Base Course.

B. Structural Fill used as backfill for the mechanically stabilized earth retaining wall (Wall Nos. 2, 3 and 4) shall be noncalcareous aggregate meeting the requirements of NMDOT Section 304.21 for Class I Base Course unless otherwise specified by the wall design or reinforcement material manufacturer.

PART 3 EXECUTION

3.01 EXCAVATION

A. General

1. Excavations shall be completed to the lines and grades indicated on the Drawings and as required in these Specifications. It shall be the Contractor's responsibility to separate and protect excavated material that is suitable for reuse (i.e., common borrow) from contamination by unsuitable excavated material or other sources. Determination of suitable material shall be preliminarily based on visual observations by the Contractor with concurrence by the Engineer. Final determination of suitable material shall be based on the results of the specified testing program and/or the professional judgment of the Engineer. The Contractor shall make his own determinations relative to subsurface conditions within the vicinity of the landfill and any areas that may yield suitable common borrow materials.

2. The Contractor shall maintain all excavation and fill operations free of water by ditching, sumps, pumping, or other methods approved by the Engineer. Each layer of fill material shall be placed so that the surface is free-draining. Runoff and other water shall be conveyed in ditches and channels to the site perimeter stormwater management system as specified herein.

B. Removal and Placement of Excess and Unsuitable Soil Materials

1. Excess soil materials generated by site excavations, and materials deemed unsuitable by the Engineer which are encountered either beneath, contiguous to or within the proposed limits of excavation or fill placement, shall be removed, transported to, and placed at a stockpile area and kept separate from other soil materials. Unsuitable materials shall be placed within the landfill.

2. Excess (but otherwise suitable) soil materials shall be segregated from and not contaminated with unsuitable soil materials.

3. Excavated boulders and other inert oversized material shall be handled as specified in Section 02266.

C. Unauthorized Excavation

1. Where unauthorized excavations are made below indicated elevations under channels, footings, pipes, structures, or outside trench limits, restore the area to proper elevations with structural fill materials that are placed and compacted, as specified herein, at no additional cost to the Engineer.

D Sheeting, Shoring, And Bracing

1. Method, design and adequacy of all temporary sheeting, shoring, and bracing systems, when applicable, shall meet the requirements of OSHA 29 CFR Part 1926 and are the responsibility of the Contractor. All damage related to or caused by improperly designed or constructed retention systems shall be repaired by the

Contractor. The design and method of the sheeting, shoring, and bracing shall provide means for its removal as backfill progresses, unless otherwise indicated on the Drawings or directed by the Engineer.

2. Provide sheeting and shoring or other appropriate retention measures as required to ensure safe working conditions; maintain required excavation dimensions for proper construction; and to prevent accidents, cave-ins, and damage to adjacent structures, facilities, and surfaces.

3. Sheeting, shoring, and bracing shall be placed so as not to interfere with the construction and shall be entirely independent of all footings, pipes, and structures.

4. Remove sheeting, shoring, bracing, and all forms concurrently with backfilling operations. Such removal shall be accomplished in a manner that precludes settlement of the backfill, cave-in of the excavation sides, and prevents damage to adjacent surfaces. Voids left or caused by the removal shall be promptly filled.

E. Trench Excavation

1. Excavate trenches, when required, to the width and depth dimensions indicated on the Drawings. Provide uniform, continuous support for pipe or structure on required bedding. Remove rock, when encountered, to a minimum depth of 6 in. below the pipe and to the same depth below the bell. In general, the trench bottom shall be excavated to conform to the shape and dimensions of the proposed pipe or structure. If the shape of the trench cannot be preserved or the trench varies from the shape of the structures, the space between the desired trench dimensions and the bottom of the excavation, as made, shall be filled with compacted aggregate backfill. Allowance shall be made for the placement of granular bedding, where specified. Materials at the bottom of the trench deemed unsuitable by the Engineer shall be removed and replaced with compacted aggregate backfill. Depth and width of removal shall be as directed by the Engineer. Damage caused to existing facilities by the Contractor's operations shall be repaired or replaced at no expense to the Engineer.

2. Unless otherwise specified herein or authorized by the Engineer, trench excavation shall proceed no more than 300 ft in advance of the placing of backfill. The Engineer may require backfilling and subsequent re-excavation of trenches left open for an unreasonable amount of time in advance of pipe installation. Trenches left open overnight, or during periods when the Contractor's forces are not present, shall be so protected or enclosed and appropriately marked as to cause no danger to the public or others.

3. Sides of trenches from a point 1 ft above the top of the pipe to the bottom of the trench shall be practically plumb. Bell holes, if required, shall be excavated in the bottom of the trench wherever necessary to permit the proper assembling of joints.

F. Excavation for Cast-in-Place Reinforced Concrete Wall

1. Excavation for the cast-in-place reinforced concrete wall shall be to the lines and grades shown on the Drawings. All over-burden soils, waste material and miscellaneous debris shall be removed from within the limits of the excavation. The excavation shall be extended to depths such that the bottom of the wall footing bears at least 2 feet below the surface of competent bedrock. If the excavation must be extended to greater depths to achieve 2 feet embedment into competent bedrock, the over-excavated portion of the trench shall be backfilled with lean concrete. The

lean concrete shall be tied to the bedrock and to the wall footing with appropriately sized and spaced reinforcing bars.

2. Excavation into bedrock shall be stepped as necessary to achieve the minimum required embedment depth.

3. The use of hydraulic hammers may be required to complete rock excavation. Blasting is not permitted.

3.02 FILL AND BACKFILL CONSTRUCTION

A General

1. Excavations shall be backfilled with Existing/Relocated Interim Cover Material, other Common Borrow approved for use by the Engineer, or Aggregate Base Course

2. Backfill around a structure or pipe shall be brought up evenly on all sides so that no unbalanced pressure shall be imposed on the structure or pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of all pipes. Extra attention shall be paid to the compaction of fill under the haunches when entering and exiting manholes. After the bedding material has been placed and compacted, the remainder of the excavation shall be backfilled with suitable Existing/Interim Cover Material.

3. Do not place, spread, or compact fill material or backfill material while it is frozen or thawing; or place upon frozen or thawing ground; or during unfavorable weather conditions. When the Work is interrupted by rain, fill operations shall not be resumed until field tests indicate that the water content and density of the exposed fill are within the limits specified. A compacted layer that has been rained on or frozen shall be removed, reworked, or recompacted by a method approved by the Engineer before the next layer is placed thereon.

4. Thoroughly mix each lift before compaction to ensure uniform distribution of water content. Distribute particles of permissible sizes throughout the fill material.

5. Placement of soil materials on underlying geosynthetics shall not proceed at an ambient temperature below 32°F or above 104°F, unless otherwise specified or approved by the Engineer. Equipment used for placing soil shall not be driven directly on the underlying geosynthetics. A minimum thickness of 12 in. of soil material is required between tracked equipment with a maximum ground pressure of 15 pounds per square inch (psi) and the underlying geosynthetics, unless otherwise specified. A minimum thickness of 3 ft of soil material is required between rubber-tired vehicles and the underlying geosynthetics.

6. Soils used at the site shall be continuously visually inspected by the Contractor's quality control personnel during construction to check that it is consistent with the soil previously used at the site. If changes in material or source occur, the quality control personnel shall inform the Engineer immediately and reject any work performed by the Contractor using the new material until the pre-construction QA/QC procedures (as outlined in the CQCP) are executed and approved by the Engineer at the expense of the Contractor.

7. The Contractor shall be responsible to repair any desiccation or other damage to soil between testing and acceptance by wetting, drying and reworking the material.

8. The finished surface of the structural fill layer component of the liner system shall be free of debris, roots, sticks, or any other foreign matter so as to provide for an acceptable bearing surface for the overlying geosynthetics, where applicable.

B. Subgrade Preparation

1. Areas where fill material is to be placed shall have all vegetation, root matter, and topsoil removed. Following this activity, the subgrade within the limits of fill material placement shall be proofrolled on-grade using a heavy-duty roller (preferably sheepsfoot) with a minimum weight of 10 tons. A minimum of four passes of the roller shall be completed over the entire area. Proof-rolling in this manner shall be completed over the entire landfill area to provide for a stable and uniform subgrade surface, unless otherwise approved by the Engineer. Additional proof-rolling of the surface may be required within the hanger footprints as directed by the Engineer. To the extent practical, the north and east slopes of the landfill shall be compacted with construction equipment.

2. Following completion of proof-rolling, the entire area will be visually inspected by the Engineer. Should any loose or otherwise unstable zones be detected by the visual inspection, these areas shall be recompacted using a roller with as many passes as are necessary to densify these materials to the satisfaction of the Engineer. If these materials cannot be densified sufficiently by the additional proofrolling, they shall be undercut and replaced with one or more lifts of large (6 to 12-inch diameter) aggregate. The aggregate shall be pushed into the soft subgrade until the area is stabilized.

3. For undercuts, the exposed subgrade shall be proofrolled on-grade until sufficiently stable, as determined by the Engineer. (If the undercut zones are of minimal areal extent, hand-operated compaction equipment may be used to densify these areas.) Unsuitable materials undercut during subgrade preparation activities shall be transported to and placed at the stockpile area under the direction of the Engineer and disposed of in the landfill.

4. The exposed subgrade and structural fill on which the mechanically stabilized earth walls will be constructed shall be thoroughly compacted. The use of vibratory compaction equipment shall be monitored closely so as to minimize the potential for waste material to be displaced from the face of the temporary slope.

C. Material Storage

1. Deposit excess excavated material at the materials on-site stockpile areas. Stockpile(s) shall be graded in such a manner so as to prevent erosion and sedimentation.

D. Placing Fill Materials

1. Prior to placing fill material, all soils to be used for construction shall be tested by the GTL approved by the Engineer, as specified in Subsection 1.04.C. Materials must be approved by the Engineer prior to their use.

2. Where structural fill or common fill is to be placed, the surface shall be scarified before placing fill. Place fill material in uniform, horizontal lifts of not more than 12 in. in loose (uncompacted) thickness. Spread each layer uniformly and evenly. Perform compaction using equipment and methods approved by the Engineer. The Contractor shall use equipment appropriate for obtaining the compaction criteria specified herein.

3. Unless otherwise indicated in these Specifications or approved by the Engineer, the fill shall be placed in a uniform, uncompacted lift thickness not exceeding 12 in. Each lift shall be spread evenly and compacted to the specified in-place dry density.

4. Prior to commencing compaction, infiltration layer fills shall be brought to within an acceptable range of their specified optimum moisture content per ASTM D698 by either aerating the material if it is too wet or spraying the material with water if it is too dry. Acceptable moisture contents shall be as specified in Table 02200-2, unless otherwise approved by the Engineer, and shall be controlled by the Contractor in order to meet the compaction requirements specified herein. Each placed lift of infiltration layer fill used to achieve prepared subgrade elevations and in berms and embankments shall be compacted to at least 98% of the maximum dry density as determined by the Standard Proctor compaction test (ASTM D698), unless otherwise approved by the Engineer.

5. Continue all filling operations until the fill has been brought up to the finished slopes and grades shown on the Drawings, making proper allowances for thickness of topsoil, channel lining, roadway aggregate, etc.

6. Place all fill materials so that surfaces shall be sloped to drain at all times so as to prevent excessive moisture accumulation from rainwater.

7. Compaction by large rollers or heavy equipment shall not be permitted within 5 ft of structures. Accordingly, compaction in these areas shall be performed using hand-operated vibratory-plate or small walk-behind compactors. Fill materials compacted using this equipment shall be placed in maximum 6-in. loose lifts, unless otherwise specified herein.

E. Placing Infiltration Layer Soil

1. Where infiltration layer fill is to be placed, the surface shall be scarified before placing fill. Place fill material in uniform lifts of not more than 12 in. in loose (uncompacted) thickness. Spread each layer uniformly and evenly. Perform compaction using equipment and methods approved by the Engineer. The Contractor shall use equipment appropriate for obtaining the compaction criteria specified herein.

2. Unless otherwise indicated in these Specifications or approved by the Engineer, the fill shall be placed in a uniform, uncompacted lift thickness not exceeding 12 in. Each lift shall be spread evenly and compacted to the specified in-place dry density.

3. Prior to commencing compaction, infiltration layer fills shall be brought to within an acceptable range of their specified optimum moisture content per ASTM D698 by either aerating the material if it is too wet or spraying the material with water if it is too dry. Acceptable moisture contents shall be as specified in Table 02200-2, unless otherwise approved by the Engineer, and shall be controlled by the Contractor in order to meet the compaction requirements specified herein. Each placed lift of infiltration layer fill shall be compacted to at least 95% of the maximum dry density as determined by the Standard Proctor compaction test (ASTM D698), unless otherwise approved by the Engineer.

4. Following compaction, in-place moisture and density testing will be performed at a frequency as specified in Table 02200-2. The Engineer may elect to reduce the test frequency if it has been demonstrated that the required density can consistently be

achieved. In no case will the test frequency be reduced to less than one test per 40,000 ft^2 per lift.

5. Equipment operation shall be as required in Subsection 3.02.A.5.

6. The surface of each lift shall be scarified prior to placement of the next lift.

F. Placing Trench Backfill

1. Unless otherwise noted or directed by the Engineer, placing trench backfill shall conform to requirements specified above for placing and compacting structural fill, except as modified below:

a. Place and compact granular bedding in accordance with the Drawings. Place and compact granular bedding to a minimum thickness of 6 in. under precast and cast-in-place structures.

b. For all other pipes, compact approved trench backfill materials to a minimum of 1 ft above the top of pipe with manual tampers. Place backfill in thin horizontal lifts not exceeding a loose thickness of 6 in. In lieu of this, the Contractor may elect to continue the granular bedding to 1 ft above the top of the pipe.

c. Utilize such compaction equipment that will not damage the pipe and pipe joints. Pipe and pipe joints damaged by the Contractor's operations shall be removed and replaced at no cost to the Engineer.

d. Trench backfill shall be placed in uniform lifts of not more than 6 in. in loose thickness. After the structure has been properly bedded, selected material from the excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along sides of the structure in layers not exceeding the specified lift thickness. The backfill shall be brought up evenly on all sides for the full height of the structure. Care shall be taken not to over-compact the backfill and cause damage to the pipe or structure.

3.03 TOPSOIL

A. Topsoil shall be placed at thicknesses required on the DDA to achieve a total in-place cover soil thickness of at least 12-in. and other disturbed areas of the site as designated on the Drawings. The spreading shall be performed in such a manner that seeding can proceed with little additional soil preparation or tillage. Irregularities in the surface resulting from topsoil placement or other operations shall be corrected so as to prevent the formation of depressions where water will pond. Topsoil shall not be placed when the subgrade surface is frozen, excessively wet, extremely dry, or in a condition otherwise detrimental to the proposed seeding program. Topsoil should not be overly compacted either deliberately or inadvertently.

B. The Contractor shall provide the necessary temporary erosion and sediment control, drainage, dust control, and safety measures during construction at no additional cost.

C. Stockpiled topsoil materials shall be placed in approved areas. The stockpiled materials shall be placed and graded for proper drainage and shall not be placed near the edge of side slopes.

D. Mud, snow, ice, or frozen earth shall not be incorporated in the topsoil.

E. After topsoil placement and finish grading, no heavy equipment, trucks, etc. shall be permitted to travel on these completed areas. The Contractor shall, through mechanical raking, and hand grading with rakes and shovels, grade all areas around fences, pipes, and other structures in preparation for final seeding. Only low ground pressure equipment may be used for seeding. Seeding will be performed in accordance with Section 02932.

F. The Contractor shall pay all costs, fees, etc. to rectify any deficiencies in placement of the topsoil layer, to the acceptance of the Construction Manager, including those deficiencies resulting from weather, erosion, etc., during the time period between placement of the topsoil layer and proper development of the vegetative cover.

3.04 FINISH GRADING

A. Perform grading operations so that the fill areas are well-drained at all times. Maintain drainage ditches and keep them open and free from soil, debris, and leaves until final acceptance of the Work. Finish all grading on neat, regular lines conforming to the lines, grades, and contours shown on the Drawings, or if not shown, in accordance with the criteria set forth herein. Perform grading work in proper sequence with all other associated operations.

B. Grade all areas disturbed during the Work of the Contract. At trench locations, excavated and filled areas, and adjacent transition areas, grade so that finished surfaces are at the proposed grade or are approximately at the grades existing prior to being disturbed. Adjust as required to provide positive drainage.

C. Finished grades of all surfaces shall be constructed within the tolerances specified. As-built surveys completed by the Contractor shall document that the approved finished surface does not deviate from the design by more than the allowable tolerance.

D. As-built surveys shall be completed by the Contractor as required in Section 02005.

E. All specified minimum thicknesses and slopes shall be achieved for the respective earthen material of the landfill cover system.

3.05 INFILRATION LAYER MAINTENANCE AND REPAIR

A. Fine-grained, low-permeability soils are susceptible to desiccation and subsequent cracking in warm weather conditions. The Contractor shall be responsible for maintaining optimum moisture (or slightly above) conditions within installed protective cover soil throughout the entire construction. Should the soil crack or separate, the Contractor shall add the necessary moisture to the material in order to properly scarify, recompact, and retest what might have once been an acceptable lift of material. Prior to placement of additional lifts of soil or geosynthetics, the surface will be inspected and approved by the Engineer immediately before placement.

B. The Contractor shall repair all erosion scars on any compacted lift of soil due to excessive rainfall.

C. The Contractor shall backfill any holes within the compacted lifts during the construction with granular or powdered bentonite (i.e., moisture/density test holes, Shelby tube holes, grade stakes, etc.).

D. If a defective area is discovered in the low-permeability soil layer, the Engineer will immediately determine the extent and nature of the defect. If the defect is indicated by an unsatisfactory test result, the Engineer will determine the extent of the defective area by additional tests, observations, a review of records, or other appropriate means. If the defect is related to adverse site conditions, such as overly wet soils or surface desiccation, the Engineer shall define the limits and nature of the defect. The Contractor shall correct the deficiency to the satisfaction of the Engineer, at no cost to the Engineer. All retests, as required by the Engineer, must verify that the defect has been corrected prior to additional work in this area.

3.06 DEWATERING AND DRAINAGE

A. To preclude surface water ponding in excavations, provide and maintain dewatering systems of sufficient capacity to remove water while each excavation is performed. Sediment-laden water shall be directed to a diversion channel and/or sediment trap as described in the Contractor's SWPPP. The Contractor is responsible for compliance with all required United States Environmental Protection Agency (EPA), DOE, and NMED stipulations as stated in other section of these Specifications and the SWPPP.

B. Methods of dewatering excavations shall be at the Contractor's discretion. Continuous investigations and checks shall be made by the Contractor to ensure that the dewatering system employed is functioning properly and is not causing damage or settlement to adjacent surfaces or structures. The system shall be modified as required, and any damage caused by the system shall be the responsibility of the Contractor to repair or restore.

C. Provide necessary temporary surface drainage and keep same operating to the satisfaction of the Engineer until permanent drainage or finish grading has been completed. Do not allow damming or ponding of water in gutters or storm drains.

3.07 GEOTECHNICAL TEST BORINGS

A. The Contractor shall complete up to 5 but no less than 3 geotechnical testing borings along the proposed alignment of Wall No.1 to verify the location and competency of the bedrock. Over-burden soils shall be sampled in accordance with ASTM D1586. Each boring shall be extended a minimum depth of 10 feet into bedrock using a core barrel. The Contractor shall report blow counts, rock quality designation (RQD) and percent recovery. A boring log shall be prepared for each test boring. The location (horizontal and vertical) of each boring shall be recorded and shown on a site plan. All bore holes shall be backfilled with grout.

END OF SECTION

SECTION 02260

ON-SITE WASTE EXCAVATION AND TRANSPORT

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. This section includes the requirements for the on-site transport of excavated materials from one area of the airport landfill to another area of the same landfill. This section is not applicable to the DDA.

1.02 RELATED SECTIONS AND REFERENCES

A. Section 02100 – Clearing and Stripping.

B. Section 02200 – Earthwork.

C. SWPPP, June 2005.

D. CQCP, June 2005.

E. Construction Plan for LASO TA-73 Airport Landfill, June 2005.

PART 2 MATERIALS

2.01 GENERAL

A. The Contractor shall provide all materials and equipment required for the excavation, transport and handling of waste and soil materials within the boundaries of the site.

PART 3 EXECUTION

3.01 EXCAVATION

A. The Contractor shall complete excavation of site materials as shown on the Drawings.

B. Contour maps are provided to the Contractor for his use in determining the “cuts” necessary to minimize over-excavation of the waste and mixture of cover soils into the waste. It is suggested that the Contractor stake the cut excavations in the field and perform “test pitting” as necessary to verify the thickness designated on the contour maps.

C. Prior to the excavation of any waste materials, test pits shall be excavated to determine the horizontal limits of waste. Pits shall be spaced at 100 ft on center on the north, south and west sides of the landfill and the delineated edge of waste marked in the field and surveyed for inclusion on the project as-builts. All relocated waste shall be placed within these limits to ensure coverage by the final cover system.

D. Excavation for wall construction shall be limited to the minimum amount of material necessary to construct the concrete wall and the mechanically stabilized earth retaining walls. All excavations in waste required to facilitate wall construction shall be cut back to a safe working slope of between 1H:1V and 1.5H:1V or flatter if dictated by the density and composition of the materials encountered. All waste shall be excavated to a distance of between approximately 3 and 8 ft from the rear face of the concrete retaining wall to permit installation of the wall footing(s). The waste shall be cut from the base level of Wall No. 1 at a slope of no steeper than 1.25H:1V to the base elevation of the Wall No. 2. From the base elevation of Wall No. 2 the waste slope shall be cut at an inclination of no steeper than 1.5H:1V. This slope inclination shall extend to the point at which the temporary slope intersects the 4H:1V permanent slope. These excavation requirements may be modified based on the actual conditions encountered in the field with the approval of the Engineer.

The exposed face of the excavated waste shall be closely monitored during excavation and for the period up until backfill is placed. If movement of the waste is observed or if tension cracks are observed on or near the top of the slope, measures shall be taken to stabilize the slope. These measures may include removal of additional waste material to create a flatter slope.

Excavated slope shall be protected from extreme precipitation and surface water runon by the use of temporary covers (soil or plastic), berms, ditches,etc.

E. If embedded debris is encountered while excavating waste from the slopes the Contractor shall cut off such debris flush with the final excavated slope face so as not to cause a potential collapse or instability of the slope. The Engineer may permit excavation of embedded debris based on size, location and composition of the embedded debris and surrounding materials.

3.02 TRANSPORTATION

A. The Contractor shall transport the waste materials to the fill areas shown on the Drawings. Vehicles shall be operated in a safe and controlled manner. Vehicles shall not be operated on airport roadway or taxiways without prior authorization of the airport manager.

3.03 MATERIAL PLACEMENT

A. The Contractor shall place excavated waste from the site in the fill areas as shown on the Drawings and in accordance with Section 02266 specifications.

3.04 CONTROL OF DUST, ODORS, AND SPILLS

A. The Contractor shall implement measures to strictly control dust, odors, and spills during the on-site transport of excavated materials. The gates of hauling vehicles shall be sealed tightly to prevent the release of materials during transport and vehicles will not be overloaded so that the waste material rolls off the tops of loaded vehicles. The Contractor shall use covers/tarps to prevent the release of dusts and odors from trucks, scrappers, etc., as necessary. Dust control measures shall be implemented as necessary to prevent hazardous conditions for aircraft operations.

END OF SECTION

SECTION 02266

LANDFILL WASTE PLACEMENT PROCEDURES

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. Capping of the airport landfill includes the relocation of waste from the north and east slopes and from areas on top of the landfill and consolidation of this waste on the flat portion of the landfill within the limit of the landfill final cover system shown on the Drawings.

B. The toe of the east slope will be relocated approximately 10 ft westward (as defined on the Drawings) to allow the inclusion of the landfill cap (concrete wall) while maintaining a buffer zone between the edge of the cap and the canyon wall. The east slope will be backfilled with free-draining structural fill to allow this area to be tied into the native soil/bedrock/waste and to provide a stable foundation for the mechanically stabilized earth retaining walls.

C. This section includes requirements for the main landfill only.

1.02 RELATED WORK

A. Section 02200 – Earthwork.

B. Section 02930 – Erosion and Sediment Control.

C. SWPPP, June 2005.

D. CQCP, June 2005.

E. Construction Plan for LASO TA-73 Airport Landfill, June 2005.

1.03 SUBMITTALS

A. Topographic survey as described in subsection 1.04.A. Survey shall be prepared and submitted with Contractor's application for payment of waste relocation.

1.04 MEASUREMENT

A. Contractor shall perform a topographic survey of the finished surface of relocated waste for use in calculating the volume of waste moved. The survey shall be compared to the pre-construction survey required by Section 02005.

PART 2 MATERIALS

2.01 GENERAL

A. The Contractor shall provide all materials and equipment to place, spread, and compact the waste and soil materials within the landfill.

B. Relocated waste shall not be used as backfill against any wall or around any pipe or structure.

PART 3 EXECUTION

3.01 GENERAL

A. All relocated waste shall be placed within the limits shown on the Drawings or as otherwise defined by the Engineer based on the findings of test pit excavations.

3.02 PLACEMENT AND COMPACTION

A. The excavated material shall be spread with dozers or similar earthmoving equipment under controlled lift and compaction construction.

B. Large pieces shall be isolated and filled around with soil or other smaller wastes in order to minimize voids.

C. Large, flat pieces shall be placed flat and filled around on all sides with soil/waste. Enough horizontal space between slabs in the same lift shall be maintained for compaction equipment to operate.

D. At least 1 foot of waste/soil shall separate large, flat pieces. No direct stacking will be permitted.

E. Waste shall be compacted until they are visually observed to be dense, stable and unyielding, or as directed by the Construction Manager. The Contractor shall complete as many passes as necessary of the compaction equipment to achieve a satisfactory condition.

F. Special care shall be taken when excavating waste, or soil approximately 10 ft east of the existing storm drain (trench drain) located along the western edge of the landfill. Any damage to existing structures designated to remain in place shall be repaired by the Contractor at no additional cost to the Owner.

G. The subgrade exposed after removal of waste from the east slope on which the MSE wall (Wall No. 2) is to be constructed shall be thoroughly compacted. A relatively smooth and level subgrade shall be provided for construction of the MSE wall.

H. The Contractor shall use extreme care when compacting waste on and around the east and north slopes. Operation of equipment in static mode may be necessary to ensure stability of excavated slopes. If equipment cannot be operated in vibratory mode heavier compaction equipment may be required to sufficiently densify the waste.

3.03 CONDITION AREAS

A. Should excavated waste material that is saturated be placed within the landfill, the Contractor shall set aside an area to dry said wastes.

B. The area to dry these soils shall not be within 5 ft of the final grades for the cover system or within 50 horizontal ft of the final side slope grades.

C. The Contractor shall spread the saturated material in thin lifts and dry the material by racking, tilling, liming, mixing in dry soil, or other approved methods.

D. Areas used to dry saturated material will not be stacked upon each other for more than two consecutive loose lifts.

3.04 PREPARATORY GRADE

A. An allowance for the dimensions of the cover system shall be incorporated into the grading.

B. Landfill outslopes will be stabilized with riprap as shown on the Drawings.

END OF SECTION

SECTION 02270

CHANNEL PROTECTION

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The work to be performed under this section includes furnishing all labor, materials, tools, and equipment necessary for providing protection for slopes, ditches, channels, and riprap outlet protection to the configuration and extents indicated in accordance with the Contract Documents.

1.02 SUBMITTALS

A. In accordance with Section 01340, submit a Certificate of Compliance before delivery of materials for the items listed below:

1. Stone.
2. Geotextiles and fasteners.
3. Erosion control blankets.
4. Erosion control mats.

PART 2 PRODUCTS

2.01 STONE FOR OUTLET AND CHANNEL PROTECTION

A. Stone shall meet the requirements of NMDOT Section 602.221.

B. Stone for riprap shall be composed of a well-graded mixture of stone size such that the material size, based on a gradation analysis, is consistent with Table 02270-1 .

C. Riprap shall be reasonably well-graded from the smallest to the largest size specified and shall be controlled by visual inspection.

D. No broken concrete shall be used on this project.

E. Riprap shall be National Crushed Stone Association (NCSA) Class Size R3 and R5.

2.02 EROSION CONTROL MATTING

A. Channel beds and newly graded sideslope protection shall utilize synthetic erosion control mats as required.

B. Temporary grass stabilization seed mixture shall meet the requirements of Section 02932.

Table 02270-1

Riprap Gradation

Rock Size (in.)	Class, Size No. (NCSA) (percent passing)	
	R5	R3
18	100*	
9	15 – 50	
6		100*
4	0 – 15	
3		15 – 50
2		0 – 15
Nominal Placement Thickness (in.)	18	12

* Maximum allowable rock size.

2.03 RENO MATTRESSES

A. Reno mattresses shall be manufactured by Maccaferri, Terra Aqua Gabions, Inc. or Engineer-approved equal. Reno mattresses shall be a minimum thickness of 9 inches. In-fill material shall be 3 to 6 in. crushed stone or as otherwise required by the reno mattress manufacturer. Crushed stone shall have an aggregate index (AI) of 35 or less as defined by NMDOT Division 900.

PART 3 EXECUTION

3.01 RIPRAP

A. Place geotextile loosely over the prepared subgrade. Overlap the geotextile panels a minimum of 18 in. Place and shingle panels parallel to the flow and slope. Anchor panels with securing pins inserted through the geotextile, along, but not closer than 2 in. to each edge and at distances required to prevent displacement before or during construction. Stagger overlaps perpendicular to the flow a minimum of 5 ft. Geotextiles damaged or displaced before, during, or after placement shall be replaced or repaired by the Contractor at no cost to the Engineer.

B. Place riprap on subgrade or geotextile material to its full specified thickness and to the extent shown on the Drawings. Placement shall be in one operation in such a manner as to not disturb underlying material. End dumping of rock upon the geotextile shall not be permitted.

C. The larger stones shall be well distributed and compact. Hand placing or rearranging of individual stones by mechanical equipment may be required to secure the required results.

D. Riprap shall be placed starting at the toe of slope and proceeding upslope.

E. Equipment operations shall meet the requirements of 02200 Part 3.02A.5.

3.02 EROSION CONTROL MATS

A. Erosion control mats for channel protection, where indicated on the Drawings or ordered by the Engineer, shall be installed in strict accordance with the manufacturer's recommendations.

3.03 RENO MATTRESSES

A. Reno mattresses, where indicated on the Drawings or ordered by the Engineer, shall be installed in strict accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 02273

MECHANICALLY STABILIZED EARTH RETAINING WALL

PART 1 GENERAL

1.01 DESCRIPTION

A. This section includes requirements for the design, construction, quality control and assurance and all related items necessary to install a mechanical stabilized earth (MSE) retaining walls on the east slope of the landfill at the locations shown on the Drawings.

B. The Retaining Wall Subcontractor (Subcontractor) shall complete a detailed design of the proposed retaining walls to determine all required wall dimensions, materials and details, and all other material components to provide for stable wall construction and long-term performance in accordance with the requirements of local building codes, the International Building Code (IBC), standard engineering design practice and this Specification. If a conflict should exist between any of the above-referenced requirements the more stringent requirements shall govern.

C. The design shall be completed under the direct supervision of a licensed Professional Engineer registered in the State of New Mexico and submitted as a shop drawing for review and approval by the Engineer.

D. The Subcontractor shall provide a construction quality assurance plan for the installation of the walls.

E. Upon approval of the shop drawing (detailed design) by the Engineer and Owner, the Subcontractor shall complete the retaining wall construction in accordance with the approved design and as specified herein.

F. The Subcontractor shall afford the Engineer the opportunity to verify and confirm the stability of the east slope of the landfill and the Subcontractor shall modify the MSE wall design as required based on the results of the analyses completed by the Engineer.

1.02 QUALITY ASSURANCE

A. Upon acceptance by the Engineer and Owner of the retaining wall design, the Subcontractor shall construct the retaining wall in accordance with the quality control and assurance requirements of this and all other applicable Specifications.

B. The Subcontractor shall provide all quality control data provided by manufacturers of all elements used in the construction of the wall to the Engineer. The Engineer reserves the right to require additional testing of any and all materials.

C. The Subcontractor shall follow the recommended handling, storage and installation guidelines and recommendations provided by the manufacturers of the wall components.

1.03 SUBMITTALS

A. Design

1. The Subcontractor shall submit a conceptual design describing the proposed wall materials including facing units, geosynthetic reinforcement and earth/rock anchors to the Engineer and Owner for approval prior to commencing detailed design.

2. The Subcontractor shall complete a detailed design that fully addresses all dimensions, construction materials (including subgrade preparation and backfilling), wall reinforcement and drainage, and installation requirements necessary to demonstrate stable wall construction and long-term performance. The design shall be such that changes in wall length and alignment can be accommodated and implemented in the field.

3. The Subcontractor shall design an anchorage system that can be installed in the event there is insufficient space to install the required length of geosynthetic reinforcement. This anchorage system shall consist of earth/rock anchors installed in pre-drilled holes and connected to the geosynthetic reinforcement via a round structural member. A typical detail of such a system is shown in Appendix A.

4. The Subcontractor shall complete any and all site and subsurface investigations it deems necessary to complete a proper wall design. All investigation activities shall be coordinated with the Owner.

5. The wall design shall be prepared under the direction of and sealed by a Professional Engineer registered in the State of New Mexico. All supporting calculations, drawings, and specifications shall be submitted for approval by the Engineer. Upon approval, the Subcontractor shall procure all materials and mobilize all labor and equipment necessary to complete the construction in accordance with the approved design and these Specifications.

B. Installation Drawings

1. Upon approval of the wall design, the Contractor shall prepare and submit detailed drawings which fully describe the construction of the retaining walls, including plan and elevation views, profiles, cross-sections, and details. Details shall include fence post installation details, termination details into the rock face, termination details into soil/armored slope, details at alignment changes, etc.

C. Materials

1. The Subcontractor shall prepare and submit for approval information and test data for all materials proposed for use in the construction of the walls. The information shall include a description of the facing units, (e.g., dimensions, color, durability, material of construction, strength, etc.). In addition, geosynthetic test data shall be provided. This data shall include, at a minimum, polymer type and test results, wide width tensile strength, elongation, creep behavior, roll dimensions, etc. If applicable, connection strength data shall be provided for the proposed geosynthetic reinforcement and the proposed facing unit.

D. Certificates of Compliance

1. The Subcontractor shall submit to the Engineer for approval Certificates of Compliance prior to delivery of materials that will be used in the construction of the retaining walls. Certificates for each material shall include job location; the Contractor's name; a copy of the manufacturer's certified test reports; types, classes, and strengths of materials (as applicable); and the manufacturer's name, address, and telephone number.

E. Certified Test Reports

1. Certified test reports within the requirements of standards and testing methods specified shall be submitted to the Engineer for approval prior to material delivery. The manufacturer and Subcontractor must satisfy the Engineer that the material that it offers to furnish and install will meet in every aspect the requirements set forth in these Specifications. The Subcontractor shall transmit to the Engineer all information supplied to him by the manufacturer or supplier prior to approval for furnishing and installing any such material.

F. Installation and Repair Recommendations

1. The Subcontractor shall submit to the Engineer the manufacturer's recommended installation and repair procedures, as applicable, for materials associated with the retaining wall construction.

2. A maintenance/inspection plan addressing long term inspection and maintenance of the retaining walls.

G. Delivery, Storage, and Handling

1. Delivery of materials shall be coordinated with installation of the materials; unloaded with proper equipment at the site and as close as possible to the final placement; and secured in place. Materials shall be stored away from work areas and traffic in a reasonable level area, well drained, away from brush, poison oak or ivy and in an area accessible for inspection. Individual pieces or bundles shall be stored within safe walking distance between to allow for full view for inspection purposes. Excavated materials or stockpiled materials shall not be placed over or against stored materials.

1.04 DESIGN REQUIREMENTS

A. International Building Code (2003)

1. The wall shall be designed in accordance with the requirements of the International Building Code (IBC) 2003, or most recent version. These requirements include the following:
   a) Minimum factor-of-safety against overturning and sliding (static) = 1.5 (Section 1806)
   b) Minimum factor-of-safety against overturning and sliding (dynamic) = 1.1
   c) Site Class D for seismic design (Section 1615)
   d) 0.2 second spectral response acceleration (5% of critical damping) for Site Class B S_s = 0.3385g (Figure 1615(1))
   e) 1 second spectral response acceleration (5% of critical damping) for Site Class B S_1= 0.0976g (Figure 1615(2))
   f) Site coefficient F_a = 1.529 (Table 1615.1.2(1))
   g) Site coefficient F_v = 2.4 (Table 1615.1.2(2))
   h) K_H = 0.345g (or other appropriate load with approval of the Engineer)
   i) K_V = 0

2. The global slope stability of the MSE walls and slopes shall be evaluated.

3. An equipment surcharge load of appropriate magnitude and size shall be incorporated in the design.

4. The walls shall be designed with batters and to heights that facilitate the construction of 4H:1V back slopes as shown on the Drawings.

B. Standard Engineering Design Practice

1. The walls shall also be designed in accordance with accepted engineering practice for MSE wall systems. Appropriate partial and global factor-of-safety values shall be applied to the strength of the reinforcing material(s).
2. The reinforcing length shall be minimized to the greatest extent permitted by design. The length of reinforcing may be governed by global slope stability in which case the reinforcing length will be increased to satisfy global slope stability.

C. Earth/Rock Anchorage System

1. If an earth/rock anchorage system is required, the system shall be designed with adequate and appropriate factor-of-safety values. A minimum factor-of-safety of 1.5 should be applied to the calculated tension load in the anchor. The design shall include a construction quality control program, which shall include a requirement to test each anchor to confirm its load carry capacity.

PART 2 MATERIALS

2.01 GENERAL

A. The Subcontractor shall provide materials in accordance with the approved design for the construction of MSE retaining walls.

B. The Subcontractor shall provide reinforcing materials that meet the requirements of the design.

C. The facing units/façade/veneer of the MSE wall shall be concrete block, natural stone, or other material approved by the Engineer and Owner. The facing units/façade/veneer shall be durable and earth tone (natural) in color. Crushed tuff is not an acceptable facing unit.

D. Earth/rock anchorage system as required to compensate for reduced length of geosynthetic reinforcement.

PART 3 EXECUTION

3.01 GENERAL

A. The Subcontractor shall coordinate all work with the Contractor. The Subcontractor shall be responsible for the handling of all materials associated with the construction of the walls including the placement and compaction of the backfill material. The Contractor will furnish and supply backfill material to a location close to the wall but will not spread, place or compact the material. The Subcontractor shall be responsible for the installation of the wall facing units.

B. The Subcontractor shall provide all labor, equipment and materials required to complete the construction of the approved wall design.

C. The Subcontractor shall maintain the geosynthetic reinforcement in the correct alignment during backfill placement.

3.02 EXCAVATION

A. Excavation of any materials required to complete the installation of the walls shall be completed by the Contractor. The Contractor shall complete excavation activities in accordance with the Specification and Drawings and as otherwise may be required to satisfy the MSE wall design requirements except that intact bedrock will not be excavated. The Subcontractor shall schedule all work so as not to interfere with excavation activities or other site work.

3.03 SURVEYS

A. The Contractor shall provide the necessary surveying services to establish the approved wall locations (alignments) and elevations. The Subcontractor shall be responsible for maintaining the correct horizontal and vertical alignment of the walls. The Contractor shall provide as-built surveys of the completed walls. The Subcontractor shall correct any and all deficiencies identified in any survey completed by the Contractor.

3.04 RETAINING WALL INSTALLATION

A. The Subcontractor shall be responsible for constructing the retaining walls to the lines and grades shown on the Drawings, and in accordance with the approved design.

B. Wall No. 2 will not be constructed until the backfill for Wall No.1 has been placed, compacted and approved by the Engineer.

3.05 RESISTANT MATERIAL

A. If, during the excavation of the waste by the Contractor, resistant material, i.e., bedrock is encountered, the Contractor shall remove as much bedrock as is deemed practicable. That is, the Contractor shall remove weathered material. If upon removal of this weathered material there is not sufficient space to permit the installation of the required length of geosynthetic reinforcement, the Subcontractor shall install earth/rock anchors as required to provide equivalent reinforcement capacity. The Subcontractor shall be responsible for designing, furnishing and installing earth/rock anchors and associated materials. It should be assumed that rock drilling/coring will be required to permit the installation of the anchors. All anchors shall be tested. Testing protocols shall be agreed upon by the Engineer, Contractor and Subcontractor prior to the installation of any anchors. Test results shall be documented.

3.06 ALIGNMENT

A. If, during the excavation of the waste by the Contractor, resistant material, i.e., bedrock is encountered at locations which will not permit the installation of any wall at the alignment and to the extents shown on the Drawings, the Engineer will modify the wall alignment and extent accordingly to accommodate the conditions encountered. The Subcontractor shall install the wall(s) to the revised alignment and extents and shall complete any necessary additional design calculations. Design revisions shall be submitted to the Engineer for review and approval prior to installation.

B. The front face of the Wall No. 2 shall be off-set from the rear face of Wall No. 1 a minimum distance as shown in Table 02273-1. The wall alignment shown on Drawing 2009 shall be constructed except that the setback distance shall never be less than shown in Table 02273-1.

3.07 BACKFILLING

A. The Subcontractor shall place and compact all backfill materials and shall ensure that the geosynthetic reinforcement is installed in accordance with the design requirements and the manufacturer’s recommendations. The Subcontractor shall ensure that all slack is removed from the geosynthetic reinforcement prior to and during backfilling operations. The Subcontractor shall confirm that the proposed backfill satisfies both the design and manufacturer’s requirements.

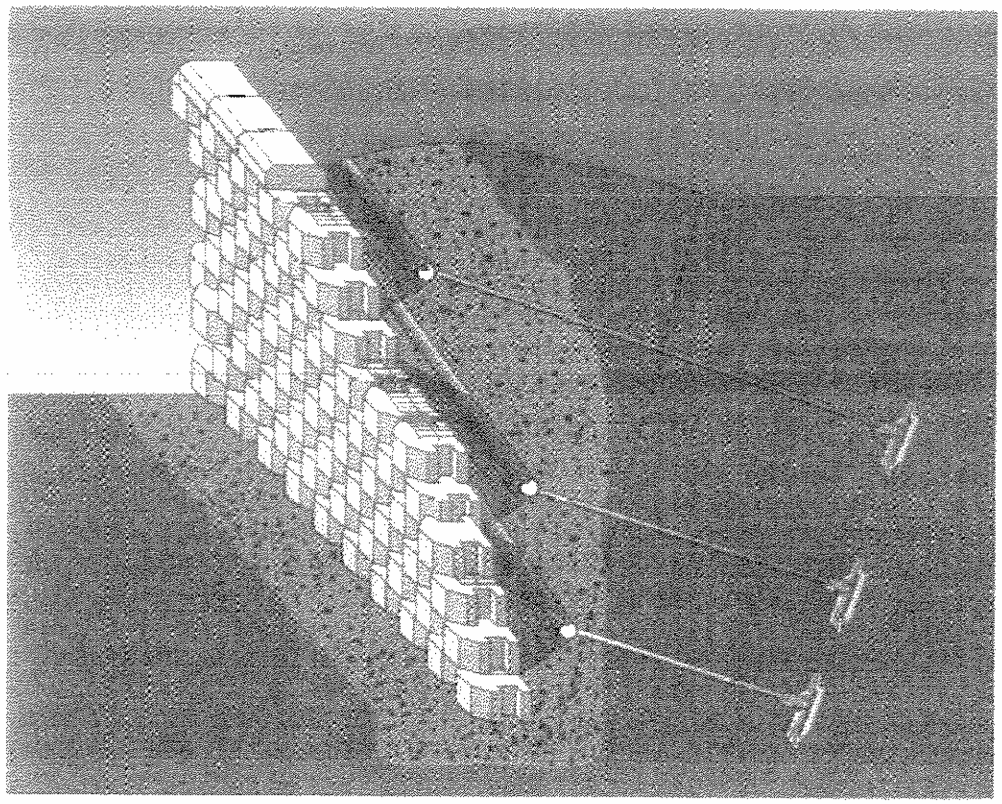
Table 02273-1
MSE Wall Minimum Required Setback Distance

Starting Station	**Required Setback from rear face to front face (ft)**
3+56	4.63
3+50	5.90
3+42	8.04
3+34	9.31
3+30	10.59
3+24	12.50
3+20	13.77
3+08	16.37
3+04	17.64
3+00	18.92
2+96	21.20
2+80	22.47
2+50	23.75
2+05	22.47
2+00	20.20
1+83	19.56
1+64	18.28
1+60	17.01
1+53	15.69
1+45	15.05
1+30	13.77
1+26	10.59
1+22	9.31
1+15	8.04
1+07	5.90
1+00	4.63

END OF SECTION

APPENDIX A

Typical Earth/Rock Anchor System



SECTION 02500

GRAVEL ROADS

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The work to be performed under this section includes requirements for constructing gravel roads where indicated, including the provision of subgrade as required, in accordance with Contract Documents. Access roads will be constructed to the DDA and main landfill, as shown on the Drawings.

1.02 SUBMITTALS

A. The Contractor shall submit a Certificate of Compliance in accordance with Section 01340 certifying the materials meet the material requirements of this Section as specified herein, before delivery of the materials.

B. For gravel road construction, the Contractor shall submit a certified report from a geotechnical testing laboratory. This report shall include the following data:

1. Material source and vendor.
2. Laboratory and date of testing.
3. A certificate of material compliance.
4. Particle size analysis.

PART 2 MATERIALS

2.01 GRAVEL

A. Gravel for road construction shall be crushed stone that is clean, durable, angular, noncalcareous fragments of rock. No slag will be accepted. Recycled concrete may be used.

B. Noncalcareous aggregates are those materials that, when tested in accordance with ASTM D3042 possesses no more than 5% loss of weight (dry basis).

PART 3 EXECUTION

3.01 TEMPORARY GRAVEL ROADS

A. When temporary roads are required, materials and placement shall be as specified herein. Contractor shall be responsible to maintain the temporary road in a condition acceptable to the Engineer until permanent surface(s) are placed. Should temporary roads become defective and create an emergency, the Contractor shall commence repair to rectify the situation within 1 hour after notification by the Engineer, or the Engineer may arrange to have the work performed by others and deduct the costs thereof from monies owed the Contractor.

Temporary driveways and pads for Contractor trailers shall be at a minimum thickness of 6 in., and compacted with the surface of the completed replacement at the same grade as the surrounding surface.

3.02 PERMANENT GRAVEL ROADS

A. Perform grading operations so that the excavation and/or structural fill will be well drained at all times. Maintain drainage ditches and keep them open and free from soil, debris, and leaves until final acceptance of the work. Finish all grading on neat, regular lines conforming to the sections, lines, grades, and contours shown on the Drawings; if not shown, perform in accordance with the criteria set forth herein. Perform grading work in proper sequence with all other associated operations.

B. Prepare the subgrade in accordance with Section 02200. Bring the entire subgrade to the proper elevation prior to installation of any permanent roadways. Provide necessary temporary surface drainage and keep the same operating to the satisfaction of the Engineer until permanent drainage or finish grading has been completed. Do not allow damming or ponding of water.

C. After subgrade elevations are achieved, install woven geotextile in accordance with Section 06020 and the manufacturer's recommendations. In general, unroll fabric in the direction of construction traffic. Do not end dump aggregate or drive any equipment directly on the geotextile. Spread the aggregate with a lightweight, less than 8 psi contact pressure, tracked bulldozer. The bulldozer should blade into the load with a slightly upward motion. Compact aggregate with two to three passes of a 10-ton smooth drum vibratory roller.

D. In areas where bituminous pavement is being replaced, coordinate construction activities.

3.03 PAVED ROADS AND RAMPS

A. The Contractor shall be responsible for the maintenance, repair and potential replacement of paved roads, airport tarmac, and ramps damaged as a result of its operations.

END OF SECTION

SECTION 02511

HOT MIX ASPHALT
MODIFIED ASPHALT TECHNOLOGY FOR WASTE CONTAINMENT
MatCon™

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The work to be performed under this section includes requirements for the design, supply, placement, and inspection of hot mix asphalt (HMA) to be installed on top of an aggregate subbase on the flat top of area of the landfill as shown on the Drawings. All aspects of the work shall be completed in conformance with the standards and procedures established by Wilder Construction Company (WCC) for the design, placement and inspection of MatCon™.

1.02 RELATED SECTIONS AND REFERENCES

A. Section 02200 – Earthwork

1.03 DEFINITIONS

A. Definitions pertinent to the earthwork requirements of this project include:

1. MatCon™ - a hot mix asphalt mix that combines a proprietary binder and strictly specified aggregates.

2. Wilder Construction Company – holder of the patent on the binder and the party responsible for designing the asphalt mix and for ensure the quality of the material and workmanship associated with the installation of MatCon™. WCC is responsible for evaluating and approving materials (aggregates) and for training and certifying asphalt manufacturing plants and installation contractors.

3. Certified Installation Contractor - a contractor certified by WCC to install MatCon™.

1.04 QUALITY CONTROL

A. General

1. WCC shall provide a quality control document that shall address inspection and testing of aggregate materials, inspection of asphalt manufacturing plants, training of installation contractors, certification of manufacturing plants and installation contractors, inspection and testing of the completed product. The quality control document shall also address repair and/or replacement procedures.

1.05 SUBMITTALS

A. Delivery Tickets

1. Delivery tickets showing the following information with each load of HMA delivered to the site shall be submitted to the SS:

a. Name and location of supplier.

b. Type and amount of material delivered.

B. Mix Design

1. Submit mix design procedure and mix design.

C. Certified Test Reports

1. Submit the results of all tests completed as part of the mix design

2. Submit the results of all tests completed on the finished pavement.

PART 2 MATERIALS

2.01 MatCon™

A. Hot Mix Asphalt

1. The HMA shall be as specified by WCC.

2. The in-place HMA shall have a permeability of no greater than $1x10^{-7}$ cm/sec.

PART 3 EXECUTION

3.01 SUBGRADE

A. General

1. The certified installation contractor shall inspect the subgrade on which the MatCon™ will be installed and ensure that it satisfies the requirements stipulated by WCC. If deficient areas are identified, the certified installation contractor shall notify the Contractor. The Contractor shall repair deficient areas to the satisfaction of the certified installation contractor.

3.02 MatCon™ INSTALLATION

A General

1. MatCon™ shall be installed in conformance with the requirements stipulated by WCC.

2. The interface between the MatCon™ and other materials shall be sealed by applying a slurry of hot asphalt to the joint as recommended by WCC. The slurry shall be applied in a manner that will result in neat lines. A fine sand shall be spread over the slurry after it has been applied, if so directed by the Engineer.

3. A bonding agent shall be applied to all vertical or near vertical surfaces against which MatCon™ will be placed.

3.03 TESTING AND INSPECTION

A. Testing and inspection of the completed MatCon™ shall be completed in accordance with WCC requirements or as otherwise required by the Engineer.

3.04 TOLERANCES

A. The MatCon™ shall be placed to the limits shown on the Drawings. The tolerance on the constructed surface shall be ±0.1-foot for every 100 feet with no compounding of tolerances. All minimum and maximum slopes shall be maintained.

END OF SECTION

SECTION 02720

STORM DRAIN SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The work to be performed under this section includes requirements to construct a storm drain system completed in place to the limits indicated in accordance with the Contract Documents.

1.02 QUALITY CONTROL

A. Test materials as set forth in the applicable referenced Specifications and as required herein.

B. Requirements for inspection and testing of concrete inlets, culverts, manholes, and trenches, as required, are specified in Section 03400.

C. As part of the QA effort, the Engineer may inspect and test all pipe, fittings, and joint material upon delivery to the site or at the factory. The Engineer may perform, on a continual basis, plant certification and in-process inspections at no cost to the Contractor.

1.03 SUBMITTALS

A. Certificates of Compliance

1. Submit Certificates of Compliance and shop drawings before delivery of materials in accordance with Section 01340 for pipe, precast concrete (manholes, inlets, etc.), and fittings furnished by the Contractor under this section. Certificates shall include the Engineer's name; job location; the Contractor's name, types, classes, and strengths of pipe; and the pipe manufacturer's name. Certificates of Compliance for concrete and masonry materials are specified in Section 03400.

B. Invoices

1. A packing list or invoice shall accompany every shipment and shall contain the following information: Engineer's name, type and class of pipe, length, and other pertinent information.

C. Installation and Repair Recommendations

1. Submit manufacturer's recommended installation and repair methods and procedures for pipe and structures. Repairs shall be performed by the manufacture using specifically trained personnel and shall proceed only after approval of the Engineer and in his presence.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery of pipe shall be coordinated with installation or shall be unloaded with proper equipment along the line of work, outside trench limits near as practicable to point of final placement, facing in proper direction, and properly wedged secure. It shall be stored away from brush and in an accessible area for inspection.

B. Pipe and appurtenances shall be unloaded and handled with a crane or backhoe of adequate capacity equipped with appropriate slings to protect the material from damage. If damage occurs and is deemed repairable, it shall be repaired as directed by the Engineer in accordance with the manufacturer's recommendations. If damage is not repairable in the opinion of the Engineer, such pipe will be rejected and shall be removed and replaced at the Contractor's expense.

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

A. Pipe product shall conform to NMDOT Section 570.

Pipe between structures or between the structure and terminus shall be of the same size and material and shall be furnished by the same manufacturer. Each pipe length and fitting shall be clearly marked with the manufacturer's name or trademark and pipe type or strength.

2.02 JOINTING MATERIAL (CONCRETE PIPE)

A. Mortar for pipe joints shall conform to NMDOT Section 570.322.

2.03 JOINT MATERIAL (CONCRETE TRENCH)

A. Joint gasket materials shall be Concrete Sealants Inc., type CS-440, rope gasket having a diameter of 1.5 inches.

B. Concrete Adhesive shall be Concrete Sealants Inc., type CS-75.

C. Joint Sealant shall be SIKA 1A..

2.04 HIGH DENISTY POLYETHYENE (HDPE) PIPE

A. HDPE pipe shall be tested prior to shipment to the site to ensure that the physical properties are in accordance with ASTM D-3350. Only newly manufactured pipe, specifically for this project will be accepted. The pipe shall be manufactured in accordance with ASTM F-714 and ASTM D-3261.

B. The HDPE piping shall have a wall thickness classification specified on the Drawings. The pipe shall be manufactured in accordance with ASTM F-714 and ASTM D-3261. The pipe material properties shall meet or exceed the characteristics of a Type III, Class C, Category 5, Grade P34 as defined by ASTM D-1248. The material cell classification shall be 345434C as defined by ASTM D-3350.

C. Joints for HDPE pipe shall be electro-fusion butt welded, to provide a joint that, as a minimum, has the physical properties of the pipe. All welding shall be performed by a trained individual according to the pipe manufacturer's recommendations.

2.05 GRANULAR BEDDING MATERIAL

A. Granular bedding material for pipe and structures is specified in Section 02200. Detail for bedding the pipe is shown on the Drawings.

2.06 CONCRETE INLETS

A. Concrete precast units shall meet the requirements of NMDOT Section 623.

B. Concrete strengths for inlets are specified in Section 03400.

2.07 CONCRETE INLETS FRAMES, GRATES, AND COVERS

A. Frames, grates, and covers shall meet the requirements of ASTM A48-83, Gray Iron, Class 35.

B. Design wheel loading shall be HS-20 for all grating.

C. Grating will be heavy duty type and bolted down type.

D. Grating shall be an "opened type", such as Neenah Foundary Company, Type A or Type P, or an approved equal.

2.08 MANHOLES AND TRENCHES

A. Concrete manholes and trenches are specified in Section 03400.

PART 3 EXECUTION

3.01 INSTALLATION OF STORM DRAIN

A. Inspection of Delivered Materials

1. Pipe, fittings, inlets, manholes, trenches delivered to the work site will be inspected prior to installation. Nonaccepted and damaged materials shall not be installed, but shall be removed or repaired, if repairable, as directed by the Engineer.

B. Handling of Pipe and Fittings

1. Pipe and appurtenances shall be handled with a crane or backhoe of proper capacity, equipped with appropriate slings to protect the exterior of the pipe.

2. Foreign matter shall be cleaned and removed from each pipe, fitting, and appurtenances before placing in the trench. Should foreign matter be observed in previously installed pipe, fittings, or appurtenances, cease work until foreign matter is removed. Open ends of pipes and fittings shall be closed with a cap or plug when work is not proceeding.

C. Excavation of Pipe and Fittings

1. Trench excavation and backfill shall be performed as specified in Section 02200. Pipe between structures or between structure and terminus shall be of the same size and material and shall be furnished by the same manufacturer. Before pipe installation, excavate sufficient trench in advance so that reasonable changes in line and grade can be made where the location of existing structures vary from that shown and then to ensure that no unforeseeable obstructions exist. Work required by failure to take such precautions shall be performed at no cost to the Engineer.

D. Bedding of Pipe and Fittings

1. Provide granular bedding in accordance with the Drawings and Section 02200. Provide encasement and/or concrete cradle where indicated. The entire length of each pipe shall be placed on firm bedding.

E. Placement of Pipe and Fittings

1. Prior to pipe installation, bring bedding material to grade along the entire length of pipe to be installed. Install pipe to a true uniform line and grade as indicated with continuous bearing of barrel on bedding material.

2. Install pipe upgrade with the bell or groove (for concrete pipe) pointing in the direction of upstream. Place each section of pipe in such a manner as to form a close concentric joint with the adjoining section and to prevent sudden offsets in the flow lines. Unless otherwise specified, opening of joints more than half the depth for concrete pipe will not be permitted.

3. Place sufficient backfill on each section of pipe as it is installed to hold it firmly in place.

3.02 JOINTS

For reinforced concrete pipe, clean joint surfaces immediately before jointing. Joints on PVC shall be gasket collar type, constructed of the same material as the pipe, and installed according to the manufacturer's recommendations.

A. Mortar Joints

1. Assemble mortar joints to ensure complete filling of the joint all around. Mortar shall be used within 1 hour after addition of water. All joints of pipe to concrete structures shall be mortared closed.

2. Joints for HDPE pipe shall be electro-fusion butt welded.

3.03 CONCRETE MANHOLES, TRENCHES, AND INLETS

A. Excavation

1. Perform excavation to the line and grade shown on the drawings and as specified in Section 02200.

2. Location and depth as shown on the Drawings, or as directed by the Engineer.

B. Installation

1. Manholes, trenches, and inlets shall be furnished and installed at the location and in accordance with the details shown on the Drawings.

2. All structures shall be set on a crushed stone base, at least 6 in. deep, in accordance with Section 02200, to proper grade and properly leveled and aligned.

3. All lifting holes shall be sealed tight with rubber plugs and cement mortar.

4. A mechanical, flexible, tight gasket shall be provided for pipe connections at manholes and inlets that meet the requirements of ASTM C923.

5. All structures shall be painted outside with a coal tar epoxy or approved equal.

6. All structures shall be free of visible leakage. Each manhole will be visually inspected and any leaks found shall be repaired in a satisfactory manner as approved by the Engineer.

3.04 FRAMES, GRATES, AND COVER

A. Install in accordance with manufacturer’s recommendations.

B. All frames and grates shall be bolted down securely to prevent any movement of the grate(s).

C. Install cast iron frame and cover on each structure, as detailed on the Drawings. Adjust the frame and cover to proper grade by using precast concrete grade rings or brick masonry when the structure is in a space dedicated for public use, a traveled way, or when designated to meet existing grade. Transition shall be a minimum of 4 in. and a maximum of 18 in. high. Otherwise, the structure shall be built without transition. Frames shall be adjusted to within 0.5 ft of final graded area.

D. Provide precast concrete grade rings, 3 in. through 6 in. thick. If required to meet proper grade, one split grade ring 2 in. thick may be used provided that this does not exceed the maximum transition heights. Precast concrete grade rings shall be set in full beds of mortar not less than 0.25 in. or more than 1.25 in. thick. Horizontal circumferential and vertical mortar joints, inside and outside, shall be pointed the full width. Depth of pointing shall not exceed 0.375 in. The mortar shall be cured a minimum of 6 hours prior to the backfilling and setting of the manhole frame. Place manhole frame and cover in a bed of mortar not less than 1 in. thick.

E. Concrete sections shall be protected from damage while in storage at the plant, while in transit, and at the contract site. They shall be handled with the proper size equipment, using only appropriate lifting holes or eyes. Joint ends of the sections shall be kept clean and placed on wooden blocks, pallets, or other appropriate material, but never on the ground. If damage is evident, it shall be repaired or the section rejected, as directed by the Owner. Thoroughly clean joint surfaces, remove all debris and foreign matter, and keep joint surfaces clean during assembly.

F. For concrete trenches; concrete section shall be installed in accordance with the manufacturer’s written assembly instructions.

G. Where the gasket material (CS-440- 1.5 diameter rope size) is to be placed on the end of the concrete trench, paint area CS-75 adhesive. Place the gasket material on the painted area in the center of the concrete trench on all three (3) sides. Install materials in accordance with manufactures recommendations.

H. After the alignment and grade of the trenches has been checked and joint sealer is in place, tighten the trenches together using the quick thread rods. Tighten quick thread rods until the trenches are firmly fix against the sealer. Paint inside joints with Sika 1A.

I. Install Concrete Sealant and Sika 1A products in accordance with the manufactures requirements.

3.02 BACKFILLING

A. Backfilling around pipes and structures shall be completed in accordance with Section 02200.

END OF SECTION

SECTION 02730

GAS COLLECTION SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

A. This Section includes requirements for the construction of a Gas Collection System in accordance with the Contract Documents. The Work includes furnishing all materials, tools, equipment, labor and supervision necessary to complete the work.

1.02 QUALITY CONTROL TESTING

A. Material Testing

As part of the Quality Assurance effort, the Engineer may inspect and test all pipe, fittings, and joint material upon delivery to the site. The Engineer may perform, on an intermittent or continual basis, plant certification and in-process inspections.

1.03 SUBMITTALS

A. Installation Drawings

The Contractor shall submit installation drawings for gas collection piping in accordance with Section 01300. Furnish laying schedules that specify all fittings (including sizes) and pipe lengths.

B. Certificate of Compliance

The Contractor shall submit to the Engineer for approval Certificates of Compliance before delivery of materials for pipe and fittings furnished by the Contractor under this Section. Certificates shall include a copy of the manufacturer's certified test reports; job location; the Contractor's name; types, classes, and strengths of pipe; and the pipe manufacturer's name.

C. Certified Test Reports

Certified test reports within the requirements of standards and testing methods specified herein shall be submitted to the Engineer for approval prior to pipe delivery. The pipe manufacturer and Contractor must satisfy the Engineer that the material that he offers to furnish and install will meet in every aspect the requirements set forth in these Specifications. The Contractor shall transmit to the Engineer all information supplied to him by the manufacturer or supplier prior to approval for furnishing and installing any such material.

PART 2 MATERIALS

2.01 PIPE MATERIALS

A. Gas piping shall be high density polyethylene (HDPE) with a wall thickness classification specified on the Drawings or herein. The pipe shall be manufactured in accordance with ASTM F-714 and ASTM D-3261. The pipe material properties shall meet or exceed the characteristics of a Type III, Class C, Category 5, Grade P34 as defined by ASTM D-1248. The material cell classification shall be 345434C as defined by ASTM D-3350. Joints for HDPE pipe shall be electro-fusion butt welded, to provide a joint that, as a minimum, has the physical properties of the pipe. All welding shall be performed by a trained individual according to the pipe manufacturer's recommendations.

B. Vertical gas piping shall be Schedule 80 PVC pipe. Joints shall be solvent welded.

C. Fittings shall be of similar material(s) as the pipe

PART 3 EXECUTION

3.01 GENERAL

A. Pipe and fittings delivered to the work site shall be inspected by the Contractor and the Engineer prior to installation. Nonaccepted and damaged pipe and fittings shall be marked by the Engineer and shall be removed or repaired as directed by the Engineer.

B. All pipe and fittings shall be unloaded and handled with proper equipment avoiding severe impact blows, especially during cold weather. Pipe and appurtenances shall be unloaded and handled with a crane or backhoe of proper capacity equipped with appropriate slings to protect the exterior of the pipe. Pipe will be inspected before installation. If damage occurs during handling and placement and is deemed repairable, it shall be repaired as directed by the Engineer in accordance with approved manufacturer's recommendation. If damage is not repairable in the opinion of the Engineer, such pipe shall be rejected, removed, and replaced at the Contractor's expense.

3.02 INSTALLATION OF GAS PIPE

A. Prior to pipe installation, bring the bedding material to the grade along the entire length of pipe to be installed and install geotextile. Install pipe to a true uniform line and grade as indicated, with continuous bearing of the pipe barrel on the bedding material. Lateral pipes shall be installed sloping away from the header pipe.

B. Foreign matter shall be cleaned and removed from each pipe, fitting, and other appurtenance before placing in the trench. Should foreign matter be observed in previously placed pipe, fitting, or appurtenance, cease work until foreign matter is removed. Open ends of pipe and fittings shall be closed with a watertight cap or plug when work is not proceeding.

C. Clean joint surfaces immediately before joining, square (face) end of each pipe to be fused, then butt (weld) pipe together according to the manufacturer's recommendations. Allow welds sufficient time to cool before working with the pipe.

D. Cap closed all open ends of pipe with end caps.

3.03 FIELD TESTING

A. No field testing is required for gas piping.

3.04 BACKFILLING

A. Backfilling shall be in accordance with Section 02200.

END OF SECTION

SECTION 02750

STORMWATER MANAGEMENT AND DISCHARGE

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. This section includes the requirements for the management and discharge of waters collected during and post construction activities.

1.02 RELATED SECTIONS

A. SWPPP, June 2005.

B. Section 02930 – Erosion and Sediment Control.

PART 2 MATERIALS

Not Applicable

PART 3 EXECUTION

3.01 STORMWATER MANAGEMENT

A. Controls to be used by the Contractor shall conform to the approved details stated in the Contractor's SWPPP.

END OF SECTION

SECTION 02930

EROSION AND SEDIMENT CONTROL

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The work to be performed under this section includes furnishing all labor, materials, tools, and equipment needed to install, operate, and maintain erosion and sediment controls as shown on the Drawings and specified herein.

1.02 RELATED SECTIONS

A. SWPPP, June 2005.

B. Construction Plan for LASO TA-73 Airport Landfill, June 2005.

1.03 STORMWATER POLLUTION PREVENTION

A. Prior to initiating earth-moving activities, implement the soil erosion and sedimentation controls as shown on the Drawings and detailed in the Contractor's SWPPP.

B. Fines and related costs resulting from failure to provide adequate protection against soil erosion and sedimentation are the obligation of the Contractor.

1. Silt, sediment, and mud leaving the site will be construed as damage to neighboring property and evidence of negligence on the part of the Contractor.

2. Damages to any property outside of the project limits due to negligence by the Contractor shall be rectified and/or restitution shall be paid by the Contractor.

C. Erosion and sedimentation control measures employed will be subject to approval and inspection by governing agencies having jurisdiction over such work.

The temporary control provisions proposed shall be coordinated with the project schedule, sequence of construction, and temporary and permanent site facilities to assure economical, effective and continuous erosion control throughout the construction and post construction period with no violation of the federal, state, and local regulations. The drainage area to sediment traps shown on the Design Calculations shall not be exceeded.

D. The Engineer may limit the active area of earthwork operations in progress commensurate with the Contractor's capability in controlling erosion and sediment-laden runoff.

1.04 SUBMITTALS

A. Samples: Submit samples of materials being used when requested by the Engineer including names, sources, and descriptions.

1.05 QUALITY CONTROL

A. All erosion and sediment control work shall comply with applicable requirements of governing authorities having jurisdiction. The Specifications and Drawings are not comprehensive, but rather convey the intent to provide complete slope protection and erosion control for both the Engineer and adjacent property.

B. Erosion control measures shall be established at the beginning of construction and maintained during the entire period of construction. On-site areas that are subject to severe erosion, and off-site areas that are especially vulnerable to damage from erosion and/or sedimentation are to be identified and receive special attention.

C. All land-disturbing activities are to be planned and conducted to minimize the size of the area to be exposed at any one time and the length of the time of exposure.

D. Surface water runoff originating upgradient of exposed areas should be controlled to reduce erosion and sediment loss during the period of exposure.

E. All land-disturbing activities are to be planned and conducted so as to minimize off-site sedimentation damage.

PART 2 MATERIALS

2.01 STRAW BALES

A. Straw bales, if used, shall be either wire-bound or string-tied with bindings around sides rather than over and under.

2.02 CRUSHED STONE

A. Crushed stone for stabilized construction entrance(s) shall be American Association of State Highway and Transportation Officials (AASHTO) #3.

2.03 SILT FENCE

A. Prefabricated silt fence shall meet the following requirements:

1. Silt fences shall be prefabricated.

2. The geotextile for the fencing shall meet the following requirements:

Property	Test Value[(1)]	Test Method
Grab Tensile Strength	90 lbs	ASTM D4632
Burst Strength	190 psi	ASTM D3786
Puncture Resistance	40 lbs	ASTM D4833
Permittivity	>0.1 sec^{-1}	ASTM D4491
AOS	>30 US sieve	ASTM D4751
UV Resistance (500 hr.)	70%	ASTM D4355

[1]Minimum average roll values (MARV)

3. Posts shall be metal or hard wood.

4. The geotextile height shall be a minimum of 3 ft and shall be provided with a tensioning cord.

2.04 GEOTEXTILES

A. Filter geotextile shall meet the requirements for geotextiles contained in Section 06020.

2.05 EROSION CONTROL MATS

A. Erosion control mats shall be American Excelsior Co., type Hi-velocity Curlex Blanket; PPS Packaging Co. type Super Duty Blanket; or approved equal.

2.06 EROSION CONTROL BLANKET

A. Erosion control blanket material shall be XCELL type regular blanket (0.98 #/sy), Curlex blanket type (0.97 #/sy), or approved equal.

PART 3 EXECUTION

3.01 STRAW BALE BARRIERS

A. Excavation shall be to the width of the bale and the length of the proposed barrier to a minimum depth of 4 in.

B. Bales shall be placed in a single row, lengthwise on proposed line, with ends of adjacent bales tightly abutting one another. In swales and ditches, the barrier shall extend to such a length that the bottoms of the end bales are higher in elevation than the top of the lower middle bale.

C. Staking shall be accomplished to securely anchor bales by driving at least two stakes or rebars through each bale.

D. The gaps between bales shall be filled by wedging straw in the gaps to prevent water from escaping between the bales.

E. Any straw bales which become clogged or otherwise deteriorate shall be properly maintained or replaced as necessary at no additional cost to the Engineer.

3.02 STABILIZED CONSTRUCTION ENTRANCE

A. Specifications include:

1. Stone Size: AASHTO #3.

2. Length: As effective, but not less than 50 ft.

3. Thickness: Not less than 6 in. in dry areas and 12 in. in wet areas.

4. Width: Not less than full width at all points of ingress or egress, but not less than 20 ft.

5. Washing: When necessary, wheels shall be cleaned to remove sediment prior to entrance onto public right-of-way or landfill entrance road. When washing is required, it shall be done on any area stabilized with crushed stone which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch, or watercourse through use of sand bags, gravel, boards, or other approved methods.

6. Maintenance: The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto the landfill entrance road or public right-of-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout or any measures used to trap sediment. All sediment

spilled, dropped, washed, or tracked onto the transfer station access road or public right-of-way must be removed immediately by the Contractor at no cost to the Engineer.

3.03 SILT FENCING

A. A 6-in. by 6-in. trench shall be excavated along the alignment of the silt fence. Excavated material shall be stockpiled on the upside of the trench.

B. Fence posts shall be positioned on the downstream side of the fence and driven into the ground. Fence posts shall be spaced no more than ten (10) ft apart.

C. The fabric flap shall be laid in the trench and backfilled with material stockpiled from excavation. The backfill shall be tamped into place.

D. The Contractor shall join fence sections together as recommended by the manufacturer and as approved by the Engineer to prevent silt from escaping through the adjoining sections.

E. The Contractor shall maintain silt fences (removing and disposing of silt, repairing fence which falls down, and replacing damaged fence, etc.) throughout the duration of the Contract at no additional cost to the Engineer. Silt shall be disposed of in such a manner that it will not erode from the site and shall be placed within the stockpile.

3.04 DUST CONTROL

A. Dust generated from the Contractor's performance of work, either inside or outside the limits of work, shall be controlled by the Contractor by applying water, calcium chloride, or other matertials with the approval of the Engineer.

B. The Engineer has the right to stop construction activity, if in his opinion; the excavations are generating excessive amounts of dust.

3.05 SOIL STABILIZATION

A. Following initial soil disturbance or redisturbance, permanent or temporary stabilization shall be completed in accordance with: a) 7 calendar days as to the surface of all perimeter controls, dikes, swales, ditches, perimeter slopes, stockpiles, and all slopes greater than 2 horizontal to 1 vertical (2:1) and b) 14 days as to all other disturbed or graded areas on the project site. The in-place sediment control measures will be maintained on a continuing basis until the site is permanently stabilized and all permit requirements are met.

3.06 CHANNELS (Temporary), SLOPES (Temporary), AND STOCKPILES

A. All channels, swales, ditches, stockpiles, etc. shall be stabilized with permanent or temporary seeding, in accordance with Section 02932 immediately upon reaching an interim grade.

B. The channel beds shall be covered with an erosion control mat. The erosion control mat shall be installed as recommended by the manufacturer of the blanket.

C. Where slopes require temporary stabilization, the Contractor shall install erosion control blankets, as directed by the Engineer.

3.07 MAINTENANCE

A. Inspection

1. Erosion and sediment control will be inspected by the Contractor the next working day after rainfall events in excess of 0.5 in. and prior to forecasted storms.

2. At a minimum, the Contractor will perform inspections of the erosion and sediment control system once every 14 calendar days and following storm events of 0.5 in. to assure the integrity of the system.

B. Repair

1. All erosion swales and gullies in excess of 6 in. deep will be filled and compacted to their original condition and reseeded as required.

2. Erosion and sediment control structures (i.e., silt fencing) will be replaced as required to assure the integrity of the system.

3.08 SEDIMENT TRAPS

A. The Contractor is solely responsible to construct and maintain the proposed sediment traps and their effluent upon commencing any earth disturbance activity.

B. The Engineer reserves the right to require upgrades to existing traps or installation of additional structures should any discharge released not meet quality standards.

END OF SECTION

SECTION 02932

SEEDING, MULCHING, AND RESTORATION

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The work to be performed under this section shall include furnishing and installing all seed, fertilizer, mulch, mulch binder, erosion mats, and initial watering of seeded areas wherever existing site surface soils will be placed as topsoil shown on the Drawings or as directed by the Engineer. This work shall also include maintaining seeded areas as shown on the Drawings until accepted by the Engineer.

B. The areas to be seeded under this item shall include all areas designated by the Engineer and as described on the Drawings.. All areas outside of specified limits where the vegetative growth has been injuriously disturbed or destroyed by the Contractor shall be restored and seeded in accordance with these specifications by the Contractor at his own expense.

1.02 RELATED SECTIONS

A. LANL Master Construction Specification, Section 02936, Seeding.

1.03 SUBMITTALS

A. The Contractor shall submit the following items:

1. Catalog data, including sources of supply for amendments, mulch, tackifier, fertilizer, and erosion control blankets.

2. Certification substantiating that material complies with specified requirements. Submit certified seed bag tags and copies of seed invoices identified by project name.

3. Installation instructions, including proposed seeding schedule. Coordinate with specified maintenance periods to provide maintenance from date of final acceptance. Once schedule is accepted, revise dates only with Engineer approval after documentation of delays.

1.04 QUALITY ASSURANCE

A. Contractor Qualifications:

1. Perform work by a single firm experienced with the type and scale of work required and having equipment and personnel adequate to perform the work satisfactorily.

B. Material Quality Control:

1. Provide seed mixture in containers showing species percentages in seed mix; test information including, purity, germination and noxious and restricted weeds; net weight; date of packaging; and location of packaging.

2. Furnish seed labeled in accordance with the requirements of federal and New Mexico statutes and regulations governing seed labeling. Such resulting

requirements include but are not necessarily limited to: Federal Seed Act and Amendments, rules and regulations established by the USDA; the New Mexico Seed Law; and all resulting regulations or restrictions established by New Mexico State University or other authorized entity.

3. In addition, ensure seed mix and its application comply with the requirements of all other federal and New Mexico statutes and regulations governing seeds, plants, and weeds. These requirements include but are not necessarily limited to: the Noxious Weed Control Act and all rules, regulations, or control measures by a noxious weed control district embracing Los Alamos County, New Mexico; and the Harmful Plant Act.

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver packaged materials in sealed containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery and while stored at site. Opened or wet seed shall be rejected and returned to the responsible party.

PART 2 MATERIALS

2.01 SEED

A. Obtain native grass seed from sources whose origin would ensure site adaptability. Plant sources from New Mexico or surrounding states are preferred.

B. Obtain shrub and wildflower seed from sources whose origin would ensure site adaptability. Plant sources from New Mexico or surrounding states are preferred.

C. Cover crops (e.g., annual barley, oats, winter rye, etc.) may be used only as a temporary stabilization measure and shall not be used in conjunction with a perennial seed mix.

D. Furnish certification, showing origin of seed and pure live seed (PLS) content as determined by a certified authority. Provide bags of seed that are tagged and sealed in accordance with the State Department of Agriculture or other local certification authority within the state of origin. The tag or label shall indicate analysis of seed and date of analysis, which shall not be more than 9 months prior to delivery date. Seed may be premixed by the seed dealer and appropriate data indicated on the bag label for each variety.

E. Seed mixture shall be:

Develop seed mixture from the following guidelines. Choose a minimum of five grass species from the list. Should wildflowers be included in the mix, use a ratio of 80 to 90% grasses and 10 to 20% wildflowers. Choose 3 to 5 species from the forb and wildflowers list. These species are applicable for both undeveloped and urban-interface areas.

NATIVE PERENNIAL MIX

Common Name	**Scientific Name**	**% of Mix**
Grasses		
Blue grama*	*Bouteloua gracilis*	5 – 10%
Galleta grass*	*Hilaria jamesii*	5- 10%
Mutton grass	*Poa fendleriana*	10-15%
Sideoats grama*	*Bouteloua curtipendula*	10-15%
Arizona fescue†	*Festuca arizonica*	10 – 15%
Prairie junegrass†	*Koeleria macrantha*	5 – 10%
Bottlebrush squirreltail*	*Elymus elymoides*	15 – 20%
Little bluestem†	*Schizachyrium scoparium*	10 – 15%
Indian ricegrass*	*Oryzopsis hymenoides*	10 – 15%
Mountain brome†	*Bromus marginatus*	10 – 15%
Sand dropseed*	*Sporobolus cryptandrus*	1 - 8%
Thickspike wheatgrass	*Agropyron dasystachyum*	20 – 25%
Needle and Thread grass*	*Stipa comata*	5 – 10%
New Mexico needlegrass*	*Stipa neomexicana*	10 - 15%
Sheep fescue	*Festuca ovina*	10 – 15%
Forbs/ Wildflowers		1%
Firewheel	*Gaillardia pulchella*	2%
Evening primrose	*Oenothera caespitosa*	1%
Gooseberry leaf Globemallow	*Sphaeralcea grossulariafolia*	1.5%
Scarlet gilia	*Ipomopsis aggregata*	1%
Plains aster	*Aster bigelovii*	1%
Western yarrow	*Achillea millefolium*	½%
Fringed sage	*Artemisia frigida*	1%
Forbs/Wildflowers		
Blue flax	*Linum perenne lewisii*	4%
Scarlet bugler	*Penstemon barbatus*	2%
Palmer penstemon	*Penstemon palmeri*	2%
Prairie coneflower	*Ratibida columnifera*	1%
Showy golden-eye	*Heliomeris multiflora*	1%
Purple geranium	*Geranium caespitosum*	5%

*Species particularly suited for especially dry sites.

†Species particularly suited for higher elevations (above 7000 ft).

2.02 STRAW MULCH

A. Straw shall be stalks from oats, wheat, rye, barley, or rice that are free from noxious weeds, mold, or other objectionable material. At least 65% of the herbage by weight of each bale of straw shall be 10 in. in length or longer. Rotted, brittle, or molded straw is not acceptable. Straw from introduced grasses is acceptable if cut prior to seed formation. If possible, provide marsh grass composed of mid to tall native grasses (usually tough and wiry grass and grass-like plants found in the lowland areas within the Rocky Mountain Region).

2.03 HYDRAULIC MULCH/TACKIFIER

A. Provide mulch material consisting of 100% virgin wood fibers manufactured expressly from whole wood chips, such as Eco-Fibre, Conwed, etc. Process chips in such a manner as to contain no growth or germination inhibiting factors. Do not produce fiber from recycled material such as sawdust, paper, cardboard, or residue from pulp and paper plants. Provide materials free from contaminants such as lead paint, varnish, or other metal contaminants. Hydraulic mulch shall contain non-toxic dye to assist in visually determining even distribution. Mulch material shall meet the following specifications:

Parameter	Value
pH at 3% consistency	4.5 +/- 0.5
Ash content	0.8% +/- 0.2%
Moisture holding capacity	1250 (grams water/100 grams oven dry fiber)
Moisture content	12% +/- 3% (Wet weight basis)

B. Combine mulch with an organic plantago-based tackifier, such as M-binder, etc., that has no growth or germination inhibiting factors and is nontoxic. Apply the uniform mixture to the seeded area.

C. Bagged mulch/tackifier mix that is homogenous within the unit package may also be used. Tackifier shall adhere to the fibers during manufacturing to prevent separation during shipment and to avoid chemical agglomeration during mixing in the hydraulic mulching equipment.

2.04 EROSION CONTROL BLANKET

A. Provide erosion control blankets of a uniform web of interlocking excelsior wood fibers, weed-free straw, or a combination of straw and coir fibers.

Use an appropriate blanket chosen for the site conditions and functionality for the desired growing seasons.

1. 3:1 slopes or gentler use single netted blankets - A machine-produced erosion control blanket using 100% straw or excelsior fibers sewn into a medium weight photodegradable bottom net. Minimum weight of blanket 0.5 lbs/ square yard, such as Greenfix America WS05, etc.

2. 3:1 – 2:1 slopes use double netted blankets - A machine-produced erosion control blanket using 100% straw or excelsior fibers sewn into a medium weight photodegradable top net and a light weight photo degradable bottom net. Minimum weight of blanket 0.7 lbs/ square yard, such as Greenfix America WS072, etc.

3. 2:1 slopes and steeper and/or 2 growing seasons of protection use straw/coir blend blankets - A machine-produced straw /coir fiber erosion control blanket using 70% straw /30% coir fibers sewn into a heavy weight photodegradable top

net and a medium weight photo degradable bottom net. Minimum weight of blanket 0.7 lbs/square yard, such as Greenfix America CFS072R, etc.

B. Staples: U-shaped, 11 gauge or heavier steel wire, minimum leg length of 8 in. after bending, with a throat approximately 2 in. wide.

C. Wood Stakes: Use 2-in. x 2-in. x 12-in. pine or fir stakes, beveled at one end, in place of wire staples in tuff locations.

2.05 BONDED FIBER MATRIX

A. Provide Bonded Fiber Matrix (BFM) composed of natural color, long-strand wood fiber, produced by therm-mechanical defribration of wood chips and joined together by a high-strength non-toxic adhesive, such as Eco-Ageis, etc. The product shall be composed of 90% wood fiber, 9% blended hydrocolloid-based binder, and 1% mineral activators, all by total weight. The BFM shall be 100% biodegradable and non-toxic to fish and wildlife, and it shall not contain any synthetic fibers.

2.06 AMENDMENTS / SOIL ADDITIONS

A. Fertilizer: Apply slow-release organic fertilizers such as Biosol Mix, Biosol, Osmocote, composted manure, or approved equal to minimize deficiencies of the topsoil. If composted manure is to be applied, test the nutrient content and interpret before it is used.

B. Water: Clean, fresh, and free of substances or matter that could inhibit vigorous growth.

C. Sand: Clean, washed, and free of toxic materials.

D. Wood chips: Wood chips shall have a relatively large surface area to volume ratio to be more easily broken down in the soil. Incorporate wood chips at low rates (0.5 ton/ AC) in order to assure the carbon to nitrogen ratio in soil is at favorable conditions for plant germination and growth. If higher rates are used, add nitrogen fertilizer to assure nutrient availability to plants.

PART 3 EXECUTION

3.01 PREPARATION

A. Preparation of the Seed bed.

1. Prepare seedbed to a maximum depth of 4 in. by tilling with a disc harrow or chiseling tool. Uproot all competitive vegetation during seedbed preparation and work soil uniformly, leaving surface rough to reduce surface erosion. Remove large clods and stones, or other foreign material that would interfere with seeding equipment.

2. Do not till on ground that is already loose to a depth of 2 in. or more that has undergone regrading and fill.

3. Do not do work when moisture content of soil is unfavorable or ground is otherwise in a non-tillable condition. To minimize dust problems for adjoining areas, do not till when wind speeds exceed 10 miles per hour (mph).

4. The extent of seedbed preparation shall not exceed the area on which the entire seeding operation can be accomplished within a 24-hour period.

B. Soil Amendments/Additions

1. Uniformly apply slow-release organic fertilizer to prepared seedbed in accordance with manufacturer recommended rates.

C. Prepare seedbed again if prior to seeding, the Engineer determines that rain or some other factor has affected prepared surfaces and that it may prevent seeding to proper depth.

D. On excessively steep slopes (steeper than 2:1), hydraulic/broadcast seeding may be appropriate. If seeding in this fashion, multiply application rate of seed by a factor of 2.

E. If cover crop has been established in area to be seeded, mow cover crop early in growing season before cover crop is ready to drop seeds.

3.02 APPLICATION OF SEED

A. Do not seed during windy weather, or when topsoil is dry, saturated, or frozen.

B. Equip seed boxes used for drill and broadcast seeding with an agitator.

C. To prevent stratification of seed mix, do not run seed box agitators while seeding is not being performed.

D. If seed mix is transported to site in a seed box or other equipment that subjects mix to shaking or similar movement that has the potential to cause stratification, remix seed prior to application.

E. Calibrate seeding equipment in presence of the Construction Manager to determine that equipment setting is appropriate to distribute seed at the specified rates.

F. Unless otherwise shown on Drawings, seed areas disturbed by or denuded by construction operations or erosion.

G. Use markers to ensure that no gaps will exist between passes of seeding equipment.

H. If cover crop has been established, mow the crop and drill seed perennial seed mix into the crop stubble.

I. When drill seeding, plant seed mix at a rate of 20 to 25 PLS lb/AC. Uniformly apply prescribed mix over area to be seeded as follows:

1. Accomplish seeding operations, where practical, by drilling in a direction across slope.

2. Plant seeds approximately 1/4 in. deep.

3. Do not exceed 4 in. distance between drilled furrows. If furrow openers on drill exceed 4 in., drill area twice to obtain a 4-in. distance between furrows.

4. Seed with grass wheels, rate control attachments, seed boxes with agitators, and separate boxes for small seed.

J. When broadcast seeding, plant seed mix at a rate of 32 to 37 PLS lbs/AC.

1. Where it is not practical to accomplish seeding by drilling, mechanically broadcast seed by use of a hydraulic mulch slurry blower, rotary spreader, or a seeder box with a gear feed mechanism. If seeding is done with a slurry blower, use highest pressure and smallest nozzle opening that will accommodate the seed.

2. Immediately following seeding operation, lightly rake seedbed or loosen with a chain harrow to provide approximately 1/4 in. of soil cover over most of the seed.

3. If hydraulically applying mulch as part of the broadcast seeding process, use a two-step process. Apply seed with a tracer (200 to 300 lb/AC) amount of mulch across entire seeded area. Once seed is applied, apply full complement of mulch (to equal 2,000 lb/AC). This shall allow seed to be in good contact with soil surface and not suspended in mulch matrix.

4. Prohibit vehicles and other equipment from traveling over the seeded areas.

3.03 STRAW MULCH

A. For locations that have not been hydraulically mulched, immediately following raking/chaining operation, add straw mulch to seeded areas.

1. Apply straw mulch at a minimum rate of 1.5 tons per AC of air-dry material. Spread straw mulch uniformly over area either by hand or with a mechanical mulch spreader to achieve 80% ground cover. When spread by hand, tear bales of straw apart and fluff before spreading. Depth of applied straw mulch shall not exceed 3 in. Do not mulch when wind velocity exceeds 10 mph.

2. Wherever use of crimping equipment is practical, place mulch in manner noted above and anchor it into the soil to a minimum depth of 2 in.. Use a crimper or heavy disc such as a mulch tiller, with flat serrated discs at least ¼-in. in thickness, having dull edges, and spaced no more than 9 in. apart. Provide discs of sufficient diameter to prevent frame of equipment from dragging the mulch. Where practical, perform crimping in two (opposite) directions. Do not use Sheep's Foot Rollers, heavy equipment tracks, and standard disc cultivators for crimping.

3. If straw mulched areas cannot be anchored by crimping, use hydraulic mulch wood fibers with tackifier. Mix slurry in a tank with an agitation system and spray under pressure uniformly over the soil surface. Keep all materials in uniform suspension throughout the mixing and suspension cycle when using hydraulic

mulching equipment. Mix 100 lb of wood fiber with 150 lb of tackifier to anchor straw mulch. Apply mixture at a rate of 250 lb/AC.

4. Use both horizontal and vertical movements in the applicator to achieve an even application of the slurry material.

3.04 HYDRAULIC MULCHING/TACKIFIER

A. Immediately following raking/chaining operation, apply hydraulic mulch fibers with tackifier to seeded areas. Mix slurry in a tank with an agitation system and spray, under pressure, uniformly over soil surface. Apply mulch evenly across landscape at a rate of 2,000 lb/AC.

Use both horizontal and vertical movements in applicator to achieve an even application of slurry material. Keep all materials in uniform suspension throughout mixing and suspension cycle when using hydraulic mulching equipment.

When using plantago based tackifier as mulch, apply tackifier at a rate of 100 lb/AC. When applied alone for dust control, apply tackifier at a rate of 150 lb/AC.

Prohibit foot/vehicle traffic from hydraulically mulched areas.

3.05 EROSION CONTROL BLANKET

A. Place blankets over native grass seeding immediately following the raking/chaining operation.

B. When using single netted products for 3:1 or flatter slopes, place blanket with netting on top and the wood/ straw fibers in contact with soil over entire seeded area.

C. For slope installations, the following guidelines or manufactures recommendations shall be used:

1. Begin at top of slope and anchor its blanket in a 6 in. deep by 6-in. wide trench. Backfill trench and tamp earth firmly.
2. Unroll blanket downslope in direction of water flow.
3. Overlap edges of adjacent parallel rolls 2 to 3 in. and staple every 3 ft.
4. When blankets are spliced, place blankets end over end (shingle style) with 6-in. overlap. Staple through overlapped area, approximately 12 in. apart.
5. Lay blankets loosely and maintain direct contact with soil – do not stretch.
6. Staple blankets sufficiently to anchor blanket and maintain contact with soil. Place staples down the center and staggered with the staples placed along the edges. Moderate slopes (2:1 – 3:1) require 1 to 2 staples per square yard. Gentle slopes require 1 staple per square yard. Use a common row of staples on adjoining blankets.

D. Use wood stakes on tuff slopes, in place of wire staples. Use same installation rate as for staples. Drive stakes in perpendicular to slope and leave 2 in. exposed above soil grade.

3.06 BONDED FIBER MATRIX

A. Hydraulically apply BFM over seeded area (or apply seed with a tracer amount, 200 to 300 lb/AC) immediately following raking/chaining operations and in accordance with manufacturer's specified procedures. Hydraulically apply BFM as a viscous mixture. Upon drying, it shall form a continuous, porous, and erosion-resistant mat. Upon drying, matrix shall not inhibit germination and growth of plants in and beneath the layer. Matrix shall retain its form despite re-wetting.

B. Apply matrix uniformly across area and apply in multiple directions to ensure a 100% soil surface coverage.

C. Apply at a rate of approximately 3,500 lb/AC in a manner that achieves uniform coverage of all exposed soils.

D. Prohibit vehicle traffic on hydraulic BFM applications.

3.07 WATERING

A. Where temporary watering is required for seeded areas, provide temporary water system which may be a sprinkler system, or a water truck with a spray boom or any other method satisfactory to distribute a uniform coverage of clean water (free or oil, acid, salt, or other substances harmful to plants) to previously seeded and mulched areas.

B. If a temporary sprinkler system is used, keep all pipe connections tight to avoid leakage and loss of water, and to prevent washing or erosion of growing areas. Maintain sprinklers in proper working order during watering.

C. Do not drive trucks with spray systems on seeded areas and ensure water force does not cause movement of mulch or seed on the ground.

D. Water revegetated areas.

E. Apply water at a maximum of 0.5 in. per hour for 2 hours. Additional applications of water may be made as designated by the Engineer. Water source will be approved by the SS, prior to use.

3.08 MAINTENANCE

A. Begin maintenance immediately after planting.

B. Maintain seeded areas for not less than 60 days after final acceptance of work and longer as required to achieve final stabilization as described in Section 3.10 ACCEPTANCE.

C. Reseed void areas greater than 6 ft^2 or repetitive voids greater than 2 ft^2 amounting to more than 10% of any area that appears the growing season following installation.

D. Keep revegetated areas free of noxious weeds until acceptance by the Engineer. Contact the Engineer prior to application of any control measure.

3.09 CLEANUP AND PROTECTION

A. After completion of work, clear site of excess soil, waste material, debris, and objects that may hinder maintenance and detract from neat appearance of site.

B. Protect work and materials from damage due to seeding operations, operations by other contractors and trades, and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged work as directed.

3.10 ACCEPTANCE

A. Seeded areas will be reviewed for acceptance by the Engineer when final stabilization has been achieved. Final stabilization is defined as “All soil-disturbing activities at the site have been completed and a uniform (e.g., evenly distributed, without large bare areas) perennial vegetative cover with a density of 70% of the native background vegetative cover for the area has been established on all unpaved areas and areas not covered by permanent structures, or equivalent permanent stabilization measures (such as the use of riprap or geotextiles) have been employed.”

B. In the event that all other work required by the Contract is completed before final stabilization is achieved or because seasonal limitations prevent seeding, partial acceptance of the work shall be made with final acceptance delayed until satisfactory vegetative growth has been established.

END OF SECTION

SECTION 02980

CHAIN LINK FENCE

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. This section shall consist of furnishing and erecting permanent and temporary construction fence in accordance with these specifications and the details, lines and grades shown on the plans or as established by the Engineer.

B. Existing fence can be relocated and reused in its entirety as construction fencing as shown on the plans, and described herein.

1.02 QUALITY ASSURANCE

A. The Airport perimeter fencing height will comply with the FAA Landing and Taxiway obstruction requirements. The final site fencing requirements will be coordinated with the Los Alamos County Airport Manager and the Owner.

B. Fencing installed on top of retaining walls will be a minimum height of 4 feet.

C. The work and material under this section shall conform to the recommended practice outlined in the following standard and as required by this specification.

1. American National Standards Institute (ANSI)/ASTM A123 – Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products.
2. ANSI/ASTM F567 – Installation of Chain-Link Fence.
3. ASTM A116 – Zinc-Coated (Galvanized) Steel Woven Wire Fence Fabric.
4. ASTM A120 – Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized) Welded and Seamless, or Ordinary Uses.
5. ASTM A121 – Zinc-Coated (Galvanized) Steel Barbed Wire.
6. ASTM A153 – Zinc-Coating (Hot-Dip) on Iron and Steel Hardware.
7. ASTM A392 – Zinc-Coated Steel Chain-Link Fence Fabric.
8. ASTM A428 – Weight of Coating on Aluminum-Coated Iron or Steel Articles.
9. ASTM A491 – Aluminum-Coated Steel Chain Link Fence Fabric.
10. ASTM A569 – Steel, Carbon (0.15 Maximum Percent), Hot-Rolled Sheet and Strip Commercial Quality.
11. ASTM A585 – Aluminum Coated Steel Barbed Wire.
12. ASTM C94 – Ready-Mixed Concrete.
13. ASTM F573 – Residential Zinc-Coated Steel Chain Link Fence Fabric.

14. ASTM F668 –PVC Coated Steel Chain Link Fence Fabric.

15. Chain Link Fence Manufacturers Institute (CLFMI) – Product Manual.

16. FS RR-F-191 – Fencing, Wire and Post Metal (and Gates, Chain Link Fence Fabric, and Accessories).

1.03 SUBMITTALS

A. Submit copies of the manufacturer's latest published literature and data on fabric, posts, accessories, fittings, and hardware for chain link fence.

B. Submit shop drawings showing details of each element. Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, and schedule of components.

C. Submit two samples of fence fabric, illustrating construction and finish for chain link fence.

D. Each roll of fabric shall carry a tag showing the kind of base metal, or plastic, the kind of coating, the gauge of the wire, the length of fencing or fabric in the roll, and the name of the manufacturer. Posts, wire, and other fittings shall be identified as to manufacturer, kind of base metal, and kind of coating.

PART 2 MATERIALS

2.01 WIRE (Fabric)

A. New fabric wire shall be of a similar height and material to the existing fence and shall have a base metal of steel with a tensile strength of 75,000 lbs per square in. and galvanized in conformance with the requirements of ASTM A392, Class II. Wire will be of 9-gauge and have a nominal diameter of 0.148 in. being woven in a 2-in. mesh. Fence for Airport perimeter to be coated to match existing fencing and fence for walls shall be galvanized.

2.02 POSTS, RAILS, GATES, AND BRACES

A. Posts, rails, gate(s), and braces shall be of galvanized steel conforming to the requirements of ASTM F1083 and shall also conform to the requirements listed in Table 02980-1. Braces shall be provided for each gate, corner, pull, and end post and shall consist of a brace extending to each adjacent line post at midheight of the fabric and a rod not less than 3/8-in. in normal diameter, or equivalent, from line post back to gate, pull or end post, with a turnbuckle or equivalent, for adjustment as shown on plans.

B. Top rails shall be lengths not less than 10 ft and shall be fitted with expansion couplings for connecting the lengths into a continuous run. Couplings shall be not less than 6 in. long, shall allow for expansion and contraction of the rail, and shall be approved by the Engineer.

TABLE 02980-1

POSTS AND RAIL SIZES AND WEIGHTS

Use and Section	O.D. In.	Weight/Lb/Ft.
Gate Posts	4.00	9.11
Corner Posts	2.875	5.79
End Posts, Pull Posts	2.875	5.79
Intermediate Posts	2.375	3.65
Top Rail and Postbrace	1.660	2.27
Gate Rails (Frame)	1.90	2.72

2.03 WIRE TIES AND TENSION WIRE

A. All wire fabric ties, wire ties, hog rings, and tension wire shall be zinc-coated steel core wire. Tension wire shall have a minimum tensile strength of 80,000 psi. Zinc coating shall be .30 oz. per square foot. Tension wire shall be 6-gauge.

2.04 MISCELLANEOUS FITTINGS AND HARDWARE

A. Miscellaneous fittings and hardware shall be zinc-coated steel, wrought iron, malleable iron, or pressed steel and shall be equal to materials specified in FS RR-F-191/4B.

2.05 GATES

A. Structural members of gates shall be fully welded on all sides and faces of joints at exposed edges. Surplus welding material shall be removed. Gates shall be swing gates or sliding gate as indicated on plans and specifications. Gates shall include all hardware and appurtenances including latches, plunger pins, etc.

B. Hinges for gate(s) shall be the pin type and shall be heavy-duty, malleable iron. Shop drawings will be required with the hinges being subject to the Engineer's approval.

2.06 CONCRETE

A. Concrete for setting posts shall have a minimum compressive strength of 3,000 psi and conform to NMDOT standards.

PART 3 EXECUTION

3.01 CLEARING FENCE LINE

A. The site of the fence shall be sufficiently cleared of obstructions, and surface irregularities shall be graded so that the fence will conform to the general contour of the ground. All holes shall be filled with common borrow or excavated material at the direction of the Engineer. When required, the Contractor shall grade the ground surface so that the fence elevation shall conform to existing or future structures. The fence line shall be cleared to a minimum width of 10 ft on each side of the centerline of the fence. This clearing shall consist of the removal of all stumps, brush, rocks, trees, or other obstructions which will interfere with proper construction of the fence. Stumps to be removed shall be grubbed or excavated. All holes remaining after the clearing and grubbing operations shall be refilled with suitable soil, gravel, or other material acceptable to the Construction Manager and shall be compacted properly with tampers.

Disturbed areas shall be seeded and mulched as directed by the Engineer and as specified in Section 02932.

3.02 CONSTRUCTION FENCE

A. Construction fence shall consist of new fence, as specified, and may be existing fence labeled as “to be removed’ or “to be relocated.” The existing fence may be reused and installed as construction fence to the lines and grades shown on the plans.

1. Line posts shall be spaced not more than 10 ft on centers in the line of fence. End or pull posts shall have a 500-ft maximum spacing.

2. End posts shall be installed in concrete foundations as shown on drawings. Line posts shall be installed in earth foundations. Concrete foundations shall extend one (1) in. above the ground at the posts, with a slope to match existing grade at the foundation’s edge. All posts shall be set vertical, true to alignment, and securely embedded in earth or concrete foundations as required.

3. After the concrete has been allowed to cure for 2 days, for the end posts, fabric, braces, and rails shall be attached. The fabric shall be attached to the posts and rails at a sufficient number of points to ensure a firm, rigid, and unyielding attachment, and shall be a maximum of two (2) in. clear of the pavement or ground surface. The fabric shall be stretched between posts so that no bends or loose places in fabric will result. Lengths of fabric shall be spliced by bringing the fabric ends close together and weaving in a picket in such a way that it engages each individual mesh of the fabric ends. Brace rails and truss rods shall be provided at all fence corners and ends.

4. The bottom of the fence shall be placed a uniform distance above the finished ground surface except where allowance is made for the irregularities in the ground contour.

3.03 GROUNDING

A. With the exception of the fence atop the retaining walls, all fence shall have at least one ground for every 500 ft of fence, at end posts, and on each side of gates. The ground shall consist of a 5/8-in. diameter copper-clad rod driven a minimum of 8 ft into the earth and attached to the fence by a copper wire and grounding clips to obtain a maximum resistance of 25 ohms and in accordance with the plans and as approved by the Engineer.

3.04 CLEANING UP

A. The Contractor shall remove from the vicinity of the completed work all tools and equipment belonging to him or used during construction. All piles of soil shall be leveled and all brush or debris of any nature shall be removed from the site.

END OF SECTION

DIVISION 3

CONCRETE

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The work to be performed shall include the construction of Wall No. 1, aircraft hanger slabs and tie-down anchors. The work may also include the construction of trench drains, manholes and other drainage structures if precast structures are not utilized. Mix design, sampling, testing and inspection of concrete are also included.

1.02 QUALITY ASSURANCE

A. Perform cast-in-place concrete work in accordance with ACI 301 unless specified otherwise.

B. Maintain copy of ACI 301 in field office for duration of project.

1.03 TESTS

A. Testing of concrete mix will be performed by independent testing laboratory appointed by the Contractor. The Contractor shall include costs for all testing. Copies of test results will be furnished by Contractor to the Engineer. Contractor shall submit name of testing laboratory to Engineer for approval.

B. Prior to start of concrete work:

1. Submit concrete mix design for each classification of strength, slump and air entrainment.

2. Mix sample batches of each concrete mix design specified.

3. Take three test cylinders for each sample batch for compression test at seven and twenty-eight days.

4. Cylinders will be cured and tested to determine criteria for judging quality of concrete placed during construction.

C. Sample concrete in accordance with ASTM C172.

D. Make slump test in accordance with ASTM C143 for each ten cubic yards or per truck load of delivered concrete. Furnish material and assistance required to make tests.

E. Test air content in accordance with ASTM C231.

F. Cure test cylinders in accordance with ASTM C192.

G. Make one set of three cylinders for each classification of concrete placed in one day, and for every 100 cubic yards of concrete placed. Make and test additional cylinders when deemed necessary by the Engineer. Lab cure two of the three cylinder specimens and field cure the remaining one. Make tests in accordance with ASTM C39.

H. Compression tests of test cylinders will be made in accordance with ASTM C31 at 28 days. Seven-day tests may be used provided that the relation between seven and 28-day strengths of the concrete has been established by earlier testing.

I. Furnish cylinder molds, materials, and assistance required for preparation of test cylinders. Single use 6 inch by 12 inch paper cylinder molds may be used if they comply with ASTM C470.

J. Do not remove forms from or apply loads to concrete structures for which strength tests have not been made and results of which have not equaled or exceeded minimum requirements.

K. In cases where average cylinder strengths are below minimum required values, the Engineer shall have the right to require conditions of temperature and/or moisture necessary to secure the required strength and may require load or core tests to be made on affected portions of the Work.

1.04 RELATED SECTIONS

A. SWPPP, June 2005

B. CQCP, June 2005

C. Construction Plan for LASO TA-73 Airport Landfill, June 2005

1.05 REFERENCE STANDARDS

A. ACI 301 - Specifications for Structural Concrete for Buildings.

B. ACI 305 – Hot Weather Concreting.

C. ACI 306 – Cold Weather Concreting.

1.06 SHOP DRAWINGS AND SUBMISSIONS

A. Submit shop drawings and product data for all products under the provisions of Section 01340.

B. Submit shop drawings of reinforcing steel.

C. Shop Drawings for reinforcement, for fabrication, bending and placement of concrete reinforcement shall comply with ACI SP-66 (04), "ACI Detailing Manual," ACI 315-99 and ACI 315R-04, showing bar schedules, stirrup spacing, diagrams of bent bars, and arrangement of concrete reinforcement. Indicate bar sizes, spacing, locations and quantities of reinforcing steel, and wire fabric, bending and cutting schedules, and supporting and spacing devices.

D. Submit Steel producer's certificates of mill analysis, tensile tests and bend tests.

E. Submit test results.

F. Submit color samples.

G. Submit written procedures for protection of concrete construction in accordance with ACI 301, ACI 305 for Hot Weather Construction, and ACI 306 for Cold Weather Construction.

PART 2 PRODUCTS

2.01 CEMENT (ACI 301 2.1)

A. Use one brand and type of cement throughout project unless otherwise specified.

B. Cement: Air entraining-type 1A. ASTM C150.

2.02 ADMIXTURES

A. Type and dosage of admixture: conform to manufacturer's instructions for temperature conditions.

B. Air entraining admixtures: conform to ASTM C260, and contain no chlorides. Maximum air content shall be six percent, plus or minus one percent of volume of concrete when tested in accordance with ASTM C173. Use air-entraining admixtures in concrete exposed to weathering and at other concrete work at Contractor's option.

C. Water reducing admixtures: hydroxylated carboxylic acid type conforming to ASTM C494, Type D with one exception that:

1. Maximum shrinkage: maximum 100 percent of control mix.

2. Relative durability factor: minimum 100 percent of control mix.

3. Use only as approved by Engineer.

D. Do not use calcium chloride in concrete containing aluminum items.

E. Color admixture for retaining wall shall produce an earth tone concrete subject to the approval of the Engineer.

2.03 MIX DESIGN (ACI 301 3.2)

A. Provide 28-day compressive strength as follows:

Location	Min. 28-Day Compressive Strength (psi)	Water-Cement Ratio by Weight
Retaining Wall	3,000	0.59 Air entrained
Hanger Slab	4,000	0.35 Air entrained

B. Provide over design factor for concrete mix of 1.15.

2.04 SLUMP

A. Slump for consolidation by vibration: 4 inches. Slump for consolidation other than by vibration: 5 inches.

2.05 PROPORTIONS (ACI 301 3.8)

A. Selection of proportions for normal weight concrete: Method 1.

2.06 REINFORCING STEEL (ACI 301 5.2)

A. Reinforcing Steel: 60 yield grade; deformed billet steel bars, ASTM A615; plain finish.

2.07 EXPANSION JOINTS (ACI 301 6.2)

A. Premolded Expansion Joint Filler: type required shown on Drawings, conforming to ASTM D1751. or ASTM D1752, Type III "Self-Expanding Cork," where indicated. The thickness and profile to match joint design.

2.08 ACCESSORIES

A. Bonding Agent: two component modified epoxy resin; Sikadur Hi-Mod manufactured by Sika Chemical Co. or Epoxtite Binder Code 2385 manufactured by W.R. Grace & Co. Polyvinyl bonding Agent shall be "Weld-Crete" manufactured by Larsen Products Corp., or approved equal.

B. Non-Shrink Grout: Grout shall be a premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; capable of developing a minimum compressive strength of 2,400 PSI in two days; 7,000 PSI in 28 days.

PART 3 EXECUTION

3.01 GENERAL

A. Install concrete work in accordance with ACI 301 except as amended by this Section.

B. Notify the Engineer a minimum 24 hours prior to placement of any concrete.

C. Transport concrete from mixer to place of final deposit in a continuous manner to prevent separation or loss of material and as rapidly as practicable until the unit of operations is complete. Do not use concrete which has reached an initial set or has contained water for more than one hour.

D. Deposit concrete as nearly as practicable to final position to prevent segregation from rehandling. In walls, place concrete in horizontal layers with first batches placed at ends and progress toward the center.

E. Compact concrete immediately after placing by thoroughly agitating the mass to force out air pockets and work the mixture into corners, around reinforcement and inserts, and prevent formation of voids. Do not use vibrators to move concrete horizontally.

F. Concrete trucks will not be permitted on existing foundations.

G. Do not deposit concrete in or under water without the permission of the Engineer.

H. Fresh concrete shall not be placed on concrete which has hardened sufficiently to cause formation of cold joints or planes of weakness within the section. If a section cannot be placed continuously, construction joints shall be located at points as provided for on the Drawings or as approved by the Engineer. When work is resumed, concrete previously placed shall be thoroughly cleansed of foreign materials and laitance, using a stiff wire brush or other tools, and a stream of water if necessary, and then slushed with grout consisting of one part Portland Cement and two parts sand.

I. Free drop of concrete for more than five feet will not be allowed. Where greater drops are required, a tremie shall be employed. Discharge of the tremie shall be controlled such that the concrete may be effectively compacted into horizontal layers not exceeding twelve inch in thickness with a minimum of lateral movement.

J. Hot weather placement of concrete shall be in strict accordance with Hot Weather Concreting, ACI 305R-91. Subgrades shall be kept moist in hot weather to prevent extraction of water from the concrete.

K. Cold weather placement of concrete shall be in strict accordance with Cold Weather Concreting, ACI 306R-88

3.02 FORMWORK (ACI 301 4.2)

A. Obtain the authorization of the Engineer for use of earth forms. When using earth forms, hand-trim sides and bottoms, and remove loose dirt prior to placing concrete.

B. Chamfer exposed edges: 3/4 in x 3/4 in unless otherwise noted on the drawings.

C. Tape or seal joints and seams to provide a smooth surface.

D. Make and erect forms so finished concrete will conform to shapes, lines, grades and dimensions shown on Drawings and to produce plumb, even, true concrete surfaces. Form all exposed concrete surfaces.

E. Tie forms together with spreader-ties. Brace and shore forms as required. Design forms to remain in correct position during and after placement of concrete and not to deflect under weight of wet concrete.

1. Make forms tight to prevent mortar leakage.

3.03 FORM SURFACES PREPARATION (ACI 301 4.4)

A. Apply form release agent on formwork in accordance with manufacturer's recommendations. Apply prior to placing reinforcing steel, anchoring devices and embedded parts. Do not apply form release agent where concrete surfaces will receive applied coverings which are affected by agent.

3.04 FINISHING FORMED SURFACES (ACI 301.10.4)

A. Formed Surface Finishes: Provide rough form finish at surfaces not exposed to view. Provide smooth form finish at surfaces exposed to view.

B. Finish concrete surfaces shall meet the requirements of ACI 117-90.

3.05 FINISHING HORIZONTAL SURFACES

A. Horizontal surfaces which will be exposed after completion, i.e., hanger slabs shall receive a broom finish.

3.06 REMOVAL OF FORMS (ACI 301 4.5)

A. Do not remove forms and bracing until concrete has gained sufficient strength to carry its own weight, construction loads, and design loads which are liable to be imposed upon it. Verify strength of concrete by compressive test results.

3.07 RESHORING (ACI 301 4.6)

A. Remove load supporting forms only when concrete has attained 75 percent of required 28-day compressive strength, provided construction is reshored.

3.08 WELDING (ACI 5.3)

A. Welding Reinforcing Steel is not permitted without the express approval of the Owner.

3.09 CONSTRUCTION JOINTS (ACI 301 6.1)

A. Install construction joints where shown on Drawings.

3.10 INSERTS, EMBEDDED PARTS AND OPENINGS

A. Provide formed openings where required for pipes, conduits, sleeves and other work to be embedded in and passing through concrete members.

B. Coordinate work involved in forming and setting openings, slots, recesses, sleeves, bolts, anchors or other inserts.

3.11 REPAIR OF SURFACE DEFECTS (ACI 301 9.1)

A. Allow the Engineer to inspect concrete surfaces immediately upon removal of forms.

B. Modify or replace concrete not conforming to required lines, detail and elevations.

C. Repair or replace concrete not properly placed resulting in excessive honeycombing and other defects. Do not patch, repair or replace exposed concrete except upon express direction of the Engineer.

3.12 CURING AND PROTECTION

A. Curing shall be in accordance with recommended practice for curing concrete ACI 308-92.

1. Apply specified curing and sealing compound to concrete surfaces as soon as final finishing operations are complete (within two hours and after surface water sheen has disappeared). Apply uniformly in continuous operation by power spray or roller in accordance with manufacturer's directions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

END OF SECTION

SECTION 03400

PRECAST CONCRETE

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. This section includes requirements for providing precast concrete structures including storm drain structures, manholes, and other specified miscellaneous structures to the size, shape, and extent in accordance with the contract documents.

1.02 QUALITY CONTROL

A. Precast concrete shall be supplied by a qualified firm with a minimum of 2 years of continuous operation experience.

B. Contractor shall not place the order for precast structures until order is reviewed and approved by Owner's engineer.

C. The manufacturer or supplier shall provide the Owner, prior to delivery of precast structures for an order, a Certificate of Compliance with the Contractor's name, section sizes, footage, or number of pieces required to fill the order.

D. The Owner reserves the right to inspect and test all precast structures, fittings, and joint material after delivery to the site or at the factory. The manufacturer or supplier shall furnish materials for the tests and labor as required to assist the Owner with the tests.

E. Only approved precast concrete structures shall be shipped to the contract site.

1.03 SUBMITTALS

A. Contractor's drawings.

B. Submit the following Contractor's drawings in accordance with Section 01340:

1. Shop drawings showing complete details, pertinent calculations, design loads, materials, strengths, sizes and thicknesses, joint and connection design, and details for all precast structures.

C. Installation methods for precast sections:

1. This submittal may be waived when the manufacturer has his recommended methods on file with the Owner.

D. Test reports:

1. Submit manufacturer's certified test reports.

1.04 DELIVERY, STORAGE AND HANDLING

A. Precast structures are considered suitable for handling to transport to the contract site after the concrete has cured to minimum strength of 80% of the design strength.

B. Delivery of precast structures shall be coordinated with installation or shall be unloaded with proper equipment along the line of work, outside work limits as near as practicable to point of final placement. They shall be stored off the ground on wood blocks, pallets, or other appropriate means away from brush, poison oak or ivy, and in an accessible area for inspection. Excavated material shall not be placed over or against the stored precast structures.

C. Precast structures and appurtenances shall be unloaded and handled with a crane, backhoe, or equipment of adequate capacity, equipped with appropriate slings and lifting devices to protect the material from damage.

D. If damage occurs and is deemed repairable, it shall be repaired as directed by the Owner in accordance with approved manufacturer's recommendations. If damage is not repairable in the opinion of the Owner, such items of material will be rejected and shall be removed and replaced at the Contractor's expense.

PART 2 MATERIALS

2.01 PRECAST CONCRETE MANHOLE(S), INLETS, AND TRENCHES

A. General

1. Precast concrete shall meet requirements of ASTM C478 and be designed to withstand an HS-20 loading. In addition, the minimum compressive strength of the concrete shall be 4,000 psi and shall have a minimum compression cylinder test of 4,000 psi, any variance being in accordance with ASTM C478; and with joints meeting requirements of ASTM C443. Cement will be Portland, Type II with an Air Content of 5% to 7% as determined in accordance with ASTM C 231. Concrete shall be comprised of cementatious material, water, fine and course aggregate, and add mixtures. The cementatious material shall be Portland or blended hydraulic cement and pozzolan where appropriate.
2. Precast concrete sections shall conform to NMDOT Section 662.2. Furnish in lengths of 1-ft minimum, except not more than one 1-ft section shall be used in a manhole. Precast manhole cone section shall have bolt inserts provided. Inserts shall be embedded a minimum of 3 in., accommodate 9.75-in.-diameter bolts. Inserts shall be provided with plugs for transporting from plant to contract site.
3. Each concrete section shall be clearly marked on the inside near the top with the following information where applicable: ASTM Specification designation, manhole setting number (bases only), date of manufacture, and name or trademark of manufacturer. Markings may be engraved or stenciled with waterproof paint or ink in minimum 1-in.-high letters.
4. Precast concrete grade rings shall meet requirements of ASTM C478, except the minimum strength of the concrete shall be 5,000 psi using Type II cement. Rings shall be drilled with holes 1.5 to 2-in.-diameter to accommodate frame anchor bolts. Grade rings with cracks or fractures passing through the height of the ring and any continuous crack extending for a length of 3 in. or more will be rejected. Planes of the surfaces of the ring shall be within the limits of plus or minus 0.25-in. of horizontal and vertical.
5. Steps shall be a minimum 1-ft wide with a 1-ft center to center spacing, drop front type, and meet the requirements of ASTM C478.

6. Precast concrete materials for trench sections shall conform to NMDOT Section 662.2. Furnish in lengths to minimize number of joints. Supply a closed end on each trench. Sections to be supplied ¾" quick thread rods and steel plate.

B. Gasket Connectors

1. Each manhole precast section shall be fitted with an "O" ring type gasket that conforms to NMDOT Section 662.25.

2. Each joint of the precast trench section will be joined with a Concrete Sealants Inc., sealer type CS-440. The interior of the trench will be painted with a Sika Corporation type Sikaflex 1A material.

2.02 BITUMINOUS COATING

A. All exterior surfaces of precast structures shall be coated with bitumastic material.

B. The bituminous coating shall conform to NMDOT Section 662.26.

2.03 GRATE AND FRAME

A. Manhole covers shall conform to NMDOT Section 662.27.

B. Castings shall be suitable for AASHTO HS-2O loading.

C. Trench grate and frame will be ductile iron, 80-55-06.

PART 3 EXECUTION

3.01 GENERAL

A. Completion of the work shall be in accordance with Section 02720, Storm Drain System

3.02 BACKFILLING

A. Backfilling shall be completed in accordance with Section 02200, Earthwork.

END OF SECTION

DIVISION 6

GEOSYNTHETICS

SECTION 06005

VERY FLEXIBLE POLYETHYLENE GEOMEMBRANE

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The Work includes the manufacture, supply, delivery, testing, and installation of smooth very flexible polyethylene (VFPE) geomembrane for channel lining. The work includes furnishing all materials, labor, supervision, tools, equipment that may be necessary to construct the work in accordance with the Contract Documents. The requirements of this specification have been reduced compared to a typical specification in light of the intended use and in consideration of the limited quantity of material required.

1.02 QUALITY ASSURANCE

A. Manufacturer Qualifications

1. The VFPE manufacturer(s) shall be a specialist in the manufacturing of VFPE geomembrane, and shall have produced and supplied at least 5 million ft^2 of said material that were used in successful applications.

B. Contractor's Geosynthetics Installer Qualifications

1. The Contractor's Geosynthetics Installer (Installer) shall meet the requirements of this Section. The Installer shall be responsible for the performance of the Installer and the installed geosynthetics.

2. The Installer shall be experienced in all aspects of VFPE geomembrane handling, storage, and installation. The Installer shall have successfully installed at least 5 million ft^2 of polyethylene geomembrane within the last 5 years, and be trained and approved by the manufacturer to install the geomembrane materials.

3. The Installer shall employ a field supervisor experienced in the installation of polyethylene geomembrane. This individual shall have installed or supervised the installation of a minimum of 2,000,000 ft^2 of polyethylene geomembrane on a minimum of five (5) different projects.

4. Each welder is required to have a minimum of 1 year of experience welding polyethylene geomembrane, except that the master welder shall have a minimum of three (3) years experience welding polyethylene geomembrane.

C. Geosynthetics Testing Laboratory Qualifications

1. Independent testing of the material is not required. However, the Engineer reserves the right to require testing of the material at an independent testing laboratory. The testing laboratory, if required, shall be accredited by the Geosynthetic Institute to perform the tests required in these Specifications.

D. Materials Testing

1. Material testing shall be completed by the manufacturer in accordance with its Quality Control/Quality Assurance Plan.

1.03 SUBMITTALS

A. General

1. The Contractor shall submit to the Engineer for review and approval the following information:

   a. Name of Manufacturer.

   b. Manufacturer's quality control test results – certified test results.

   c. A Certificate of Compliance along with QC test results from the manufacturer stating that the polymer (raw material) used to manufacture the geomembrane and the geomembrane to be delivered to the site meets all of the physical property requirements presented in Tables 06005-1 and 06005-3, respectively.

   d. Manufacturer's warranty for the installed geomembrane (example).

   e. Proposed installation panel layout drawings, including panel and seam identification, panel orientation, seaming details, and penetration details. Engineer or Owner approval of these drawings does not relieve the Installer of the responsibility to properly install/lay out the geomembrane. The proposed panel layout drawing is tentative and may be modified by the Engineer.

   f. Manufacturer's recommended product defect repair and construction repair procedures.

   g. Manufacturer's recommended field seaming procedures and techniques, including: methods, overlap, personnel identification, QA/QC of seaming operations, temperatures, and preparation of materials.

   h. Manufacturer's nondestructive and destructive seam testing procedures, including: type(s) of tests, a list of equipment required, frequency of tests with locations, methods, qualifications of personnel that perform the tests, and acceptance/rejection criteria for tested seams.

   i. Installer's daily quality control (QC) log and Report of Welds format to be used during geomembrane installation.

Table 06005-1

Polyethylene Polymer(s) for Geomembranes and Extrudate

Property	Test Method	Required Minimum Value	Unit
Density (compounded resin)	ASTM D1505 or D792	0.91	g/cc
Melt Flow Index	ASTM D1238 (Condition E)	<1.0	g/10 min.

Test Frequency: One per shipping container compartment.

Table 06005-2

Conformance and “Fingerprinting” Testing Requirements
for Geomembrane Liners

Property	Test Method
Thickness	ASTM D5199
Tensile Properties	ASTM D638 Type IV
Tear Resistance	ASTM D1004
Puncture Resistance	ASTM D4833
Carbon Black Content	ASTM D1603
Carbon Black Dispersion	ASTM D3015 or D5596
Density	ASTM D1505
Melt Flow Index	ASTM D1238

Table 06005-3

Physical Properties of LDPE/VFPE Geomembrane Liners
(Minimum Average Roll Values)

Property	Test Method	Units	Required Minimum Value
Gauge Thickness (nominal)	ASTM D5199	mils	40
Sheet Density	ASTM D1505	g/cm^3	0.92
Tensile Properties – Tensile strength at break – Elongation at break	ASTM D638 Type IV	 lb/in %	 150 700
Dimensional Stability[a]	ASTM D1204	%	$\underline{+}2$
Puncture Resistance	ASTM D4833	lbs	55
Tear Resistance	ASTM D1004	lbs	22
Coefficient of Linear Thermal Expansion[a]	ASTM D696	$cm/cm^{o}C$	$\leq 2x10^{-4}$
Low Temperature Brittleness[a]	ASTM D746B	^{o}C	$<-70^{o}$
Carbon Black Content	ASTM D1603	%	2-3
Carbon Black Dispersion	ASTM D5596	score	1 or 2 or A1 or A2
Melt Flow Index	ASTM D1238 condition E	g/10 min	≤ 1
ESCR[a]	ASTM D5397	hrs	>200

[a] Certification by manufacturer is adequate.

j. Method of construction procedures for preparation of earthen subgrade and placement of earthen material above the geosynthetics including method of placement, equipment, and personnel.

k. The Installer shall provide a Certificate of Compliance from the manufacturer stating that the resin used to produce the geomembrane to be used on this project has an environmental stress crack resistance of greater than 200 hours as tested in conformance with ASTM D5397.

l. Copies of quality control certificates issued by the resin supplier used to manufacture the geomembrane to be used on this project. These certificates, at a minimum, shall include reports of tests conducted to verify the material quality, including specific gravity, and melt flow index.

m. Documentation shall be submitted to demonstrate chemical compatibility of the geomembrane with any municipal solid waste leachate. The chemical compatibility testing shall be performed using the EPA 9090 testing method with all test results submitted for approval to the Engineer.

n. The Installer shall provide a certificate from the manufacturer stating that the geomembrane to be used on this project will have been produced within one year of receipt of material at the site.

B. Certified Test Reports

1. Certified test reports within the requirements of standards and testing methods specified herein shall be submitted to the Engineer for review and approval prior to delivery. The geomembrane manufacturer and Installer must satisfy the Engineer that the material they offer to furnish and install shall meet in every aspect the requirements set forth in these Specifications. The Installer shall transmit to the Engineer all information given to them by the manufacturer or supplier prior to approval for furnishing and installing any such material.

2. If the manufacturer uses test methods other than those specified, an explanation of the alternate test method shall be provided.

C. Installer's Qualifications

1. At least three (3) weeks prior to commencement of geomembrane installation, the Installer shall submit written notification to the Engineer of the field supervisor and individual welders' work experience relative to polyethylene geomembrane installation and welding. No geomembrane welding shall begin until the Engineer has received the notifications and has approved the field supervisor and the individual welder qualifications.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Materials shall be delivered to the site only after the required submittals have been furnished and approved by the Engineer. Storage and handling of the materials shall conform to the manufacturer's recommendations and shall be done in such a manner as to prevent damage to any part of the Work. The Installer shall provide labor and equipment to properly unload material upon arrival at the site. Storage shall be in an area reasonably free of dirt, dust, direct sunlight, extreme heat, and disturbance. The material shall be stored in a reasonably-level area that is well-drained, away from oils/fuels, brush, poison oak or ivy, in an accessible area for inspection, and on a smooth surface so that the material is well-supported and not resting on sharp objects that could damage it. Geomembrane roll goods shall be underlain by a bedding geotextile and not stacked more than three rolls high. Individual pieces or bundles shall be stored with safe walking space and clearance between them to allow full view for inspection purposes. The protective covers used to wrap each roll of geomembrane, if used by the manufacturer, shall not be removed until immediately before the material is to be installed in the field.

B. Each roll delivered shall have a tag attached that identifies the following:

1. Manufacturer.
2. Product type and thickness.
3. Manufacturer batch code.
4. Manufacturer date.
5. Roll number.
6. Physical dimensions.

PART 2 MATERIALS

2.01 RAW MATERIAL (RESIN)

A. Raw material for the VFPE geomembrane shall be tested for density and melt index. At a minimum, one sample shall be obtained from each shipping container (typically a railcar) compartment. One (1) test for each of the properties in Table 06005-1 shall be performed on each compartment sample. The material shall be accepted for production use if all test results conform to the material requirements listed in Table 06005-1 and are comparable within the various shipment compartments.

2.02 SHEET GEOMEMBRANE

A. The geomembrane shall be smooth VFPE containing no fillers or extenders.

B. The VFPE geomembrane shall be tested prior to shipment to ensure that the physical and chemical properties of the finished product are in conformance with the Specifications. The required conformance testing of geomembranes are presented in Table 06005-2, with the exception of ASTM D5321. The Contractor shall perform three tests of ASTM D5321 for each of the required interfaces prior to shipment of the geosynthetic materials to the job site. Test frequency shall be one of each test per every 50,000 ft^2 of geomembrane produced or as noted. In addition, one 50 ft^2 (minimum) coupon of geomembrane per every 100,000 ft^2 of geomembrane produced shall be retained intact by the manufacturer until construction of the lining system, for which the geomembrane is used, is complete. These coupons shall be submitted to the Engineer upon request.

2.03 EXTRUDATE RESIN (WELDING ROD)

A. Resin used for extrusion welding adjacent sheets and pipe penetrations shall be VFPE produced from the same resin as the sheet geomembrane. Physical properties of the extrudate shall be in conformance with Table 06005-1. The resin shall be supplied in black.

PART 3 EXECUTION

3.01 SUBBASE ACCEPTANCE BY THE CONTRACTOR

A. Prior to installation of the geomembrane, the Installer shall verify the conditions of the installed earthen material surface to ensure that this surface represents a smooth, stable surface reasonably free of stones, organic matter, irregularities, protrusions, loose soil, and any abrupt changes in grade. The Installer shall notify the Engineer in writing of acceptance of the prepared earthen surface prior to installation of the geomembrane. This notification shall be consistent with the requirements of the geomembrane supplier for the bedding layer surface in order to preserve the warranty for the geomembrane.

3.02 INSPECTION OF SHEET GEOMEMBRANE AT JOB SITE

A. The Installer shall be responsible for the inspection of the geomembrane rolls upon their arrival at the job site. Should rolls show damage from transit, they shall be so identified by the Installer and set aside for either return to the manufacturer or repaired in accordance with the manufacturer's recommendations.

B. During unrolling of the geomembrane, the Installer shall carry out visual inspection of the geomembrane surface. Any faulty areas shall be repaired by the Installer using the preapproved techniques. Such repairs shall be recorded on the as-built drawings and reported to the Engineer by means of a daily QC log (see Subsection 3.06). At any point in the Work, if the daily QC log has not been submitted, the Engineer has the right to stop Work at the cost of the Installer until the daily QC log is submitted.

C. During installation of the geomembrane, the Engineer has the option to perform thickness measures at locations along the edges of the geomembrane panel. Any panel deployed having insufficient thickness shall be removed from the site by the Installer at no additional cost to the Owner.

3.03 INSTALLATION

A. General

1. The limits of geomembrane installation shall be as shown on the Drawings. The geomembrane shall be laid out and installed by the approved Installer in accordance with the applicable panel installation drawings approved by the Engineer.

2. All geomembrane shall be installed in a down gradient manner to minimize the potential of surface water flowing beneath placed geomembrane.

3. The Installer shall at all times maintain a clean work area to protect the geomembrane from incidental damage. This activity shall be done on an ongoing

basis throughout the work. There shall be no smoking, glass bottles, or metal cans allowed in an area where geosynthetics are being installed.

4. When placing materials upon any geomembrane(s) or geotextile(s) the Installer shall stage his operations to minimize/eliminate any wrinkles associated with that operation. Furthermore, the Engineer shall notify the Installer when such wrinkling and associated problems are present. It shall be the responsibility of the Installer to modify his operations to minimize/eliminate this problem at no additional cost to the Owner.

B. Field Panel Placement

1. Adjacent geomembrane panels shall be overlapped a minimum of 6 inches prior to hot wedge seaming, unless the Engineer approves a lesser overlap due to limitations of the Installer's welding equipment. In no case shall an overlap of less than 3 inches be approved. The required minimum geomembrane overlap for extrusion welding shall be no less than 3 inches. If excess overlap exists, the bottom sheet shall be field cut. Areas cut to remove wrinkles or fishmouths in excess of six (6) inches shall be cut along the ridge of the wrinkle and seamed.

C. Seam Preparation

1. Prior to seaming, the seam area shall be clean and free of moisture, dust, dirt, debris of any kind, and foreign material. No seaming of the VFPE geomembrane shall be conducted when the material is exposed to moisture from either dew or precipitation. Seams shall be aligned to create the fewest possible number of wrinkles and fishmouths. All seam interfaces shall be visually examined for scratches, blemishes, flaws, and texture.

2. Trimming of seams and patches shall be accomplished using a shielded blade or hook-knife and performed such that all corners are rounded. Whenever possible, the cutting of the geomembrane shall be from the underside, in an upward motion. Any trimming of test strips or patch pieces on the geomembrane shall be performed with a scrub sheet between the geomembrane and the cutting operation. All trimming of seams shall be completed at least 50 ft ahead of seaming operations.

3. For extrusion-welded seams, a small hand-held electric rotary grinder with circular disc grit grinding paper shall be used to remove oxidation at the seam locations. The grinding plate shall be approximately 4 inches in diameter, and No. 80 or No. 100 grit paper shall be used. The depth of the grinding shall be no greater than 10% of the sheet thickness, and in general should only be approximately 5% of the sheet thickness. The grinding shall extend beneath the full width of the extrudate and no greater than 0.25 inch beyond the limit of extrudate after it is placed. Grinding shall precede welding by approximately 15 minutes, and shall be oriented perpendicular to the seam direction rather than parallel to it.

D. Seaming

1. General

a. The approved seaming techniques for the Work are hot-wedge and extrusion fillet welding.

b. Welding of VFPE shall not take place when ambient temperatures are less than 41°F (5°C) or exceed 104°F (40°C), when measured 1 ft above the geomembrane. Weather conditions shall have no precipitation, dew or fog, nor shall winds be in excess of 20 mph during welding.

2. Hot-Wedge Seaming

a. The operator shall keep constant visual contact with the temperature controls, as well as with the completed seam coming out of the machine. Occasional adjustments of the temperature or speed may be necessary to maintain a consistent weld.

b. If an excessive amount of squeeze-out is observed, reduce the temperature and/or pressure to correct the situation. Nip/drive roller marks shall be able to be observed visually, but just barely evident to the touch.

c. Cleaning of the hot-wedge welder shall be performed at least daily.

d. A smooth-insulating plate or heat-insulating fabric shall be placed beneath the hot-welding apparatus after usage.

e. Seams exhibiting burnout due to excessive heat or roller slippage shall be repaired in accordance with Subsection 3.04 as directed by the Engineer.

3. Extrusion Fillet Seaming

a. Grinding of the sheets shall be completed in accordance with Subsection 3.03.C.3. A hot-air welder may be used to tack weld sheets together in order to hold them in proper position for extrusion welding.

b. The extrusion welder is to be purged of all heat-degraded extrudate in the barrel prior to beginning a seam. This shall be done every time the extruder is restarted after a 2-minute or longer downtime. The purged extrudate shall be properly disposed of.

c. Extrudate in the form of a molten, viscous bead shall be deposited over the overlapped seam. The center of the extrudate shall be directly over the edge of the upper sheet.

d. The extrudate thickness shall be approximately two times the specified sheet thickness measured from the top of the bottom sheet to the top or crown of the extrudate. Excessive squeeze-out (or flashing) is acceptable as long as it is equal on both sides and does not interfere with subsequent vacuum box testing. Excessive extrudate build-ups shall be removed, and a patch shall be placed in accordance with Subsection 3.04 if so directed by the Engineer.

e. After seaming, visual inspection of the extrudate bead shall be made, particularly for straight-line alignment, height, and uniformity of surface texture. There shall be no bubbles or pockmarks in the extrudate. Grind marks shall only be visible for no more than 0.25 inch beyond the extrudate. They shall be extremely faint and shall never appear as heavy gouge marks. A patch shall be placed in accordance with Subsection 3.04 over the entire seam where the excessive grinding is observed.

f. Seam weld runs shall terminate at a panel end or tail off gradually. Where extrusion fillet welds are temporarily terminated long enough to cool, they shall be ground prior to applying new extrudate over the existing seam. This restart procedure shall be followed on patches, pipes, fittings, appurtenances, and “T” or “Y” seams.

4. Trial Seams

a. Trial seams shall be made at the beginning of each seaming period (start of day, midday and at the conclusion of the day’s seaming) for each welding apparatus and operator of said apparatus. Trial seams shall be made at least every five hours and every time the seaming equipment or operator is changed. Trial seams shall be made under the same conditions as actual seams (i.e., welding apparatus, electrical cord length, operator, and ambient temperature). The Installer shall make additional trial seams if ambient temperatures vary more than 10°F (0.5°C) from initial trial seam conditions or as directed by the Engineer.

The trial seam sample shall be at least 3 ft long by 2 ft wide (after seaming) with the seam centered lengthwise. Seam overlap shall be nominally 4 inches, with a 3-inch minimum.

b. Six adjoining coupon specimens, each 1-inch wide, shall be cut from the trial seam sample by the Installer using a die cutter to ensure precise 1-inch wide coupons. The coupons shall be tested in peel (outside and inside track) and shear using an electronic readout field tensiometer, at a strain rate of 2 in./min, and they shall not fail in the seam (i.e., Film Tear Bond (FTB), failure in the parent sheet material, is required). The specimen shall not fail at a stress less than 25% of the break strength of the parent material in peel or no less than 30% of the break strength in shear.

Ideally, samples shall be conditioned at 23± 2°C at a relative humidity of 50± 5% for two hours prior to testing. If test conditions vary from these conditions, a 1-inch wide coupon of the parent geomembrane material (no weld) shall be tested in the same manner as the seam specimens to determine the break strength at this condition.

c. If a coupon specimen fails, the entire operation shall be repeated. If the additional coupon 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 trial seams are achieved. All welded seams installed by the seaming apparatus/operator between the period of time when an acceptable coupon specimen and a deficient coupon specimen were obtained shall be evaluated. The evaluation shall consist of cutting three 12-inch wide by 12-inch long samples from the suspect deficient seam. The samples shall be taken at locations directed by the Engineer. The samples shall be field tested by the Installer in shear and peel. If any of the three samples fail the shear and peel criteria, the entire length of deficient welding shall be repaired in accordance with Subsection 3.04.

d. The test weld samples shall be classified according to NSF 54 standards, marked with the date, roll/seam number, operator, ambient temperature, welding machine number, temperature and load at failure. A copy of this information shall be attached to each coupon specimen, which will be retained by the Engineer.

5. Nondestructive Seam Continuity Testing

a. The Installer shall nondestructively test all field seams over their full length using a vacuum test unit, air pressure testing, or other approved method. Continuity testing shall be carried out as the seaming work progresses in accordance with the following procedures unless otherwise recommended by the geomembrane manufacturer:

b. Vacuum Testing

i. A non-detergent soapy solution shall be applied to the surface of the geomembrane immediately prior to testing the seam.

ii. Test shall be performed with a tank pressure of approximately 5 psi (10 inches of Hg) gauge.

iii. Examine the geomembrane seam through the viewing window for 10 seconds.

iv. The next adjoining area shall overlap the previously tested area by a minimum of 3 inches (75 mm).

v. All areas indicating leaks shall be repaired in accordance with Subsection 3.04.

vi. Vacuum-tested seams shall be recorded on the daily QC log (Subsection 3.06) including location, date, test unit number, name of tester, and results of test.

c. Air Pressure Testing

i. Sustain a pressure of 24 to 30 psi of the air channel for approximately 5 minutes.

ii. If the loss of pressure exceeds 3 psi over a five minute period or does not stabilize, locate the faulty area and repair in accordance with Subsection 3.04.

iii. Verify that the length of the tested channel is unobstructed by cutting the air channel at the end opposite the pressure gauge.

iv. Seal test holes with extrudate.

v. Air pressure tested seams shall be recorded on the daily QC log (Subsection 3.06), including location, date, test unit number, name of tester, and results of test.

3.04 DEFECTS AND REPAIRS

A. Identification

1. All seams and nonseam areas of the geomembrane shall be evaluated by the Engineer for identification of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane aids in the detection of defects, the surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be broomed or washed by the Installer if the amount of dust or mud inhibits inspection.

B. Evaluation

1. Each suspect location, both in seams and in nonseam areas, shall be nondestructively tested using the methods described in Subsection 3.03.D, as appropriate. Each location that fails the nondestructive testing shall be marked by the Engineer and repaired by the Installer. Scratches, abrasions, or other imperfections in the geomembrane and welds that are deemed significant by the Engineer shall be repaired.

C. Repair Procedures

1. Repair procedures shall be agreed upon between the Installer and the Engineer prior to geomembrane installation.

2. Defective seams shall be repaired by reconstruction. Seam reconstruction for the fusion welding process shall be achieved by welding a replacement strip (cap) over the failed seam. The replacement strip shall extend at least 12 inches beyond the faulty seam at all locations and shall be extrusion welded completely around its perimeter. A reconstructed seam shall not consist of extrusion welding the outside edge (flap) of the existing weld.

3. Tears or pinholes or other imperfections shall be repaired by seaming or patching. Patches shall be round or oval in shape, made of the same material as the geomembrane, and extend a minimum of 6 inches beyond all edges of the defect.

4. Each repair shall be numbered and logged in the Installer’s daily QC log.

D. Verification of Repairs

1. Each repair shall be nondestructively tested using the methods described in Subsection 3.03.D, as appropriate. Repairs that pass the nondestructive test shall be taken as an indication of an adequate repair. Repairs that fail shall be redone and retested until a passing test results. The Engineer shall observe all nondestructive testing of repairs, and record the number of each patch, date, name of patcher, and test outcome.

2. Seam reconstruction areas resulting from failures in destructive sampling shall also have one destructive test performed within the repair area in accordance with Subsection 3.03.D.6.

3.05 DAILY QUALITY CONTROL LOG

A. The Installer shall maintain a daily quality control (QC) log during all phases of geomembrane installation. This log shall document the daily progression of the geomembrane installation from delivery to final acceptance. The daily QC log shall designate those construction activities that influence the integrity of the geomembrane during installation. The log, at a minimum, shall include entries and detailed documentation of the following:

1. Weather (temperature, winds, precipitation).

2. Preparation activities, including removal of water, sediment, geomembrane cleaning, or subbase smoothing and repair.

3. Document that the roll number and sheet lot number are placed in the required panel locations.

4. Maps or sketches indicating material installed during that day, and material installed previously. Maps or sketches shall indicate the amount of material installed that day, the amount installed previously and the total amount installed to date.

5. Repairs and replacements.

6. Document seaming activities, including name of welder(s) for each seam and any leakage detected in testing of that seam.

7. Results and locations of destructive and nondestructive testing performed as part of geomembrane installation, including corrective action taken.

8. Equipment used to place the geomembrane.

9. Calibration dates for each piece of seaming equipment and seam test equipment.

10. Time periods, locations, and procedures administered when tents are used for geomembrane installation during periods of low temperature.

B. Prior to performing the work, the Installer shall submit the daily QC log format for approval by the Engineer.

END OF SECTION

SECTION 06020

GEOTEXTILES

PART 1 GENERAL

1.01 DESCRIPTION OF WORK

A. The Work includes the manufacture, supply, delivery, testing, storage, and installation of woven and nonwoven geotextiles to be used for filtering and separation media within the drainage and cover systems as indicated on the Contract Drawings. The Contractor shall supply all equipment, tools, labor, supervision, materials, and quality control required to complete the Work in accordance with the Contract Documents.

1.02 QUALITY CONTROL

A. Manufacturer Qualifications

1. The geotextile manufacturer(s) shall be specialist(s) in the manufacturing of polyester, polyethylene, and/or polypropylene geotextile (as applicable), and shall have produced and manufactured a minimum of 5 million ft^2 of said geotextiles that were used in successful installations.

B. Materials Testing

1. Quality control testing of materials shall be as set forth in the applicable referenced Specifications and as required herein. Testing of the geotextiles shall be in accordance with Subsection 2.01.B.

C. Laboratory Testing

1. Unless otherwise indicated, testing shall be performed by the manufacturer.

D. Visual Inspection During Installation

1. During placement of the geotextiles, the Contractor shall carry out visual inspections of the material surface. Any faulty areas relating to material integrity, uniformity, rips or tears, sewing incompleteness, and seam overlap shall be repaired by the Contractor using pre-approved techniques and in accordance with manufacturer recommendations. Such repairs shall be reported to the Owner by means of a daily QC log. At any point in the Work, if the daily QC log has not been submitted, the Owner has the right to stop work at the expense of the Contractor until the daily QC log is submitted.

1.03 SUBMITTALS

A. Certified Test Reports

1. Certified test reports for a minimum of two (2) samples tested in accordance with the standards and testing methods specified herein shall be submitted to the Owner for approval for each geotextile proposed for this project prior to material delivery. The material manufacturer and Contractor must satisfy the Owner that the materials they offer to furnish and install shall meet every aspect of the requirements listed in Table 06020-1 and as stated in PART 2, MATERIALS. The Contractor shall transmit to the

Owner all information given to them by the manufacturer or supplier prior to approval for furnishing and installing any such material.

Table 06020-1

Physical and Mechanical Properties of Geotextiles

Property	Test Method	Required Value [1]	
		Nonwoven	Woven
Visual Inspection	--	Packaging, visible defects	Packaging, visible defects
Mass per Unit Area[(2)]	ASTM D5261	12 oz/yd^2	---
Puncture Strength	ASTM D4833	170 lbs	90 lbs
Apparent Opening Size	ASTM D4751	$\leq$ No. 100 Sieve	---
Grab Tensile Strength	ASTM D4632	300 lbs	200 lbs
Grab Elongation	ASTM D4632	> 50 %	15 %
Tear Strength	ASTM D4533	115 lbs	90 lbs
Burst Strength	ASTM D3786	550 psi	---
Permittivity	ASTM D4491	$\geq$ 0.25 sec[2]	---
UV Resistance[3] (@500 Hours)	ASTM D4355	> 70 % strength retained	---

[1] MARV.
[2] For information only, not a required property.
[3] Manufacturer's certification required which states product exceeds required value for typical roll values.

B. Installation And Repair Recommendations

1. Within three (3) weeks after award of the Contract, submit manufacturer's recommended installation procedures for the sewing of the geotextiles and procedures for repair. All sewing shall be performed by trained personnel of the Contractor or their subcontractors; the geotextile installer must be approved by the Owner. The Contractor may also be requested to submit training or experience records of the installer personnel to the Owner for approval.

C. The Contractor shall submit to the Owner for approval within three (3) weeks after award of the Contract the following information:

1. Contractor's daily QC log format to be used during geotextile installation. This log shall document the daily progression of geotextile installation from delivery to final acceptance. The daily log shall designate these construction activities that influence the integrity of the geotextile during installation. The log, at a minimum, shall include entries and detailed documentation of the following:

a. Weather (temperature, winds, precipitation).

b. Repairs and replacements.

c. Document the roll number and location of each roll when placed.

d. Quantity of material installed that day; quantity installed to date.

D. Laboratory test results shall be submitted as the Work progresses.

E. Sewing equipment information, stitch type, and density proposed for use at the project shall be submitted to the Owner for review prior to placement of geotextile in the field.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Materials shall be delivered to the site only after the required submittals have been approved by the Owner. Storage and handling of the materials shall conform to the manufacturer's recommendations and shall be done in such a manner as to prevent damage to any part of the Work. The Contractor shall provide labor and equipment to properly unload material upon arrival at the site. The material shall be stored in a reasonably level, smooth, and well-drained area that is away from sharp objects or rocks that may puncture the material, away from brush, oil, grease, or fuels, and in an accessible area for inspection. Individual rolls shall be stored with safe walking space and clearance between them to allow full view for inspection purposes. To prevent ultraviolet degradation of the material, the protective wrapper on each geotextile roll shall not be removed until the material is ready for use. Any rolls that are delivered without protective wrappers shall be rejected by the Owner at no cost to the Owner. Any rolls of geotextile that will not be installed within 21 days following delivery to the site shall be covered with tarps to protect the rolls from the elements.

PART 2 MATERIALS

2.01 GEOTEXTILES

A. Geotextiles shall be provided to meet the minimum physical and mechanical properties outlined in Table 06020-1 and as designated on the Drawings. The properties shown represent the MARV for the installed materials, unless otherwise indicated.

B. Geotextiles shall be tested by the manufacturer prior to shipment to ensure that the physical and mechanical properties of the finished product are in accordance with these Specifications. The required material properties, test methods, values, and units are presented in Table 06020-1. Test frequencies shall be one (1) of each test for every 100,000 ft^2 of geotextile produced for this project or as noted in Table 06020-1.

PART 3 EXECUTION

3.01 INSTALLATION RESPONSIBILITY

A. The Contractor shall be responsible for installing the geotextiles and all components and details associated with these materials.

3.02 GEOTEXTILE PLACEMENT

A. Geotextiles shall be placed by the Contractor at the locations and to the limits shown on the Drawings. All seams placed on slopes of 4H:1V or greater shall be overlapped a minimum of twelve (12) in.. All other seams shall be overlapped a minimum of eight (8) in. Seams on slopes shall be oriented with the slope. End-of-roll seams shall be offset a minimum of 5 ft between adjacent roll ends. Cross-slope seams shall be avoided as much as possible.

B. A minimum of 12 in. of the aggregate/soil shall be placed onto the geotextiles and spread in advance of construction equipment not exceeding 15 psi contact pressure. When contact pressures exceed 15 psi, construction equipment shall be limited to operating on 36 in. of aggregate/soil above geosynthetics. The material shall be spread in the same direction as the fabric is seamed. Extreme care shall be required by the Contractor so that the equipment operator pushes the soil materials ahead without damage to the geotextile. At no time shall construction equipment be permitted to track directly on the geotextile. Any damage to the fabric or other geosynthetics shall be repaired by the Contractor (using approved methods) at no expense to the Owner.

C. During periods of high winds, sandbags, or other methods approved by the manufacturer(s) shall be used by the Contractor to temporarily secure any exposed geotextile in place.

3.03 COVERING GEOTEXTILES

A. All geotextiles shall be covered within 21 calendar days, following removal of their protective wrapping and their placement in the field, to protect them from ultraviolet (UV) degradation. The Contractor shall stage construction activities to accomplish the schedule. Any geotextile left exposed longer than the 21 calendar days shall, at the Owner's direction, be removed and replaced at no cost to the Owner.

END OF SECTION

CLIENT/SUBJECT TA-73 LOS ALAMOS AIRPORT LANDFILL CLOSURE W.O. NO 13104.002.001

TASK DESCRIPTION Differential Settlement Evaluation (100% Design Submittal) TASK NO. 7000

PREPARED BY A. Harpur DEPT 1495 DATE 5/24/05

MATH CHECK BY K. Moser DEPT 1495 DATE 5/25/05

METHOD REV. BY A. Harpur DEPT 1495 DATE 5/25/05

BACKGROUND

As part of the closure of the Los Alamos Airport Landfill existing waste will be relocated from the east and north slopes and placed on the flat top area of the landfill. The relocated waste will be placed in a controlled manner, i.e., placed in thin lifts and compacted using dozers, rollers, etc. In order to facilitate the expansion of the airport an asphalt cap will be installed on the flat top area. With the relocation of waste and the construction of the cap there exists a potential for settlement to occur, caused by the application of a surcharge load over potentially compressible materials. Based on the final grading plan, it has been determined that relocated waste and/or cover soils are to be placed in thicknesses up to about 8 feet on the flat top area. The proposed cap on the flat top area will add an additional 18 inches of material and will consist of a minimum 6 inches of existing or relocated interim cover material, 6 inches of aggregate base course (aggregate) and 4 inches of asphalt pavement (MatCon™). The MatCon™ will be replaced by a reinforced concrete slab within the proposed airplane hanger footprints. If there is insufficient waste and existing interim cover soil onsite to achieve the top of Existing/Interim Cover Material grades fill will be imported to achieve the specified elevation.

Waste will be primarily excavated from the east and north slopes of the landfill in order to achieve the desired effective slope inclination of 3H:1V and 4H:1V, respectively and to facilitate the installation of the retaining walls. For purposes of this analysis the waste will be assumed to be municipal solid waste (MSW). This is likely a conservative assumption as the landfill contains construction and miscellaneous debris with some MSW rather than MSW alone.

The design slope inclination for the flat portion of the landfill cap is 2%. The final slope inclination of the flat portion of the landfill, per NMAC regulations must be between 2 and 5%. In order to demonstrate that the minimum final slope will be maintained it is necessary to complete a settlement analysis.

Settlement can be induced by several processes including the following:

1. An increase in the load imposed on potentially compressible materials.
2. Self-weight consolidation, i.e., the material itself densifies and consolidates under its own weight.
3. Degradation/decomposition of existing subsurface materials.
4. Dewatering of the subsurface.

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For the purposes of this analysis, settlement will be calculated based on two factors:

a. Increased load (stress) imposed on undisturbed waste as a result of placing relocated waste and capping materials on the flat top of the landfill.
b. Self-weight consolidation of the relocated waste, including the stress imposed by the weight of the capping materials.

Settlement due to degradation of the waste material will be neglected. The justification for neglecting potential settlement due to this process is the age of the waste, which has been in place for 30 to 60 years (placed 1943 to 1973), the climatic conditions (18 inches of precipitation per year), and the fact that a cap (that will limit infiltration) will be constructed to further retard the degradation process, if it is indeed still active. Settlement due to dewatering will also be neglected as no dewatering of the waste mass has been proposed. Furthermore, there is no evidence of a perched water table or leachate mound within the landfill.

In some areas of the site, predominantly on the north and east sideslopes, there will be a net decrease in load due to waste relocation. In these areas, it is reasonable to assume that settlement will not occur or will be negligible.

Finally, it is assumed that the relocated site soils and the imported materials used to construct the cap, which will be placed in a controlled manner and compacted, will be essentially incompressible and therefore will not contribute to the overall settlement of the landfill. The underlying native soils/bedrock were also assumed to be incompressible.

Settlement of soils may occur almost immediately (elastic settlement) or can occur over an extended period of time (primary consolidation and secondary compression). Generally speaking, granular soils (sand and gravel) experience immediate settlement, while fine-grained soils (silt and clay) experience time-dependant settlement. The three stages or phases of settlement are primary consolidation, secondary compression (creep) settlement. Waste settlement behavior is similar to soils. For purposes of this analysis, the equation used to calculate the waste settlement implicitly assumes 100% primary consolidation of the compressible material. It therefore includes the elastic and primary consolidation components of settlement, but does not encompass time dependant secondary compression which occurs after primary consolidation is complete and is analogous to biodegradation settlement for waste material containing organic constituents.

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The existing grade, the estimated thickness of waste, and the proposed (final) grade are shown on Figures 1, 2, and 3.

ANALYSIS

In order to complete this settlement analysis, a 100 by 100 foot grid was placed over the landfill footprint. The total settlement at each nodal point was then calculated. The differential settlement between nodal points was subsequently determined and the slope of the landfill surface between nodal points was estimated and compared with the regulatory values listed above.

The following equation was used to calculate settlement based on one-dimensional primary consolidation theory. The following is a fundamental equation in basic soil mechanics and is referenced in many soil mechanics text books.

$$\Delta H = C'_c H \log\left(\frac{p_{o(i)} + \Delta p}{p_{o(i)}}\right) \qquad \text{Equation 1}$$

$$\Delta H = \frac{C_c H}{1+e_o} \log\left(\frac{p_{o(i)} + \Delta p}{p_{o(i)}}\right) \qquad \text{Equation 1A}$$

Where:
ΔH = calculated settlement of compressible layer
C_c = compression index of compressible material [*note*: $C'_c = C_c / (1 + e_o)$]
H = thickness of compressible layer
e_o = initial void ratio of compressible material before load application
$p_{o(i)}$ = initial average effective overburden stress at mid-height of compressible layer
$\Delta p_{(i)}$ = attenuated increase in vertical load at mid-height of compressible layer

The input parameters listed above were determined as follows:

- C'_c, for waste was obtained from work performed by WESTON at a municipal solid waste landfill in eastern Pennsylvania[1]. From this study, the average value of C_c' based on a 56-point data base was determined to be 0.22. A value of 0.3 was calculated based on the mean value plus two standard deviations of the data base. There is therefore a 95.4% confidence level that the actual value of C_c' will be less than 0.3, or, stated differently, 95.4% of the time, a measured value of C_c' for MSW will be less than 0.3.
- H, thickness of the compressible layer, i.e., waste, was based on the results of the CPT work and subsurface data provided in the VCM Plan indicating the thickness of waste.
- e_o, initial void ratio of the waste – not required when using C_c'
- $p_{o(i)}$, the initial overburden stress at the mid-height of the waste, was based on the estimated unit weight of the waste and the thickness of the waste. The unit weight of the waste was based on the results of CPT work and literature values.
- $\Delta p_{(i)}$, the attenuated increase in vertical load at the mid-height of the waste, was based on the regraded geometry of the landfill and included the thickness of relocated waste, relocated soils, imported soils and capping materials.

The analysis was separated into two parts: 1) settlement of the undisturbed waste due to the load generated by the placement of relocated waste and capping materials and 2) settlement of relocated waste due to self-weight consolidation.

Since the analysis was repeated at variation locations within the landfill footprint, a spreadsheet was developed for efficiency. An example/verification calculation is presented below to demonstrate that the spreadsheet functions correctly.

An example calculation has been completed for point B4. At this location, the thickness of in-place waste is approximately 19 feet with a thickness of relocated waste of approximately 1.0 feet. The analysis will be completed in two parts as discussed below.

[1] Deutsch, W.L., O. Esterly, and J. Vitale. 1994 "Modeling Settlements of an Existing Municipal Solid Waste (MSW) Landfill Sideslope Using an Earthen Surcharge Pile." Proceedings of "Settlement 94" Conference, Texas A&M University, College Station, Texas. See Appendix A.

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Table 1 lists the parameters used in the analysis.

Table 1 – Material Properties

Material	Total Unit Weight (pcf)	Thickness (ft)
Undisturbed Waste	85	varies
Relocated Waste	90	varies
Interim Cover Soil	110	0.5
Aggregate Base Course	120	0.5
MatCon™	130	.33
Concrete	150	1

Assume the capping system is a composite thickness of 1.5 feet with a unit weight of 130 pcf.

Settlement due to consolidation of undisturbed waste

With respect to point B4:

The existing ground surface elevation is 7133. *This is the top of the existing interim cover obtained from plan view – Figure 1.*
Subtract 1-foot of interim cover soil (assumed thickness) to determine the top of waste elevation.
Top of existing waste elevation is 7133 – 1 = 7132 feet.
The thickness of waste is 18 feet. *Refer to Figure 2.*
The bottom of waste elevation is 7132 – 19 = 7113.
Final grade (top of cap) elevation is 7135.4. *Refer to Figure 3.*
Prep grade (top of relocated interim cover) elevation is 7135.4 – 1.5 = 7133.9.
Therefore, the top of relocated waste elevation is 7133.9 – 1 = 7132.9. *It is assumed that 1-foot of relocated interim cover soil will be placed above the relocated waste.*
Top of existing waste elevation is 7133 – 1 = 7132 feet, see above.
Therefore the thickness of relocated waste is 7132.9 – 7132 = 0.9 feet. Round to nearest ½-foot increment so say 1-foot.
Load due to relocated waste is 1.0 ft x 90 pcf = 90 psf.
Thickness of proposed cap is 1.5 feet.

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Load due to new cover system = 1.5 ft x 130 pcf = 195 psf.

Change in load = 90 psf + 195 psf = 285 psf.
This is the net increase in load that will cause settlement.

The thickness of in-place waste is 19 feet. *Refer to Figure 2.*
Therefore the mid-height of the layer is 19/2 = 9.5 feet.
The existing interim cover is assumed to be 1-foot thick.
The effective stress at the mid-height of the waste layer is
(9.5 feet x 85 pcf) + (1-foot x 110 pcf) = 917.5 psf.

Now, use Equation 1 above to determine the change in thickness of the in-place waste.

$$\Delta H = C_c' H \log\left(\frac{p_{o(i)} + \Delta p}{p_{o(i)}}\right) \qquad \text{Equation 1}$$

$$\Delta H = 0.3 \times 19\text{ft} \ \log\left(\frac{917.5\text{psf} + 285\text{psf}}{917.5\text{psf}}\right) = 0.67 \text{ feet}$$

The calculated settlement at each nodal point is presented in Attachment 1.

Settlement due to self-weight consolidation of relocated waste

In order to complete this analysis, the relocated waste thickness must be subdivided into a number of sublayers of equal thicknesses. For this analysis, the waste thickness was subdivided into 6-inch thick sublayers. Therefore, a total of 2 sublayers were analyzed for nodal point B4 (1-foot of relocated waste). The consolidation of each sublayer will be estimated considering the load imposed on it by the overlying waste layers and the cover system soils. For purposes of this analysis, the cover system soils will consist of 1-foot of interim cover and 1.5 feet of final cap components.

Thickness of each sublayer is 0.5 feet.
Effective stress at mid-height of each sublayer is 0.25 ft x 90 pcf = 22.5 psf.

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Thickness of relocated waste is 1.0 feet.
Therefore the top of the lowest sublayer is 1-foot below the top of waste.
The stress generated by the relocated waste on the top of the lowest sublayer is
0.5 ft x 90 pcf = 45 psf.
The stress generated by 1-foot of interim cover is 1 ft x 110 pcf = 110 psf.
The stress generated by 1.5 feet of cover soil is 1.5 ft x 130 pcf = 195 psf.
Therefore, the total stress generated by the overlying mass is 45 + 110 + 195 = 350 psf.

Now, use Equation 1 above to determine the change in thickness of the in-place waste.

$$\Delta H = C_c H \log\left(\frac{p_{o(i)} + \Delta p}{p_{o(i)}}\right)$$

$$\Delta \mathrm{H} = 0.3 \times 0.5\,\mathrm{ft}\ \log\left(\frac{22.5\,\mathrm{psf} + 350\mathrm{psf}}{22.5\mathrm{psf}}\right) = 0.183 \text{ feet for 2nd sublayer}$$

This is only the anticipated settlement of the 2nd sublayer due to the stress imposed by 0.5 feet of relocated waste, the relocated soil and the capping materials. It is necessary to estimate the settlement that will be caused in the overlying 2 sublayers due to the stress imposed by the respective overlying materials and add the settlement of each sublayer in order to determine the total settlement for the 1.0 foot thick relocated waste layer. This is done following the same procedure presented above. The calculated settlement of each sublayer is presented in Attachment 2. As can be seen in this spreadsheet, the consolidation of each ½-foot thick sublayer increases with increasing thickness of overlying waste, i.e., increasing overburden pressure

Attachment 2 presents a summary table which documents these self-weight consolidation results for relocated waste thicknesses ranging from 0.5 feet to 10 feet in ½-foot increments.

Combined Settlement

With the settlement of the undisturbed waste due to the imposition of additional load in the form of relocated waste and final cover soil at each nodal point and the settlement of the relocated waste due to self-weight consolidation plus interim cover and final cover soil weight calculated for various ½-foot increments of relocated waste thickness, the total anticipated settlement at each nodal point can be determined. The combined settlement requires the addition of the settlement estimated at each nodal point with the settlement estimated for the corresponding relocated waste thickness at the same point. For nodal point B4, the settlement of the undisturbed waste was estimated to be 0.67 feet. The settlement of the relocated waste (1.0-foot) was estimated to be 0.36 feet resulting in a combined total settlement of 1.027 feet. The combined settlement is shown in Attachment 3.

Evaluation of post-settlement cover system inclination

With the settlement determined at each nodal point, the slope of the post-settlement landfill cap can be estimated. While the differential settlement between each point can be mathematically determined, it may not be meaningful in regards to the slope, and ultimately the drainage pattern of the final cover system. Therefore, differential settlement and slope will only be determined between those nodal points which relate to drainage.

RESULTS

The results of the settlement analysis are presented in Attachments 1, 2 and 3. The initial (design) slope between various nodal points and the post-settlement slopes between the same nodal points are shown on Attachment 4. As can be seen, based on these analyses, the slope between some of the nodal points drops below the NMED required minimum of 2%. The minimum post-settlement slope was calculated to be 1.3% (nodes C3 and C5).

CONCLUSIONS

Based on the analysis, it can be concluded that positive drainage will be maintained on the flat top area of the landfill. Although the long-term slope of the cap is less than the prescribed NMED slope of 2%, positive drainage will still be maintained. For asphalt surfaces a minimum slope of 1% is typically recommended. The minimum slope predicted is greater than 1% and so it is concluded that long-term positive drainage will be maintained. Theses analyses did not and cannot address the potential formation of localized depressions. Localized depressions may develop in areas at which dissimilar materials are present, e.g., MSW adjacent to crushed concrete. Localized depressions should be addressed by placing additional MatCon™ as part of the operation and maintenance (O&M) of the cap.

It is acknowledged that the value of C_c' utilized in these calculations is likely conservative as compared

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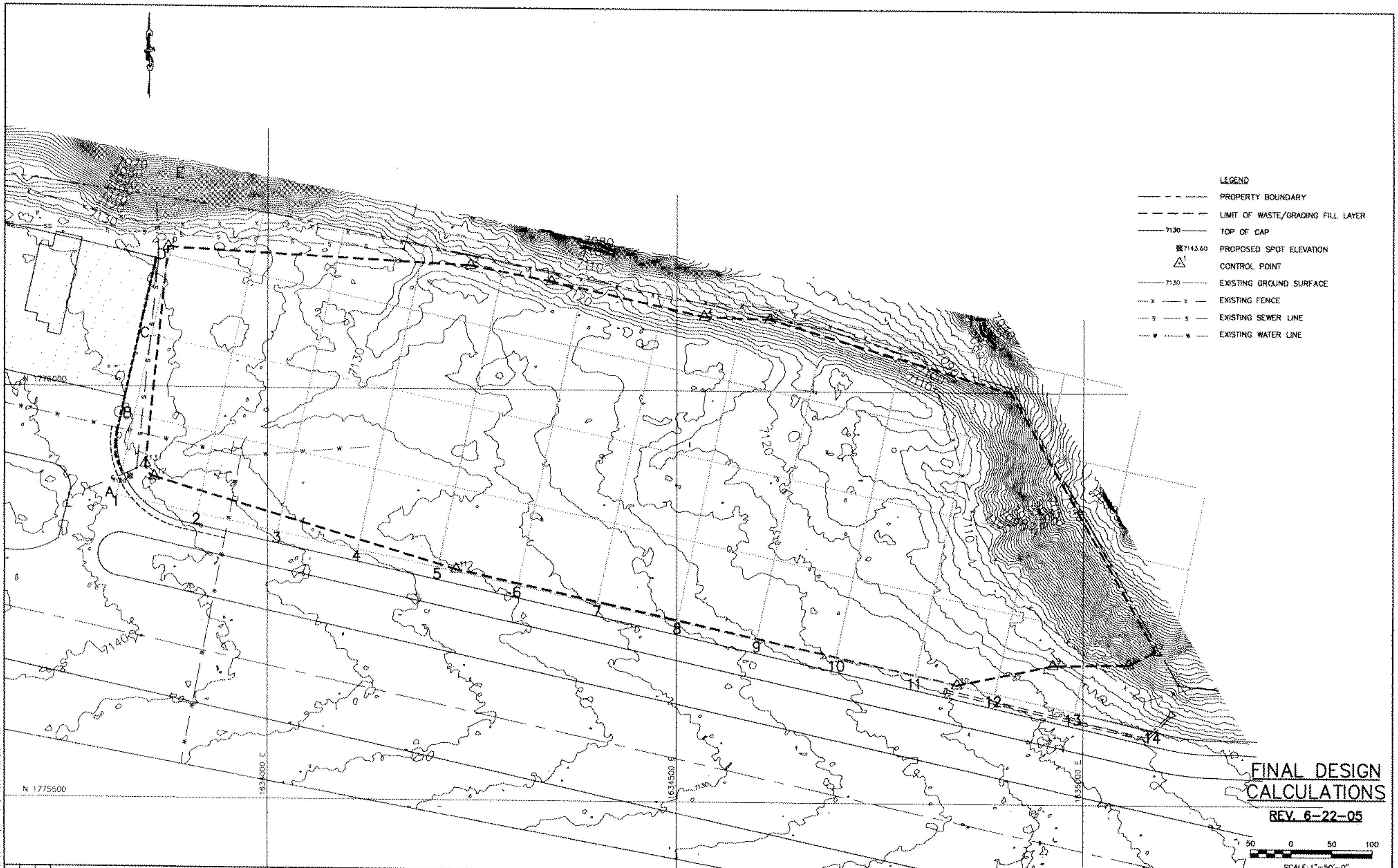
to the actual C_c' value of the in-place waste. The presence of non-MSW debris such as concrete, asphalt and brick in the waste mass will tend to decrease the value of C_c' and therefore decrease the magnitude of settlement that will occur. Regardless of the value of C_c', the calculations show the relative settlement between the various points. A reduction in the value of C_c' will reduce the magnitude of settlement that occurs at any single location, but the relative change in elevation between adjacent points will remain the same. There is a one-to-one correlation between the magnitude of settlement and the value of C_c'; that is, if C_c' is reduced by 50%, the magnitude of settlement will also be reduced by 50%.

It should be noted that the magnitude of settlement estimated for relocated waste will be significantly less than the magnitude presented in these calculations. Because the relocated waste will be placed in thin lifts and compacted using construction equipment it is likely that only minimal settlement of the relocated waste will occur post-construction. Therefore, the total settlement may be more accurately assessed by considering the consolidation of the undisturbed waste only. The maximum predicted settlement under this scenario would be less than 2 feet.

In addition, due to settlement of the landfill and consolidation of the relocated waste due to compaction by construction equipment, it is possible that the final grades shown on the project drawings will not be achieved. A significant portion of the settlement will likely occur during construction assuming granular soil-like waste behavior occurs. The rate of consolidation will be significantly slower if fine-grained or sludge-like materials are encountered or if these types of materials are present within the undisturbed waste mass. It will be necessary to sequence the excavation and placement of waste such that the intent of the final grading plan can be achieved even if the actual elevations cannot be achieved. It is particularly important to provide positive drainage and a design slope of approximately 2% on the top area of the landfill. Likewise it is necessary to achieve positive slope and drainage in channels and culverts. The design may have to be modified as construction progress and changes to the sequence of construction may be required in order to achieve the design intent in order to minimize the volume of waste that must be transported off-site or the volume of fill that must be imported.



NO.	DATE	APPR.	REVISION
B			BOX DESIGN SUBMITTAL
A			BOX DESIGN SUBMITTAL

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

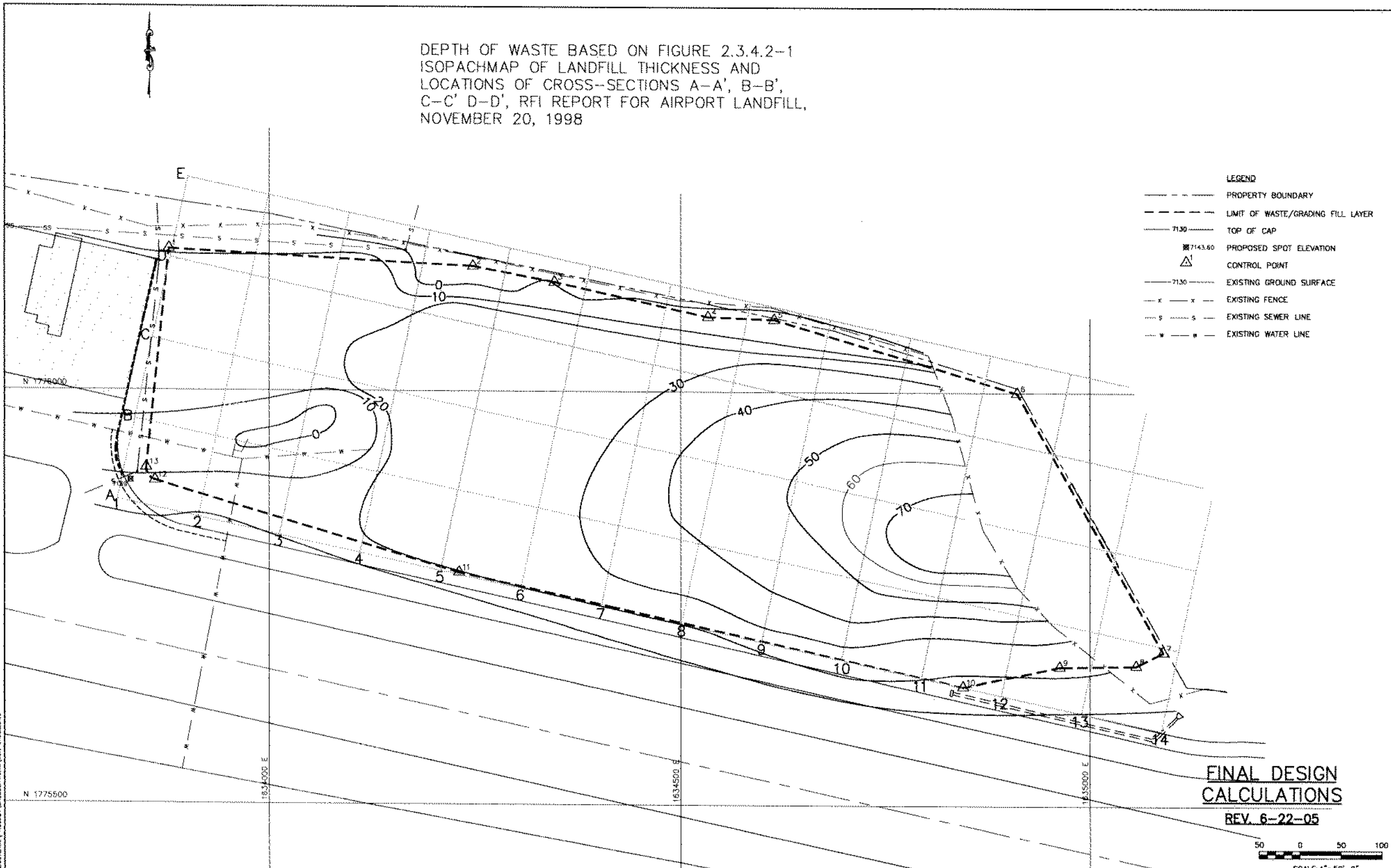
North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	03/23/04
DESIGN ENG.	SW	03/23/04
PROJ. ENG.	AH	03/23/04
PROJ. MGR.	BK	03/23/04
APPROVED	BK	03/23/04

LANDFILL
EXISTING GRADE

DRAWN	DATE	DWG NO.	REV NO.
GDM	02/06/04	FIG. 1	A
SCALE AS SHOWN	W.O. NO. 13104.002.001		

G:\ACADPROJ\13104.002.001\LANL\PROJECT\CALCULATIONS\BOXCALCS.DWG



LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON TEAM

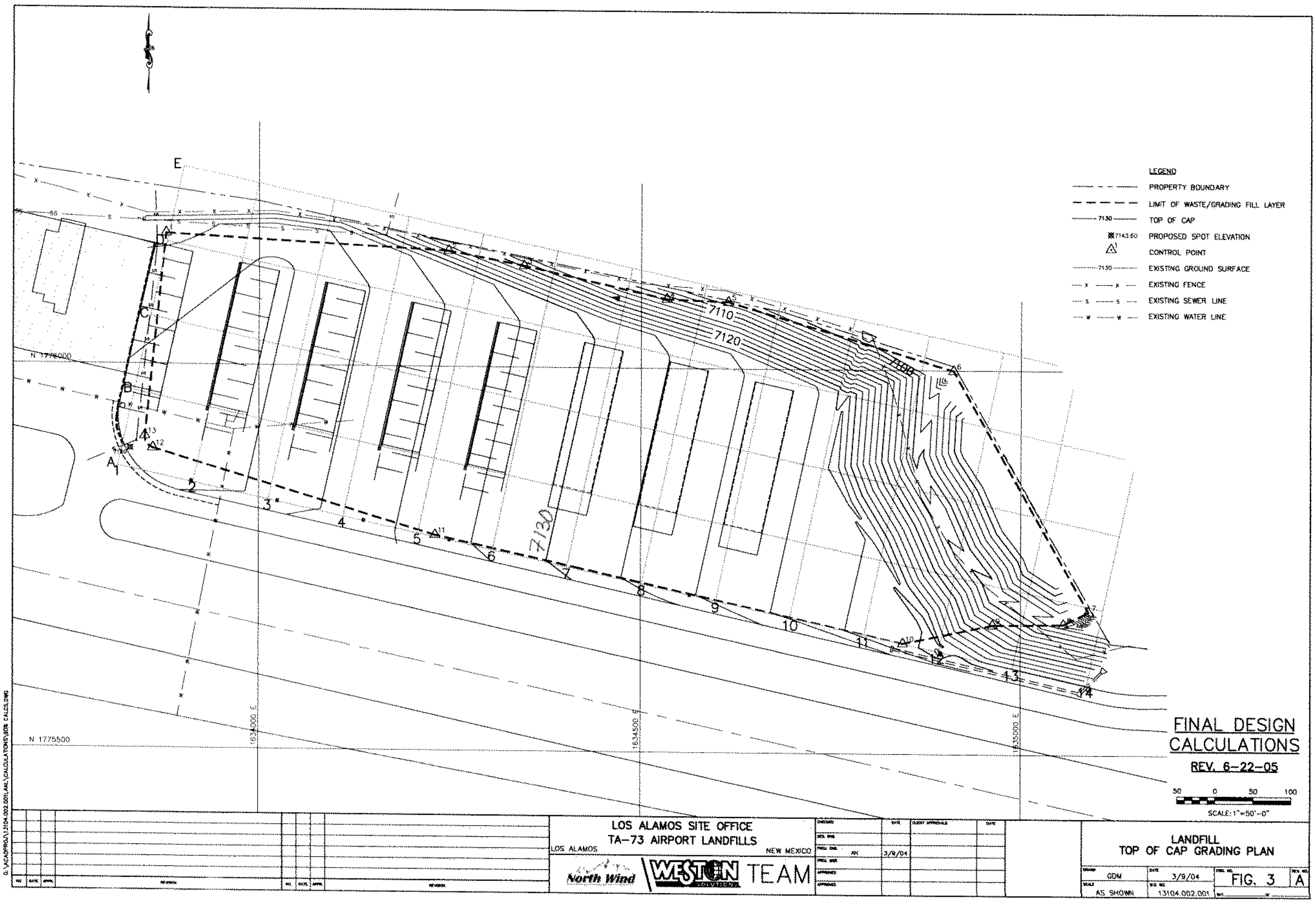
B	90% DESIGN SUBMITTAL		
A	60% DESIGN SUBMITTAL		
NO.	DATE	APPR.	REVISION

CHECKED	RWW	03/23/04
SCH. ENG.	SW	03/23/04
PROJ. ENG.	AH	03/23/04
PROJ. MGR.	BK	03/23/04
APPROVED	BK	03/23/04

LANDFILL
WASTE THICKNESS
ISOPACH MAP

DRAWN: GDM | DATE: 02/06/04 | DWG NO.: FIG. 2 | REV: A
SCALE: AS SHOWN | W.O. NO.: 13104.002.001

G:\ACADPROJ\13104.002.001LANL\PROJECT\CALCULATIONS\90% CALCS.DWG


LEGEND
PROPERTY BOUNDARY
LIMIT OF WASTE/GRADING FILL LAYER
7130 TOP OF CAP
7143.60 PROPOSED SPOT ELEVATION
CONTROL POINT
7130 EXISTING GROUND SURFACE
EXISTING FENCE
EXISTING SEWER LINE
EXISTING WATER LINE
7110
7120
7130
N 1776000
N 1775500
1634000 E
1634500 E
1635000 E
FINAL DESIGN CALCULATIONS
REV. 6-22-05
SCALE: 1"=50'-0"
LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS
NEW MEXICO
North Wind
WESTON SOLUTIONS
TEAM
AH
3/9/04
LANDFILL
TOP OF CAP GRADING PLAN
GDM
3/9/04
AS SHOWN
13104.002.001
FIG. 3
A

ATTACHMENTS

Grid Point	Bottom of Waste (Elevation)	Thickness of Waste (feet)	Top of Waste (Elevation)	Thickness of Existing Cover Soil (feet)	Existing Grade (Elevation)	Prep Grade (Elevation)	Thickness of Relocated Waste (feet)	Thickness of Cover Soil (feet)	Top of Cap (Elevation)	Total Unit Weight of Existing Waste (pcf)	Total Unit Weight of Existing Cover Soil (pcf)	Total Unit Weight of Relocated Waste (pcf)	Total Composite Weight of Proposed Cover System (pcf)	Change in Load (psf)	Effective Stress at Midheight of Waste (psf)	C_c'	Δ_H undistrubed waste (feet)
B2	7128	5	7133	1	7134	7138.1	4.0	1.5	7139.6	85	110	90	130	555	322.5	0.3	0.65
B3	7127	5	7132	1	7133	7135.9	3.0	1.5	7137.4	85	110	90	130	465	322.5	0.3	0.58
B4	7113	19	7132	1	7133	7133.9	1.0	1.5	7135.4	85	110	90	130	285	917.5	0.3	0.67
B5	7107	24	7131	1	7132	7131.9	0.0	1.5	7133.4	85	110	90	130	85	1130	0.3	0.23
B6	7101	28	7129	1	7130	7129.9	0.0	1.5	7131.4	85	110	90	130	85	1300	0.3	0.23
B7	7092.5	34	7126.5	1	7127.5	7128	0.5	1.5	7129.5	85	110	90	130	240	1555	0.3	0.64
B8	7085	39	7124	1	7125	7125.9	1.0	1.5	7127.4	85	110	90	130	285	1767.5	0.3	0.76
B9	7076.5	45	7121.5	1	7122.5	7124	1.5	1.5	7125.5	85	110	90	130	330	2022.5	0.3	0.89
B10	7069.5	50	7119.5	1	7120.5	7122	1.5	1.5	7123.5	85	110	90	130	330	2235	0.3	0.90
~~B11~~	~~7065~~	~~52~~	~~7117~~	~~1~~	~~7118~~	~~7106.5~~	~~-11.5~~	~~1.5~~	~~7108~~	~~85~~	~~110~~	~~90~~	~~130~~	~~-950~~	~~2320~~	~~0.3~~	~~0.00~~
~~B12~~	~~7068.5~~	~~45~~	~~7113.5~~	~~1~~	~~7114.5~~	~~7084.5~~	~~-30.0~~	~~1.5~~	~~7086~~	~~85~~	~~110~~	~~90~~	~~130~~	~~-2615~~	~~2022.5~~	~~0.3~~	~~0.00~~
~~B13~~	~~7039~~	~~54~~	~~7093~~	~~1~~	~~7094~~	~~7066~~	~~-28.0~~	~~1.5~~	~~7067.5~~	~~85~~	~~110~~	~~90~~	~~130~~	~~-2435~~	~~2405~~	~~0.3~~	~~0.00~~
C2	7123	12	7135	1	7136	7137.1	1.0	1.5	7138.6	85	110	90	130	285	620	0.3	0.59
C3	7116	15	7131	1	7132	7135.9	4.0	1.5	7137.4	85	110	90	130	555	747.5	0.3	1.09
C4	7108.5	21	7129.5	1	7130.5	7133.9	3.5	1.5	7135.4	85	110	90	130	510	1002.5	0.3	1.13
C5	7105.5	24	7129.5	1	7130.5	7131.9	1.5	1.5	7133.4	85	110	90	130	330	1130	0.3	0.80
C6	7100	27	7127	1	7128	7129.9	2.0	1.5	7131.4	85	110	90	130	375	1257.5	0.3	0.92
C7	7091	33	7124	1	7125	7128	3.0	1.5	7129.5	85	110	90	130	465	1512.5	0.3	1.15
C8	7078.5	43	7121.5	1	7122.5	7125.9	3.5	1.5	7127.4	85	110	90	130	510	1937.5	0.3	1.31
C9	7069	50	7119	1	7120	7124	4.0	1.5	7125.5	85	110	90	130	555	2235	0.3	1.44
C10	7051	65	7116	1	7117	7122	5.0	1.5	7123.5	85	110	90	130	645	2872.5	0.3	1.72
~~C11~~	~~7042~~	~~70~~	~~7112~~	~~1~~	~~7113~~	~~7087.5~~	~~-25.5~~	~~1.5~~	~~7089~~	~~85~~	~~110~~	~~90~~	~~130~~	~~-2210~~	~~3085~~	~~0.3~~	~~0.00~~
~~C12~~	~~7039~~	~~40~~	~~7079~~	~~1~~	~~7080~~	~~7060.5~~	~~-19.5~~	~~1.5~~	~~7062~~	~~85~~	~~110~~	~~90~~	~~130~~	~~-1670~~	~~1810~~	~~0.3~~	~~0.00~~
D2	7124	11	7135	1	7136	7136.1	0.0	1.5	7137.6	85	110	90	130	85	577.5	0.3	0.20
D3	7115.5	15	7130.5	1	7131.5	7135.9	4.5	1.5	7137.4	85	110	90	130	600	747.5	0.3	1.15
D4	7109	18	7127	1	7128	7133.9	6.0	1.5	7135.4	85	110	90	130	735	875	0.3	1.43
D5	7105.5	22	7127.5	1	7128.5	7131.9	3.5	1.5	7133.4	85	110	90	130	510	1045	0.3	1.14
D6	7102.5	23	7125.5	1	7126.5	7129.9	3.5	1.5	7131.4	85	110	90	130	510	1087.5	0.3	1.15
D7	7099	25	7124	1	7125	7128	3.0	1.5	7129.5	85	110	90	130	465	1172.5	0.3	1.09
D8	7089.5	33	7122.5	1	7123.5	7125.9	2.5	1.5	7127.4	85	110	90	130	420	1512.5	0.3	1.05
D9	7077	40	7117	1	7118	7124	6.0	1.5	7125.5	85	110	90	130	735	1810	0.3	1.78
~~D10~~	~~7071~~	~~45~~	~~7116~~	~~1~~	~~7117~~	~~7122~~	~~5.0~~	~~1.5~~	~~7123.5~~	~~85~~	~~110~~	~~90~~	~~130~~	~~645~~	~~2022.5~~	~~0.3~~	~~1.62~~
~~D11~~	~~7039~~	~~72~~	~~7111~~	~~1~~	~~7112~~	~~7082.5~~	~~-29.5~~	~~1.5~~	~~7084~~	~~85~~	~~110~~	~~90~~	~~130~~	~~-2570~~	~~3170~~	~~0.3~~	~~0.00~~
~~D12~~	~~7039~~	~~13~~	~~7052~~	~~1~~	~~7053~~	~~7051.5~~	~~-1.5~~	~~1.5~~	~~7053~~	~~85~~	~~110~~	~~90~~	~~130~~	~~-50~~	~~662.5~~	~~0.3~~	~~0.00~~

SELF-WEIGHT CONSOLIDATION

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Relocated Waste			Stress at mid-height of 0.5-ft thick layer	Interim Cover			Capping System			Total Combined Load	C'c	ΔH for .5-ft sublayer	ΔH
2	Thickness	Unit Weight	Load		Thickness	Unit Weight	Load	Thickness	Unit Weight	Load				
3	(ft)	(pcf)	(psf)	(psf)	(ft)	(pcf)	(psf)	(ft)	(pcf)	(psf)	(psf)		(ft)	(ft)
4														
5	0.5	90	0	22.5	1	110	110	1.5	130	195	305	0.3	0.174	0.174
6	1.0	90	45	22.5	1	110	110	1.5	130	195	350	0.3	0.183	0.357
7	1.5	90	90	22.5	1	110	110	1.5	130	195	395	0.3	0.190	0.548
8	2.0	90	135	22.5	1	110	110	1.5	130	195	440	0.3	0.197	0.745
9	2.5	90	180	22.5	1	110	110	1.5	130	195	485	0.3	0.203	0.947
10	3.0	90	225	22.5	1	110	110	1.5	130	195	530	0.3	0.209	1.156
11	3.5	90	270	22.5	1	110	110	1.5	130	195	575	0.3	0.214	1.370
12	4.0	90	315	22.5	1	110	110	1.5	130	195	620	0.3	0.218	1.588
13	4.5	90	360	22.5	1	110	110	1.5	130	195	665	0.3	0.223	1.811
14	5.0	90	405	22.5	1	110	110	1.5	130	195	710	0.3	0.227	2.038
15	5.5	90	450	22.5	1	110	110	1.5	130	195	755	0.3	0.231	2.268
16	6.0	90	495	22.5	1	110	110	1.5	130	195	800	0.3	0.234	2.503
17	6.5	90	540	22.5	1	110	110	1.5	130	195	845	0.3	0.238	2.741
18	7.0	90	585	22.5	1	110	110	1.5	130	195	890	0.3	0.241	2.982
19	7.5	90	630	22.5	1	110	110	1.5	130	195	935	0.3	0.244	3.226
20	8.0	90	675	22.5	1	110	110	1.5	130	195	980	0.3	0.247	3.474
21	8.5	90	720	22.5	1	110	110	1.5	130	195	1025	0.3	0.250	3.724
22	9.0	90	765	22.5	1	110	110	1.5	130	195	1070	0.3	0.253	3.977
23	9.5	90	810	22.5	1	110	110	1.5	130	195	1115	0.3	0.256	4.232
24	10.0	90	855	22.5	1	110	110	1.5	130	195	1160	0.3	0.258	4.490

Grid Point	ΔH undistrubed waste (feet)	$\Delta H_{relocated\ waste}$ (feet)	ΔH_{total} (feet)	DesignTop of Cap (Elevation)	Long Term Top of Cap (Elevation)
B2	0.65	1.59	2.240	7139.6	7137.4
B3	0.58	1.16	1.738	7137.4	7135.7
B4	0.67	0.36	1.027	7135.4	7134.4
B5	0.23	0.00	0.227	7133.4	7133.2
B6	0.23	0.00	0.231	7131.4	7131.2
B7	0.64	0.17	0.810	7129.5	7128.7
B8	0.76	0.36	1.117	7127.4	7126.3
B9	0.89	0.55	1.434	7125.5	7124.1
B10	0.90	0.55	1.445	7123.5	7122.1
C2	0.59	0.36	0.949	7138.6	7137.7
C3	1.09	1.59	2.673	7137.4	7134.7
C4	1.13	1.37	2.495	7135.4	7132.9
C5	0.80	0.55	1.349	7133.4	7132.1
C6	0.92	0.74	1.663	7131.4	7129.7
C7	1.15	1.16	2.309	7129.5	7127.2
C8	1.31	1.37	2.679	7127.4	7124.7
C9	1.44	1.59	3.033	7125.5	7122.5
C10	1.72	2.04	3.753	7123.5	7119.7
D2	0.20	0.00	0.197	7137.6	7137.4
D3	1.15	1.81	2.962	7137.4	7134.4
D4	1.43	2.50	3.933	7135.4	7131.5
D5	1.14	1.37	2.509	7133.4	7130.9
D6	1.15	1.37	2.522	7131.4	7128.9
D7	1.09	1.16	2.244	7129.5	7127.3
D8	1.05	0.95	2.001	7127.4	7125.4
D9	1.78	2.50	4.279	7125.5	7121.2

SUMMARY OF SLOPE BETWEEN NODAL POINTS

Point	B2	B4	B4	B6	B6	B8	B8	B10	C3	C4	C3	C5
Initial Elevation (ft)	7139.6	7135.4	7135.4	7131.4	7131.4	7127.4	7127.4	7123.5	7137.4	7135.4	7137.4	7133.4
Change in elevation	4.2		4.0		4.0		3.9		2.0		4.0	
Length (ft)	200		200		200		200		100		200	
Design Slope	2.1%		2.0%		2.0%		1.9%		2.0%		2.0%	
	Acceptable		Acceptable		Acceptable		Acceptable		Acceptable		Acceptable	
Post-Settlement Elevation (ft)	7137.4	7134.4	7134.4	7131.2	7131.2	7126.3	7126.3	7122.1	7134.7	7132.9	7134.7	7132.1
Change in elevation	3.0		3.2		4.9		4.2		1.8		2.7	
Length (ft)	200		200		200		200		100		200	
Final (post-settlement) Slope	1.5%		1.6%		2.4%		2.1%		1.8%		1.3%	
	Less than NMED min. slope		Less than NMED min. slope		Acceptable		Acceptable		Less than NMED min. slope		Less than NMED min. slope	

Point	C5	C6	C6	C8	C8	C9	C9	C10	D3	D5	D5	D6	D7	D9
Initial Elevation (ft)	7133.4	7131.4	7131.4	7127.4	7127.4	7125.5	7125.5	7123.5	7137.4	7133.4	7133.4	7131.4	7129.5	7125.5
Change in elevation	2.0		4.0		1.9		2.0		4.0		2.0		4.0	
Length (ft)	100		200		100		100		200		100		200	
Design Slope	2.0%		2.0%		1.9%		2.0%		2.0%		2.0%		2.0%	
	Acceptable		Acceptable		Acceptable		Acceptable		Acceptable		Acceptable		Acceptable	
Post-Settlement Elevation (ft)	7132.1	7129.7	7129.7	7124.7	7124.7	7122.5	7122.5	7119.7	7134.4	7130.9	7130.9	7128.9	7127.3	7121.2
Change in elevation	2.3		5.0		2.3		2.7		3.5		2.0		6.0	
Length (ft)	100		200		100		100		200		100		200	
Final (post-settlement) Slope	2.3%		2.5%		2.3%		2.7%		1.8%		2.0%		3.0%	
	Acceptable		Acceptable		Acceptable		Acceptable		Less than NMED min. slope		Acceptable		Acceptable	

APPENDIX A

Modeling Settlements of an Existing Municipal Solid Waste Landfill Sideslope Using an Earthen Surcharge Pile

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Abstract: This paper discusses the results of a large-scale field compressibility test completed on municipal solid waste (MSW). The test consisted of surcharging the waste mass with an earthen surcharge pile. A survey control system permitted the total settlement of the waste mass induced by the surcharge loading to be determined. Mathematical models for predicting MSW settlement under an applied surcharge loading were subsequently developed using normally consolidated soil settlement and multiple linear regression theories.

Introduction

The large-scale field study discussed in this paper was completed for the purpose of determining design parameters for potential overfilling of existing landfill sideslopes at the Lanchester Landfill facility in Honey Brook, Pennsylvania. In particular, to maximize future waste disposal quantities at this facility, the Chester County Solid Waste Authority (CCSWA) is proposing to overfill additional MSW within the available air space between the eastern sideslope of their closed Municipal Site Landfill and the adjacent western sideslope of Cell No. 1 of their currently active Area B landfill. In accordance with current Pennsylvania Department of Environmental Resources (DER) MSW landfill lining system regulations, CCSWA

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must initially install a geosynthetic lining/leachate collection system over the existing landfill sideslope prior to placement of additional waste at this location. The intent of this project was to simulate the total settlements and lateral movements of the existing waste mass when subjected to the additional applied stress of overfilled waste materials. These vertical and lateral movements would allow the maximum strains generated within the geosynthetics of an overfill lining system to be calculated. Based on these calculated strains, appropriate geosynthetic reinforcement criteria for the overfill lining system could be developed. The reinforcement would protect the geosynthetic components of this lining system, in particular, the geomembrane, from excessive straining and possible tear resulting from underlying waste settlements.

To complete this study, an earthen surcharge pile, whose maximum height modeled the stress of the proposed overfilled waste, was constructed on the eastern sideslope of the closed Municipal Site Landfill following an initial survey of the topography of this slope. This pile was removed at a later date and the area was resurveyed. This database allowed total settlements and lateral movements of the underlying waste mass to be determined, as discussed in the remainder of this paper.

Existing Site Conditions

The site of the field study consisted of the eastern sideslope of a closed portion of the landfill. The length of the referenced sideslope is approximately 250 feet (ft) (76.2 m). The inclination of this sideslope is approximately 3H:1V. At the time of this study, the landfill sideslope was covered with an intermediate soil layer and a vegetative cover.

Fieldwork

The following activities were completed as part of the construction of the earthen surcharge pile on the eastern sideslope of the Municipal Site Landfill and are discussed in detail below.

I. Test Pit Investigation

Two test pits were excavated along the eastern sideslope of the closed landfill to determine the typical composition and degree of degradation of the buried waste. It was observed that the encountered waste was relatively "fresh" (i.e., very little biodegradation of the waste had occurred), and that newspapers dated from the mid-1970s were intact and readable. The generally "fresh" condition of this waste was an indication that settlement of this mass under the surcharge loading would occur within a reasonably short period of time consistent with the project schedule.

II. Settlement Plates Installation

Six settlement plates were installed on the landfill sideslope in order to monitor the settlement of the MSW as a function of time, both during construction and upon completion of the earthen surcharge pile. The steel settlement plates of 3-ft (0.9-m)-square plan dimensions were set on level earthen benches at approximately 25-ft (7.6-m) intervals along the center line of the surcharge pile in the direction from the toe to the top of the landfill sideslope. Vertical extension rods consisting of 1-inch (2.54-cm)-diameter galvanized pipe were fastened to the plates and then surrounded by a 3-inch (7.62-cm)-diameter pipe casing that directly contacted the adjacent fill soils. This construction allowed the inner pipe, which was used to obtain the survey control measurements, to move freely (i.e., settle) in response to underlying waste settlements.

III. Construction of Survey Control System

Subsequent to installation of the settlement plates, a nonwoven needlepunched (NWNP) geotextile was placed directly on the landfill sideslope beneath the entire footprint of the surcharge pile. The geotextile provided a clean working surface upon which the survey control system discussed below could be established. The geotextile fabric was extended approximately 5 ft (1.5 m) beyond the footprint of the surcharge pile on all sides and secured to the sideslope to avoid potential uplift from wind.

Sixty-four (64) metal pins that served as survey nodal points were subsequently nailed through the geotextile and into the landfill sideslope. The pins were installed in a grid-like pattern at a 25-ft (7.6-m)spacing interval over a 175-ft (53.3-m)-square footprint. Each nodal point was identified with a specific alphanumeric designation (e.g., A1, F6), as shown in Fig. 1. The geotextile surrounding each nodal point was subsequently painted so that these survey points could be easily located during the "post-settlement" survey. A second geotextile was installed atop this geotextile as a protective cover for the survey control system.

Prior to constructing the earthen surcharge pile, the project surveyors determined the northern and eastern coordinates (i.e., plan location) and the elevation of each nodal point and the top of riser pipe for each of the six settlement plates. The "pre-settlement" plan coordinates and elevation of each nodal point and settlement plate were tabulated and later compared to the "post-settlement" survey measurements (i.e., once the surcharge pile was removed from the sideslope). This comparison permitted computation of the total settlement and lateral movements of the underlying waste mass that had occurred under the loading, as discussed later in this paper.

IV. Construction of Surcharge Pile

The geometry of the soil surcharge pile was selected to model the applied stresses resulting from the proposed future overfilled MSW loadings. Recognizing that the unit weight of the soils used to construct the surcharge pile would be approximately twice that of typical MSW, the design height of the surcharge pile was selected to be approximately 50% of the proposed maximum height to which future overfilled refuse would be landfilled. A cross section showing the approximate design dimensions of the earthen surcharge pile in relation to the eastern sideslope of the closed landfill is presented in Fig. 2.

Construction of the surcharge soil pile was completed using two different colored and textured soils that were obtained from on-site borrow areas. The initial soil lift (i.e., approximately 1 ft (0.3 m) of material) placed directly upon the upper

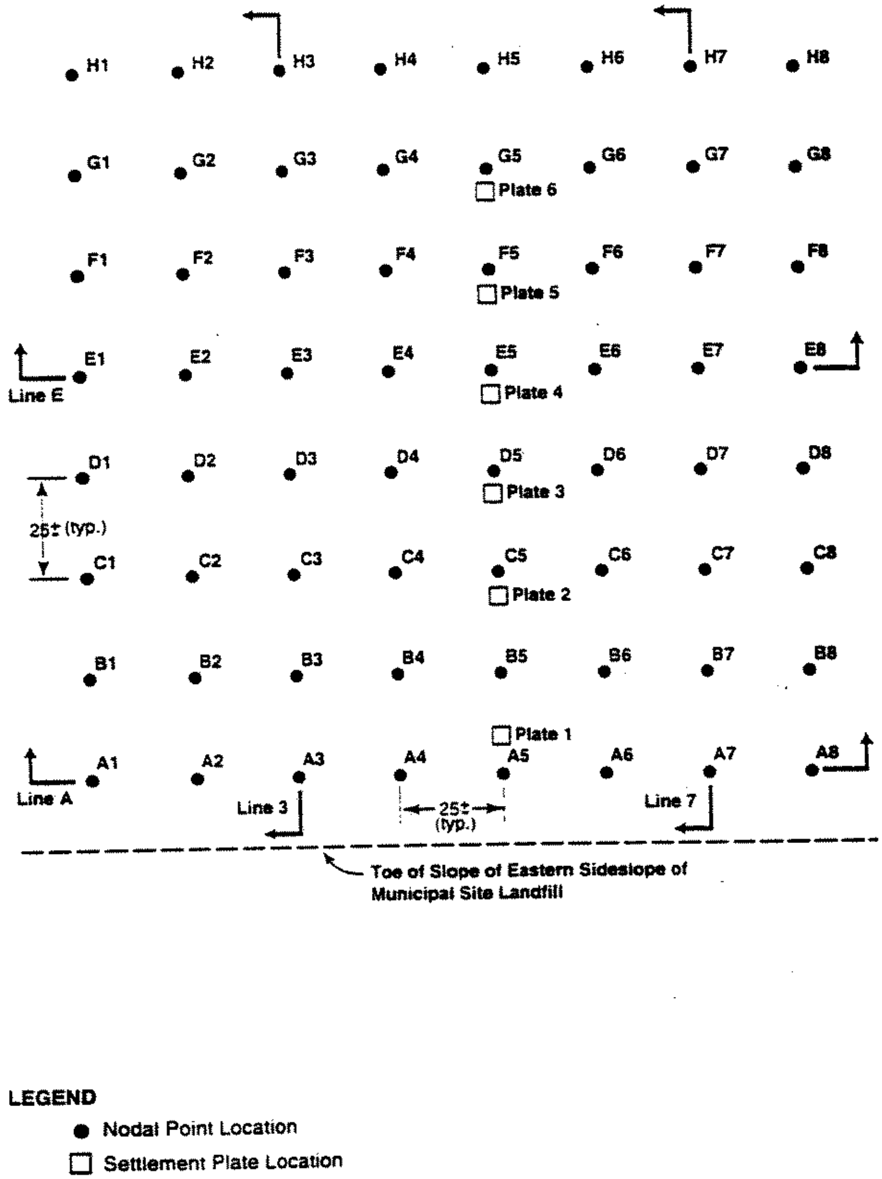

FIG. 1. Survey Control System, CCSWA, Lanchester Landfill

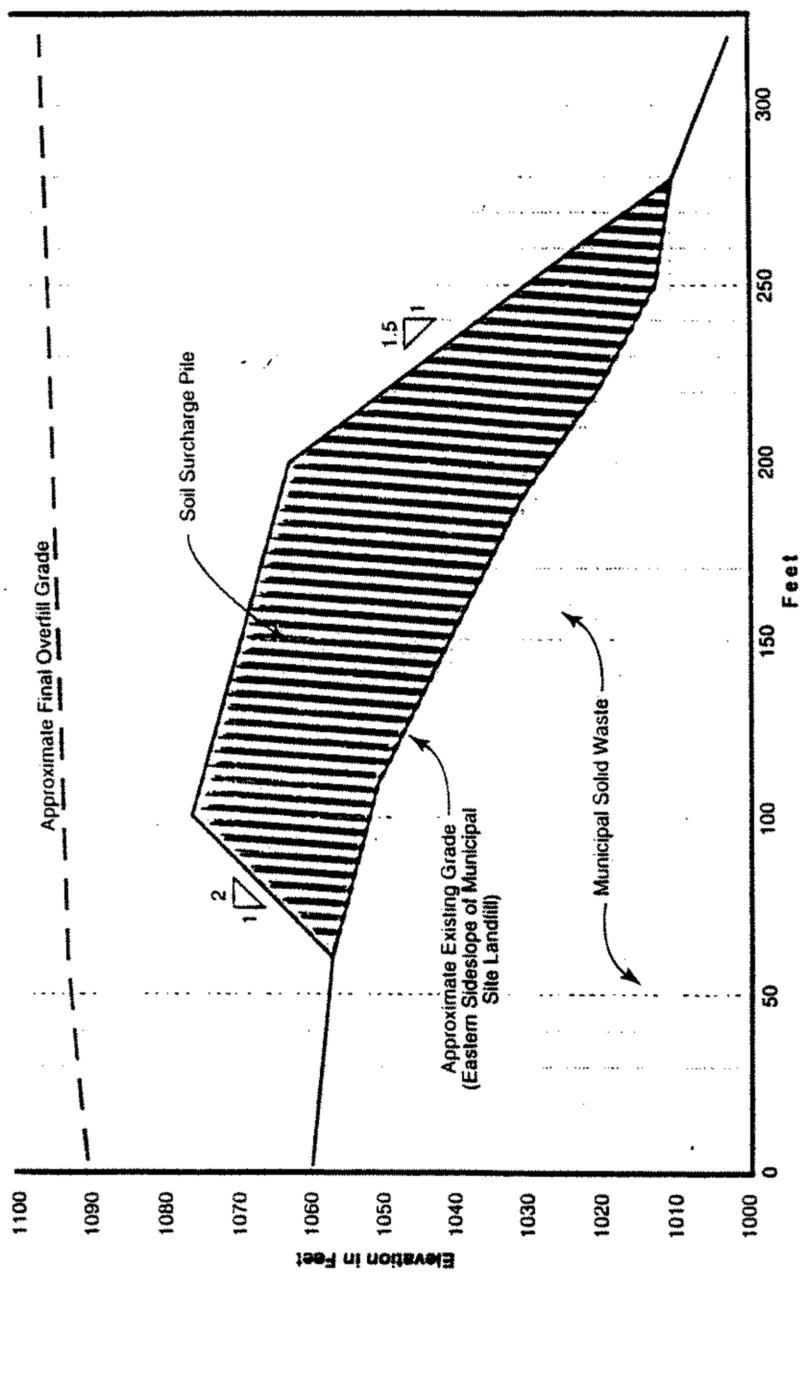

FIG. 2. Cross-Section of Soil Surcharge Pile

exposed geotextile was a dark reddish-brown, predominantly fine-grained soil. The second soil material, a tan predominantly nonplastic granular soil, was placed in near horizontal lifts of approximately 12 inches (30.5 cm) in loose thickness beginning at the landfill toe of slope and compacted until dense and stable. In this manner, the earthen surcharge pile was constructed to the approximate design dimensions presented in Fig. 2. Following completion of the pile, survey spot elevations were determined on the "flattop" of the surcharge pile to permit its thickness, and therefore its loading, to be calculated as discussed subsequently.

Throughout the placement and compaction of the surcharge pile fill materials, the in-place compacted wet and dry density and the moisture content of the fill soils were periodically measured using a Troxler nuclear moisture-density gauge. From these data, it was determined that the average unit weight of the soil surcharge pile was 124.2 pcf (1,990 kg/m^3). This value is slightly less than twice that of typical wet, biodegraded MSW (i.e., approximately 70 pcf (1,121 kg/m^3)).

V. Settlement Plate Monitoring

During construction of the surcharge pile, the settlement plate extension rods were periodically lengthened with additional pipe sections such that they would extend several feet above the top of installed fill soils. Immediately following completion of the pile, the top elevations of the rods were also determined by survey. Periodic measurements of the top elevations of these rods were also obtained at regular time intervals subsequent to completion of the pile. This allowed monitoring of the time distribution of the settlement of the underlying waste mass. A plot showing the total settlement of each settlement plate as a function of time is presented in Fig. 3.

Once the settlement plate data indicated that settlement of the waste mass under the surcharge loading had stabilized (i.e., total settlements had become essentially constant with increasing time, indicating that the waste had fully consolidated under the applied loading), the surcharge pile was removed from the landfill sideslope. As shown in Fig. 3, full consolidation of the waste mass under the surcharge loading occurred approximately 120 days (i.e., 4 months) after construction of the pile began.

VI. Removal of Surcharge Pile

Following completion of waste settlement under the surcharge loading as determined by the settlement plate data, the surcharge pile fill soils were excavated with heavy-duty construction equipment. Once the dark reddish-brown initial lift of cover soil was encountered, careful hand excavation of this material at each of the 64 nodal point locations was completed to uncover these survey control points.

VII. Post-Load Survey

Following exposure of the 64 nodal point locations, the northern and eastern coordinates and elevations of these control points were resurveyed and tabulated for analysis. Based on the data from the pre- and post-load surveys, as well as the topographic map of the surcharge pile, cross sections of the surcharge pile/landfill

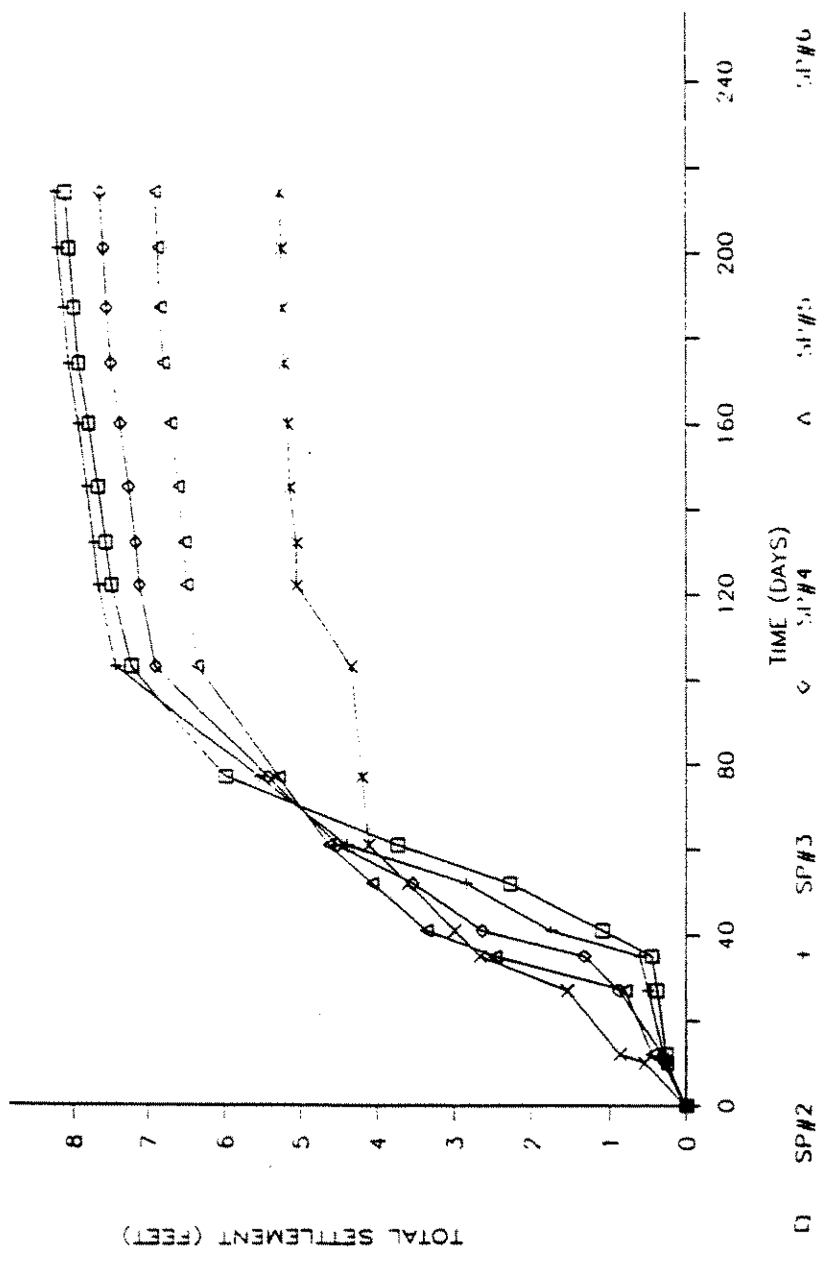

FIG. 3. Surcharge Pile Settlement versus Time

sideslope geometry were developed. Two of these are presented in Figs. 4 and 5. The locations of these cross sections are shown in Fig. 1. Fig. 4 illustrates the geometry of the surcharge pile in a direction parallel to the toe of slope of the closed landfill's eastern sideslope, while Fig. 5 illustrates the geometry of the surcharge pile in a direction perpendicular (i.e., upslope) to the toe of slope. Note that both the pre- and post-settlement profiles of the eastern sideslope of the landfill are shown in Figs. 4 and 5. The elevation difference between these two profiles at any location represents the waste settlement that occurred at this location as a result of the surcharge pile loading.

DATA REDUCTION

The total settlement of the waste mass that resulted from the applied stress of the earthen surcharge pile was determined by subtracting the elevation of a given nodal point after the pile was removed from the sideslope (i.e., the "post-settlement" elevation) from the elevation of this same nodal point prior to construction of the surcharge pile (i.e., the "pre-settlement" elevation). Based on these data, it was determined that total settlement of the waste mass due to the surcharge loading was significant, ranging from approximately 1.5 ft (0.46 m) to approximately 6.5 ft (2.0 m) in magnitude. As anticipated, these settlements were generally lowest for nodal point locations along the perimeter of the survey control system and increased in magnitude for nodal point locations near the center of the survey control system. It is obvious that this is a result of the sloping geometry of the surcharge pile around its perimeter, which resulted in less height (and therefore loading) of this mass at these locations than near the center of the pile, where the height of this mass was fairly constant and of greatest magnitude. A comparison of the total settlements of the waste mass at adjacent nodal points also indicates that differential settlements between these survey control points were reasonably uniform in both the downslope and cross-slope direction. This is graphically illustrated in Figs. 4 and 5, which show the geometry of the settled landfill sideslope. It is noted from these figures that the geometry of the settled sideslope is reasonably parallel to the original sideslope, indicating the generally uniform nature of the settlement.

It was also determined from a comparison of the pre-settlement and post-settlement survey data (i.e., the northern and eastern coordinates of the 64 nodal points) that the lateral movements of the sloping waste mass, both parallel and perpendicular to the toe of the slope of the landfill, were minimal and generally less than 6 inches (15.2 cm) in magnitude. These data, therefore, indicate that movements of the waste mass upon loading were primarily in the vertical direction (i.e., settlement) rather than in the downslope or cross-slope direction.

DATA ANALYSIS

Two quantitative analyses of the 64-point survey database were completed as part of this study. These are discussed in the following subsections of this paper.

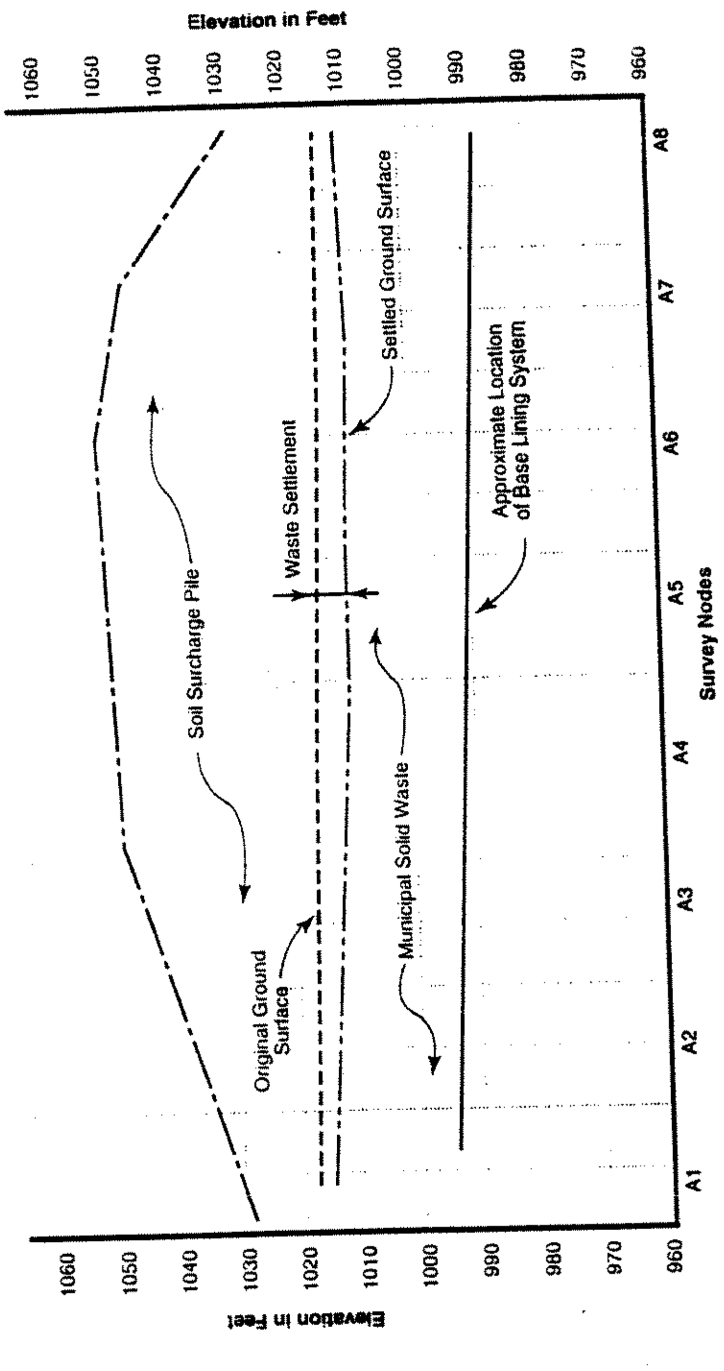

FIG. 4. Cross-Section: Line A

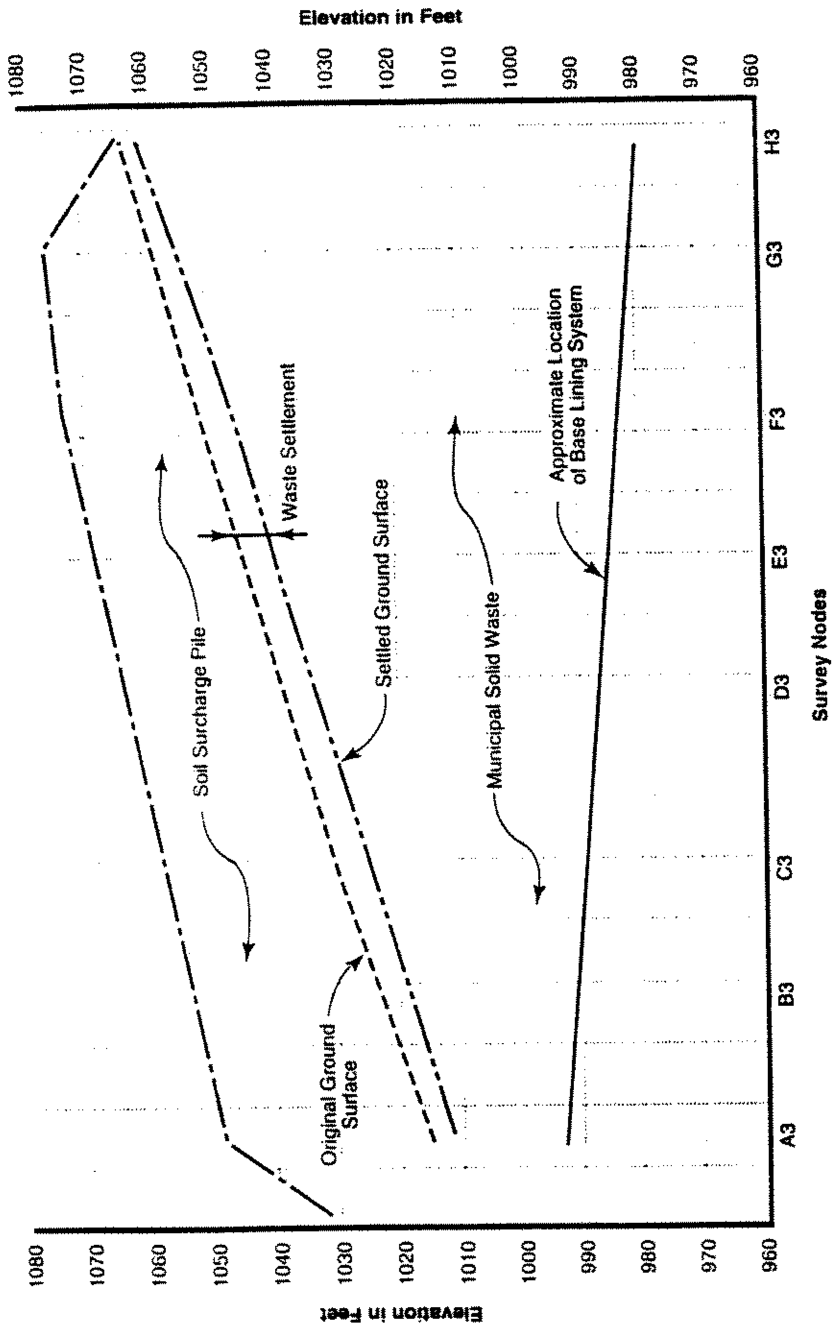

FIG. 5. Cross-Section: Line 3

I. Analysis Using Normally Consolidated Soil Settlement Equation

The first analysis assumed that the settlement behavior of the waste was similar to the settlement of a normally consolidated soil stratum, and could therefore be predicted by the following equation (Holtz and Kovacs 1981):

$$\Delta H_w = \frac{H_w C_c}{(1+e_o)} \log \left[\frac{\sigma_{o_w} + \Delta\sigma_s}{\sigma_{o_w}} \right] \quad (1)$$

where:

ΔH_w	=	waste settlement, feet (meters);
H_w	=	waste thickness, feet (meters);
C_c	=	compressibility index of the waste;
e_o	=	in situ void ratio of the waste before loading;
σ_{o_w}	=	in situ effective vertical overburden pressure at the midheight of the waste stratum, psf (kg/m^2);
$\Delta\sigma_s$	=	applied surcharge loading at the midheight of the waste stratum, psf (kg/m^2).

It is noted that the concept of normally consolidated settlement behavior assumes that the existing overburden stress condition at any point within the consolidating stratum is the maximum stress condition that these materials have ever experienced. In addition, normally consolidated behavior also implies that the compressible materials have fully consolidated under this overburden condition. Both of these conditions are reasonable assumptions for a MSW landfill that has been sequentially raised in height over many years, and that has existed in its present geometrical configuration for more than a decade.

As noted in Eq. (1), the parameters C_c and e_o directly relate to the compressibility properties of the waste. These parameters represent unknowns in this study. The parameters ΔH_w, H_w, σ_{o_w}, and $\Delta\sigma_s$ represent parameters that can be directly measured from field data obtained in this study (i.e., ΔH_w) or calculated (H_w, σ_{o_w}, and $\Delta\sigma_s$) from existing landfill records data. Therefore, a "modified compressibility index" (C′) for the waste materials, defined as shown below, can be calculated from the known parameters of this study using the following equation:

$$C' = \frac{C_c}{1+e_o} = \frac{\Delta H_w}{H_w \log \left[\frac{\sigma_{o_w} + \Delta\sigma_s}{\sigma_{o_w}} \right]} \quad (2)$$

The following paragraphs describe the manner in which the four known parameters discussed above were determined.

The final equilibrium values of waste settlement (i.e., ΔH_w) were determined as discussed previously. The thickness of the waste (H_w) at each nodal point was determined by subtracting the known elevation of the top of landfill lining system at the respective nodal point location from the pre-settlement elevation of the nodal point located on the landfill sideslope. The former value was estimated from

CCSWA drawings of the base lining system for this area of the landfill. The calculated H_w values were not modified to account for daily and final cover soil thickness. It is noted that the waste thickness is approximately equal along each alpha nodal point line and increases in thickness from nodal point line A to H.

The in situ effective vertical overburden pressure at the midheight of the waste stratum was calculated as follows:

$$\sigma_{o_w} = \frac{H_w \gamma_{MSW}}{2} \tag{3}$$

where: γ_{MSW} = unit weight (density) of the waste, which was assumed to be 70 pcf (1,121 kg/m³) for this calculation based on the authors' extensive experience in landfill design work. This value is representative of wetted, "fresh" MSW combined in approximately 9 to 1 proportions with daily/final cover soil.

It is also noted that the calculation of vertical effective stress at the midheight of the compressible waste layer thickness as quantified by Eq. (3) assumes that no liquid (i.e., leachate) level, which would generate hydrostatic pressures and buoyancy effects, exists within the waste mass. This is a reasonable assumption since it is reported that a leachate collection and removal system located directly above the cell's base lining system was installed as part of the construction of the landfill.

The applied surcharge loading at the midheight of the waste stratum (i.e., $\Delta\sigma_s$) was calculated as follows:

$$\Delta\sigma_s = T_{sp}\gamma_s \tag{4}$$

where: T_{sp} = height of the surcharge pile at the nodal point location, feet (meters); and

γ_s = average unit weight of the surcharge pile soil = 124.2 pcf (1,990 kg/m³), as discussed previously.

The T_{sp} parameter was calculated as the difference between the elevation of the top of the surcharge pile at a respective nodal point location and the pre-settlement ground surface elevation of this same nodal point. It is noted that this calculation neglects edge effects for nodal points located adjacent to the sloping faces of the surcharge pile. However, it is believed that these effects are not significant when compared to the degree of accuracy of the other measured and calculated independent variables.

Values of the independent variables for each of the 64 nodal point locations were subsequently input into Eq. (2) in order to calculate the "modified compressibility index" (C′) of the waste. The calculated values of C′ define a fairly limited range of values, with the exception of nodal points H1 through H8. In particular, the C′ values for the 56-nodal point database consisting of lines A through G varied from 0.15 to 0.39, averaging 0.22, while the C′ database consisting of H line values varied from 0.66 to 0.98, averaging 0.80. It is clear that the H line values are anomalous. This is believed to be due to the minimal and highly variable surcharge pile thicknesses that existed in the vicinity of the nodal points along the H line resulting from the sloping geometry of the back face of the pile at these locations. As a result, the surcharge loading varies considerably in the vicinity of each H line nodal point location. Therefore, there is significant error in assuming that the load at these nodal point locations can be accurately calculated using Eq. (4). Based on the above discussion, it was believed appropriate to disregard the H line C′ values in generating pertinent statistics for this database as discussed in the following paragraph.

The 56-point database was analyzed statistically. A quantitative procedure was used to confirm that the database is normally distributed. The mean ($\bar{x}$), standard deviation (σ), variance (σ^2), and coefficient of variation (C_v) of the database were also calculated. These values are as follows:

$$\bar{x} = 0.22; \quad \sigma = 0.0402; \quad \sigma^2 = 0.0016; \quad \text{and } C_v = 10.27\%$$

Based on the properties of a normal distribution, it is known that 97.5% of the database lies below the random variable value of $\bar{x}+2\sigma$. For this database, this value is equal to 0.22 + 2(0.402) = 0.30. Therefore, it can be concluded that calculation of surcharge load induced MSW settlement using Eq. (1) with known values of H_w, σ_{o_w}, and $\Delta\sigma_s$ will yield a conservative estimate of this settlement 97.5% of the time if a value of $C' = C_c/(1+e_o) = 0.30$ is used in the equation.

II. Analysis Using a Multiple Linear Regression Model

The 56-point database was also analyzed using a multiple linear regression model, in which the dependent variable, waste settlement (ΔH_w), was assumed to be a linear function of the independent variable's waste thickness (H_w) and applied surcharge loading ($\Delta\sigma_s$). The form of this equation is as follows (Walpole and Myers 1972):

$$\Delta H_w = b_0 + b_1 H_w + b_2 \Delta\sigma_s$$

The regression coefficients (b_0, b_1, and b_2) were determined using acceptable "least squares estimation" regression procedures. The resulting regression coefficients are as follows:

$$b_0 = -0.35366 \qquad b_1 = +0.04325 \qquad b_2 = +0.000836$$

Therefore, the "best fit" multiple linear regression equation that most accurately models the measured waste settlements is:

$$\Delta H_w = 0.04325\, H_w + 0.000836\, \Delta\sigma_s - 0.35366 \tag{5}$$

In this equation, the terms ΔH_w and H_w are in units of feet, and the term $\Delta\sigma_s$ is in units of pounds per square foot (psf). It is noted that different regression coefficients would result from using metric units for the input variables ΔH_w, H_w, and $\Delta\sigma_s$. Regression analysis using metric units was not completed as part of this study.

Statistics pertinent to this multiple linear regression model include the standard error (S.E.), the Coefficient of Determination (R^2), and the Correlation Coefficient (R). These values are as follows:

$$S.E. = 0.65 \qquad R^2 = 0.72 \qquad R = 0.85$$

CONCLUSIONS

The results of this large-scale field study have allowed predictor equations to be developed for estimating the settlement of MSW induced by an applied surcharge loading. A predictor equation was developed under the assumption that the waste mass behaved as a normally consolidated soil stratum. It was shown that a "modified compressibility index" (C') of 0.30, when used in the normally consolidated soil settlement equation, would provide a conservative estimate of waste settlement 97.5% of the time. A second predictor equation was also developed that utilized multiple linear regression theory to correlate waste settlement (i.e., the dependent variable) to waste thickness and applied surcharge loading (i.e., the independent variables).

APPENDIX - REFERENCES

Holtz, R. D., and Kovacs, W. D. (1981). *An Introduction To Geotechnical Engineering*, Prentice-Hall, Englewood Cliffs, New Jersey.

Walpole, R. E., and Myers, R. H. (1972). *Probability and Statistics for Engineers and Scientists*, Macmillan Publishing Inc., New York, New York.

LANDFILL GAS PRODUCTION SUMMARY
FOR LOS ALAMOS SITE OFFICE TA-73 AIRPORT LANDFILL

This summary examines the quantity of landfill gas (LFG) produced, regulatory drivers for LFG and recommendations for LFG at the TA-73 Airport Landfill.

1.0 GAS ESTIMATION

The estimation of LFG generation rates is not an exact science. No two landfills are alike, and the many factors that affect LFG production can vary significantly over time, from one site to another, and even from place to place within the same landfill. A variety of methods are used to estimate LFG generation, including computer models, mathematical calculations, observed readings and empirical estimates.

Anaerobic bacteria that consume organic matter in refuse produces landfill gas. It is composed primarily of methane (about 55%) and carbon dioxide (CO_2, about 45%) (SWANA). Methane is a colorless, odorless, flammable and potentially explosive gas. In addition to methane and $CO_{2,}$ other major gases that may be present include oxygen, nitrogen, and water vapor, traces of hydrogen and many other trace gases including volatile organic compounds (VOCs). Oxygen and nitrogen are usually present because of air in the landfill.

Landfill gas production usually begins as early as six months after waste is deposited and continues for many years after waste is accepted at the landfill. Typically, by the time waste is about 20 years old, gas generation significantly decreases as the amount of organic matter available for decomposition diminishes.

The rate of landfill gas generation and resulting migration is dependent on the physical characteristics of the waste (e.g., volume, type, age, moisture, pH, temperature, and compaction) and the landfill design (configuration, containment setting, geology, climate, cover material, and liner system). LFG migrates either horizontally or vertically based on the path of least resistance, by means of either pressure-driven flow (convection) or diffusion (diffusive flow). The gas migrates by either or both convection or diffusive flow in an attempt to reach ground surface and disperse into the atmosphere or collection systems.

An estimate of the amount of LFG generated by the landfill (SWANA 1993) is required to properly evaluate an extraction system. The empirical calculation of LFG production rate presented in the following subsection seeks to estimate the probable maximum and minimum landfill gas generation rates over time. The use of estimates often is more accurate than the use of theoretical models or equations since the estimates are based on parameters derived from actual refuse degradation and gas generations observed in landfills and laboratory analyses. A probable average generation rate can also be suggested based on a broad interpretation of contributing factors such as moisture, pH, refuse age, input rate, compaction, etc. Calculations are based on the approximate tonnage in the landfill. The landfill is evaluated based on its environment and is not compared to other sites. The calculations provide probable best and worst-case conditions.

1.1 Models and Equations

LFG models and equations are based upon an assumption that each truckload, ton or cubic yard of refuse generates an equal quantity of LFG at a consistent but ever decreasing rate over a specific period of time. A “gas generation curve” can be plotted by entering an actual or assumed refuse input rate and an assumed gas generation rate that decreases over time. However, this does not take into account the many variables that determine actual gas generation rates, such as moisture content, pH or composition of the refuse stream itself, nor have such models been verified by comparing predicted generation with actual results. In the few cases where comparisons have been made, correlation has been poor.

1.1.1 Factors Affecting LFG Generation

Composition, compaction, age, and placement of refuse are factors affecting LFG generation. Although these factors are known to have an impact on LFG generation rates, no precise quantifiable relationships have ever been established. The effect of these factors can therefore only be expressed in broad, general terms. Assumptions for the TA-73 airport landfill are presented below.

Composition and Compaction: The Voluntary Corrective Measure (VCM) Plan (LANL 2002, ER2002-0359) states the TA-73 airport landfill accepted typical municipal sanitary solid waste (MSW), construction debris, and laboratory waste. It is assume the waste was placed and compacted in a typical manner using heavy equipment (bulldozers and track loaders). There is no evidence of heavy liquid or hazardous waste placement. The typical composition of the refuse would result in an average gas production rate, whereas the lighter compaction density might result in more exposed surface area within the refuse and therefore more rapid decomposition of organic material during the early years, leaving even less material to generate gas currently.

Age and Placement of Refuse: The VCM Plan (LANL 2002, ER2002-0359) indicates the TA-73 airport landfill began receiving waste in 1943 and ceased accepting waste 1973. The landfill covers a surface area of approximately 11.5 acres, and the VCM Plan calculated the volume of waste as approximately 536,800 cubic yards (cy). The landfill is 30 to 60 years old, and therefore probably now produces LFG at a lower than average rate due to the fact that much of the organic refuse has already decomposed, leaving less material to generate gas.

Total Tonnage Estimate Based On VCM Plan Waste Estimates:

Using the formula A x B = Tonnage

Where:

A = Volume of waste = 536,800 cy

B = A constant to convert cy to tons = 1000 lb/cy / (2000 lb/ton)

A x B = (536,800 cy) x (1000 lb/cy / (2000 lb/ton)) = 268,400 Tons

A total of 268,400 tons is the value used for further calculations.

1.1.2 Estimated Ranges of Gas Generation Rates

Published material (SWANA 1993) estimates the theoretical range of LFG production rates from a low of 0.02 cubic feet of LFG per pound of refuse per year in standard cubic feet per pound per year (scf/lb yr) in small, dry sites, to a theoretical high of 0.14 scf/lb yr in large, new sites in very rainy areas. The maximum rate observed in the field at a number of operating LFG recovery facilities typically does not exceed 0.10 scf/lb yr.

The LFG production rate is not the same as the total LFG production volume, which is primarily dependent on the total volume of refuse, and can range from 1.0 scf/lb to 7.0 scf/lb generated over a 10 to 100 year period. Only the rate of production of gas volume is significant in the evaluation or design of LFG control systems.

Maximum Estimated LFG Production Volume

The maximum estimate LFG production volume was calculated as follows:

Using the formula (A x D x L) / y = Maximum LFG Production Volume, where:

A = Amount of waste (estimated) in tons;
D = Conversion of waste tons to pounds;
L = LFG production rate, assume maximum rate = 0.10 scf/lb yr;
y = Days per year.
A x D x L / y = (268,400 tons x 2,000 lb/ton x 0.1 scf/lb/yr)/(365 days/yr)
= 147,068 scfd

Converted to standard cubic feet per minute (scfm)
147,068 scfd/1,440 minutes/day
Maximum LFG production volume = 102 scfm

The maximum estimated gas production volume for the TA-73 Airport Landfill, under ideal conditions with fresh refuse, is 102 scfm. It also represents the size requirement for maximum gas collection.

Minimum Estimated LFG Production Volume

The minimum estimated LFG production volume was calculated using the same approach with the landfill production rate (L) assumed to be the minimum found in published literature, equal to 0.02 scf/lb/yr. Using this minimum L value, results in a rate of 29,414 scfd or 20 scfm for the minimum probable estimated gas production volume for this site. As the landfill ages, it decreases toward these production levels. This minimum volume also represents the lower end of the required operating capacity range for the LFG control system equipment.

Estimated Midrange LFG Production Volume

The estimated midrange estimated LFG production volume can be calculated similarly using an LFG production rate of 0.06 scf/lb/yr, resulting in an estimated production volume of 88,241 scfd or 61 scfm. This provides a working figure based on a conservative midrange of potential estimated gas production for the TA-73 Airport Landfill.

Summary of Estimated Ranges of Gas Generation Rates

The refuse's age, placement, and compaction at the TA-73 Landfill suggest that a lower than average gas generation rate should be expected. Composition content appears to be average for a site of this size and age. Moisture content appears to be below average for a site of this size and age, and the effect of these factors could support an average to below average LFG production rate from waste decomposition. However, the effect of the above-listed factors is estimated to be a slight lowering of the average production volume from 61 scfm to 57 scfm. (Waste Management, 1990). Table 1 summarizes the calculations. The calculations in this table are consistent with the Gas Generation Rates presented in Appendix H of the VCM Plan (LANL 2002, ER2002-0359).

Table 1. TA-73 Airport Landfill Gas Generation Rates

Landfill Volume (cy)	Waste Density (lb/ton)	Waste Volume (tons)	LFG Generation Range (ft^3/min)	Average LFG Generation (ft^3/min)	LFG Collection Efficiency Range	LFG Collection Efficiency Range (ft^3/min)
Total Landfill – Estimated based on published literature values						
536,800	0.5	268,400	20 - 102	57	45% - 65%	26 - 37
Year 2002 Landfill Gas Generation Rates – VCM Plan						
536,750	0.5	268,400	0.51 – 9.1	3.8	--	19.06[a]

Notes:
LFG = Landfill Gas which consists of methane (40-60% by volume), carbon dioxide (30-50% by volume), oxygen (0.1-1% by volume), and nitrogen (0-12% by volume)
[a] This is the Year 2002 Total LFG generation rate for the entire landfill

1.2 Collection Efficiency

The collection efficiency of a landfill gas collection system is measured by the percentage of generated LFG that it can draw from the refuse without drawing air. The lower end of the collection efficiency range may be 50% or less for small landfills with compacted earthen covers. Since air is easily drawn through a loose earthen cover, less vacuum can be applied. This lower vacuum, combined with the lowered porosity of the refuse due to moisture infiltration results in less gas being drawn and lower collection efficiency.

The upper end of the collection efficiency range can exceed 90% for large landfills with geomembrane caps that preclude air and water intrusion. The highest collection efficiencies can be achieved by installing wells in a matrix (“checkerboard”) layout with a maximum spacing of 300 feet, and by sealing wells and other points of air entry into the refuse.

The estimated collection efficiency for the TA-73 Airport Landfill depends on several factors. The collection efficiency is reduced due to the lack of liner in the landfill to preclude drawing air from the surrounding loose soils. Based on these factors, the collection efficiency of the landfill is estimated at 45% to 65%, and the average gas generation production volume of 57 scfm results in a probable gas collection volume of 26 to 37 scfm.

2.0 REGULATORY AND TECHNICAL DRIVERS

New Federal regulations limit the amount of volatile contaminants that can be emitted from larger, newer landfills, but due to the age of the TA-73 Airport Landfill, it is exempt from this rule. The estimated in-place tonnage of 268,400 tons is less than the 2.75 million ton regulatory threshold.

The most significant technical driver associated with landfill gas is the vertical emission of gases into the atmosphere, and the horizontal underground migration of the gas onto adjacent properties. The most significant current problem at this site is the potential for offsite migration of LFG. Air quality and odor problems do not appear to be significant at this time, but this could change in the future if the gas composition changes.

If the cover material, such as compacted soil, is impervious enough to slow or block the escape of the LFG, the gas will build up in the voids in the refuse from top to bottom, seeking another path of least resistance to follow. If such a path is found through adjacent soils, the gas may travel underground for some distance before rising to the surface. If it enters an enclosed space, the methane component of the gas can be explosive or flammable under certain conditions. Federal and state regulations limit the concentration of methane to five percent at the landfill property line and to 25% of that amount at on-site structures. The TA-73 Airport Landfill is subject to these rules.

Passive or active systems may be used to control the gas. When used for migration control, passive control systems rely on pressure gradients to move gases toward wells, trenches or other vents placed around the perimeter of the refuse as a means of interdicting horizontal gas flow. Continuous trenches with membrane barriers on their exterior wall are the best passive control for venting gas to the atmosphere while blocking its further movement off site.

Passive vents placed in the refuse may reduce the pressure gradient that causes migration by allowing gases to vent more freely when there is an impervious cover. This may also raise the potential for increased odor emanating from the landfill. There is far too little LFG generated by the TA-73 Airport Landfill for a passive system to affect any significant change in horizontal migration.

Active control systems use wells, pipes and blowers to physically collect and remove the gas under vacuum before it can move into an unwanted area or carry odors and contaminants into the atmosphere. Collection wells are placed in the interior of the landfill, and the gas is carried to a flare station, where it is burned. Typical systems operate at systems that can produce LFG between 200 to over 2000 scfm. Landfills with production rates of between 20 and 200 scfm are marginal at best in maintaining full time operation of a flare for the purposes of controlling LFG. The TA-73 Airport Landfill is in the lower end of LFG production (20 to 102 scfm) and is not likely to benefit from the installation of an active or passive collection system.

3.0 CONCLUSIONS

The age of the waste placed in the landfill indicates that the generation rate of LFG is past its prime and will either remain at the same generation rate or continue to decrease over time. This is confirmed by in the VCM Plan (Appendix H, Figure 2). The explosive component of LFG is methane that is typically 40-60% of landfill gas. The above calculations result in methane generation in the range of 10 scfm to 22 scfm. There is currently little evidence to indicate that there is enough methane to produce an explosive condition in the landfill and since the generation rate is either stable or getting lower, there is no reason to believe that this landfill would create an explosive condition in the landfill.

The New Mexico Solid Waste Management Regulations (NMAC 20.9.1.400.B.2) require that methane not exceed 25% of the lower explosive limit (LEL) in structures and at the property boundary. There is no evidence that there is a horizontal methane migration issue at the site. There are no structures near the landfill for methane to gather in. However, the VCM Plan and the RFI Report indicate that methane may be gathering in deeper portions of the landfill at low concentrations. This is neither a regulatory concern nor a safety issue.

There is no evidence that LFG is the source of any VOC contamination in groundwater. Depth to groundwater is nearly 1,000 feet below ground surface. The depth of groundwater prevents to potential for mixing of landfill gas with groundwater that can produce VOC contamination.

The facility is below the in-place waste volume that Federal Rules require a landfill to obtain a Title V permit for air emissions. Therefore, the facility is not required to install a gas collection and control system.

High concentration of LFG near the ground surface for long periods of time can stress vegetation. However, there is no actual evidence of stressed vegetation caused by excess LFG that would require a gas collection and control system.

A landfill gas collection or control system would provide little if any technical benefit for this landfill and there is no regulatory requirement for the control of LFG at this landfill. Gas generation is already at the low end of a typical landfill and is continuing to decrease with time. The proposed cover will further reduce water infiltration into the landfill, therefore, gas generation should continue to decrease.

However, to minimize potential for gas migration to the surface, a horizontal gas collection system (HGCS) is proposed. The HGCS will be comprised of a series of HDPE pipes (header and collection) and spinners. The HDPE gas collection pipes will be perforated and placed within an aggregate annulus that is situated directly below the MATCON cap. To prevent clogging of the connection between collection and header pipes, all collection pipes will slope away from the header pipe to allow any condensation to drain back into the landfill. There are nine (9) collection pipes which are typically spaced at an interval of 115 feet. All collection pipes are connected to a single header pipe with both header and collection pipes being 4 inches in diameter. To aid in the evacuation of gas, a series of three (3) spinners are proposed. Each spinner is mounted on a vertical PVC pipe. The HGCS has an additional 3 - "T" 's that are fitted with blind flanges for connecting additional spinners and/or monitoring of the HGCS.

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22 June 2005

Reviewed by
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22 June 2005

Professional Engineering Review and Approval

Engineering Design Package
Los Alamos Site Office TA-73 Airport Landfill
Final, Rev. 1

I hereby certify that these calculations, specifications, and drawings were prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of New Mexico.

Signed and Sealed by:

Berg Keshian, NMPE #8590

6/27/05

Date

Note: The original, signed, full-size drawings are on file at the Weston Solutions, Inc, Albuquerque, NM office, project number 13104.002.001.7000.

CLIENT/SUBJECT TA-73 LOS ALAMOS AIRPORT LANDFILL CLOSURE W.O. NO 13104.002.001

TASK DESCRIPTION Global Slope Stability (100% Design Submittal) TASK NO. 7000

PREPARED BY P. Harr DEPT 1495 DATE 5/24/05

MATH CHECK BY A. Harpur DEPT 1495 DATE 5/25/05

METHOD REV. BY A. Harpur DEPT 1495 DATE 5/25/05

BACKGROUND

As part of the closure of the Los Alamos Airport Landfill existing waste will be relocated from the east and north slopes and placed on the flat top area of the landfill. The relocated waste will be placed in a controlled manner, i.e., placed in thin lifts and compacted using dozers, rollers, etc. In order to facilitate the expansion of the airport an asphalt cap will be installed on the flat top area. Retaining walls will also be constructed at the toe of and on the regraded east slope in order to maximize the flat area available for expansion. The lower wall (Wall No. 1) will be a cast-in-place (CIP) reinforced concrete wall. The upper walls (Wall Nos. 2, 3 and 4) will be mechanically stabilized earth (MSE) walls. The slopes behind the MSE walls will be inclined at 4H:1V unless rock is encountered. If rock is encountered, the slope of the finished surface will more-or-less follow the slope of the rock. Again, in order to maximize the available flat top area the north slope will be regraded to an inclination of 3H:1V. This slope inclination is consistent with the inclination presented in the original (2004) permit application.

The Los Alamos Airport Landfill received waste from about 1943 to about 1973. Between 1943 and about 1965 the waste was burned at the edge of the landfill and then pushed into the landfill using heavy construction equipment. The intentional burning of waste was terminated in 1965. The landfill was filled from west to east so the youngest and freshest waste is anticipated to be encountered during excavation activities on the east slope. It is not anticipated that burned waste or ash will be encountered in the area of the east slope. Burned waste and ash may be encountered along the north slope.

ANALYSIS

Geotechnical data was obtained from cone penetrometer testing (CPT) completed within the landfill footprint. Particular attention was focused on those CPT borings completed close to the east end of the landfill (CPT-106, 135, 105B, 111, 136, 104). In reviewing the data the average internal friction angle (ϕ) of the waste was estimated to be 37°. From the same borings, the average cohesive strength was found to be 2,326 pounds per square foot (psf). The cohesive strength ranged from 165 to 3,232 psf. A summary of the CPT data is presented in Attachment 1.

In order to verify and confirm the CPT-recorded shear strength parameters, and in particular the internal friction angle, three existing sections on the east slope were evaluated. The internal friction angle of the waste was varied until a factor-of-safety (FS) of 1.0 was achieved. A FS of 1.0 represents the condition of imminent failure and is likely a conservative approach to estimate the internal friction angle of the

CLIENT/SUBJECT TA-73 LOS ALAMOS AIRPORT LANDFILL CLOSURE W.O. NO 13104.002.001

TASK DESCRIPTION Global Slope Stability (100% Design Submittal) TASK NO. 7000

PREPARED BY P. Harr DEPT 1495 DATE 5/24/05

MATH CHECK BY A. Harpur DEPT 1495 DATE 5/25/05

METHOD REV. BY A. Harpur DEPT 1495 DATE 5/25/05

waste considering the slope has been standing with no evidence of movement for over 30 years. A slightly less conservative, but still reasonable approach to estimate the internal friction angle of the waste is to assume the existing FS of the slope is greater than 1.0. The higher FS value, if used should be conservatively estimated based on conditions observed at the site. As previously stated, the existing slope has been standing for a period of at least 30 years with no indication of movement. It should be noted that there has been erosion of surficial slope cover soils as a result of run-off from the flat top area of the landfill. The findings of the evaluation of the existing slopes are summarized in Table 1. A nominal cohesive strength of 25 and 50 pounds per square foot (psf) was assigned to the waste to preclude shallow surface failures. Three separate cross-sections (Sections 5, 6 and 8) on the east slope were evaluated. The cross-sections and their location on the east slope are shown in Attachment 2. The unit weight of the waste was estimated to be 100 pounds per cubic foot (pcf). This value is above the upper bound of the unit weight for degraded municipal solid waste (MSW) which ranges from 60 to 90 pcf and reflects the potential presence of heavier construction debris. The interface between the waste and the original floor of the hanging valley was also conservatively estimated in that it was assumed that the valley floor continued at the same elevation beneath the landfill as is visible at the toe of the slope.

From Figure 1 it can be seen that for a FS of 1.0 the shear strength parameters range between about 29° and 50 psf to 35.5° and 25 psf. For a FS of 1.1 the shear strength parameters range between about 32° and 50 psf to 38° and 25 psf. These values correlate well with the average CPT-reported internal friction angle of 35.8°. Based on the data, analyses and engineering judgment, an internal friction angle of 35.5° and a cohesive strength of 25 psf were deemed to be reasonable shear strength parameters for the waste. This internal friction angle corresponds to the upper bound established for a FS of 1.0 and the average CPT-reported internal friction angle. It is about equal to the average internal friction angle value established for a FS of 1.1.

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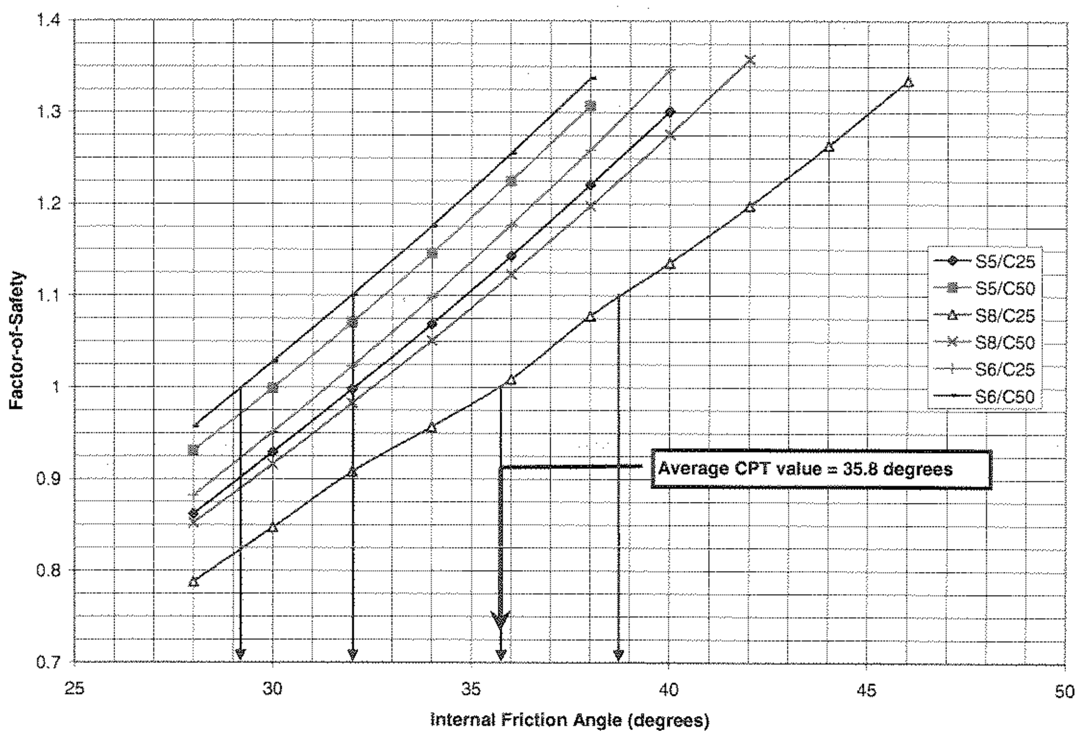

Figure 1 – Factor-of-Safety versus Internal Friction Angle for Existing Conditions

Two interim conditions were evaluated as part of the analysis prior to evaluating the final slope configuration. The most critical interim condition exists when the existing slope is regraded to accommodate the construction of the CIP and MSE retaining walls. The analysis was completed to evaluate a temporary cut slope of 1.25H:1V from the floor of the landfill to a level equal to the top elevation of the CIP wall, the construction of a bench to accommodate the MSE wall and a temporary slope of 1.5H:1V up to the point at which the proposed final ground surface was intersected. Based on a visual inspection of the cross-sections it was determined that Section 5 was the most critical due to the geometry of the slope and the volume of cut required. For a temporary condition a FS of greater than 1.25 is typically required.

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The second interim condition evaluated the stability of the slope following construction of the CIP wall and placement of structural fill backfill. The wall was modeled as a thin, high strength element. The structural fill was modeled as a typical soil. The material parameters are listed in Table 1. Since this was still a temporary condition, a FS of 1.25 was required.

Table 1 – Material Parameters

Material	Unit Weight (pcf)	Internal Friction Angle (°)	Cohesion (psf)
Reinforced Concrete	150	50	4000
Structural Fill	130	34	25

The long-term condition with both the CIP and MSE walls in place was evaluated. The same material parameters were used to evaluate the final condition as were used in the analysis of the second interim condition. The strength of the MSE wall geosynthetic reinforcement was based on a preliminary MSE wall design completed for the purpose of estimating the length of the reinforcement material(s). The reinforcement was assigned a value (allowable tensile strength) of 2,000 pounds per foot (ppf).

The final condition analyzed considered seismic stability. A seismic coefficient of 0.262g was incorporated in the analysis. This coefficient was based on a 98% probability of non-exceedance in 50 years, or stated conversely, a 2% probability of exceedance in 50 years[1]. The coefficient was determined from the USGS Probabilistic Hazard Lookup by Zipcode, 1996 using a zip code of 87544 for the Los Alamos County Airport, see Attachment 3 and http://eqint.cr.usgs.gov/eq/html/zipcode.shtml. A FS of 1.0 to 1.1 is typically required for slope stability under seismic loading.

The slope stability analysis was completed using a commercially available computer program, Slope/W distributed by Geo-Slope International. Two failure mechanisms were evaluated, circle arc and planar (linear).

[1] As shown in Attachment 3, a seismic coefficient which has a statistical probability of non-exceedance of 98% in 50 years is approximately the same as one having a statistical probability of non-exceedance of 90% in 250 years, the CFR standard for MSW landfills (see 40 CFR, Part 258).

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RESULTS

The results of the slope stability analysis are presented in the form of graphical cross-sections that depict the location of the critical failure surfaces (circular arc or planar) with the lowest factor-of-safety. For reference, the corresponding input files have also been included to illustrate the limits of the search routine executed. The input and output files are presented in Attachment 4. The results are summarized in Table 2.

Table 2 – Summary of Results

Condition	Description	Minimum Required FS	Calculated FS	Status
Existing	Existing slope	1.0 to 1.1	1.0 to 1.1	---
Interim 1	Temporary cut slope to allow wall construction	1.25	1.288	ok
Interim 2	Construction of CIP wall complete	1.25	1.268	ok
Final	CIP and MSE walls complete	1.5	1.484	ok
Final w/seismic	CIP and MSE walls complete – $K_h = 0.262g$	1.1	0.913	fail

Because the seismic stability resulted in a FS of less than 1.1, a deformation analysis was completed to estimate the potential deformation (movement) of the slope during a seismic event. The deformation analysis is presented in Attachment 5. The analysis indicated that the slope, under a seismic event may experience movements of up to 2 inches. There is currently no regulated deformation limit for slopes but movements on the order to 6 to 12 inches are generally accepted.

CONCLUSIONS

Based on the results of the slope stability and deformation analyses it was concluded that the east slope of the landfill will be stable both during construction and in the long-term. Because the shear strength parameters of the waste are not precisely defined, the Contractor should use caution and monitor the slope during excavation activities. If tension cracks develop on the slope or at the top of the slope work on the slope or at the toe of the slope should be immediately terminated and measures implemented to

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stabilize the slope. During the temporary conditions storm water should not be permitted to run over the slope as this may cause instability.

Comments on North Slope

The configuration of the north slope is similar to the configuration presented in the 2004 permit application and was therefore not re-evaluated as part of this submission.

ATTACHMENT 1

Summary of CPT Data

INTERNAL FRICTION ANGLE REPORTED ON SELECT CPT LOGS

CPT Locations											
106		135		105B		111		136		104	
SPT N1 Values	φ	SPT N1 Values	φ	SPT N1 Values	φ	SPT N1 Values	φ	SPT N1 Values	φ	SPT N1 Values	φ
0	-	0	-	11	50	0	-	0	-	0	-
8	50	8	50	26	50	5	50	11	50	27	50
21	50	44	50	29	50	6	47	69	50	78	50
26	50	44	50	24	50	15	50	104	-	68	50
23	50	32	-	20	47	38	50	90	-	41	50
11	45	24	47	15	45	48	50	59	-	21	47
5	41	17	45	12	45	57	50	39	50	12	45
5	-	12	-	11	43	51	-	23	45	8	-
5	-	11	43	11	43	48	-	11	-	11	43
6	-		45	8	41	45	47	9	41	8	-
5	-		47	14	43	38	47	9	-	5	-
9	41		45	14	41	30	45	15	-	18	45
6	-	11	41	14	43	17	-	9	-	17	43
6	37	5	-	14	43	11	-	9	-	8	-
6	39	5	-	3	-	11	39	14	41	6	37
6	37	6	37	3	33	8	-	6	-	3	-
5	-	14	41	3	-	9	39	9	39	9	39
3	-	6	-	5	35	12	-	6	-	5	-
6	37	6	-	6	37	14	-	6	35	6	37
9	39	4	-	15	41	12	39	6	-	4	-
6	-	6	-	10	-	17	41	9	-	10	39
8	37	4	-	5	-	14	41	5	-	10	39
8	37	5	35	3	-	8	37	5	-	5	33
9	37	8	37	3	31	6	37	5	-	5	35
6	37	6	-	5	33	4	-	10	39	4	-
6	35	8	37	7	37	6	37	6	-	4	-
6	35	7	35	6	35	6	35	3	-	2	-
9	37	6	-	7	-	9	37	6	35	5	33
11	39	8	37	9	37		45	13	41	10	39
12	39	9	-	15	41	13	-	10	37		43
6	-	16	41	9	37	3	-	9	39	16	41
6	35	10	37	6	35	6	35	16	41	2	-
9	37	7	35	9	37	3	-	8	-	0	-
7	37	15	39	16	39	8	37	8	37	2	28
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7	35	11	39	7	35	7	35	6	33	13	39
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5	-	4	-	8	37	8	37	13	39	9	37
6	35	6	35		43	8	35	17	39	12	39
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4	-	6	33	6	35	4	-	7	35	7	35
1	-	7	35	6	35	7	35	16	39	2	-
4	31	8	37	7	35	8	-	12	-	2	28
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4	31	4	-	1	-	5	-	6	33		
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7	33	3	28			18	39	5	31		
6	-	2	28			12	37	5	33		
8	35	5	33			14	39	6	33		
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6	-							4	28		
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21	41							3	28		
								4	28		
								2	-		
								3	28		
								7	35		
								7	31		
								17	39		
								7	33		
φ average	35.8		36.6		38.3		39.0		35.4		37.9

φ = angle of waste reported on CPT logs

(shaded) = entries above 20 blows per foot deleted for conservatism

(dotted) = entries estimated to be cover soil and tuff and therefore ignored

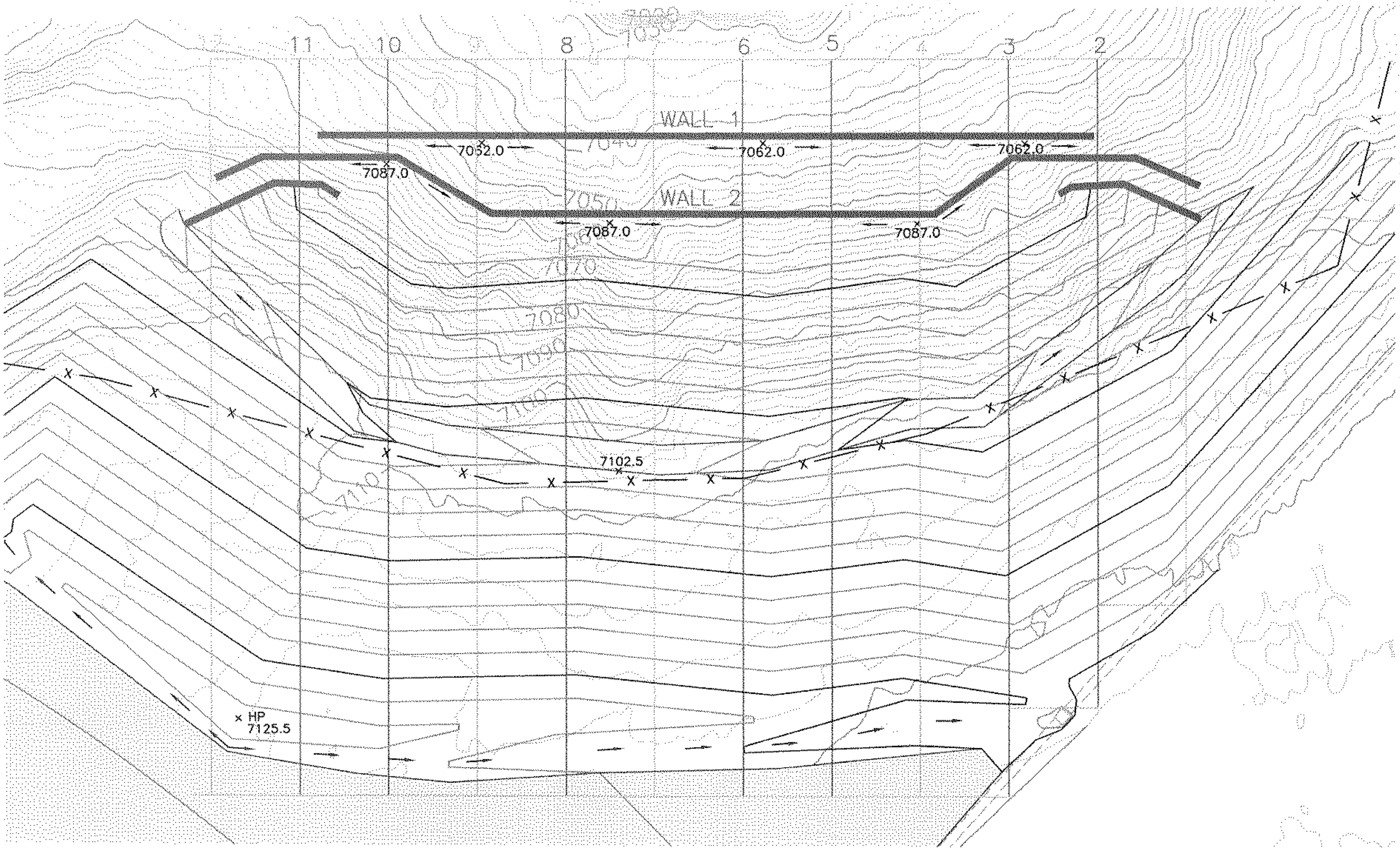
φ (deg)	
37.06	Average at site
35.80	Average in waste
4.28	stdev
27.23	95% Confidence

ATTACHMENT 2

East Slope Cross-Section Location Plan

and

Select Cross-sections



CROSS SECTIONS

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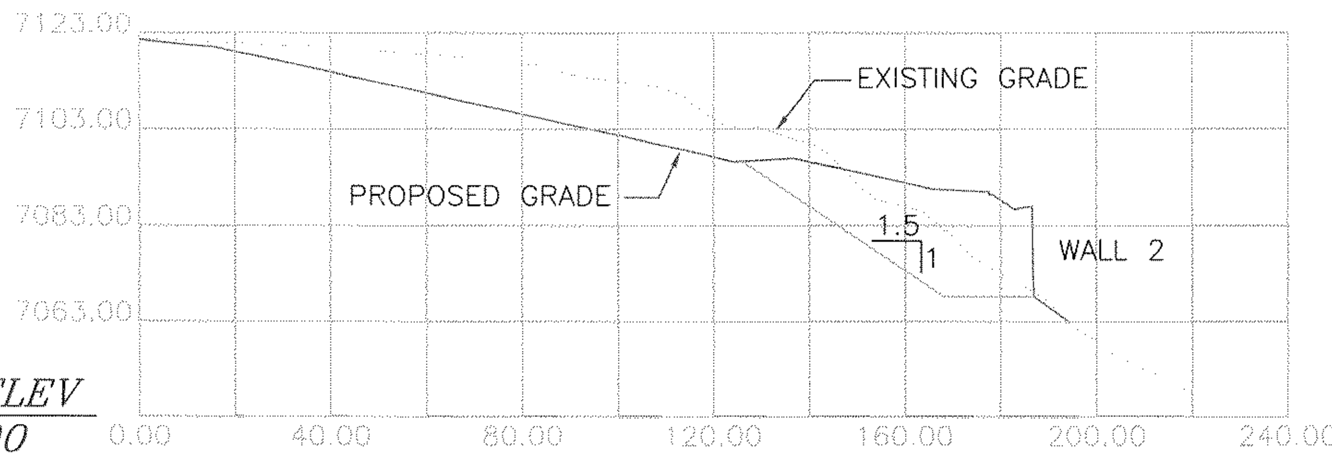

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SECTION 2

WESTON SOLUTIONS

SECTION 2
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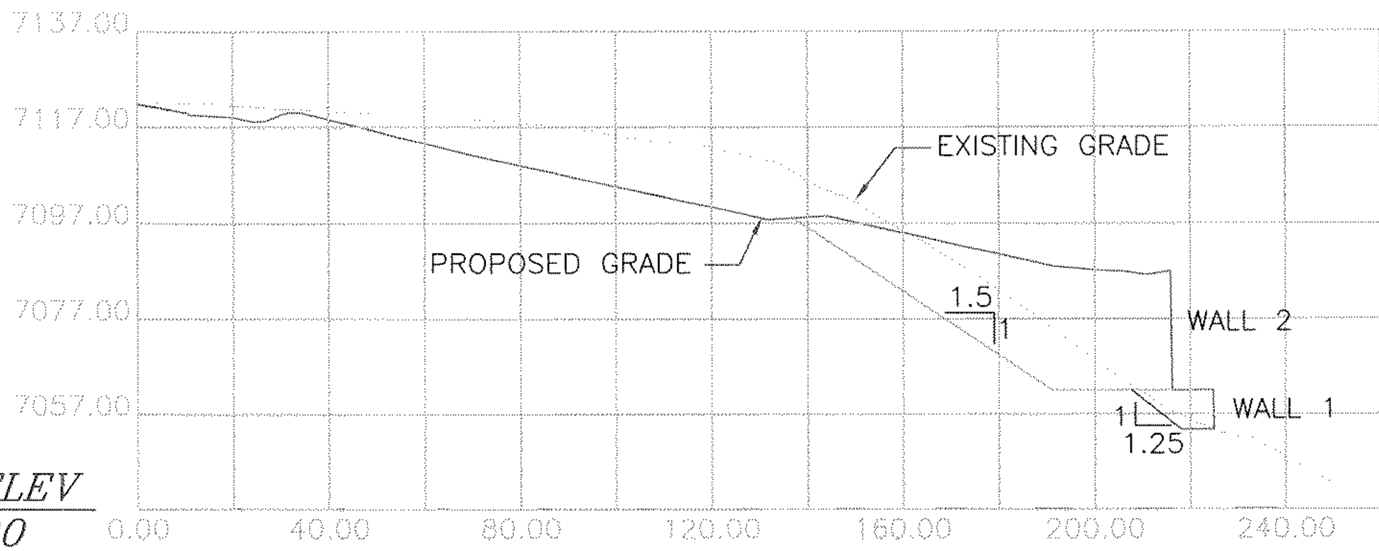

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SECTION 3

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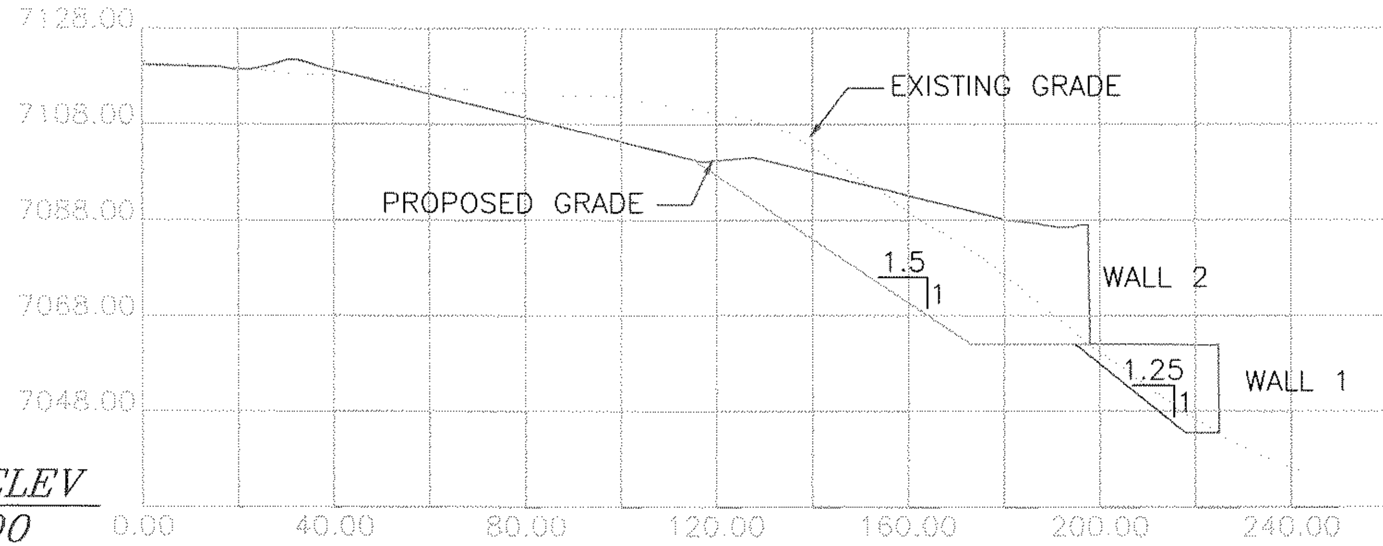

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SECTION 5
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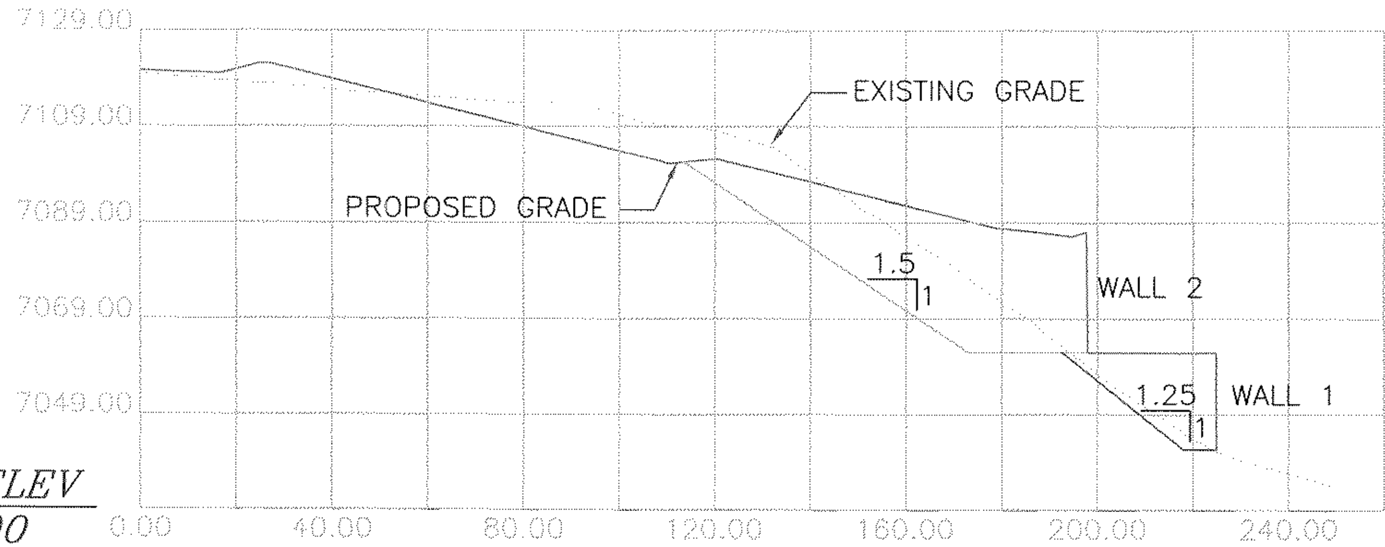

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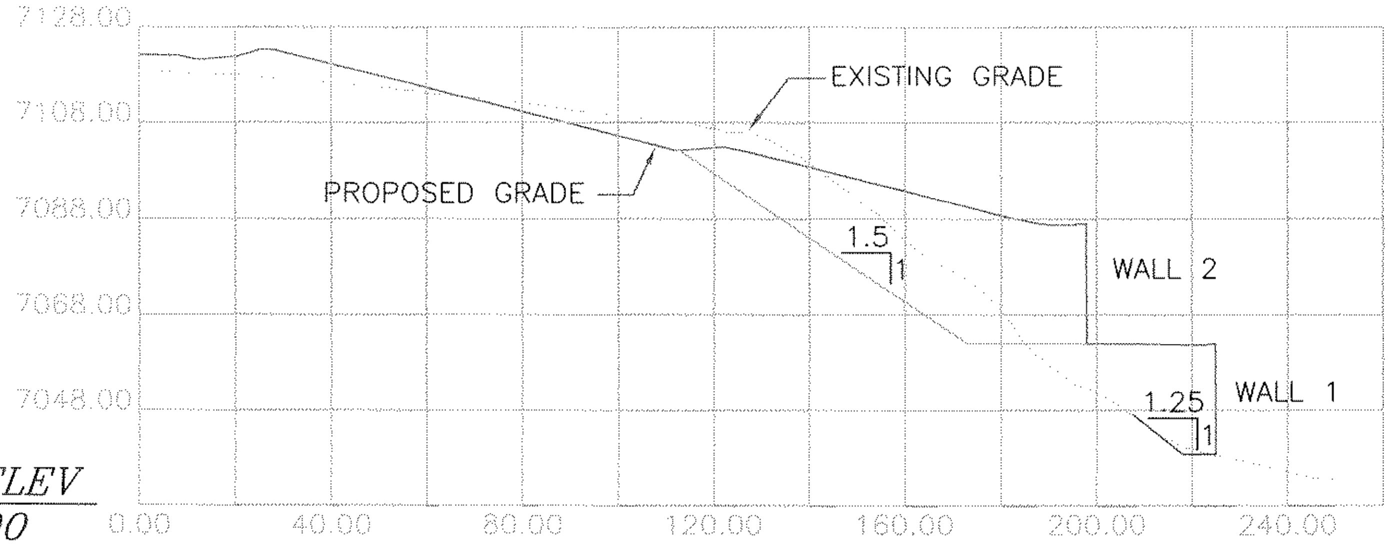

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SECTION 8

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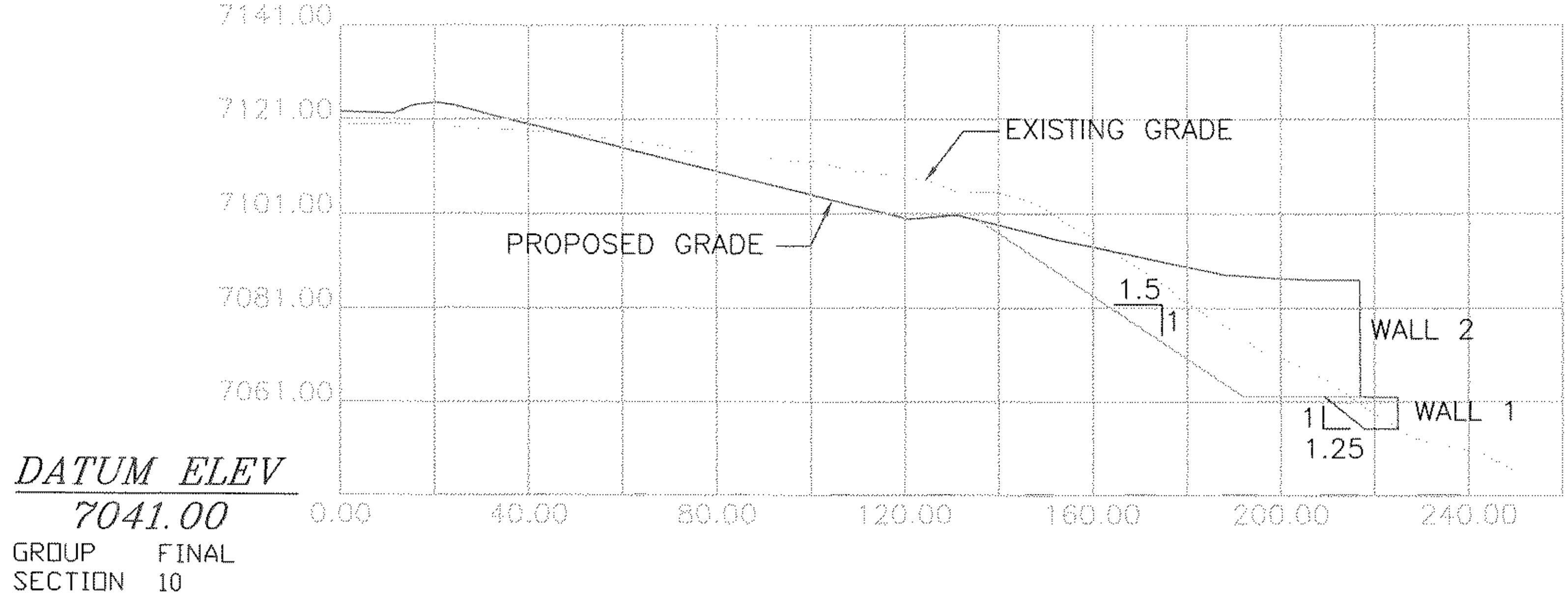

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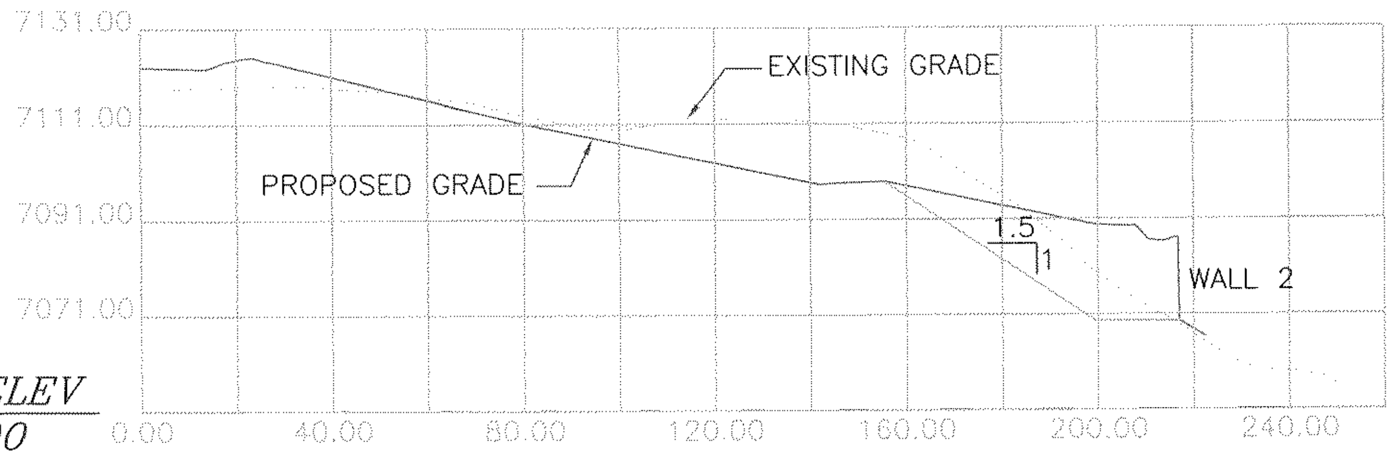

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SECTION 11

WESTON SOLUTIONS

SECTION 11

N.T.S.

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ATTACHMENT 3

Seismic Coefficient Determination

USGS
Earthquake Hazards Program

```
The input zip-code is 87544.
ZIP CODE                          87544
LOCATION                          35.8678 Lat. -106.2682 Long.
DISTANCE TO NEAREST GRID POINT    4.5840 kms
NEAREST GRID POINT                35.9 Lat. -106.3 Long.
Probabilistic ground motion values, in %g, at the Nearest Grid point are:
              10%PE in 50 yr   5%PE in 50 yr   2%PE in 50 yr
   PGA          8.963270        14.212500       26.153641
0.2 sec SA     20.231220        33.854210       59.950050
0.3 sec SA     18.002939        28.778629       54.664909
1.0 sec SA      5.927866         9.756920       18.967649
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Los Alamos, NM

For slope stability analysis $k_H = 0.262g$

The input zip-code is .
Zip code is zero and we go to the end and stop.

PROJECT INFO: Home Page
SEISMIC HAZARD: Hazard by Zip Code

UNITED STATES POSTAL SERVICE®

ZIP Code Lookup

ZIP + 4® Code Lookup Results

Important Note
An exact match for the address you provided couldn't be found. The closest matches are presented below.

You Gave Us
airport road
LOS ALAMOS NM

Lookup another ZIP Code >

Address (Standard Format) What is This?	Mailing Industry Information What is This?
1040 AIRPORT RD LOS ALAMOS NM 87544-3308	Carrier Route: C001 County: LOS ALAMOS
1040 AIRPORT RD STE (Range 1 - 7) LOS ALAMOS NM 87544-3308	Carrier Route: C001 County: LOS ALAMOS
(EVEN Range 1000 - 1098) AIRPORT RD LOS ALAMOS NM 87544-3307	Carrier Route: C001 County: LOS ALAMOS

Lookup another ZIP Code >

Ready to mail your letter or package?

Calculate Postage
Calculate postage for your letter or package online!
Rate Calculator

Print Shipping Labels
Print shipping labels from your desktop and pay online.
Click-N-Ship® Other Postage

Request Package Pickup
Save time, arrange for your carrier to pickup your package.
Pickup Options

Related Services & Links

Yellow Pages or White Pages powered by Switchboard
Find a residential or business listing nationwide.

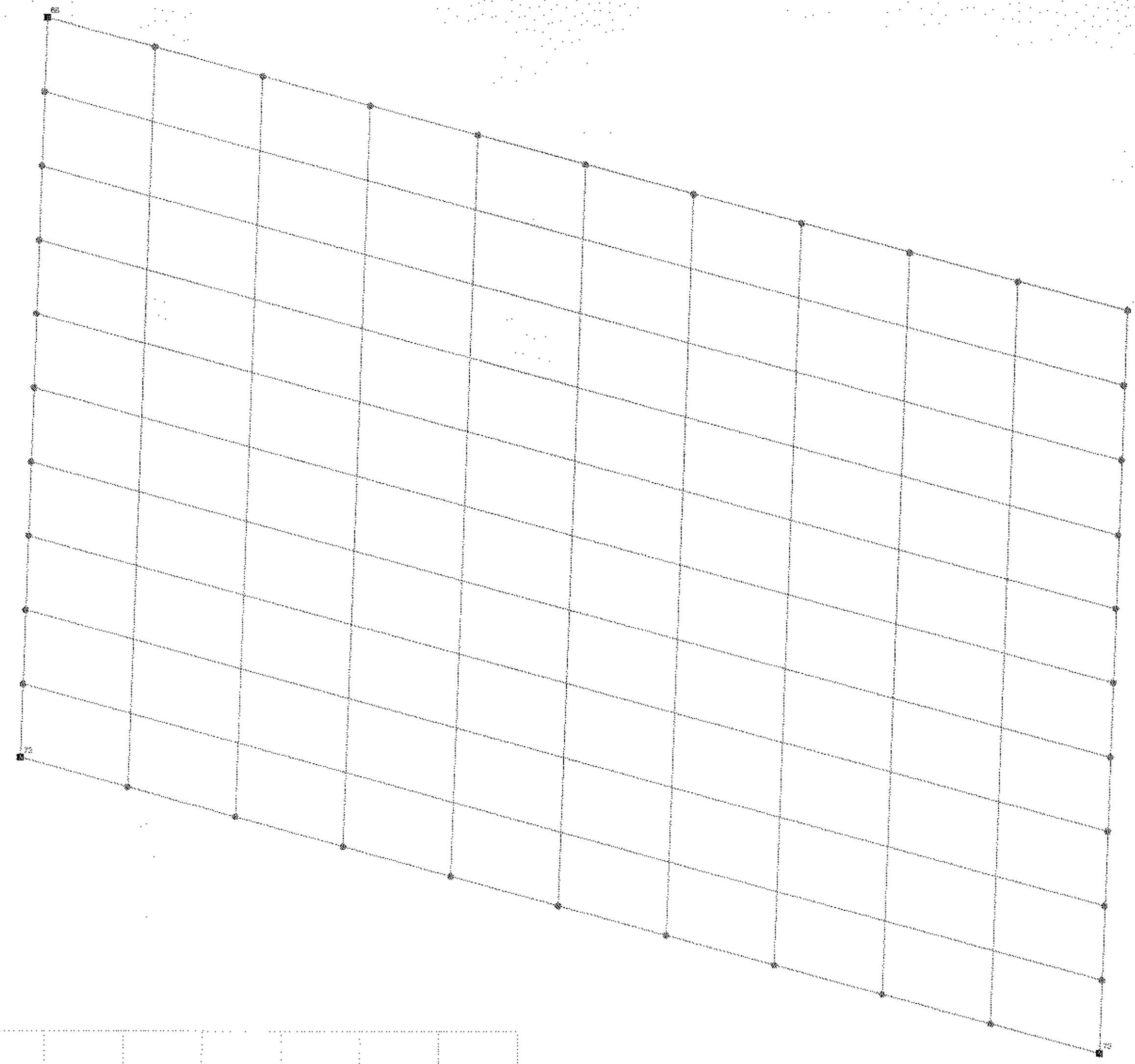
Frequently Asked Questions
Find information on using the ZIP Code™ lookup Feature.

Web Tools
Access online tools to verify addresses, calculate postage and more.

Address Information Services (AIS) Product
Standardize your address database or find detailed address information.

ATTACHMENT 4

Slope Stability Input and Output Files



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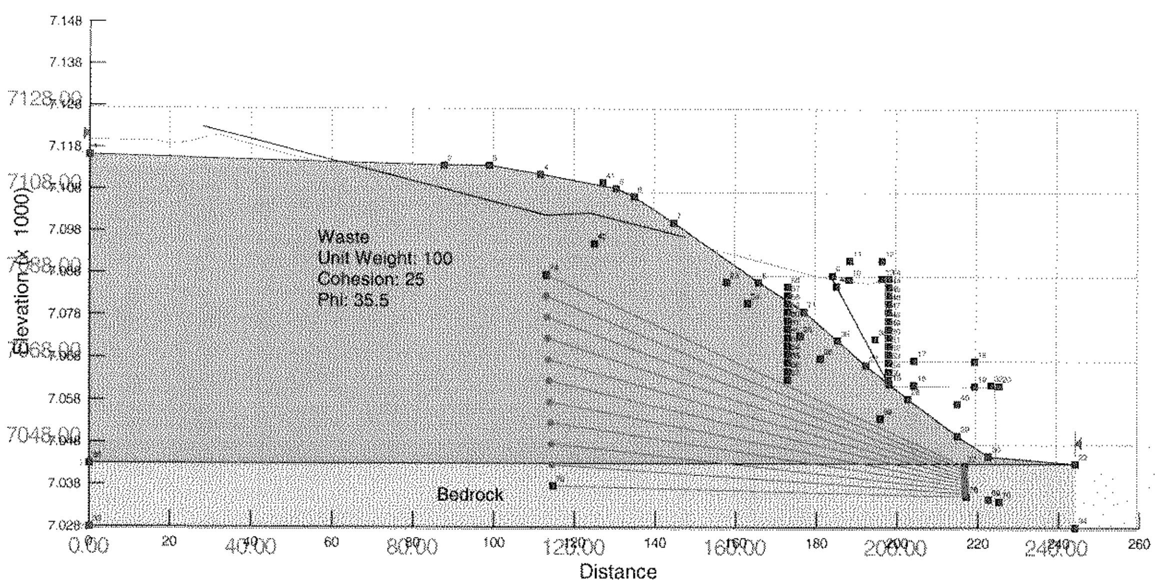
Analysis Method: Bishop (with Ordinary & Janbu)



WESTON SOLUTIONS

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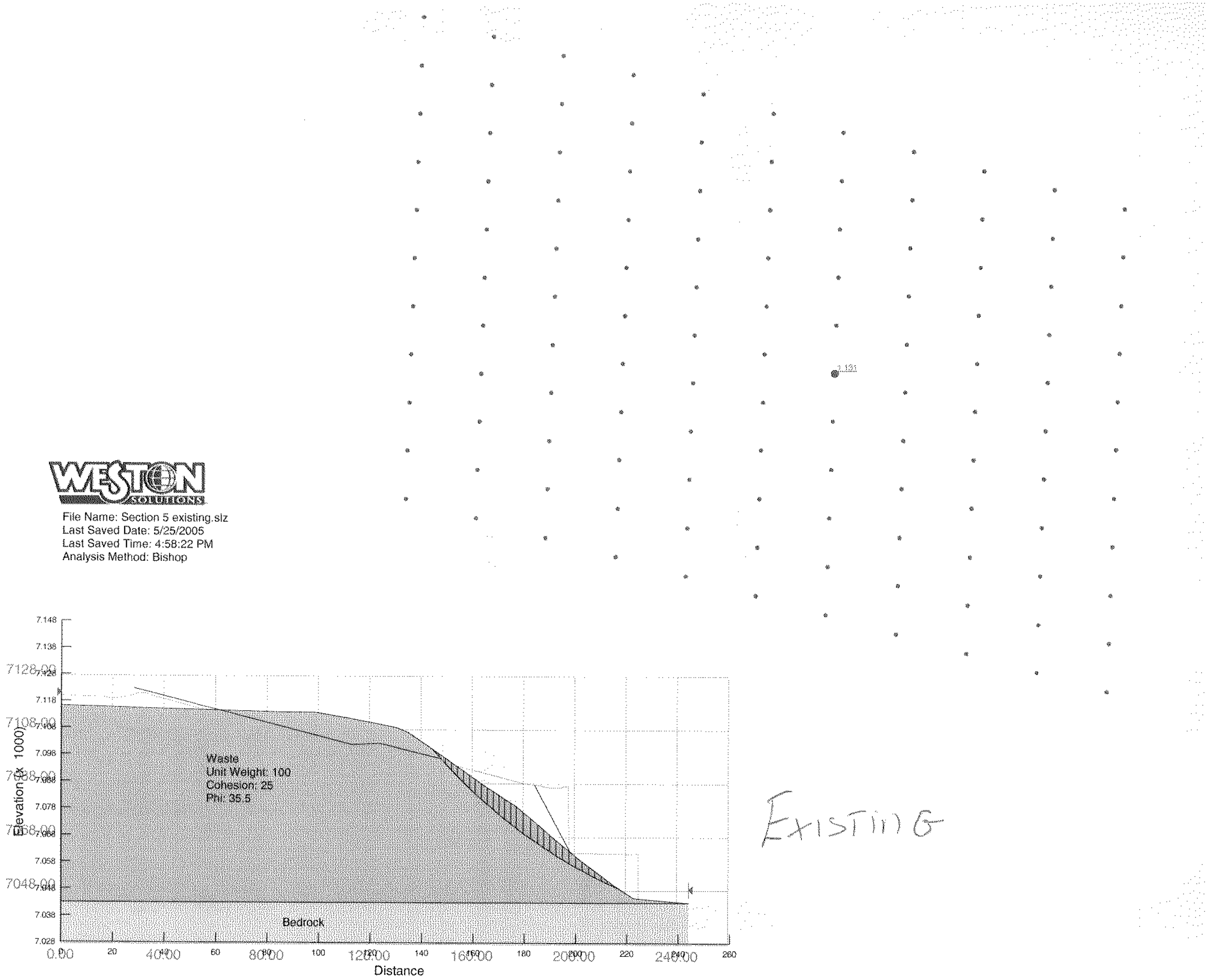

EXISTING

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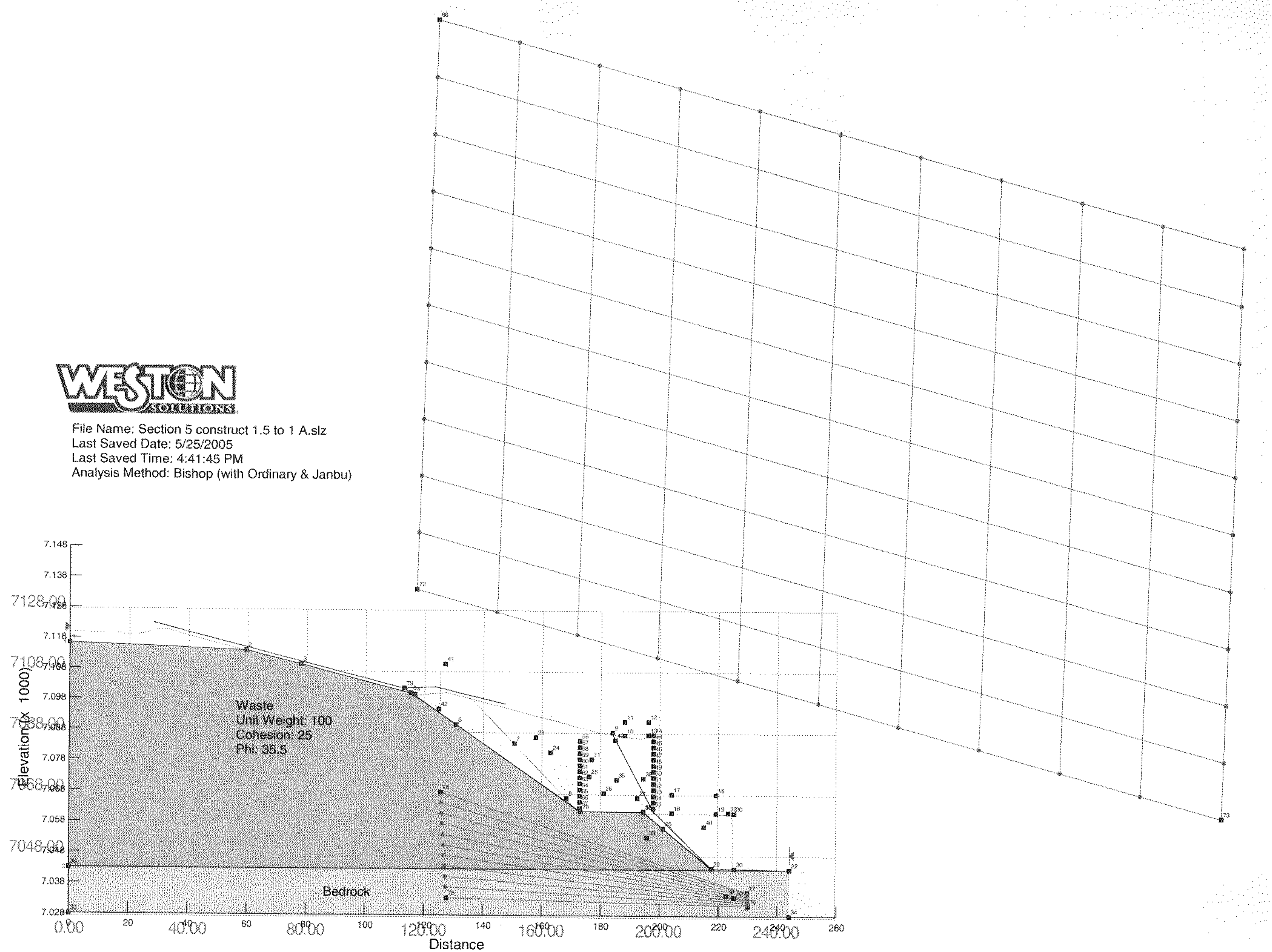

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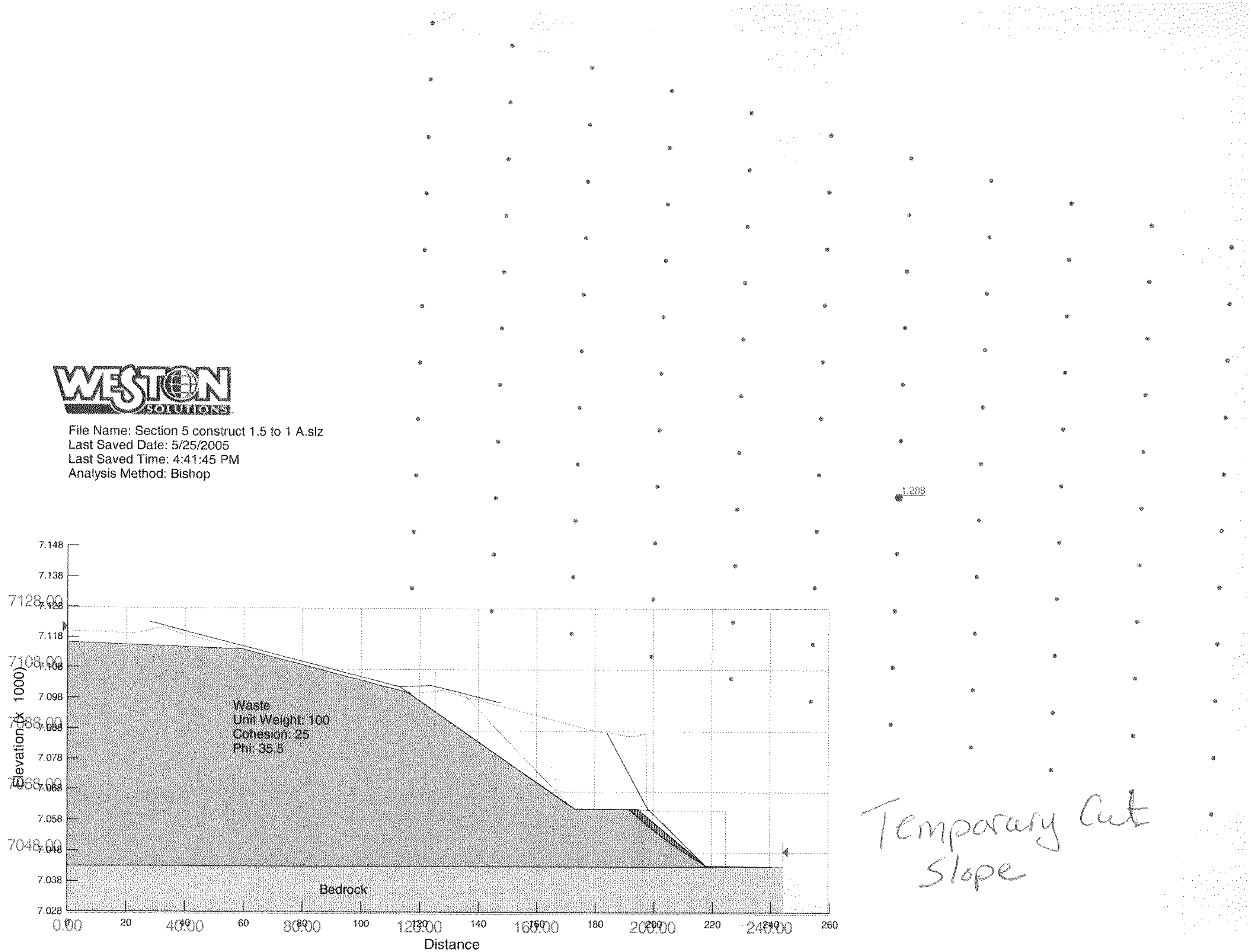

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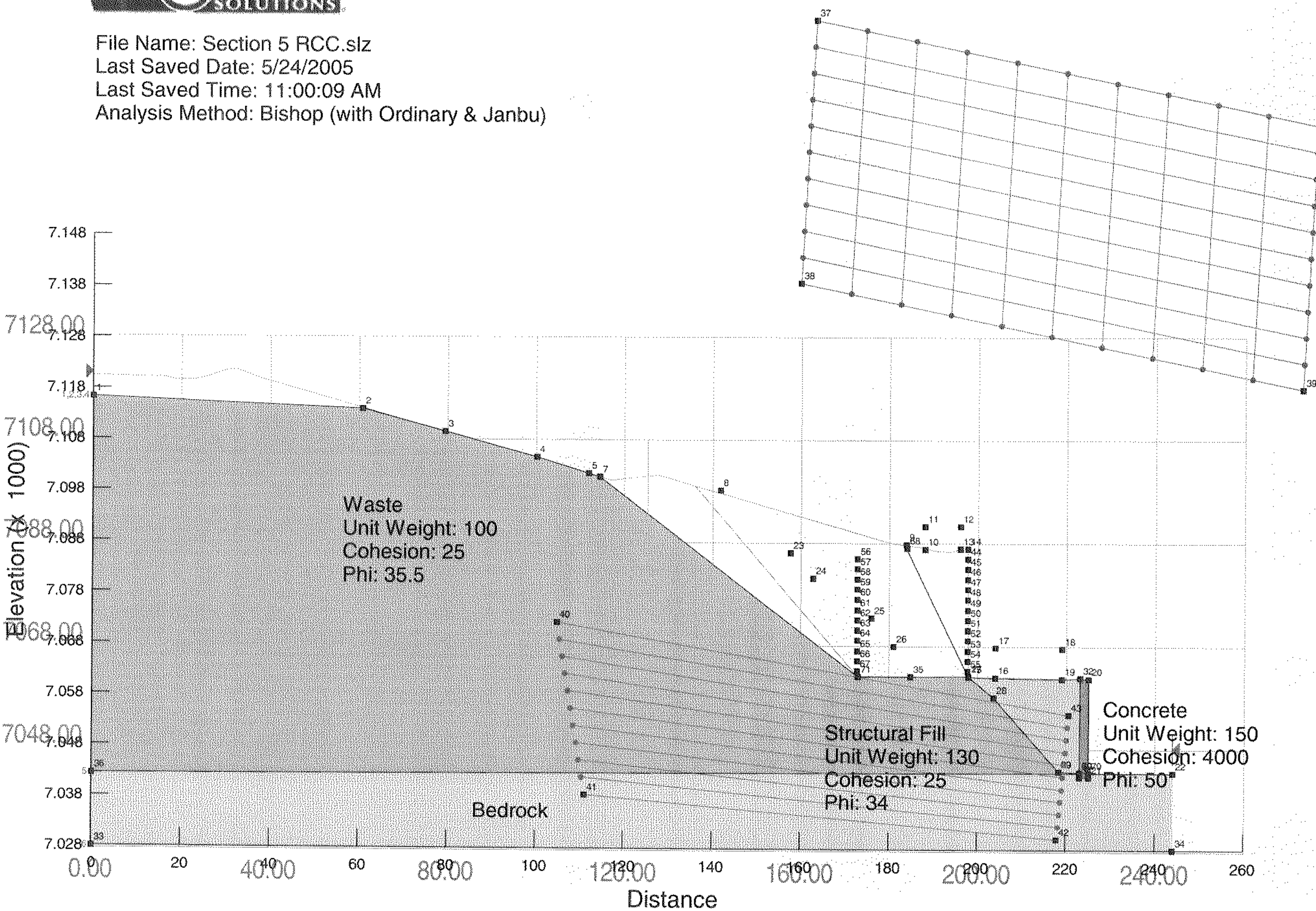

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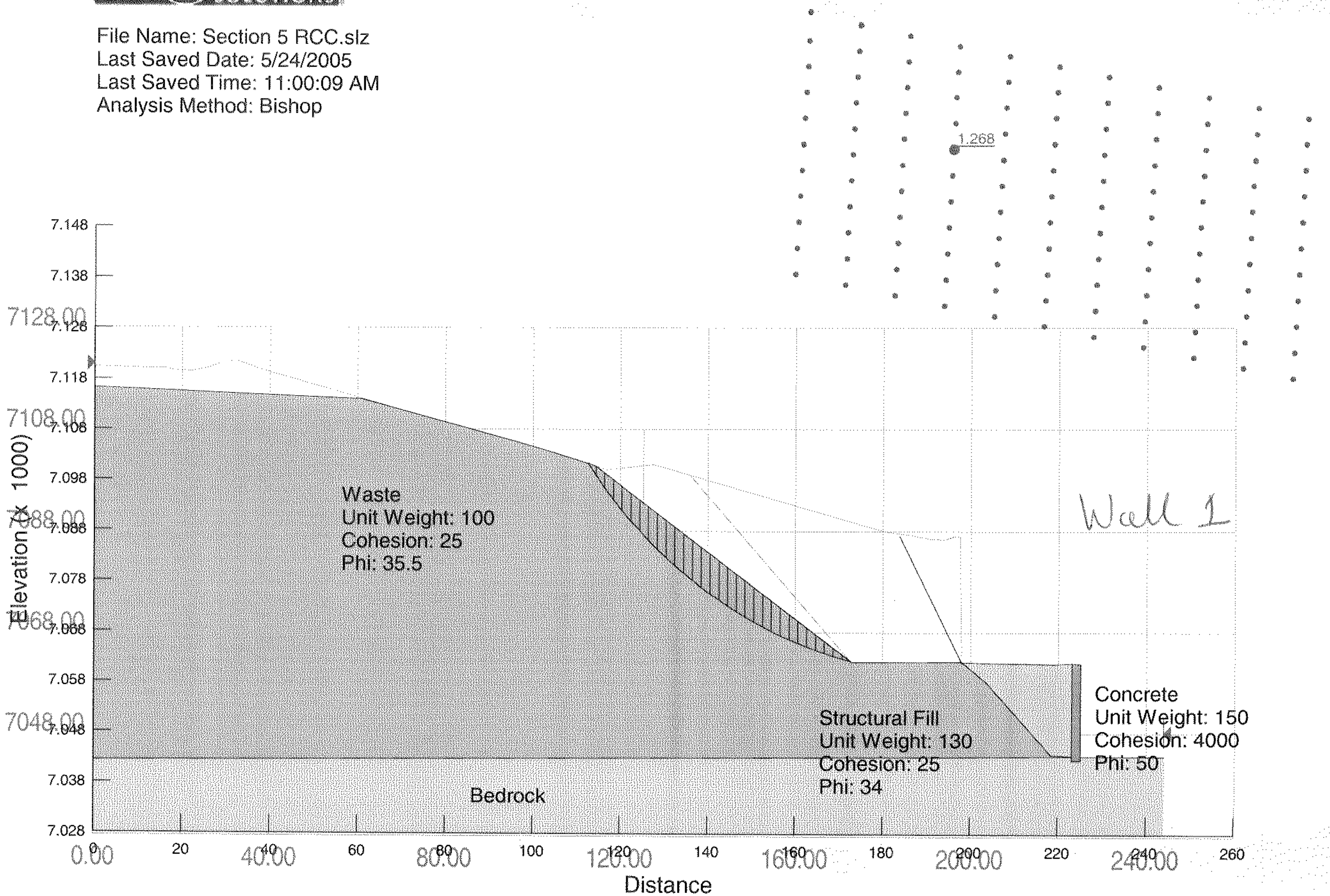

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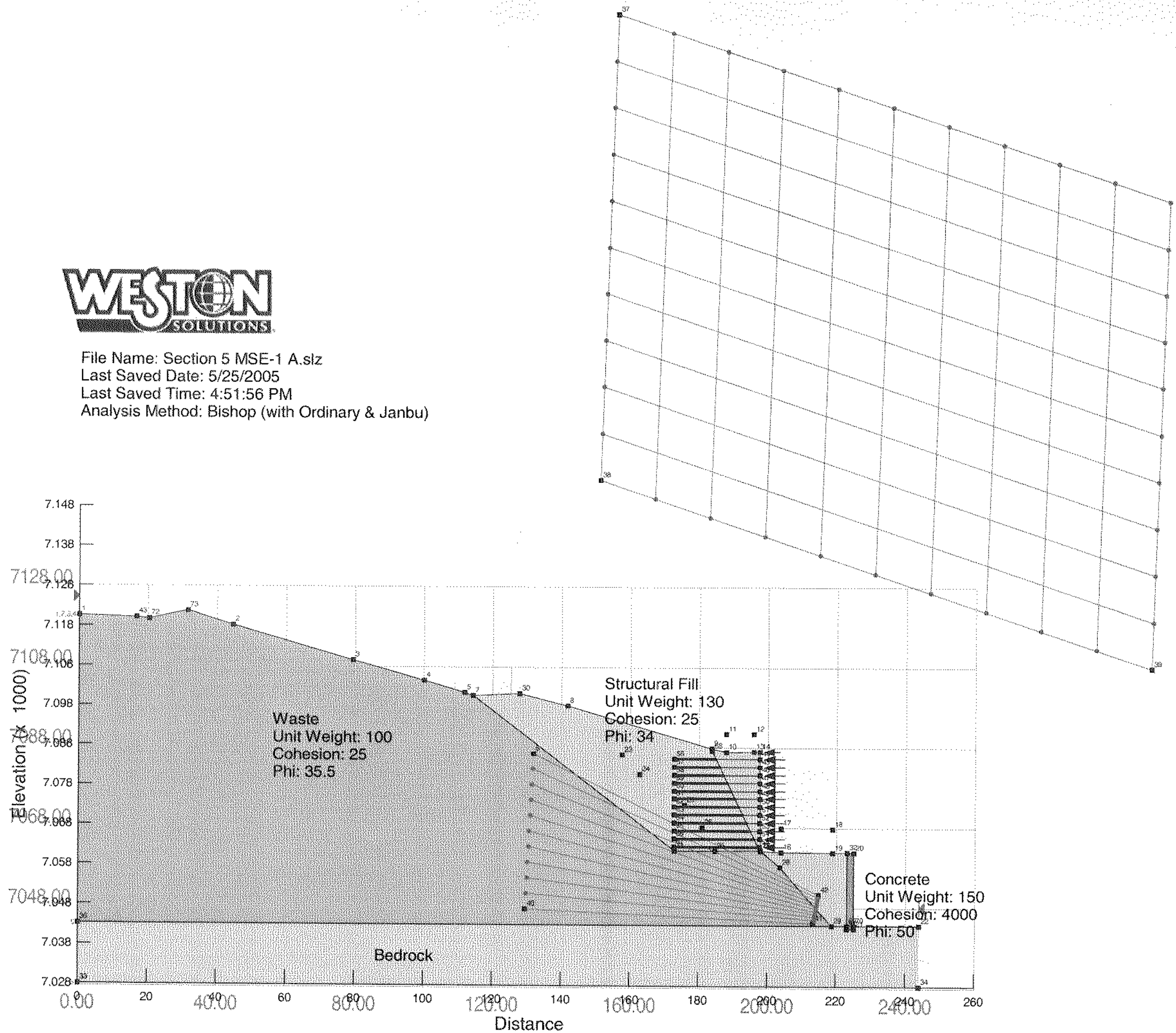

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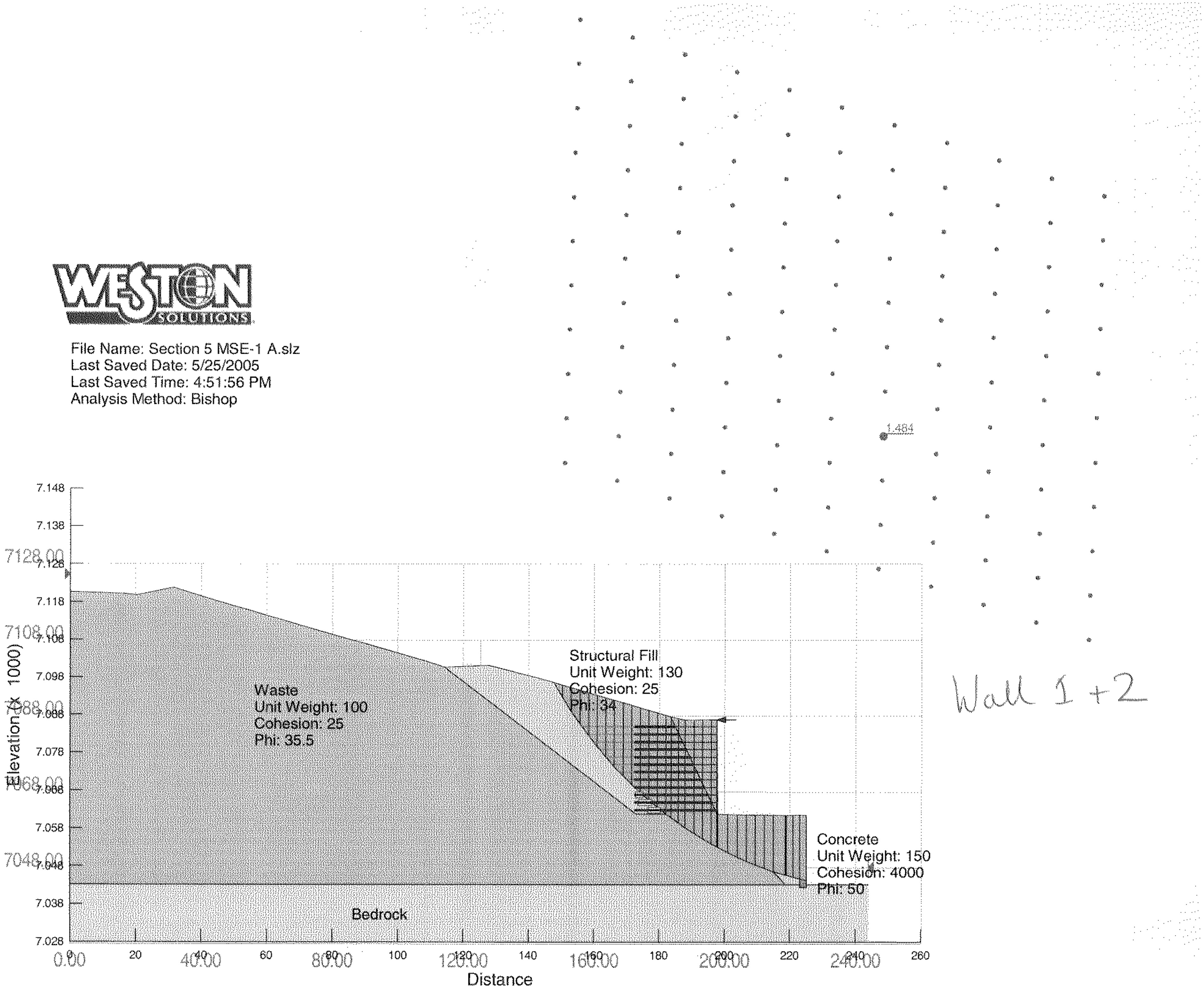
Analysis Method: Bishop

Wall 1 + 2



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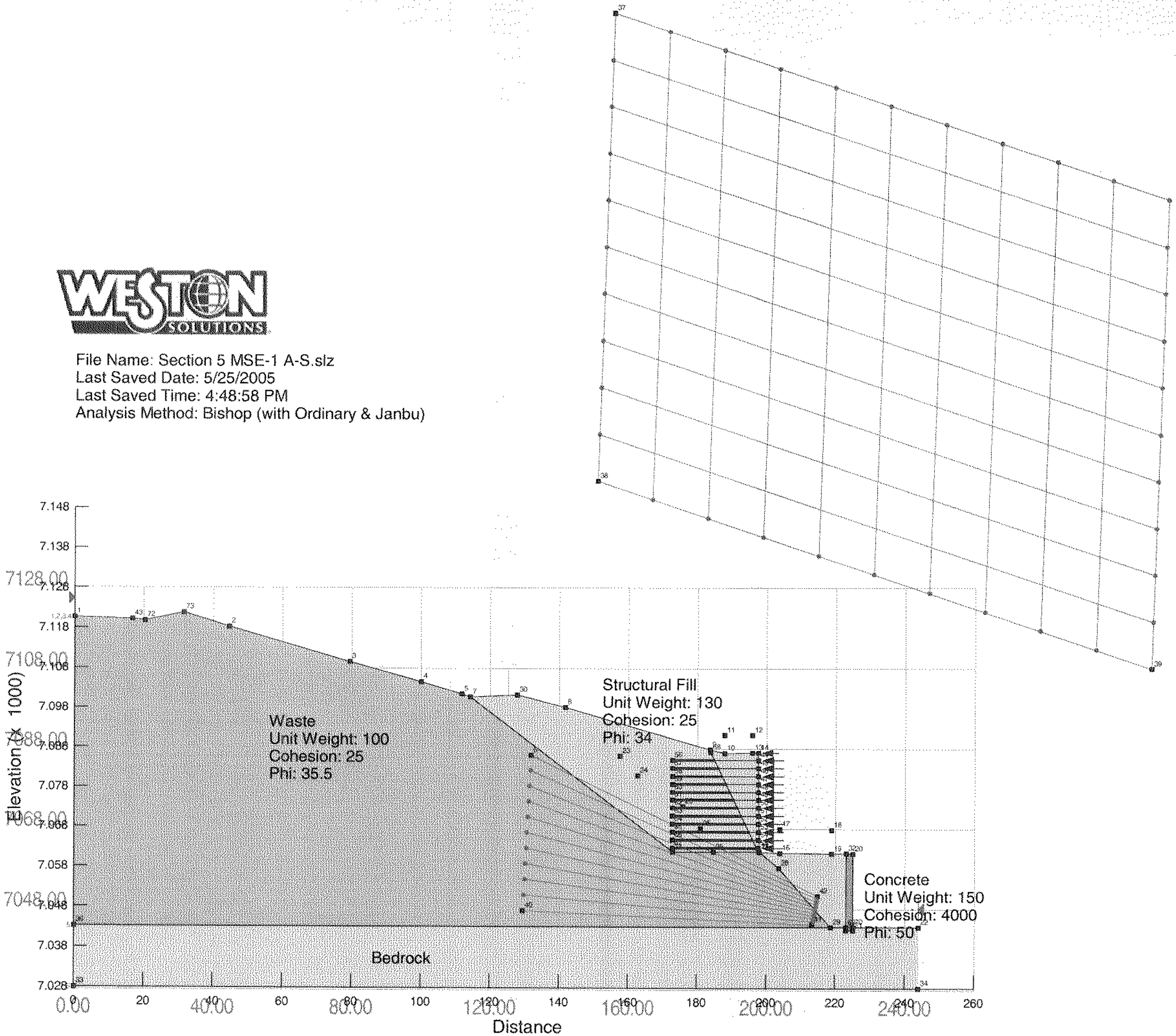
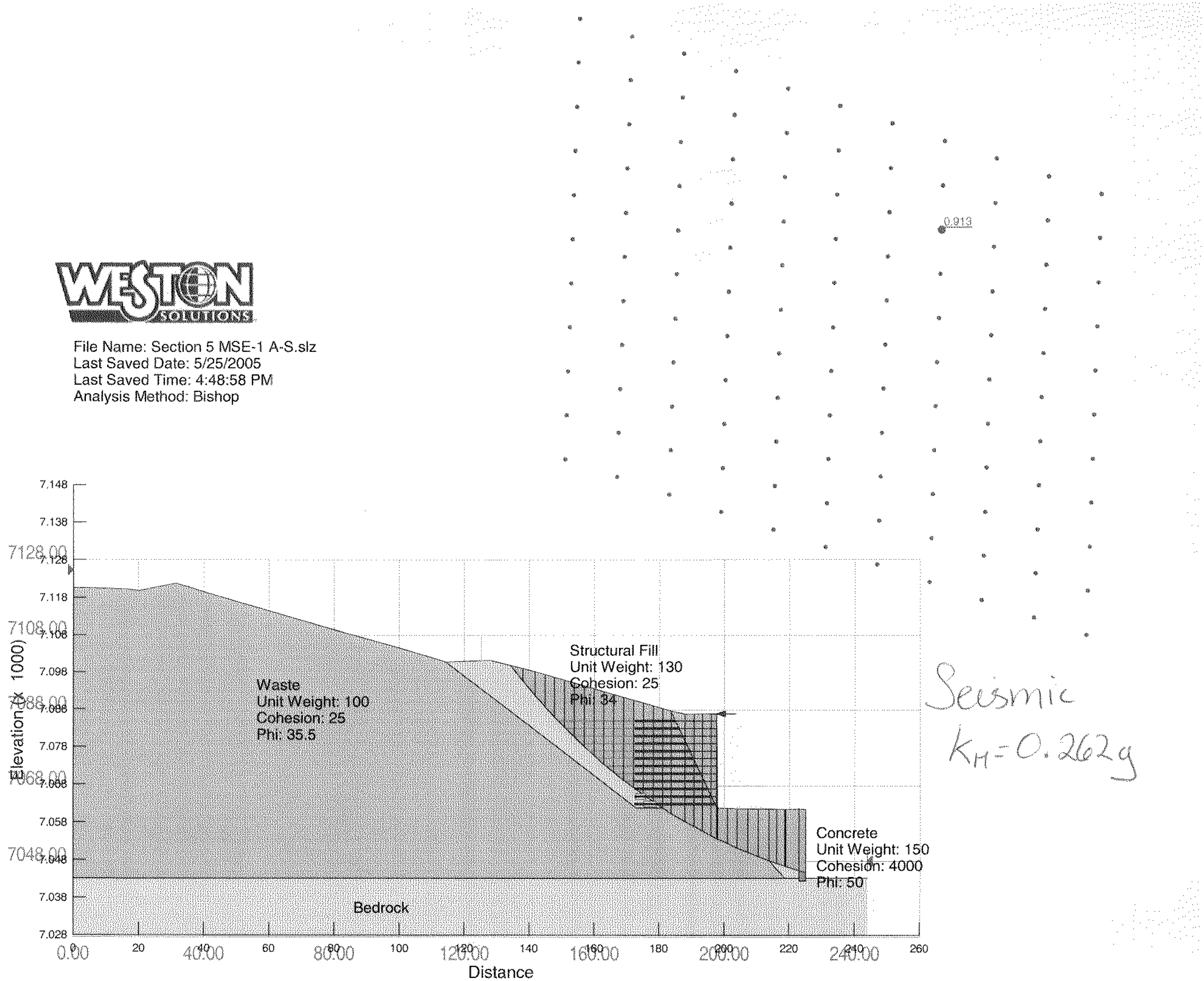
Last Saved Date: 5/25/2005
Last Saved Time: 4:48:58 PM
Analysis Method: Bishop (with Ordinary & Janbu)



File Name: Section 5 MSE-1 A-S.slz
Last Saved Date: 5/25/2005
Last Saved Time: 4:48:58 PM
Analysis Method: Bishop



WESTON SOLUTIONS

ATTACHMENT 5

DEFORMATION ANALYSIS

Since the acceptable factor-of-safety of 1.1 was not achieved for the seismic or pseudo-static global slope stability analysis, a deformation analysis was completed which follows an approach developed by Newmark (1965). This procedure allows for an estimation of the seismically induced magnitude of permanent displacement. The procedure is based on the assumption that the slope will be permanently displaced during the period when the yield acceleration (K_y) is exceeded.

The yield acceleration, an input parameter to the deformation procedure, was determined by varying the magnitude of the horizontal seismic force input to the slope stability analysis until a factor-of-safety of 1.0 was achieved. For the final slope configuration the yield acceleration was determined to be 0.20g (FS = 1.016). The ratio of the yield acceleration (K_y -= 0.20g) to the peak ground acceleration (K_{max} = 0.262g), was calculated to be 0.76. From the Makdisi and Seed chart, for a magnitude 7.5 earthquake based on the Pajarito fault (M = 7.2), the displacement was estimated to range between 0.38 and 2.9 cm, 0.15 to 1.14 inches, see Figure 1.

At this time there is no regulatory prescribed upper limit for slope deformation. Rather, the acceptability of the magnitude of movement must be based on experience and engineering judgment. Movement of up to 12 inches is generally deemed to be acceptable for MSW sites. For any magnitude of displacement greater than about 6 to 12 inches it should be anticipated that slope maintenance and cap repairs will be required following a seismic event.

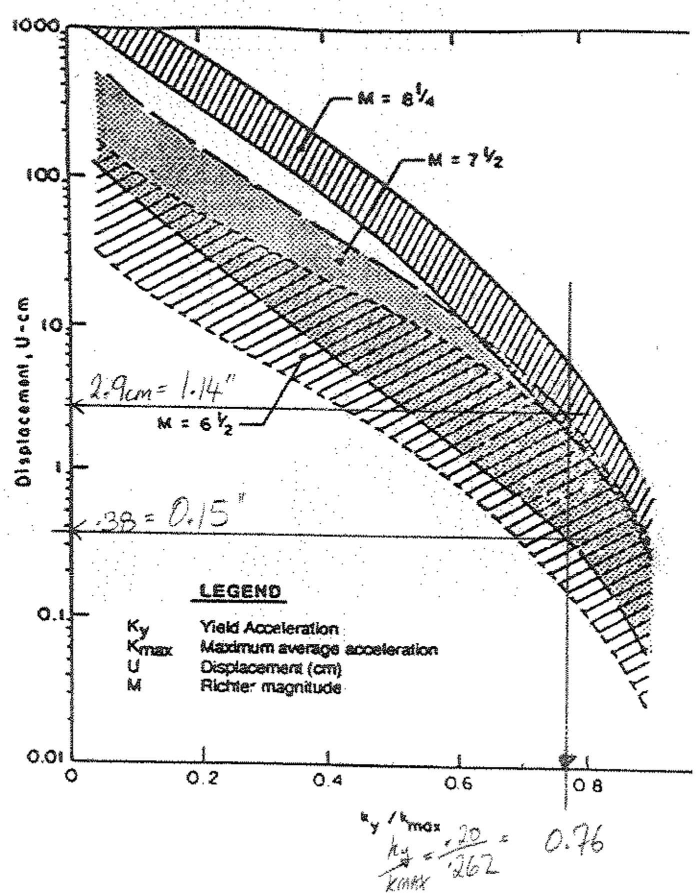


Figure 1 - Makdisi and Seed Permanent Displacement Chart

Restoring Resource Efficiency

CLIENT/SUBJECT LANL W.O. NO 00000000000

TASK DESCRIPTION Stormwater Design TASK NO 000000

PREPARED BY SW DEPT 1495 DATE 6/22/05

MATH CHECK BY KTM DEPT 1495 DATE 6/22/05

METHOD REV. BY RWM DEPT 1495 DATE 5/18/05

APPROVED BY

DEPT DATE

Objective: Determine runoff and size stormwater structures for the LANL landfill based on the Draft 60% design review comments of May 2005.

Discussion: North Wind 60% design review suggested designing stormwater structures per county standards for the high-intensity summer thunderstorms (100-yr 6-hr storm). The accepted methods included the Rational Method and The SCS Type II-A distribution.

Stormsewer System

Rational Method: Suggested I value for the rational method is 5.75 inches per hour. Based on the characteristics of the MATCON pavement material, the surface is assumed to be impermeable and the runoff coefficient is assumed to be 1. The table below summarizes estimated peak runoff for each of the drainage structures listed:

	Area A, Ac	Rainfall Intensity I, in/hr	Runoff Coefficient C	Peak Runoff Q, CFS
Trench 1	0.15	5.75	1	0.86
Trench 2	0.55	5.75	1	3.16
Trench 3	0.55	5.75	1	3.16
Trench 4	0.55	5.75	1	3.16
I 2	0.22	5.75	1	1.27
I 4	0.34	5.75	1	1.96
I 6	0.34	5.75	1	1.96
I 8	0.34	5.75	1	1.96
I 9	0.96	5.75	1	5.52
I 10	2.04	5.75	1	11.73

The resulting peak flow values were used to size the trenches, pipes, and channels. The attached hydraulic calculations were performed based on Manning's equation using Haestad's FlowMaster software. In order to check for surcharging and inlet and outlet control, the peak flows were also used in

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a simplified SWMM model routing (see attached). The model indicated that the system was adequately sized to pass the peak flow estimated by the rational method.

SCS Type II-A: The suggested values for the 100-yr 6-hr SCS Type II-A distribution were 1.87 inches in the first 15 minutes, 2.35 inches in the first hour, 2.8 inches in six hours. These values were used to create a hydrograph for the SWMM model. Then the system designed using the Rational Method as described above was subjected to the flows generated by the hydrograph as check of system capacity. The results of the simulation show that Rational Method sizing provided adequate capacity to pass a SCS Type II-A storm.

Channels

Surface drainage features on the site will include Channels 1 and 2 at the eastern edge of the landfill. The trapezoidal channels will be constructed by grading a shallow channels and building up a berm behind the channel on the eastern edge. Channel 1 will drain northward and discharge into the Downchute 1, while Channel 2 will drain southward and discharge into the stormwater system via Inlet 10. The Rational Method peak runoff values are listed below. Benches 1 and 2 are designed to break up the flow along the 4:1 eastern slope of the landfill and direct the runoff north and south, discharging beyond the limits of the landfill and away from the retaining walls. Energy dissipaters will be used at all points of discharge to prevent scour. Haestad FlowMaster software was used to provide hydraulic calculations for channels and benches, with separate shear check. Minimum of 0.5 ft freeboard is provided for each structure.

	Area A, Ac	Rainfall Intensity I, in/hr	Runoff Coefficient C	Peak Runoff Q, CFS
Channel 1 & Downchute	1.11	5.75	1	6.38
Channel 2	2.04	5.75	1	11.73
Bench 1	0.51	5.75	0.35	1.03
Bench 2	0.68	5.75	0.35	1.37

CLIENT/SUBJECT LANL W.O. NO 00000000000

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METHOD REV. BY RWM DEPT 1495 DATE 5/18/05

APPROVED BY

DEPT DATE

Stormsewer System Calculations

1. FlowMaster Hydraulic Calculations

2. Rational Method

3. SCS Type II-A Distribution

Trench 1
Worksheet for Rectangular Channel

Project Description	
Worksheet	Trench 1
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Slope	0.038000	ft/ft
Bottom Width	0.83	ft
Discharge	0.86	cfs

Results		
Depth	0.18	ft
Flow Area	0.2	ft²
Wetted Perimeter	1.20	ft
Top Width	0.83	ft
Critical Depth	0.32	ft
Critical Slope	0.007704	ft/ft
Velocity	5.64	ft/s
Velocity Head	0.49	ft
Specific Energy	0.68	ft
Froude Number	2.32	
Flow Type	Supercritical	

I1-I2
Worksheet for Circular Channel

Project Description	
Worksheet	I1-I2
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Slope	0.006000	ft/ft
Diameter	12	in
Discharge	0.86	cfs

Results		
Depth	0.38	ft
Flow Area	0.3	ft^2
Wetted Perimeter	1.34	ft
Top Width	0.97	ft
Critical Depth	0.39	ft
Percent Full	38.3	%
Critical Slope	0.005729	ft/ft
Velocity	3.10	ft/s
Velocity Head	0.15	ft
Specific Energy	0.53	ft
Froude Number	1.02	
Maximum Discharg	2.97	cfs
Discharge Full	2.76	cfs
Slope Full	0.000583	ft/ft
Flow Type	Supercritical	

I2-I4
Worksheet for Circular Channel

Project Description	
Worksheet	I2-I4
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Slope	0.009000	ft/ft
Diameter	15	in
Discharge	2.13	cfs

Results		
Depth	0.51	ft
Flow Area	0.5	ft²
Wetted Perimeter	1.73	ft
Top Width	1.23	ft
Critical Depth	0.58	ft
Percent Full	40.7	%
Critical Slope	0.005547	ft/ft
Velocity	4.54	ft/s
Velocity Head	0.32	ft
Specific Energy	0.83	ft
Froude Number	1.30	
Maximum Discharg	6.59	cfs
Discharge Full	6.13	cfs
Slope Full	0.001087	ft/ft
Flow Type	Supercritical	

Trench 2, 3, and 4
Worksheet for Rectangular Channel

Project Description	
Worksheet	Trench 2, 3, and 4
Flow Element	Rectangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Slope	0.010200	ft/ft
Bottom Width	0.83	ft
Discharge	3.16	cfs

Results		
Depth	0.78	ft
Flow Area	0.7	ft²
Wetted Perimeter	2.40	ft
Top Width	0.83	ft
Critical Depth	0.76	ft
Critical Slope	0.010806	ft/ft
Velocity	4.85	ft/s
Velocity Head	0.36	ft
Specific Energy	1.15	ft
Froude Number	0.97	
Flow Type	Subcritical	

I3-I4, I5-I6, and I7-I8
Worksheet for Circular Channel

Project Description	
Worksheet	I3-I4, I5-I6, and I7-I8
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Slope	0.004300	ft/ft
Diameter	15	in
Discharge	3.16	cfs

Results		
Depth	0.80	ft
Flow Area	0.8	ft^2
Wetted Perimeter	2.33	ft
Top Width	1.20	ft
Critical Depth	0.72	ft
Percent Full	64.4	%
Critical Slope	0.006126	ft/ft
Velocity	3.78	ft/s
Velocity Head	0.22	ft
Specific Energy	1.03	ft
Froude Number	0.80	
Maximum Discharg	4.56	cfs
Discharge Full	4.24	cfs
Slope Full	0.002393	ft/ft
Flow Type	Subcritical	

I4-I6
Worksheet for Circular Channel

Project Description	
Worksheet	I4-I6
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Slope	0.019000	ft/ft
Diameter	18	in
Discharge	7.25	cfs

Results		
Depth	0.75	ft
Flow Area	0.9	ft^2
Wetted Perimeter	2.36	ft
Top Width	1.50	ft
Critical Depth	1.04	ft
Percent Full	50.0	%
Critical Slope	0.006918	ft/ft
Velocity	8.20	ft/s
Velocity Head	1.04	ft
Specific Energy	1.79	ft
Froude Number	1.88	
Maximum Discharg	15.57	cfs
Discharge Full	14.48	cfs
Slope Full	0.004764	ft/ft
Flow Type	Supercritical	

I6-I8
Worksheet for Circular Channel

Project Description	
Worksheet	I6-I8
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Slope	0.020000	ft/ft
Diameter	24	in
Discharge	12.36	cfs

Results		
Depth	0.86	ft
Flow Area	1.3	ft²
Wetted Perimeter	2.87	ft
Top Width	1.98	ft
Critical Depth	1.26	ft
Percent Full	43.1	%
Critical Slope	0.005662	ft/ft
Velocity	9.53	ft/s
Velocity Head	1.41	ft
Specific Energy	2.27	ft
Froude Number	2.08	
Maximum Discharg	34.41	cfs
Discharge Full	31.99	cfs
Slope Full	0.002985	ft/ft
Flow Type	Supercritical	

I8-I9
Worksheet for Circular Channel

Project Description	
Worksheet	I8-I9
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Slope	0.020000	ft/ft
Diameter	24	in
Discharge	17.48	cfs

Results		
Depth	1.05	ft
Flow Area	1.7	ft²
Wetted Perimeter	3.25	ft
Top Width	2.00	ft
Critical Depth	1.51	ft
Percent Full	52.7	%
Critical Slope	0.007105	ft/ft
Velocity	10.41	ft/s
Velocity Head	1.68	ft
Specific Energy	2.74	ft
Froude Number	2.00	
Maximum Discharg	34.41	cfs
Discharge Full	31.99	cfs
Slope Full	0.005971	ft/ft
Flow Type	Supercritical	

I9-I10
Worksheet for Circular Channel

Project Description	
Worksheet	I9-I10
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Slope	0.024000	ft/ft
Diameter	24	in
Discharge	23.00	cfs

Results		
Depth	1.18	ft
Flow Area	1.9	ft²
Wetted Perimeter	3.51	ft
Top Width	1.97	ft
Critical Depth	1.71	ft
Percent Full	59.1	%
Critical Slope	0.009682	ft/ft
Velocity	11.90	ft/s
Velocity Head	2.20	ft
Specific Energy	3.38	ft
Froude Number	2.12	
Maximum Discharg	37.70	cfs
Discharge Full	35.04	cfs
Slope Full	0.010338	ft/ft
Flow Type	Supercritical	

I10-MH1
Worksheet for Circular Channel

Project Description	
Worksheet	I10-MH1
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.013	
Slope	0.005000	ft/ft
Diameter	36	in
Discharge	34.73	cfs

Results		
Depth	1.91	ft
Flow Area	4.8	ft²
Wetted Perimeter	5.55	ft
Top Width	2.88	ft
Critical Depth	1.91	ft
Percent Full	63.8	%
Critical Slope	0.004994	ft/ft
Velocity	7.30	ft/s
Velocity Head	0.83	ft
Specific Energy	2.74	ft
Froude Number	1.00	
Maximum Discharg	50.73	cfs
Discharge Full	47.16	cfs
Slope Full	0.002712	ft/ft
Flow Type	Supercritical	

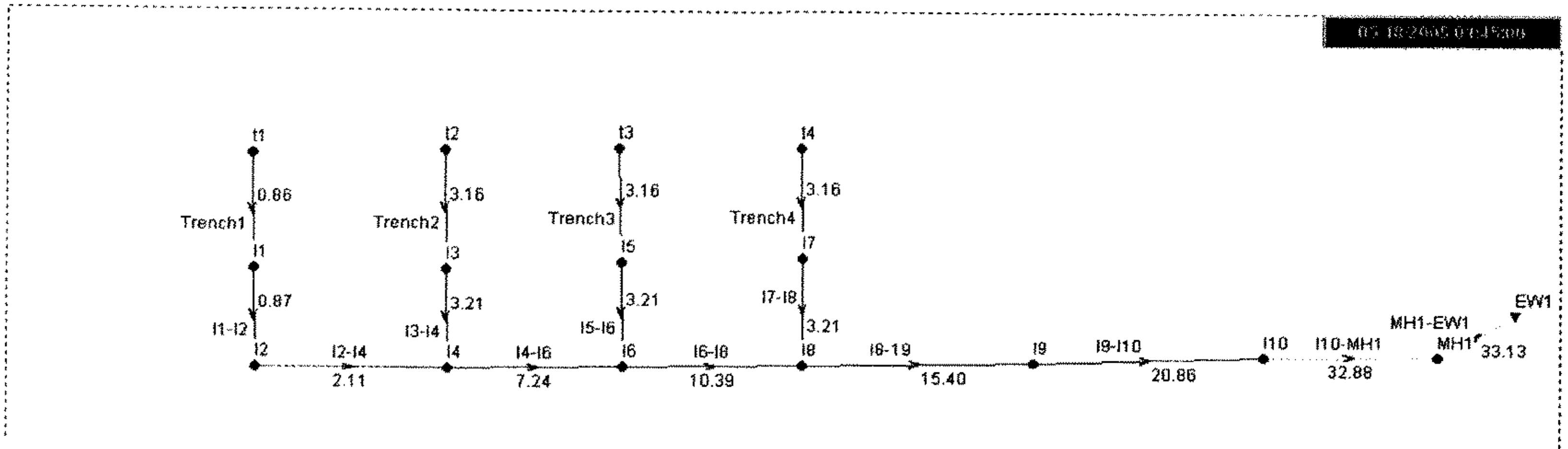
MH1-EW1
Worksheet for Circular Channel

Project Description	
Worksheet	MH1-EW1
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Channel Depth

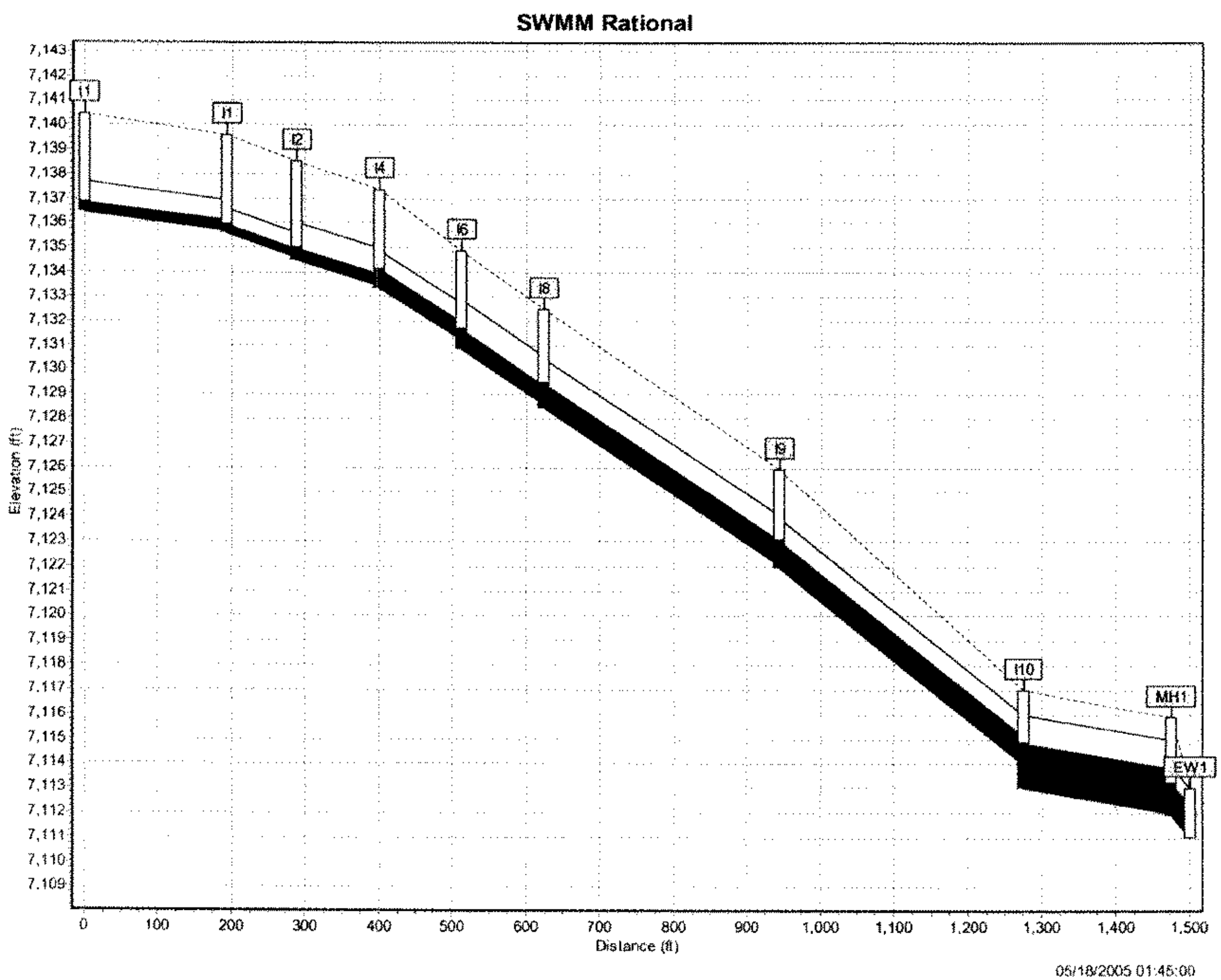
Input Data		
Mannings Coefficient	0.013	
Slope	0.050000	ft/ft
Diameter	36	in
Discharge	34.73	cfs

Results		
Depth	0.98	ft
Flow Area	2.0	ft^2
Wetted Perimeter	3.66	ft
Top Width	2.82	ft
Critical Depth	1.91	ft
Percent Full	32.8	%
Critical Slope	0.004994	ft/ft
Velocity	17.19	ft/s
Velocity Head	4.59	ft
Specific Energy	5.58	ft
Froude Number	3.58	
Maximum Discharg	160.42	cfs
Discharge Full	149.13	cfs
Slope Full	0.002712	ft/ft
Flow Type	Supercritical	

SWMM MAP
RATIONAL METHOD



Flow (cfs)


SWMM Rational
Elevation (ft)
7,143
7,142
7,141
7,140
7,139
7,138
7,137
7,136
7,135
7,134
7,133
7,132
7,131
7,130
7,129
7,128
7,127
7,126
7,125
7,124
7,123
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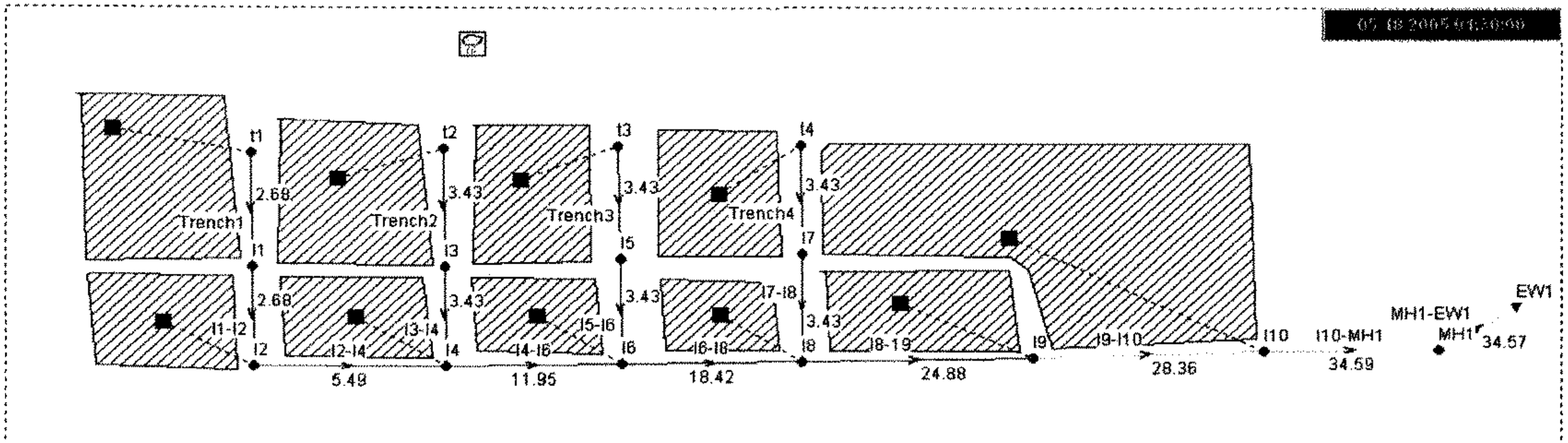
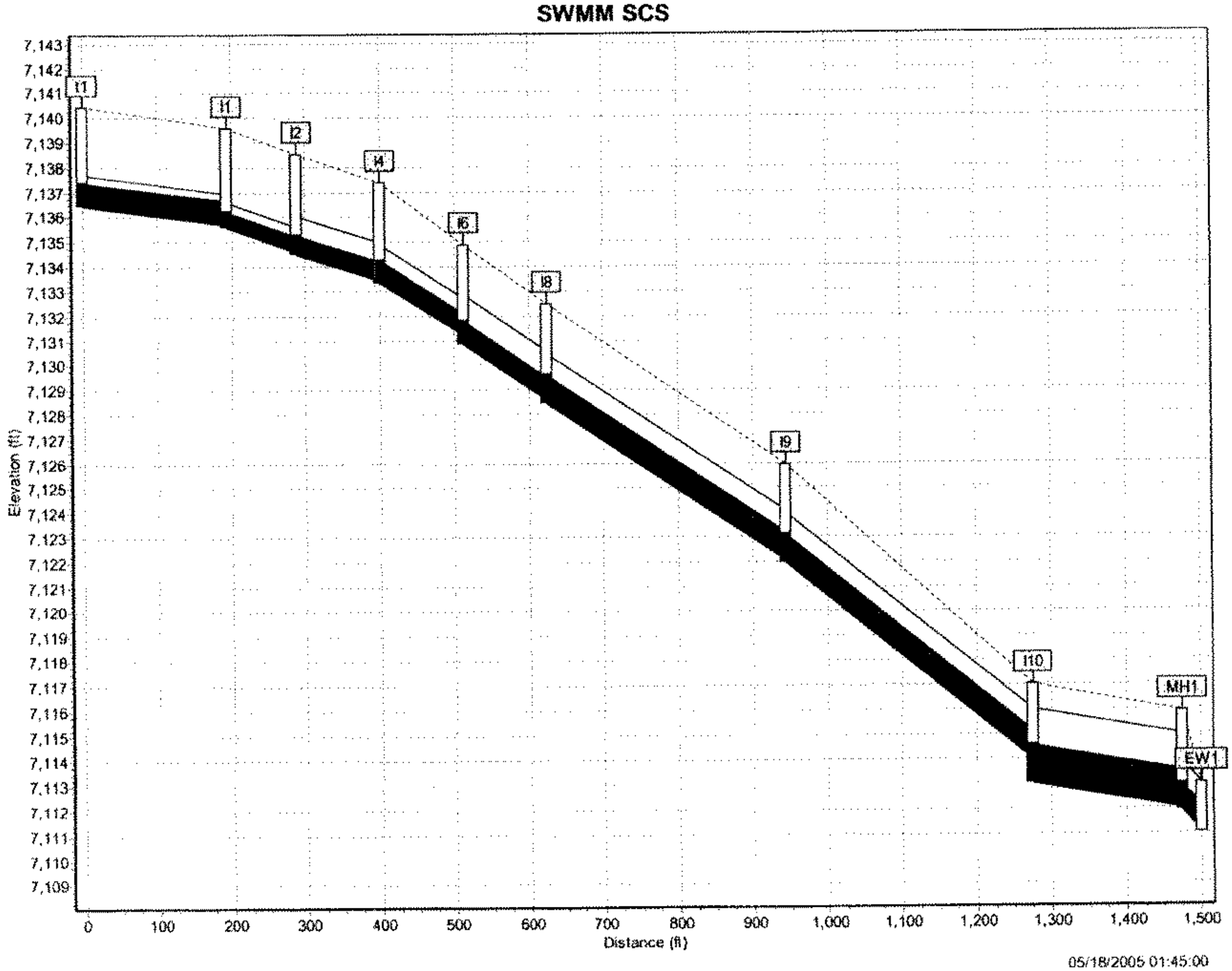
7,121
7,120
7,119
7,118
7,117
7,116
7,115
7,114
7,113
7,112
7,111
7,110
7,109
I1
I1
I2
I4
I6
I8
I9
I10
MH1
EW1
0
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
1,400
1,500
Distance (ft)
05/18/2005 01:45:00

SWMM Map
SCS Method



Flow (cfs)

SWMM SCS



Elevation (ft)
7,143
7,142
7,141
7,140
7,139
7,138
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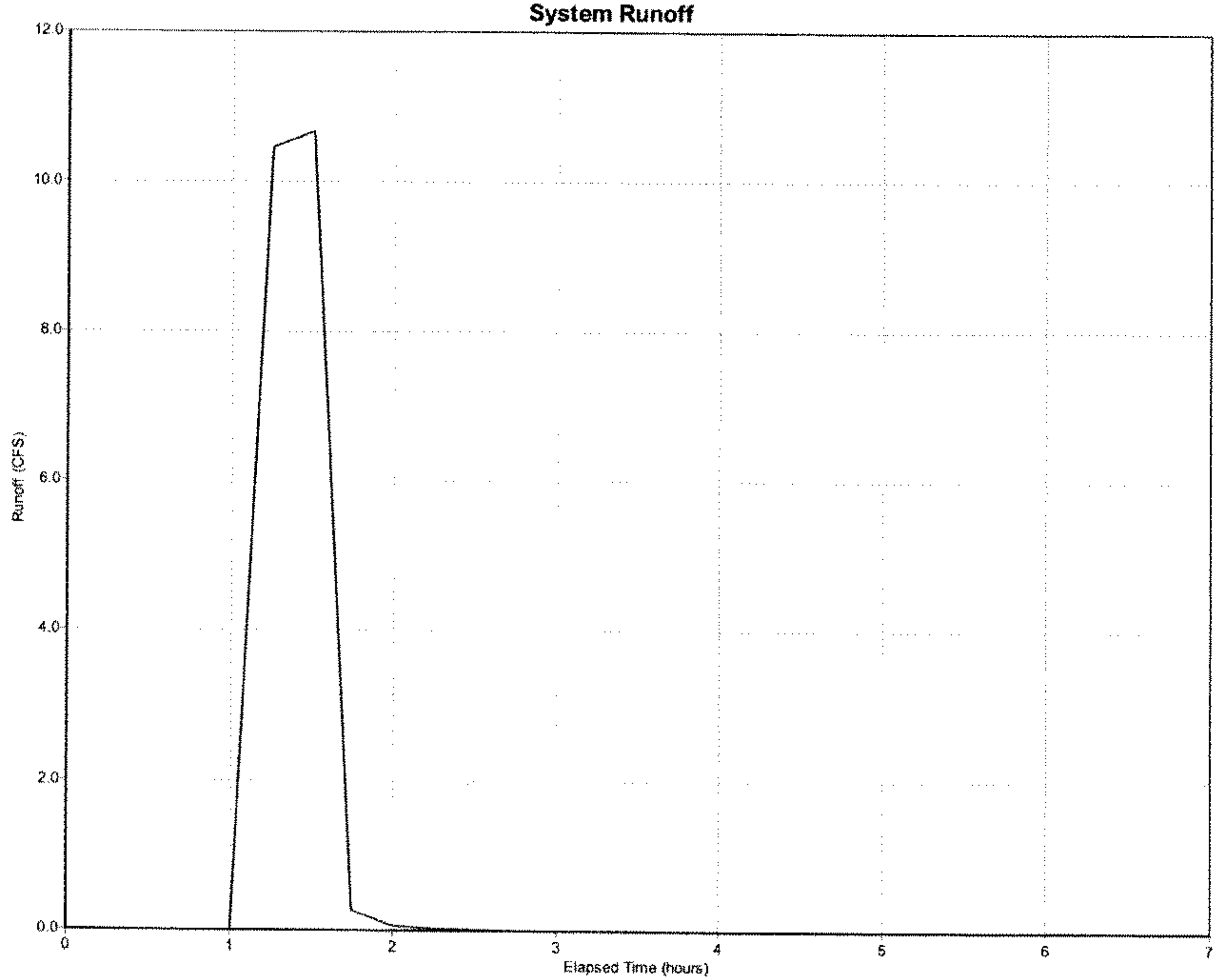
7,120
7,119
7,118
7,117
7,116
7,115
7,114
7,113
7,112
7,111
7,110
7,109
I1
I1
I2
I4
I6
I8
I9
I10
MH1
EW1
0
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
1,400
1,500
Distance (ft)
05/18/2005 01:45:00

System Runoff



CLIENT/SUBJECT LANL W.O. NO 00000000000

TASK DESCRIPTION Stormwater Design TASK NO 000000

PREPARED BY SW DEPT 1495 DATE 6/22/05

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METHOD REV. BY RWM DEPT 1495 DATE 5/18/05

APPROVED BY

DEPT DATE

Channels and Berms Calculations

Channel 1
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Channel 1
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Slope	0.020000	ft/ft
Left Side Slope	3.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	2.00	ft
Discharge	6.38	cfs

Results		
Depth	0.56	ft
Flow Area	2.1	ft²
Wetted Perimeter	5.54	ft
Top Width	5.36	ft
Critical Depth	0.52	ft
Critical Slope	0.026125	ft/ft
Velocity	3.10	ft/s → R-3 OK (6.5 ft/s Max)
Velocity Head	0.15	ft
Specific Energy	0.71	ft
Froude Number	0.88	
Flow Type	Subcritical	

Shear:

$\tau = 62.4 \times 0.56 \times 0.02 = 0.7$ psf

R-3 OK (1 psf Max)

Channel 2
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Channel 2
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Slope	0.020000	ft/ft
Left Side Slope	3.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	2.00	ft
Discharge	11.73	cfs

Results		
Depth	0.75	ft
Flow Area	3.2	ft²
Wetted Perimeter	6.77	ft
Top Width	6.52	ft
Critical Depth	0.72	ft
Critical Slope	0.024021	ft/ft
Velocity	3.65	ft/s → R-3 OK (6.5 ft/s Max)
Velocity Head	0.21	ft
Specific Energy	0.96	ft
Froude Number	0.92	
Flow Type	Subcritical	

Shear

$\tau = 62.4 \times 0.75 \times 0.02 = 0.9$ psf

R-3 OK (1 psf Max)

Downchute
Worksheet for Trapezoidal Channel

Project Description	
Worksheet	Downchute
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.027	
Slope	0.333300	ft/ft
Left Side Slope	3.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	6.00	ft
Discharge	6.38	cfs

Results		
Depth	0.13	ft
Flow Area	0.8	ft²
Wetted Perimeter	6.81	ft
Top Width	6.77	ft
Critical Depth	0.31	ft
Critical Slope	0.016644	ft/ft
Velocity	7.76	ft/s
Velocity Head	0.94	ft
Specific Energy	1.06	ft
Froude Number	3.93	
Flow Type	Supercritical	

→ Reno Mattress OK (12 ft/s Max)

Shear $\tau = 62.4 \times 0.13 \times 0.33 = 2.7$ psf
Reno Mattress OK (8.35 psf Max)

Inlet 10
Worksheet for Ditch Inlet In Sag

Project Description	
Worksheet	Ditch Inlet - 10
Type	Ditch Inlet In Sag
Solve For	Spread

Input Data		
Discharge	11.73	cfs
Left Side Slope	3.00	H : V
Right Side Slope	3.00	H : V
Bottom Width	2.00	ft
Grate Width	2.00	ft
Grate Length	4.00	ft
Local Depression	2.0	in
Local Depression Width	10.00	ft
Grate Type	30 Deg Tilt Bar	
Clogging	0.0	%

Results		
Spread	4.86	ft
Depth	0.48	ft
Wetted Perimeter	5.02	ft
Top Width	4.86	ft
Open Grate Area	2.7	ft^2
Active Grate Weir Length	12.00	ft

Bench 1
Worksheet for Triangular Channel

Project Description	
Worksheet	Bench 1
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Slope	0.040000	ft/ft
Left Side Slope	4.00	H : V
Right Side Slope	10.00	H : V
Discharge	1.03	cfs

Results		
Depth	0.26	ft
Flow Area	0.5	ft^2
Wetted Perimeter	3.69	ft
Top Width	3.65	ft
Critical Depth	0.27	ft
Critical Slope	0.035523	ft/ft
Velocity	2.17	ft/s → R-3 OK (6.5 ft/s Max)
Velocity Head	0.07	ft
Specific Energy	0.33	ft
Froude Number	1.06	
Flow Type	Supercritical	

Shear

$\tau = 62.4 \times 0.26 \times 0.04 = 0.65$ psf

R-3 OK (1 psf MAX)

Bench 2
Worksheet for Triangular Channel

Project Description	
Worksheet	Bench 2
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Slope	0.040000	ft/ft
Left Side Slope	4.00	H : V
Right Side Slope	10.00	H : V
Discharge	1.37	cfs

Results		
Depth	0.29	ft
Flow Area	0.6	ft²
Wetted Perimeter	4.11	ft
Top Width	4.06	ft
Critical Depth	0.30	ft
Critical Slope	0.034197	ft/ft
Velocity	2.33	ft/s → R-3 OK (6.5 ft/s max)
Velocity Head	0.08	ft
Specific Energy	0.37	ft
Froude Number	1.08	
Flow Type	Supercritical	

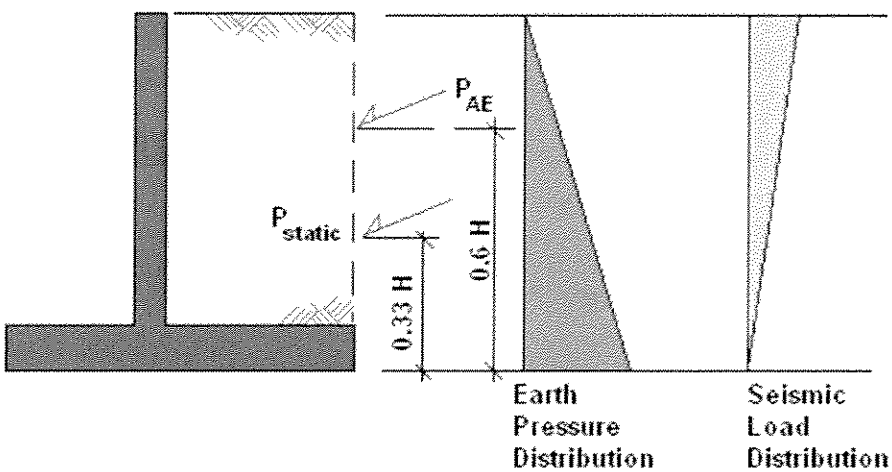
Shear

$\tau = 62.4 \times 0.29 \times 0.04 = 0.72$ psf

R-3 OK (1 psf Max)

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS

DESIGN CALCULATIONS FOR WALL No. 1



June, 2005

by

TCPI
436 Creamery Way
Suite 100
Exton, Pennsylvania 19341

Design Calculations Retaining Wall 1

Index

1.0 Design Criteria

1.1 **General:** The reinforced concrete retaining wall (i.e. Wall No. 1) was design using the following documents. See Appendix 'A' for a list of references.

1.1.1 Retaining Wall No. 1 was design in accordance with International Building Code (IBC) 2003 Edition.

1.1.2 ACI 318-02 "Building Code Requirements for Structural Concrete".

1.2 **Wall Heights:** The retaining wall was design in height increments of 5'-0" from Grade to a maximum height of 24'-0". The following is a list of wall mark numbers and the maximum height for that wall.

Mk. No.	**From**	**To**
A	Grade	5'-0"
B	≥ 5'-1"	10-0"
C	≥ 10'-1"	15'-0"
D	≥ 15'-1"	20'-0"
E	≥ 20'-1"	24'-0"

1.3 **Load Cases:** The following four (4) load cased were evaluated for each wall height

1.3.1 Normal Load: This is the basic design load on the wall. It consisted of the following items

1.3.1.1 EFP (equivalent fluid pressure) of 51 pcf. Sheet 9 of Appendix B recommends an EFP of 45.5 pcf based on the average of the active (Ka) and the at-rest (Ko) lateral earth pressure coefficients. The actual lateral earth pressure condition is somewhere between the active and the at-rest cases. The wall is not free to translate (footing embedded in rock) but it is free to deflect so the active case cannot fully develop. Similarly, since the wall is free to deflect, it is not completely restrained, and therefore the at-rest condition cannot fully develop. Selecting the lateral earth pressure coefficient as the average of the two conditions is based on engineering judgment.

1.3.1.2 The higher, and therefore more conservative EFP used in this analysis was calculated based on the following lateral earth pressure coefficient K = Ka +¾(Ko-Ka) = 0.259 +¾(0.441 – 0.259) = 0.396. With an assumed in-place density of the backfill of 130 pcf, (γ = 130) this gives an EFP of 51 pcf.

1.3.1.3 Allowable soil bearing condition is 4,000 psf. Actual rock capacity is higher.

1.3.1.4 There are no surcharge effects from the uphill MSE Walls. See appendix 'C' for details.

1.3.1.5 Stability ratio for overturning is a minimum of 2.0 to 1.0.

1.3.2 Seismic Condition 1: This upset condition consists of an earthquake event.

1.3.2.1 EFP of 62 pcf was used with a normal triangular, with increasing pressure toward the bottom of the wall. See Figure 1 and sheet 14 of Appendix 'B' for details.

1.3.2.2 Allowable soil bearing condition is 5,000 psf. Actual rock capacity is higher.

1.3.2.3 There are no surcharge effects from the uphill MSE Walls. See appendix 'C' for details.

1.3.2.4 Stability ratio for overturning is a minimum of 2.0 to 1.0.

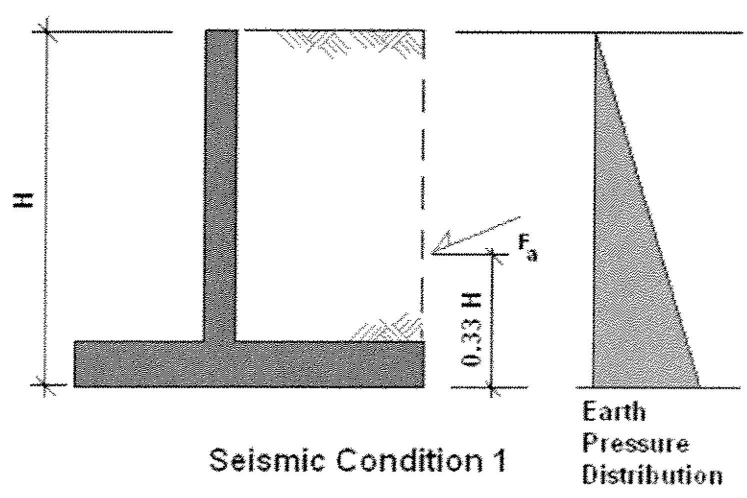


Figure 1

1.3.3 Compaction Equipment Load Case: This temporary load case consist of the following items:

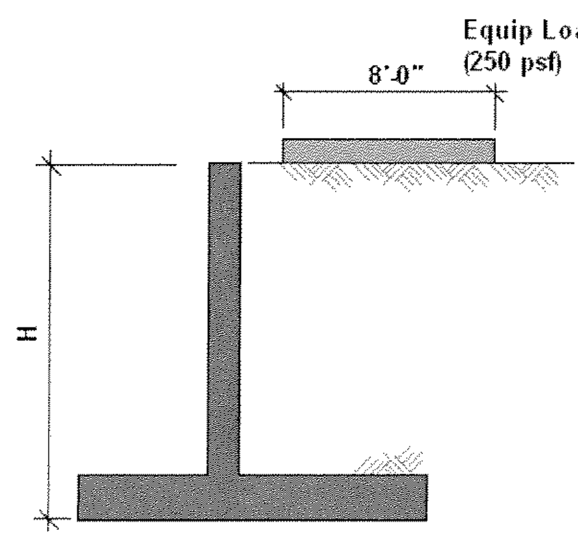
1.3.3.1 EFP of 46 pcf. This value was calculated using the average of the active (Ka) and the at-rest (Ko) lateral earth pressure coefficients. The actual lateral earth pressure is somewhere between the active and the at-rest cases. The wall is not free to translate (footing embedded in rock) but it is free to deflect so the active case cannot fully develop. Similarly, since the wall is free to deflect, it is not completely restrained, and therefore the at-rest condition cannot fully develop. Selecting the lateral earth pressure coefficient as the average of the two conditions is based on engineering judgment. (See Sheet 9 of Appendix B) Since this is a temporary condition a more conservative approximation of the EFP is not warranted.

1.3.3.2 A surcharge from compaction equipment was applied behind the wall. This consisted of a 2,000 pound load spread over an 8'-0" width. Or 250 psf over 8'-0" continuous along the length of the wall. See diagrams that are included with each wall design for this load case, and figure 2.

1.3.3.3 Allowable soil bearing condition is 5,000 psf. Actual rock capacity is higher.

1.3.3.4 There are no surcharge effects from the uphill MSE Walls. See appendix 'C' for details.

1.3.3.5 Stability ratio for overturning is a minimum of 2.0 to 1.0.



Compaction Equipment Load

Figure. 2

1.3.4 Seismic Condition 2: This upset condition consists of an earthquake event.

1.3.4.1 K_{AE} of 62 pcf was used with an inverse triangular distribution, with increasing pressure toward the bottom of the wall. See Figure 3 and sheets 15 to 17 of Appendix 'B' for details. Also see Appendix 'D' for a detailed discussion of the Mononobe-Okabe equations and their application.

1.3.4.2 Allowable soil bearing condition is 5,500 psf. Actual rock capacity is higher.

1.3.4.3 There are no surcharge effects from the uphill MSE Walls. See appendix 'C' for details.

1.3.4.4 Stability ratio for overturning is a minimum of 1.5 to 1.0.

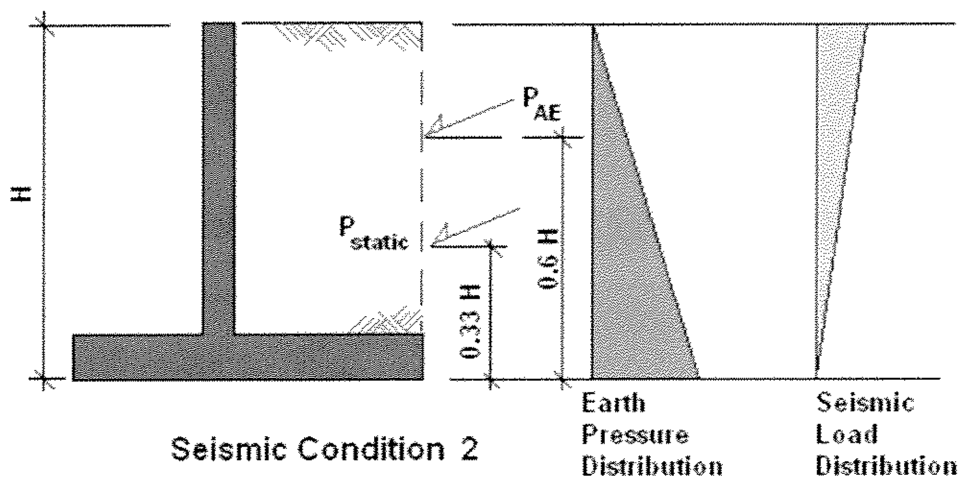


Figure 3

1.4 **Sliding Resistance**: The calculations for the sliding resistance of the retaining walls are based upon a friction between the base and the supporting rock. In general the results show a factor of less that 1.5 to 1. However in order for the base to move it would require the rock to shear, or the key in the footing to shear off. In addition the foundations will be dowel to the rock using 2-#7 bars at 4'-0" centers. This would give an additional shear capacity of 10,000 lbs. Per foot of wall, using a safety factor of 2.70. With this in mind and the high capacity of the rock to sustain loads sliding resistance is not an issue.

WALL MK. 'A'

Loading Case	Overturning Ratio	Sliding Ratio	Maximum Soil Bearing Pressure	Controlling Case for Strength Design	Remarks
Normal	3.65	2.12	980		
Seismic 1	3.00	1.74	1150		
Compaction Equipment	3.0	1.75	1230	+	
Seismic 2	2.6	1.56	870		

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	5.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	9.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	51.0 psf/ft
Toe Active Pressure	=	51.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	1.25 ft
Heel Width	=	2.75
Total Footing Width	=	4.00
Footing Thickness	=	15.00 in
Key Width	=	0.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	0.00 ft

f'c = 3,000 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top = 2.00 in @ Btm.= 3.00 in

Surcharge Loads

Surcharge Over Heel = 0.0 psf
Used To Resist Sliding & Overturning
Surcharge Over Toe = 0.0 psf
Used for Sliding & Overturning

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	3.65 OK
Sliding	=	2.11 OK
Total Bearing Load	=	2,972 lbs
...resultant ecc.	=	2.53 in
Soil Pressure @ Toe	=	978 psf OK
Soil Pressure @ Heel	=	508 psf OK
Allowable	=	4,000 psf

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	1,084 psf
ACI Factored @ Heel	=	562 psf
Footing Shear @ Toe	=	1.4 psi OK
Footing Shear @ Heel	=	6.5 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	894.1 lbs
less 100% Passive Force	= -	108.0 lbs
less 100% Friction Force	= -	1,782.8 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	0.0 lbs OK

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem
		Stem OK
Design Height Above Ftg	ft =	0.00
Wall Material Above "Ht"	=	Concrete
Thickness	=	10.00
Rebar Size	=	# 5
Rebar Spacing	=	12.00
Rebar Placed at	=	Edge
Design Data		
fb/FB + fa/Fa	=	**0.169**
Total Force @ Section	lbs =	997.1
Moment....Actual	ft-# =	1,694.3
Moment.....Allowable	=	10,037.3
Shear.....Actual	psi =	11.1
Shear.....Allowable	psi =	82.2
Wall Weight	=	125.0
Rebar Depth 'd'	in =	7.50
LAP SPLICE IF ABOVE	in =	21.36
LAP SPLICE IF BELOW	in =	
HOOK EMBED INTO FTG	in =	9.59
Masonry Data		
f'm	psi =	
Fs	psi =	
Solid Grouting	=	
Special Inspection	=	
Modular Ratio 'n'	=	
Short Term Factor	=	
Equiv. Solid Thick.	=	
Masonry Block Type = Medium Weight		
Concrete Data		
f'c	psi =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	1,084	562 psf
Mu' : Upward	=	804	1,185 ft-#
Mu' : Downward	=	267	2,548 ft-#
Mu: Design	=	537	1,362 ft-#
Actual 1-Way Shear	=	1.44	6.50 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 5 @ 12.00 in	
Heel Reinforcing	=	# 5 @ 12.00 in	
Key Reinforcing	=	None Spec'd	

Other Acceptable Sizes & Spacings

Toe: Not req'd, Mu < S * Fr
Heel: Not req'd, Mu < S * Fr
Key: No key defined

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	996.1	2.08	2,075.2
Toe Active Pressure	=	-102.0	0.67	-68.0
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	894.1	**O.T.M.** =	2,007.2

Resisting/Overturning Ratio = **3.65**

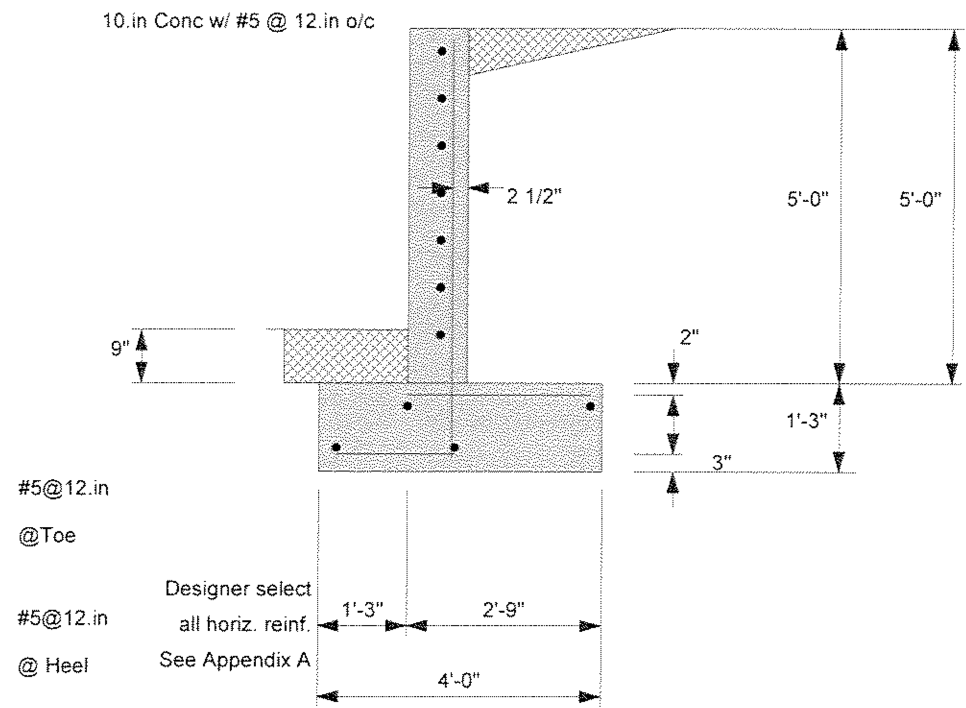
Vertical Loads used for Soil Pressure = 2,971.6 lbs

Vertical component of active pressure used for soil pressure

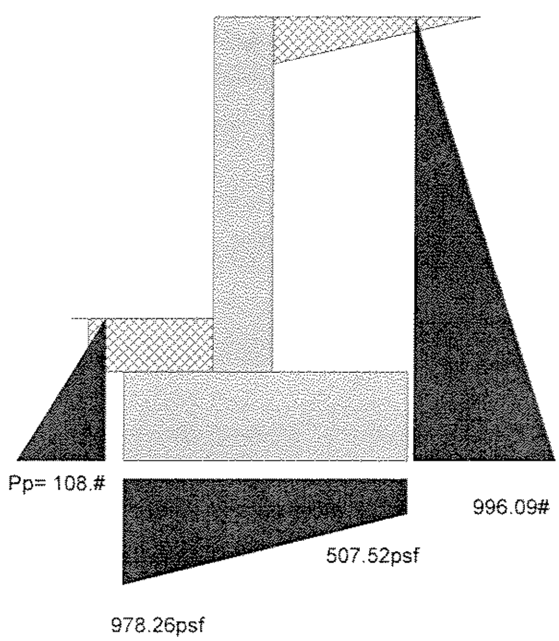
.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	1,245.8	3.04	3,789.4
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	121.9	0.63	76.2
Surcharge Over Toe	=			
Stem Weight(s)	=	625.0	1.67	1,041.7
Earth @ Stem Transitions	=			
Footing Weight	=	750.0	2.00	1,500.0
Key Weight	=			
Vert. Component	=	228.9	4.00	915.4
Total =		2,971.6 lbs	**R.M.=**	7,322.7

DESIGNER NOTES:



10.in Conc w/ #5 @ 12.in o/c
2 1/2"
5'-0"
5'-0"
9"
2"
1'-3"
3"
#5@12.in
@Toe
Designer select
all horiz. reinf.
See Appendix A
#5@12.in
@ Heel
1'-3"
2'-9"
4'-0"



Pp= 108.#
996.09#
507.52psf
978.26psf

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	5.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	9.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	62.0 psf/ft
Toe Active Pressure	=	62.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	1.25 ft
Heel Width	=	2.75
Total Footing Width	=	4.00
Footing Thickness	=	15.00 in
Key Width	=	0.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	0.00 ft
f'c = 3,000 psi	Fy =	60,000 psi
Footing Concrete Density	=	150.00 pcf
Min. As %	=	0.0018
Cover @ Top = 2.00 in	@ Btm.=	3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.99 OK
Sliding	=	1.74 OK
Total Bearing Load	=	2,964 lbs
...resultant ecc.	=	4.35 in
Soil Pressure @ Toe	=	1,144 psf OK
Soil Pressure @ Heel	=	338 psf OK
Allowable	=	4,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	1,270 psf
ACI Factored @ Heel	=	375 psf
Footing Shear @ Toe	=	1.9 psi OK
Footing Shear @ Heel	=	7.7 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	1,086.9 lbs
less 100% Passive Force	= -	108.0 lbs
less 100% Friction Force	= -	1,782.8 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	0.0 lbs OK

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.400
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem
		Stem OK
Design Height Above Ftg	ft =	0.00
Wall Material Above "Ht"	=	Concrete
Thickness	=	10.00
Rebar Size	=	# 5
Rebar Spacing	=	12.00
Rebar Placed at	=	Edge
Design Data		
fb/FB + fa/Fa	=	**0.180**
Total Force @ Section	lbs =	1,060.6
Moment....Actual	ft-# =	1,802.2
Moment.....Allowable	=	10,037.3
Shear.....Actual	psi =	11.8
Shear.....Allowable	psi =	82.2
Wall Weight	=	125.0
Rebar Depth 'd'	in =	7.50
LAP SPLICE IF ABOVE	in =	21.36
LAP SPLICE IF BELOW	in =	
HOOK EMBED INTO FTG	in =	9.59
Masonry Data		
f'm	psi =	
Fs	psi =	
Solid Grouting	=	
Special Inspection	=	
Modular Ratio 'n'	=	
Short Term Factor	=	
Equiv. Solid Thick.	=	
Masonry Block Type = Medium Weight		
Concrete Data		
f'c	psi =	3,000.0
Fy	psi =	60,000.0

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall 'A' H = 5' Seismic
Job # : E-05129 Dsgnr: JJF
Page: ______
Date: MAY 24,2005
Description....
Low Wall "A" Height H= 5'-0" Seismic load EFP = 62

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

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www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	1,270	375 psf
Mu' : Upward	=	920	952 ft-#
Mu' : Downward	=	267	2,526 ft-#
Mu: Design	=	652	1,574 ft-#
Actual 1-Way Shear	=	1.85	7.67 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 5 @ 12.00 in	
Heel Reinforcing	=	# 5 @ 12.00 in	
Key Reinforcing	=	None Spec'd	

Other Acceptable Sizes & Spacings
Toe: Not req'd, Mu < S * Fr
Heel: Not req'd, Mu < S * Fr
Key: No key defined

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	1,210.9	2.08	2,522.8
Toe Active Pressure	=	-124.0	0.67	-82.7
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	1,086.9	**O.T.M.** =	2,440.1

Resisting/Overturning Ratio = **2.99**

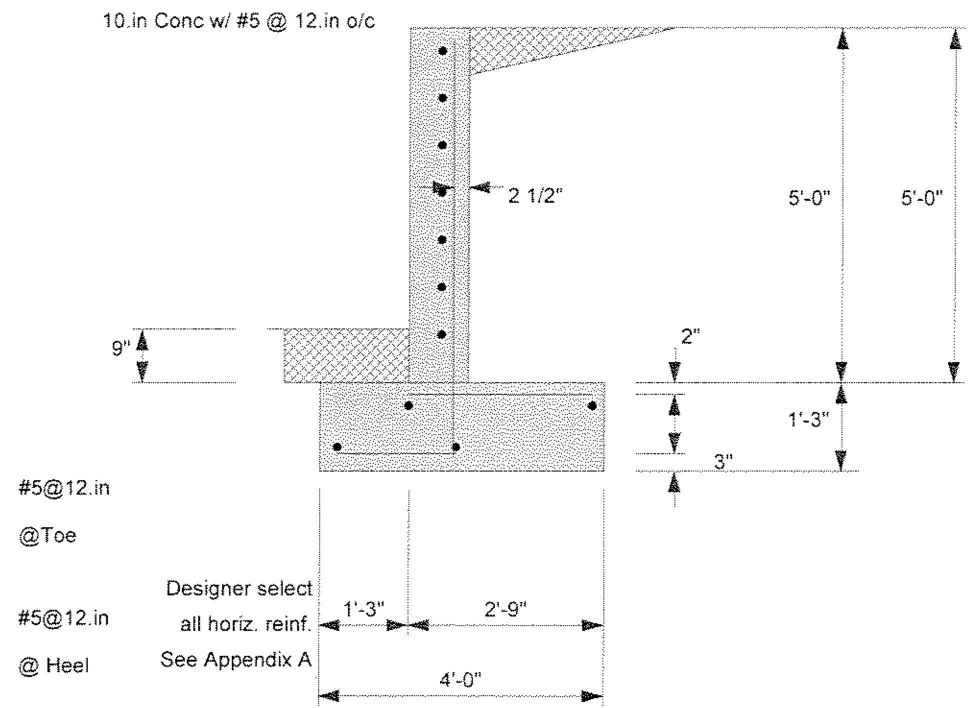
Vertical Loads used for Soil Pressure = 2,964.3 lbs

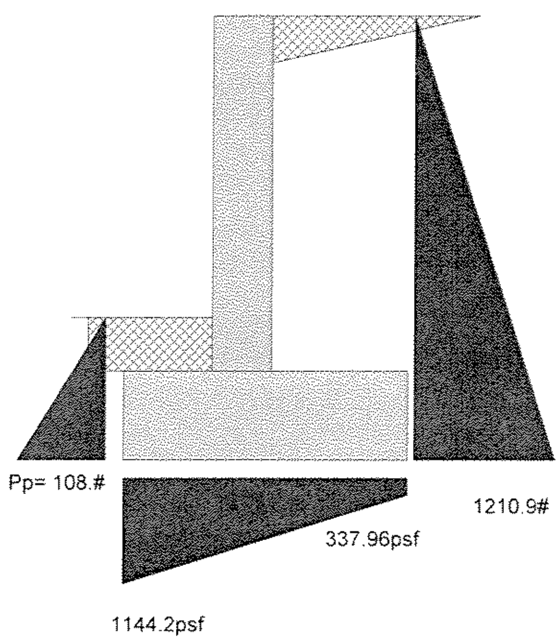
Vertical component of active pressure used for soil pressure

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	1,245.8	3.04	3,789.4
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	121.9	0.63	76.2
Surcharge Over Toe	=			
Stem Weight(s)	=	625.0	1.67	1,041.7
Earth @ Stem Transitions	=			
Footing Weight	=	750.0	2.00	1,500.0
Key Weight	=			
Vert. Component	=	221.6	4.00	886.6
Total =		2,964.3 lbs	**R.M.=**	7,293.8

DESIGNER NOTES:


10.in Conc w/ #5 @ 12.in o/c
2 1/2"
5'-0"
5'-0"
9"
2"
1'-3"
3"
#5@12.in
@Toe
Designer select
all horiz. reinf.
See Appendix A
#5@12.in
@ Heel
1'-3"
2'-9"
4'-0"


Pp= 108.#
1210.9#
337.96psf
1144.2psf

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall 'A' H= 5' Equiplent Load
Job # : E-05129 Dsgnr: JJF
Page: ______
Date: MAY 25,2005
Description....
Wall "A" Height (H) = 5'-0" Equipment Load with EFP =

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

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www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	5.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	9.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	5,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	46.0 psf/ft
Toe Active Pressure	=	46.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	1.25 ft
Heel Width	=	2.75
Total Footing Width	=	4.00
Footing Thickness	=	15.00 in
Key Width	=	0.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	0.00 ft

f'c = 3,000 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top = 2.00 in @ Btm.= 3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	2,000.0 lbs
Footing Width	=	8.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	4.00 ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.97 OK
Sliding	=	1.75 OK
Total Bearing Load	=	3,297 lbs
...resultant ecc.	=	3.94 in
Soil Pressure @ Toe	=	1,231 psf OK
Soil Pressure @ Heel	=	418 psf OK
Allowable	=	5,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	1,423 psf
ACI Factored @ Heel	=	484 psf
Footing Shear @ Toe	=	2.1 psi OK
Footing Shear @ Heel	=	6.2 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	1,203.1 lbs
less 100% Passive Force	= -	108.0 lbs
less 100% Friction Force	= -	1,994.8 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	0.0 lbs OK

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem
		Stem OK
Design Height Above Ftg	ft =	0.00
Wall Material Above "Ht"	=	Concrete
Thickness	=	10.00
Rebar Size	=	# 5
Rebar Spacing	=	12.00
Rebar Placed at	=	Edge
Design Data		
fb/FB + fa/Fa	=	**0.241**
Total Force @ Section	lbs =	1,376.0
Moment....Actual	ft-# =	2,415.9
Moment.....Allowable	=	10,037.3
Shear.....Actual	psi =	15.3
Shear.....Allowable	psi =	82.2
Wall Weight	=	125.0
Rebar Depth 'd'	in =	7.50
LAP SPLICE IF ABOVE	in =	21.36
LAP SPLICE IF BELOW	in =	
HOOK EMBED INTO FTG	in =	9.59
Masonry Data		
f'm	psi =	
Fs	psi =	
Solid Grouting	=	
Special Inspection	=	
Modular Ratio 'n'	=	
Short Term Factor	=	
Equiv. Solid Thick.	=	
Masonry Block Type = Medium Weight		
Concrete Data		
f'c	psi =	3,000.0
Fy	psi =	60,000.0

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	1,423	484 psf
Mu' : Upward	=	1,035	1,164 ft-#
Mu' : Downward	=	267	2,546 ft-#
Mu: Design	=	768	1,382 ft-#
Actual 1-Way Shear	=	2.13	6.22 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 5 @ 12.00 in	
Heel Reinforcing	=	# 5 @ 12.00 in	
Key Reinforcing	=	None Spec'd	

Other Acceptable Sizes & Spacings
Toe: Not req'd, Mu < S * Fr
Heel: Not req'd, Mu < S * Fr
Key: No key defined

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	898.4	2.08	1,871.7
Toe Active Pressure	=	-92.0	0.67	-61.3
Surcharge Over Toe	=			
Adjacent Footing Load	=	396.7	2.50	991.0
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	1,203.1	O.T.M. =	2,801.4

Resisting/Overturning Ratio = 2.97

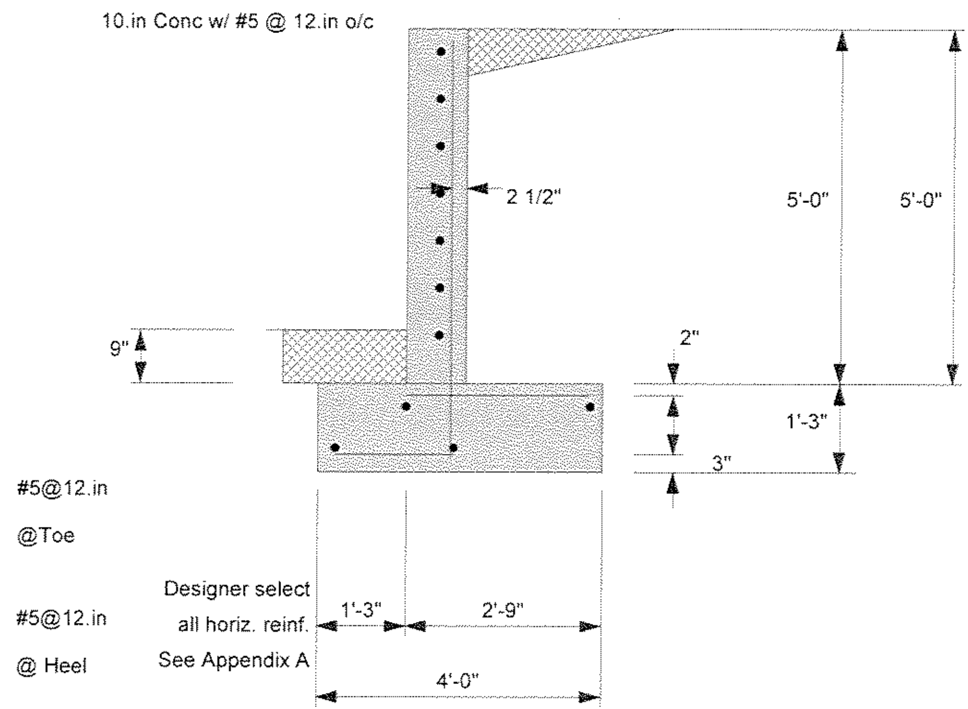
Vertical Loads used for Soil Pressure = 3,297.2 lbs

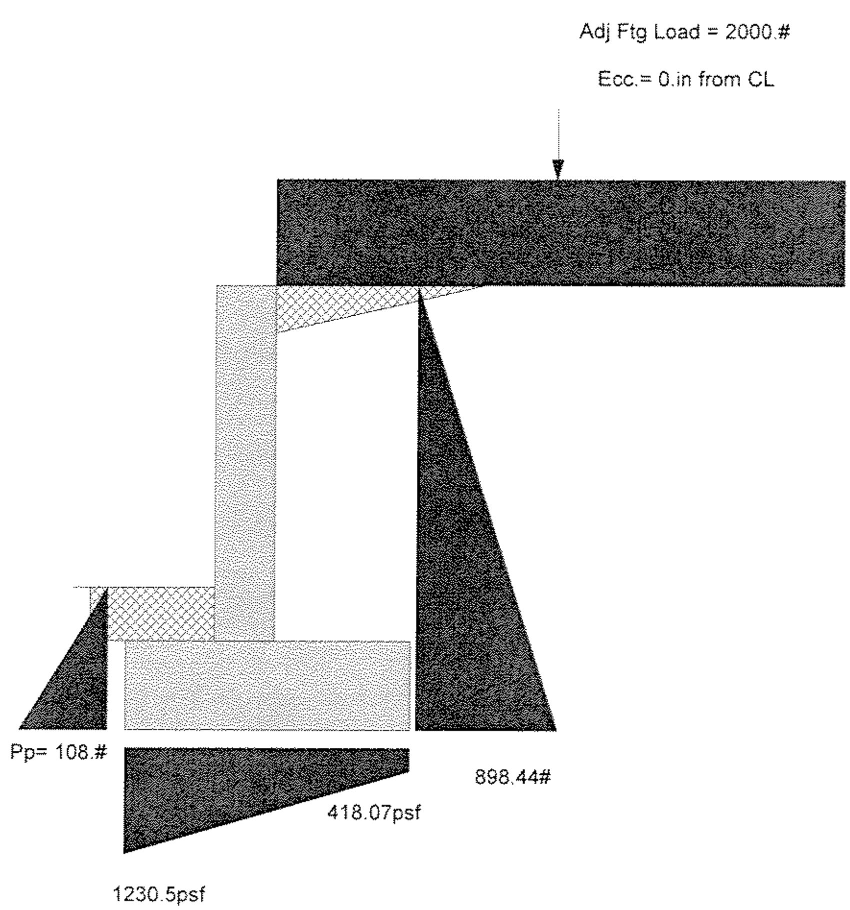
Vertical component of active pressure used for soil pressure

.....RESISTING.....

Item		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	1,245.8	3.04	3,789.4
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=	326.2	3.04	992.3
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	121.9	0.63	76.2
Surcharge Over Toe	=			
Stem Weight(s)	=	625.0	1.67	1,041.7
Earth @ Stem Transitions	=			
Footing Weight	=	750.0	2.00	1,500.0
Key Weight	=			
Vert. Component	=	228.2	4.00	912.9
Total	=	3,297.2 lbs	**R.M.=**	8,312.5

DESIGNER NOTES:


10.in Conc w/ #5 @ 12.in o/c
2 1/2"
5'-0"
5'-0"
9"
2"
1'-3"
3"
#5@12.in
@Toe
Designer select
all horiz. reinf.
See Appendix A
#5@12.in
@ Heel
1'-3"
2'-9"
4'-0"


Adj Ftg Load = 2000.#
Ecc.= 0.in from CL
Pp= 108.#
898.44#
418.07psf
1230.5psf

WALL Mark 'A' Seismic Loads

Definitions:

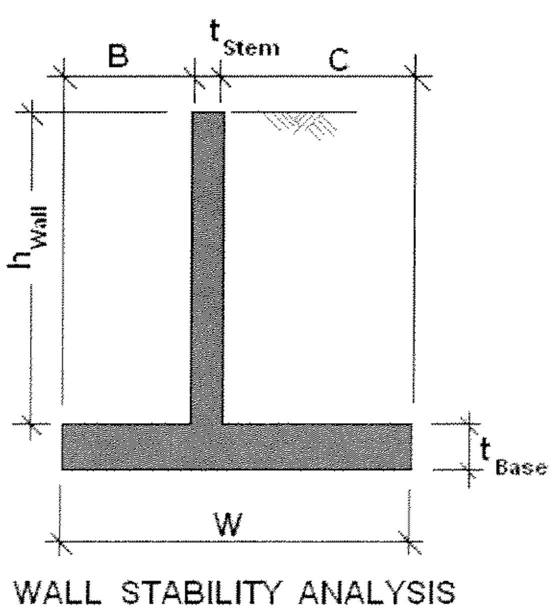
B = Width of Toe (feet)
C = Width of Heel (feet)
W = Width of Base (feet)
h wall = Height of Wall over base (feet)
t_{base} = thickness of Base (feet)
t_{stem} = Thickness of Stem (feet)
γ = density of backfill (pcf)
$\gamma_{concrete}$ density = 150 pcf
EFP_{static} = Design equivalent fluid pressure (pcf), static condition.
EFP_{AE} = Design equivalent fluid pressure (pcf), Active Earth pressure under seismic conditions..
ϕ = Internial angle of friction of the soil.
δ = Friction angle of soil to concrete wall.
K_h = Alternate seismic force developed from the Geotechnical Calculations page 12 in Appendix 'B'

Wall Mk. 'A' Data:

$B := 1.25$ (feet) $h_{wall} := 5.0$ (feet) $t_{stem} := 0.83$ (feet)

$C := 1.92$ (feet) $W := 4.00$ (feet) $t_{base} := 1.25$ (feet)

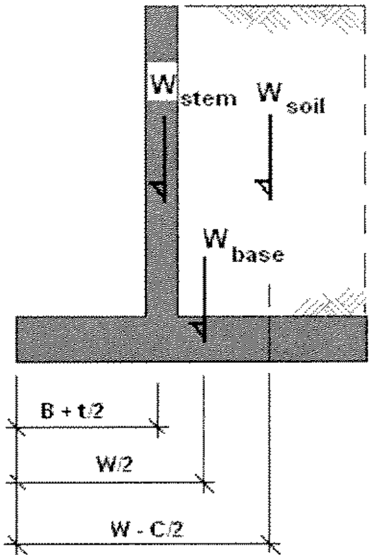
Soil Data: $\gamma := 130$ (pcf) $\delta := 22 \cdot deg$ $\phi := 32 \cdot deg$



$EFP_{static} := 46$ (pcf)

$EFP_{AE} := 62$ (pcf)

$K_h := 0.09$



Stabilizing Forces

Weights: (kips.per foot)

$W_{stem} := (0.150) \cdot h_{wall} \cdot t_{stem}$ $W_{stem} = 0.622$

$W_{base} := (0.150) \cdot W \cdot t_{base}$ $W_{base} = 0.75$

$W_{soil} := \dfrac{\gamma \cdot h_{wall} \cdot C}{1000}$ $W_{soil} = 1.248$

$H := h_{wall} + t_{base}$ $H = 6.25$ (feet)

Driving Forces:

$P_{ST} := \dfrac{(EFP_{static}) \cdot \frac{1}{2} \cdot (H)^2}{1000}$ $P_{ST} = 0.898$ (kips)

$P_{SE} := \dfrac{(EFP_{AE}) \cdot \frac{1}{2} \cdot (H)^2}{1000}$ $P_{SE} = 1.211$ (kips)

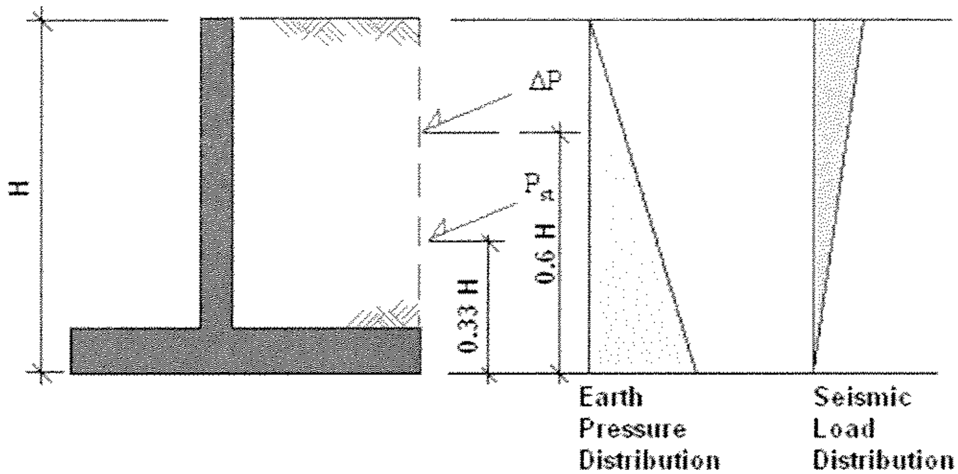
$\Delta P_1 := P_{SE} - P_{ST}$ $\Delta P_1 = 0.313$ (kips)

$\Delta P_2 := \dfrac{K_h \cdot \gamma \cdot (H)^2}{1000}$ $\Delta P_2 = 0.457$ (kips)

The larger value of either ΔP_1 or ΔP_2 is to be used in the seismic analysis

Let: $\Delta := \begin{pmatrix} \Delta P_1 \\ \Delta P_2 \end{pmatrix}$ $\Delta P := \max(\Delta)$ $\Delta P = 0.457$ (kips)

Driving Forces and Moments about the Toe:



Horizontal Driving Force (**HDF**) is the sum of P_{st} and ΔP in the horizontal direction:

$HDF := (P_{ST} + \Delta P) \cdot \cos(\delta)$ $\quad$ $HDF = 1.257$ $\quad$ (kips)

Driving Moment (**M_d**) is the sum of the driving moments about the Toe.

$M_d := (P_{ST} \cdot 0.333 \cdot H) \cdot \cos(\delta) + (\Delta P \cdot 0.6 \cdot H) \cdot \cos(\delta)$ $\quad$ $M_d = 3.323$ $\quad$ (ft-kips)

Resisting Forces and Moments about the Toe:

Resisting Forces (**RF**) neglecting passive pressure, a conservative analysis:

$RF := \tan(\phi)(W_{stem} + W_{base} + W_{soil} + P_{ST} \cdot \sin(\delta) + \Delta P \cdot \sin(\delta))$

$RF = 1.955$ $\quad$ (kips)

"Factor of Safety" against sliding is the ratio of **RF** to **HDF**

$Ratio_{sliding} := \frac{RF}{HDF}$ $\quad$ $Ratio_{sliding} = 1.555$

Resisting Moments about the Toe M_r :

$$M_r := W_{stem} \cdot (B + t_{stem}) + W_{base} \cdot \left(\frac{W}{2}\right) + W_{soil} \cdot \left(W - \frac{C}{2}\right) + (P_{ST} + \Delta P) \cdot W \cdot \sin(\delta)$$

$M_r = 8.62$ (ft-kips)

"Factor of Safety" against overturning the ratio of $\mathbf{M_r}$ to $\mathbf{M_d}$

$Ratio_{OT} := \frac{M_r}{M_d}$ $Ratio_{OT} = 2.594$

Calculate Soil Bearing Pressurs:

Net Moment: $\Delta M := M_r - M_d$ $\Delta M = 5.297$ (ft-kips)

$$X := \frac{\Delta M}{(W_{stem} + W_{base} + W_{soil} + P_{ST} \cdot \sin(\delta) + \Delta P \cdot \sin(\delta))}$$ $X = 1.693$ (feet)

$R := (W_{stem} + W_{base} + W_{soil} + P_{ST} \cdot \sin(\delta) + \Delta P \cdot \sin(\delta))$ $R = 3.128$ (kips)

Eccentricity (e): $e := \frac{W}{2} - X$ $e = 0.307$ (feet) $\frac{W}{6} = 0.667$ (feet)

Eccentricity := | "OK Within Middle Third" if $e \le \frac{W}{6}$
| "Non in Middle one-third" otherwise

Eccentricity = "OK Within Middle Third"

$SP_2 := \frac{R}{W} \cdot \left(1 + \frac{e}{W}\right)$ $SP_2 = 0.842$ Maximum Soil Pearing Pressure (kips/ft²)

$SP_1 := \frac{R}{W} \cdot \left(1 - \frac{e}{W}\right)$ $SP_1 = 0.722$ Minimum Soil Pearing Pressure (kips/ft²)

Concrete Design:

The design on the concrete elements will be in accordance with ACI 318-02.

See Section 9.2 of ACI 319-02

$U_{DL} := 1.2 \qquad U_H := 1.6 \qquad U_E := 1.0$

$$R_{ult} := \left(U_{DL} \cdot W_{stem} + U_{DL} \cdot W_{base} + U_E \cdot W_{soil} + U_E \cdot P_{ST} \cdot \sin(\delta) + U_E \cdot \Delta P \cdot \sin(\delta)\right)$$

$$M_{d\_ult} := U_E \cdot \left[\left(P_{ST} \cdot 0.333 \cdot H\right) \cdot \cos(\delta) + \left(\Delta P \cdot 0.6 \cdot H\right) \cdot \cos(\delta)\right]$$

$$M_{r\_ult\_1} := U_{DL} \cdot W_{stem} \cdot \left(B + t_{stem}\right) + U_{DL} \cdot W_{base} \cdot \left(\frac{W}{2}\right) + U_{DL} \cdot W_{soil} \cdot \left(W - \frac{C}{2}\right)$$

$$M_{r\_ult\_2} := U_{DL} \cdot \left[\left(P_{ST} + \Delta P\right) \cdot W \cdot \sin(\delta)\right]$$

$$M_{r\_ult} := M_{r\_ult\_1} + M_{r\_ult\_2}$$

Net Ultimate Moment: $\Delta M_{ult} := M_{r\_ult} - M_{d\_ult} \qquad \Delta M_{ult} = 7.021$ (ft-kips)

$X_{ult} := \frac{\Delta M_{ult}}{\left(R_{ult}\right)} \qquad X_{ult} = 2.063$ (feet)

$R_{ult} = 3.403$ (kips)

Eccentricity (e): $e_{ult} := \frac{W}{2} - X_{ult} \qquad e_{ult} = -0.063$ (feet) $\qquad \frac{W}{6} = 0.667$ (feet)

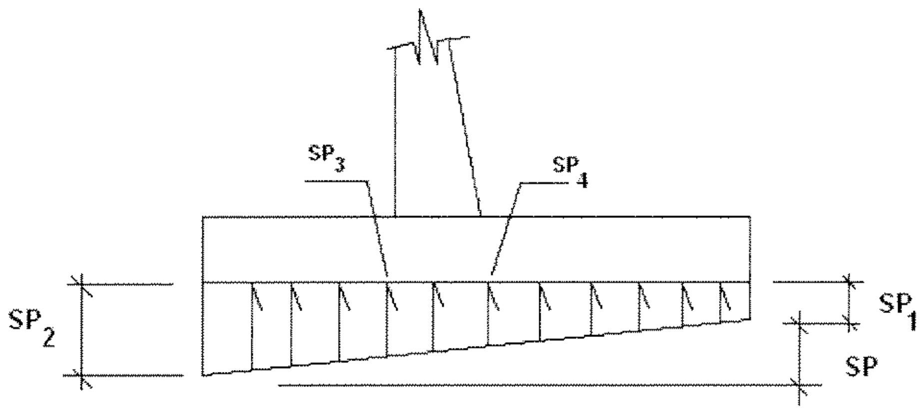
Eccentricity := | "OK Within Middle Third" if $e_{ult} \le \frac{W}{6}$
| "Non in Middle one-third" otherwise

Eccentricity = "OK Within Middle Third"

$SP_{2\_ult} := \frac{R_{ult}}{W} \cdot \left(1 + \frac{e_{ult}}{W}\right) \qquad SP_{2\_ult} = 0.837$ Maximum Soil Pearing Pressure (kips/ft²)

$SP_{1\_ult} := \frac{R_{ult}}{W} \cdot \left(1 - \frac{e_{ult}}{W}\right)$ $SP_{1\_ult} = 0.864$ Minimum Soil Pearing Pressure (kips/ft²)

$\Delta SP_{ult} := SP_{2\_ult} - SP_{1\_ult}$ $\Delta SP_{ult} = -0.027$ (kips/ft²)



Pressure Diagram - Toe & Heel

Soil Pressure at Front Face of Stem:

$SP_{3\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W} \cdot (B)$ $SP_{3\_ult} = 0.846$ (ksf)

Soil Pressure at Rear Face of Stem:

$SP_{4\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W} \cdot (B + t_{stem})$ $SP_{4\_ult} = 0.851$ (ksf)

Moment at Front Face of Stem:

$$M_{toe} := SP_{3\_ult} \cdot \frac{B^2}{2} + (SP_{2\_ult} - SP_{3\_ult}) \cdot \frac{(B)}{2} \cdot \left(\frac{2}{3}\right) \cdot B - U_{DL} \cdot (0.150) \cdot t_{base} \cdot \left(\frac{B^2}{2}\right)$$

$M_{toe} = 0.48$ (ft-kips)

Concrete Data:

$f'_c := 3$ ksi $\quad f_y := 60$ ksi $\quad M_u := M_{toe}$ ft-kips

$b := 12$ inches $\quad d := (12)\cdot t_{base} - 4 \quad d = 11$ inches $\quad \phi_f := 0.90$

A_s calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7\cdot f'_c\cdot b\cdot d}{2\cdot f_y} - \frac{1}{2}\cdot\sqrt{\frac{2.89\cdot(f'_c\cdot b\cdot d)^2}{(f_y)^2} - \frac{6.8\cdot f'_c\cdot b\cdot M_u\cdot 12}{\phi_f\cdot(f_y)^2}}$$

$A_{s\_required} = 9.715\times 10^{-3}$ Inches² $\quad \rho := \frac{A_{s\_required}}{12\cdot d} \quad \rho = 0.0001$

Shear in Toe:

Soil Pressure at d from front face:

$$SP_{31\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W}\cdot\left(B - \frac{d}{12}\right) \qquad SP_{31\_ult} = 0.839 \quad \text{(ksf)}$$

$$V_{toe} := SP_{31\_ult}\cdot\left(B - \frac{d}{12}\right) + (SP_{2\_ult} - SP_{31\_ult})\cdot\left(\frac{1}{2}\right)\cdot\left(B - \frac{d}{12}\right)$$

$V_{toe} = 0.279$ (kips/foot)

$$\phi V_n := \frac{0.75\cdot 12\cdot d\cdot(2)\cdot\sqrt{f'_c\cdot 1000}}{1000} \qquad \phi V_n = 10.845 \quad \text{(kips/foot)}$$

Moment at Rear Face of Stem in the Heel:

$$M_{heel} := SP_{1\_ult}\cdot\frac{C^2}{2} + (SP_{4\_ult} - SP_{1\_ult})\cdot\frac{(C)}{2}\cdot\left(\frac{1}{3}\right)\cdot C - U_{DL}\cdot(0.150)\cdot t_{base}\cdot\left(\frac{C^2}{2}\right)$$

$M_{heel} = 1.17$ (ft-kips) $\quad$ Let: $\quad M_u := M_{heel}$

$\mathbf{A_s}$ calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7 \cdot f'_c \cdot b \cdot d}{2 \cdot f_y} - \frac{1}{2} \cdot \sqrt{\frac{2.89 \cdot (f'_c \cdot b \cdot d)^2}{(f_y)^2} - \frac{6.8 \cdot f'_c \cdot b \cdot M_u \cdot 12}{\phi_f \cdot (f_y)^2}}$$

$A_{s\_required} = 0.024$ Inches² $\rho := \frac{A_{s\_required}}{12 \cdot d}$ $\rho = 0.0002$

Shear in Hell:

Soil Pressure at d from front rear face of stem:

$$SP_{41\_ult} := SP_{1\_ult} + \frac{\Delta SP_{ult}}{W} \cdot \left(C - \frac{d}{12}\right) \qquad SP_{41\_ult} = 0.857 \qquad \text{(ksf)}$$

$$V_{heel} := SP_{1\_ult} \cdot \left(C - \frac{d}{12}\right) + \left(SP_{41\_ult} - SP_{1\_ult}\right) \cdot \left(\frac{1}{2}\right) \cdot \left(C - \frac{d}{12}\right)$$

$V_{heel} = 0.864$ (kips/foot)

$$\phi V_n := \frac{0.75 \cdot 12 \cdot d \cdot (2) \cdot \sqrt{f'_c \cdot 1000}}{1000} \qquad \phi V_n = 10.845 \qquad \text{(kips/foot)}$$

Moments in Stem:

Driving Forces:

$$P_{ST} := \frac{(EFP_{static}) \cdot \frac{1}{2} \cdot (h_{wall})^2}{1000} \qquad P_{ST} = 0.575 \qquad \text{(kips)}$$

$$P_{SE} := \frac{(EFP_{AE}) \cdot \frac{1}{2} \cdot (h_{wall})^2}{1000} \qquad P_{SE} = 0.775 \qquad \text{(kips)}$$

$$\Delta P_1 := P_{SE} - P_{ST} \qquad \Delta P_1 = 0.2 \qquad \text{(kips)}$$

$\Delta P_2 := \dfrac{K_h \cdot \gamma \cdot (h_{wall})^2}{1000}$ $\Delta P_2 = 0.292$ (kips)

The larger value of either ΔP_1 or ΔP_2 is to be used in the seismic analysis

Let: $\Delta := \begin{pmatrix} \Delta P_1 \\ \Delta P_2 \end{pmatrix}$ $\Delta P := \max(\Delta)$ $\Delta P = 0.292$ (kips)

$M_{stem} := U_E \cdot \left[\left(P_{ST} \cdot \cos(\delta) \cdot 0.333 h_{wall} \right) + \left(\Delta P \cdot 0.600 \cdot h_{wall} \right) \right]$

$M_{stem} = 1.765$ (ft-kips) Let: $M_u := M_{stem}$ $d := 12 t_{stem} - 3.0$

$d = 6.96$ (inches)

$\mathbf{A_s}$ calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7 \cdot f'_c \cdot b \cdot d}{2 \cdot f_y} - \frac{1}{2} \cdot \sqrt{\frac{2.89 \cdot (f'_c \cdot b \cdot d)^2}{(f_y)^2} - \frac{6.8 \cdot f'_c \cdot b \cdot M_u \cdot 12}{\phi_f \cdot (f_y)^2}}$$

$A_{s\_required} = 0.057$ Inches² $\rho := \dfrac{A_{s\_required}}{12 \cdot d}$ $\rho = 0.0007$

WALL MK. 'B'

	Loading Case	Overturning Ratio	Sliding Ratio	Maximum Soil Bearing Pressure	Controlling Case for Strength Design	Remarks
.25	Normal	2.58	1.60	2160		
.28	Seismic 1	2.12	1.31	2600		
.37	Compaction Equipment	2.04	1.33	2800	✓	
	Seismic 2	1.89	1.30	1660		

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	10.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	51.0 psf/ft
Toe Active Pressure	=	51.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	2.00 ft
Heel Width	=	4.25
Total Footing Width	=	6.25
Footing Thickness	=	18.00 in
Key Width	=	12.00 in
Key Depth	=	18.00 in
Key Distance from Toe	=	2.00 ft

f'c = 3,000 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top = 2.00 in @ Btm.= 3.00 in

Surcharge Loads

Surcharge Over Heel = 0.0 psf
Used To Resist Sliding & Overturning
Surcharge Over Toe = 0.0 psf
NOT Used for Sliding & Overturning

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.58 OK
Sliding	=	1.59 OK
Total Bearing Load	=	8,261 lbs
...resultant ecc.	=	7.92 in
Soil Pressure @ Toe	=	2,160 psf OK
Soil Pressure @ Heel	=	484 psf OK
Allowable	=	4,000 psf

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	2,349 psf
ACI Factored @ Heel	=	526 psf
Footing Shear @ Toe	=	8.5 psi OK
Footing Shear @ Heel	=	21.2 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	3,270.4 lbs
less 100% Passive Force	= -	330.8 lbs
less 100% Friction Force	= -	4,866.1 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	0.0 lbs OK

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem	2nd
		Stem OK	Stem OK
Design Height Above Ftg	ft =	3.75	0.00
Wall Material Above "Ht"	=	Concrete	Concrete
Thickness	=	12.00	12.00
Rebar Size	=	# 5	# 7
Rebar Spacing	=	12.00	12.00
Rebar Placed at	=	Edge	Edge
Design Data			
fb/FB + fa/Fa	=	**0.259**	**0.565**
Total Force @ Section	lbs =	1,593.8	4,069.8
Moment....Actual	ft-# =	3,320.3	13,598.3
Moment.....Allowable	ft-# =	12,827.3	24,057.0
Shear.....Actual	psi =	14.0	35.7
Shear.....Allowable	psi =	82.2	82.2
Wall Weight	psf =	150.0	150.0
Rebar Depth 'd'	in =	9.50	9.50
LAP SPLICE IF ABOVE	in =	21.36	37.38
LAP SPLICE IF BELOW	in =	21.36	
HOOK EMBED INTO FTG	in =		13.42
Masonry Data			
f'm	psi =		
Fs	psi =		
Solid Grouting	=		
Special Inspection	=		
Modular Ratio 'n'	=		
Short Term Factor	=		
Equiv. Solid Thick.	=		
Masonry Block Type = Medium Weight			
Concrete Data			
f'c	psi =	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall "B" H = 10 Normal
Page: ______
Job # : E-05129 Dsgnr: JJF Date: MAY 24,2005
Description....
Wall 'B' Height (H) =10'-0" Normal Loads EFP = 51

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

Retain Pro 2005 , 7-April-2005, (c) 1989-2005
www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	2,349	526 psf
Mu' : Upward	=	4,308	4,447 ft-#
Mu' : Downward	=	696	13,694 ft-#
Mu: Design	=	3,612	9,247 ft-#
Actual 1-Way Shear	=	8.46	21.17 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 5 @ 9.00 in	
Heel Reinforcing	=	# 5 @ 12.00 in	
Key Reinforcing	=	# 5 @ 18.00 in	

Other Acceptable Sizes & Spacings
Toe: Not req'd, Mu < S * Fr
Heel: #4@ 7.25 in, #5@ 11.25 in, #6@ 16.00 in, #7@ 21.75 in, #8@ 28.50 in, #9@ 36
Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	3,372.4	3.83	12,927.4
Toe Active Pressure	=	-102.0	0.67	-68.0
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	3,270.4	O.T.M. =	12,859.4

Resisting/Overturning Ratio = 2.58

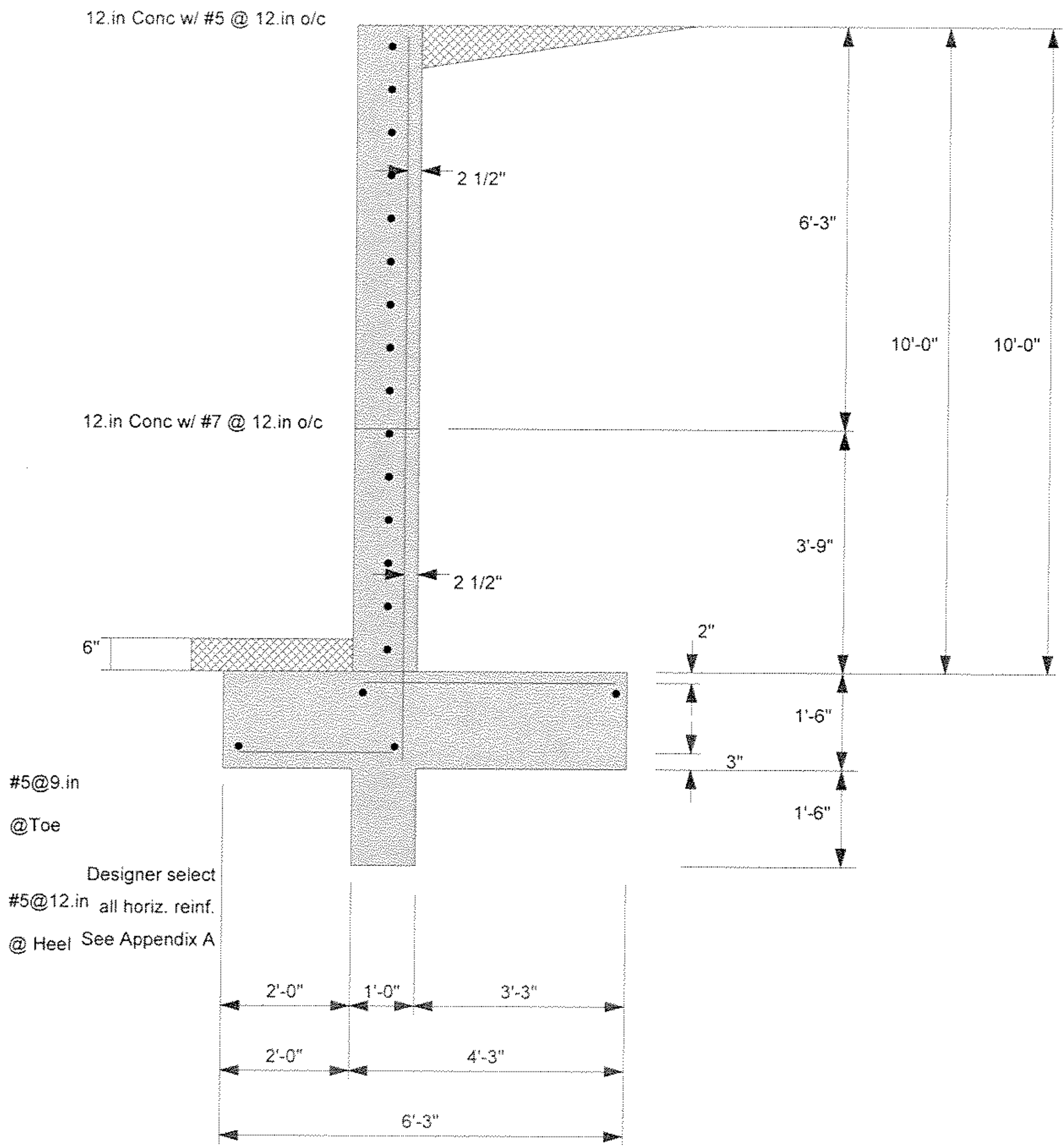
Vertical Loads used for Soil Pressure = 8,261.1 lbs

Vertical component of active pressure used for soil pressure

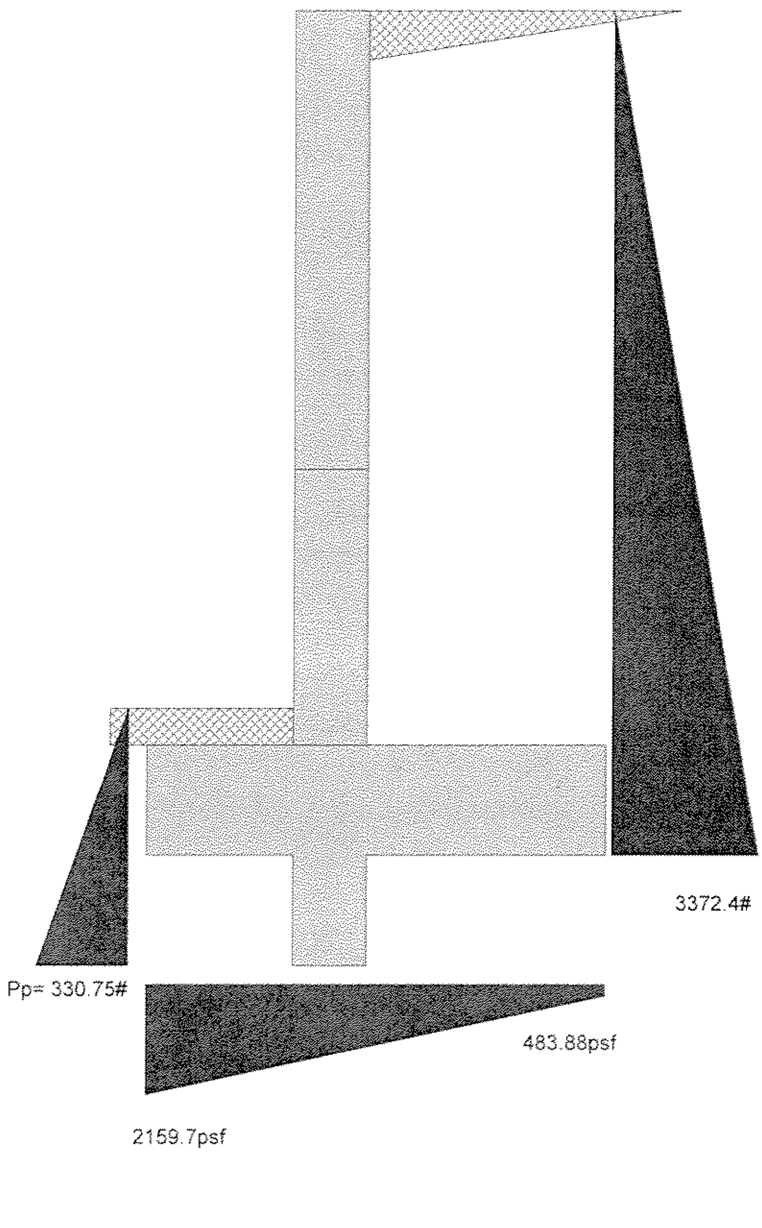
.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	4,225.0	4.63	19,540.6
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	130.0	1.00	130.0
Surcharge Over Toe	=			
Stem Weight(s)	=	1,500.0	2.50	3,750.0
Earth @ Stem Transitions	=			
Footing Weight	=	1,406.3	3.13	4,394.5
Key Weight	=	225.0	2.50	562.5
Vert. Component	=	774.8	6.25	4,842.6
Total =		8,261.1 lbs	R.M.=	33,220.2

DESIGNER NOTES:



12.in Conc w/ #5 @ 12.in o/c
2 1/2"
6'-3"
10'-0"
10'-0"
12.in Conc w/ #7 @ 12.in o/c
3'-9"
2 1/2"
2"
6"
1'-6"
3"
1'-6"
#5@9.in
@Toe
Designer select
all horiz. reinf.
See Appendix A
#5@12.in
@ Heel
2'-0"
1'-0"
3'-3"
2'-0"
4'-3"
6'-3"


3372.4#
Pp= 330.75#
483.88psf
2159.7psf

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	10.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	5,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	62.0 psf/ft
Toe Active Pressure	=	62.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	2.00 ft
Heel Width	=	4.25
Total Footing Width	=	6.25
Footing Thickness	=	18.00 in
Key Width	=	12.00 in
Key Depth	=	18.00 in
Key Distance from Toe	=	2.00 ft

f'c = 3,000 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top = 2.00 in @ Btm.= 3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.12 OK
Sliding	=	1.31 Ratio < 1.5!
Total Bearing Load	=	8,237 lbs
...resultant ecc.	=	12.10 in
Soil Pressure @ Toe	=	2,594 psf OK
Soil Pressure @ Heel	=	42 psf OK
Allowable	=	5,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	2,829 psf
ACI Factored @ Heel	=	46 psf
Footing Shear @ Toe	=	10.4 psi OK
Footing Shear @ Heel	=	25.0 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	3,975.8 lbs
less 100% Passive Force	= -	330.8 lbs
less 100% Friction Force	= -	4,866.1 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	766.8 lbs NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.400
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem	2nd
		Stem OK	Stem OK
Design Height Above Ftg	ft =	3.75	0.00
Wall Material Above "Ht"	=	Concrete	Concrete
Thickness	=	12.00	12.00
Rebar Size	=	# 5	# 7
Rebar Spacing	=	12.00	12.00
Rebar Placed at	=	Edge	Edge
Design Data			
fb/FB + fa/Fa	=	**0.275**	**0.601**
Total Force @ Section	lbs =	1,695.3	4,329.2
Moment....Actual	ft-# =	3,531.9	14,464.9
Moment.....Allowable	ft-# =	12,827.3	24,057.0
Shear.....Actual	psi =	14.9	38.0
Shear.....Allowable	psi =	82.2	82.2
Wall Weight	psf =	150.0	150.0
Rebar Depth 'd'	in =	9.50	9.50
LAP SPLICE IF ABOVE	in =	21.36	37.38
LAP SPLICE IF BELOW	in =	21.36	
HOOK EMBED INTO FTG	in =		13.42
Masonry Data			
f'm	psi =		
Fs	psi =		
Solid Grouting	=		
Special Inspection	=		
Modular Ratio 'n'	=		
Short Term Factor	=		
Equiv. Solid Thick.	=		
Masonry Block Type	=		
Concrete Data			
f'c	psi =	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	2,829	46 psf
Mu' : Upward	=	5,064	2,790 ft-#
Mu' : Downward	=	696	13,567 ft-#
Mu: Design	=	4,368	10,776 ft-#
Actual 1-Way Shear	=	10.43	24.98 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 5 @ 9.00 in	
Heel Reinforcing	=	# 5 @ 12.00 in	
Key Reinforcing	=	# 5 @ 18.00 in	

Other Acceptable Sizes & Spacings

Toe: Not req'd, Mu < S * Fr
Heel: #4@ 7.25 in, #5@ 11.25 in, #6@ 16.00 in, #7@ 21.75 in, #8@ 28.50 in, #9@ 36
Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	4,099.8	3.83	15,715.7
Toe Active Pressure	=	-124.0	0.67	-82.7
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	3,975.8	**O.T.M.** =	15,633.0

Resisting/Overturning Ratio = **2.12**

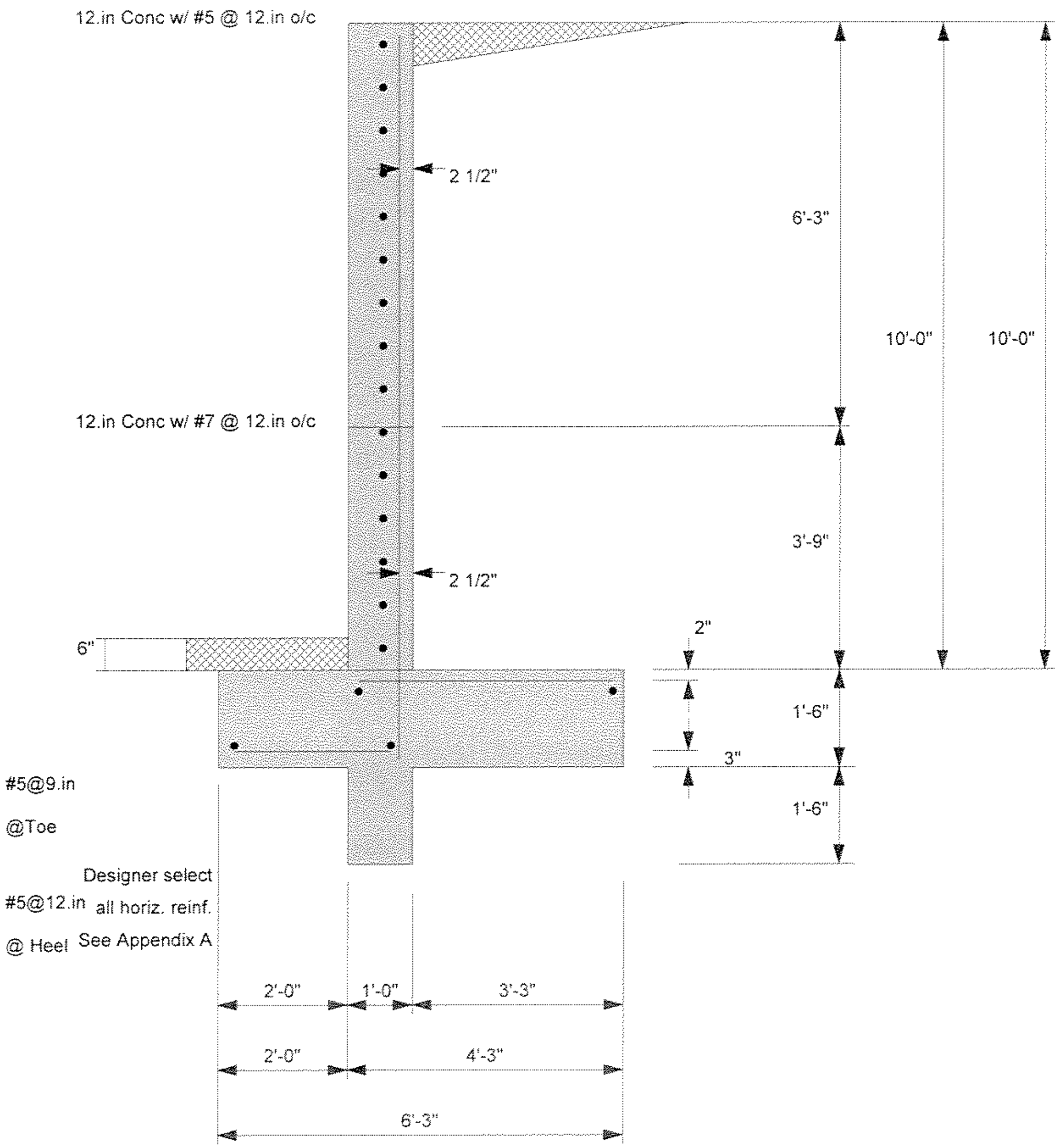
Vertical Loads used for Soil Pressure = 8,236.6 lbs

Vertical component of active pressure used for soil pressure

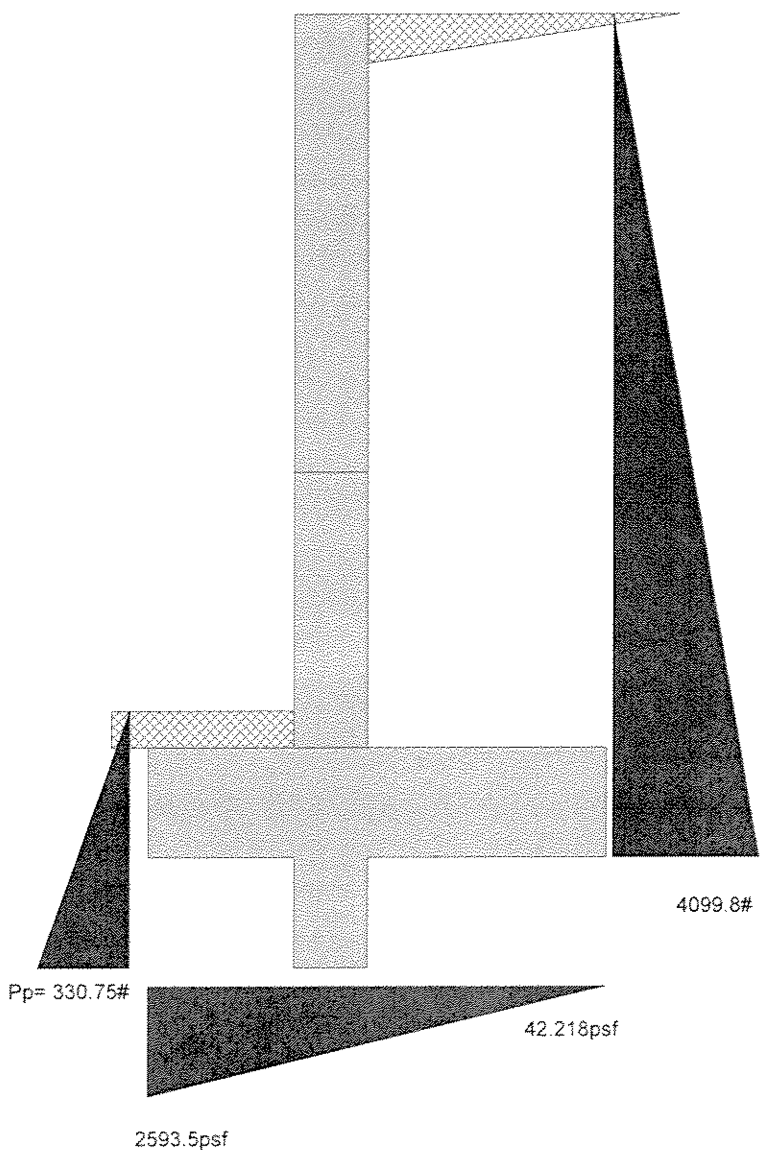
.....RESISTING.....

Item		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	4,225.0	4.63	19,540.6
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	130.0	1.00	130.0
Surcharge Over Toe	=			
Stem Weight(s)	=	1,500.0	2.50	3,750.0
Earth @ Stem Transitions	=			
Footing Weight	=	1,406.3	3.13	4,394.5
Key Weight	=	225.0	2.50	562.5
Vert. Component	=	750.4	6.25	4,689.9
	Total =	8,236.6 lbs	**R.M.=**	33,067.5

DESIGNER NOTES:



12.in Conc w/ #5 @ 12.in o/c
2 1/2"
6'-3"
10'-0"
10'-0"
12.in Conc w/ #7 @ 12.in o/c
3'-9"
2 1/2"
6"
2"
1'-6"
3"
1'-6"
#5@9.in
@Toe
Designer select
all horiz. reinf.
See Appendix A
#5@12.in
@ Heel
2'-0"
1'-0"
3'-3"
2'-0"
4'-3"
6'-3"


4099.8#
Pp= 330.75#
42.218psf
2593.5psf

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall 'B' H= 10' Equipment Load Page: ______
Job # : E-05129 Dsgnr: JJF Date: MAY 25,2005
Description....
Wall 'B' Height (H) = 10'-0" Equipment Load with EFP =

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

Retain Pro 2005 , 7-April-2005, (c) 1989-2005
www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	10.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	51.0 psf/ft
Toe Active Pressure	=	51.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	2.00 ft
Heel Width	=	4.25
Total Footing Width	=	6.25
Footing Thickness	=	18.00 in
Key Width	=	12.00 in
Key Depth	=	18.00 in
Key Distance from Toe	=	2.00 ft
f'c = 3,000 psi	Fy =	60,000 psi
Footing Concrete Density	=	150.00 pcf
Min. As %	=	0.0018
Cover @ Top = 2.00 in	@ Btm.=	3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
NOT Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	2,000.0 lbs
Footing Width	=	8.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	6.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.04 OK
Sliding	=	1.32 Ratio < 1.5!
Total Bearing Load	=	8,643 lbs
...resultant ecc.	=	12.69 in
Soil Pressure @ Toe	=	2,787 psf OK
Soil Pressure @ Heel	=	0 psf OK
Allowable	=	4,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	3,094 psf
ACI Factored @ Heel	=	0 psf
Footing Shear @ Toe	=	11.5 psi OK
Footing Shear @ Heel	=	24.9 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	4,110.0 lbs
less 100% Passive Force	= -	330.8 lbs
less 100% Friction Force	= -	5,114.6 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	719.7 lbs NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem Stem OK	2nd Stem OK
Design Height Above Ftg	ft =	3.75	0.00
Wall Material Above "Ht"	=	Concrete	Concrete
Thickness	=	12.00	12.00
Rebar Size	=	# 5	# 7
Rebar Spacing	=	12.00	12.00
Rebar Placed at	=	Edge	Edge
Design Data			
fb/FB + fa/Fa	=	**0.366**	**0.770**
Total Force @ Section	lbs =	2,256.3	5,260.5
Moment....Actual	ft-# =	4,695.3	18,512.2
Moment.....Allowable	ft-# =	12,827.3	24,057.0
Shear.....Actual	psi =	19.8	46.1
Shear.....Allowable	psi =	82.2	82.2
Wall Weight	psf =	150.0	150.0
Rebar Depth 'd'	in =	9.50	9.50
LAP SPLICE IF ABOVE	in =	21.36	37.38
LAP SPLICE IF BELOW	in =	21.36	
HOOK EMBED INTO FTG	in =		13.42
Masonry Data			
f'm	psi =		
Fs	psi =		
Solid Grouting	=		
Special Inspection	=		
Modular Ratio 'n'	=		
Short Term Factor	=		
Equiv. Solid Thick.	=		
Masonry Block Type	=		
Concrete Data			
f'c	psi =	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall 'B' H= 10' Equipment Load Page: ______
Job # : E-05129 Dsgnr: JJF Date: MAY 25,2005
Description....
Wall 'B' Height (H) = 10'-0" Equipment Load with EFP =

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

Retain Pro 2005 , 7-April-2005, (c) 1989-2005
www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	3,094	0 psf
Mu' : Upward	=	5,524	2,729 ft-#
Mu' : Downward	=	696	13,694 ft-#
Mu: Design	=	4,828	10,964 ft-#
Actual 1-Way Shear	=	11.48	24.89 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 7 @ 12.00 in	
Heel Reinforcing	=	# 5 @ 12.00 in	
Key Reinforcing	=	# 5 @ 18.00 in	

Other Acceptable Sizes & Spacings
Toe: Not req'd, Mu < S * Fr
Heel: #4@ 7.25 in, #5@ 11.25 in, #6@ 16.00 in, #7@ 21.75 in, #8@ 28.50 in, #9@ 36
Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	3,372.4	3.83	12,927.4
Toe Active Pressure	=	-102.0	0.67	-68.0
Surcharge Over Toe	=			
Adjacent Footing Load	=	839.6	5.08	4,261.4
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	4,110.0	**O.T.M.** =	17,120.8

Resisting/Overturning Ratio = **2.04**

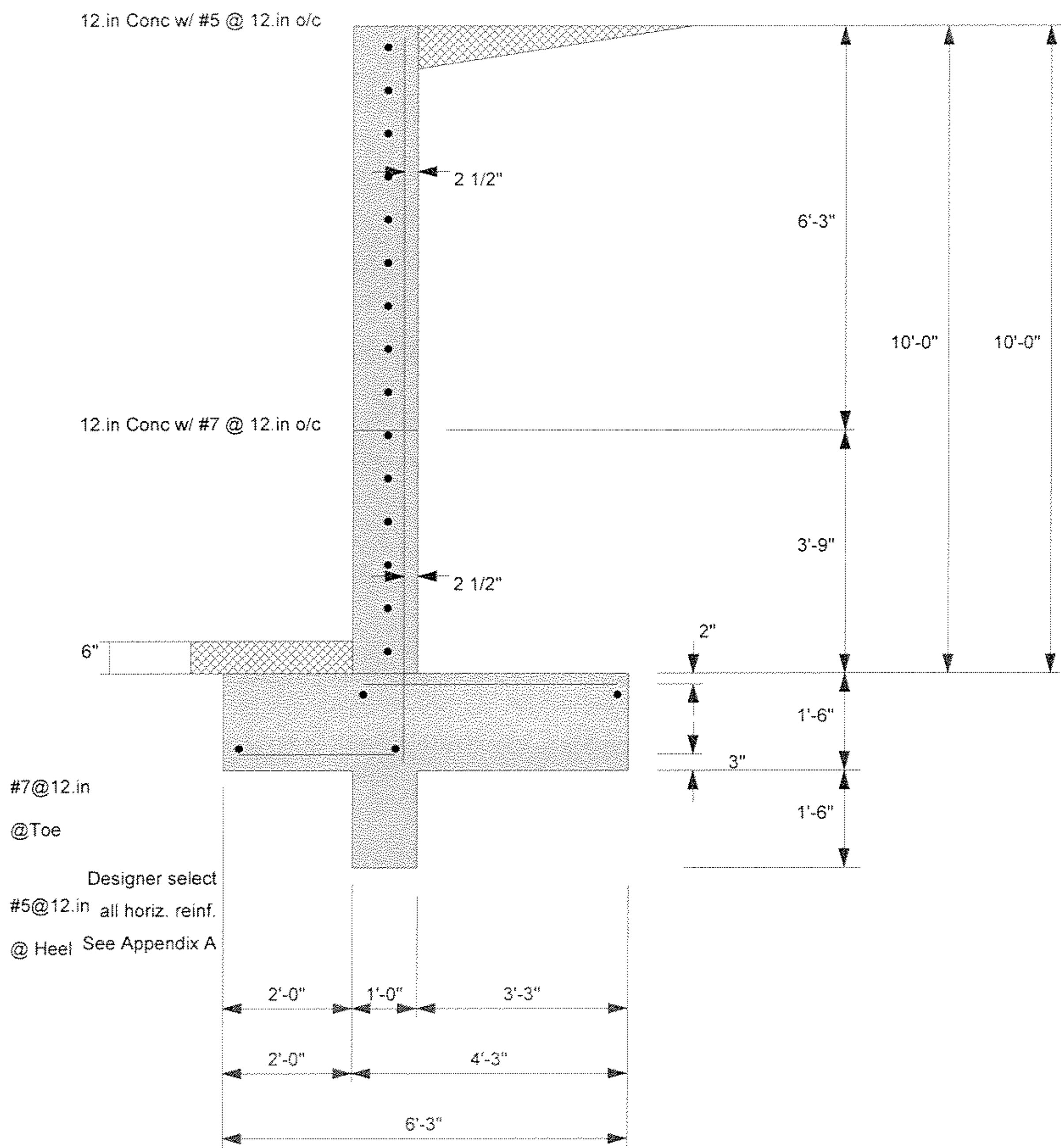
Vertical Loads used for Soil Pressure = 8,643.4 lbs

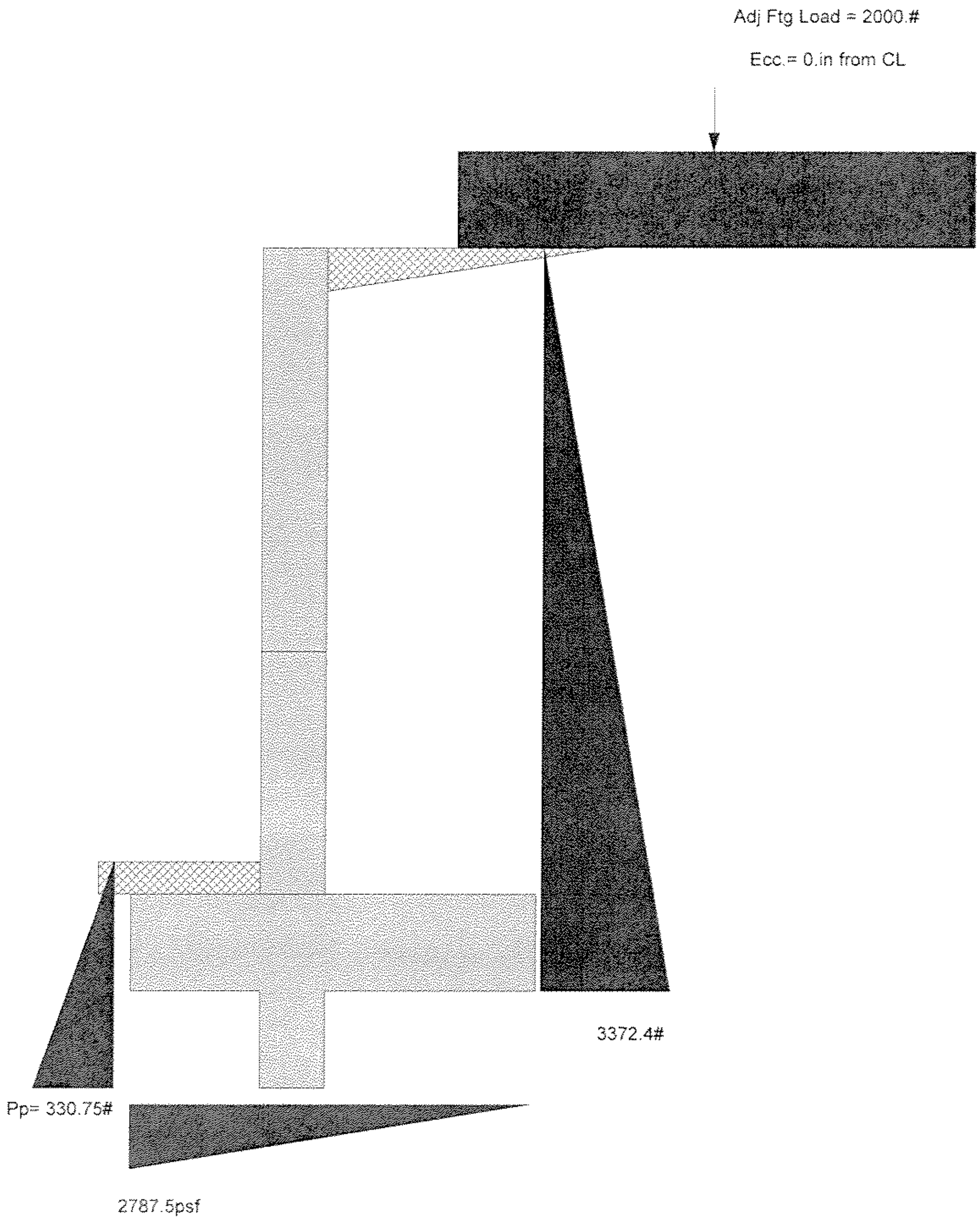
Vertical component of active pressure used for soil pressure

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	4,225.0	4.63	19,540.6
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=	382.4	4.63	1,768.4
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	130.0	1.00	130.0
Surcharge Over Toe	=			
Stem Weight(s)	=	1,500.0	2.50	3,750.0
Earth @ Stem Transitions	=			
Footing Weight	=	1,406.3	3.13	4,394.5
Key Weight	=	225.0	2.50	562.5
Vert. Component	=	774.8	6.25	4,842.6
Total =		8,643.4 lbs	**R.M.**=	34,988.6

DESIGNER NOTES:


12.in Conc w/ #5 @ 12.in o/c
2 1/2"
6'-3"
10'-0"
10'-0"
12.in Conc w/ #7 @ 12.in o/c
3'-9"
2 1/2"
2"
6"
1'-6"
3"
#7@12.in
@Toe
1'-6"
Designer select
#5@12.in
all horiz. reinf.
@ Heel
See Appendix A
2'-0"
1'-0"
3'-3"
2'-0"
4'-3"
6'-3"


Adj Ftg Load = 2000.#
Ecc.= 0.in from CL
3372.4#
Pp= 330.75#
2787.5psf

WALL Mark 'B' Seismic Loads

Definitions:

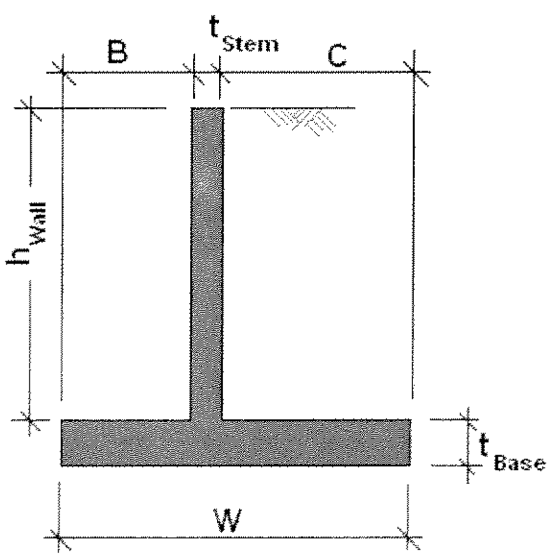
B = Width of Toe (feet)
C = Width of Heel (feet)
W = Width of Base (feet)
h wall = Height of Wall over base (feet)
t_{base} = thickness of Base (feet)
t_{stem} = Thickness of Stem (feet)
γ = density of backfill (pcf)
$\gamma_{concrete}$ density = 150 pcf
EFP_{static} = Design equivalent fluid pressure (pcf), static condition.
EFP_{AE} = Design equivalent fluid pressure (pcf), Active Earth pressure under seismic conditions..
ϕ = Internial angle of friction of the soil.
δ = Friction angle of soil to concrete wall.
K_h = Alternate seismic force developed from the Geotechnical Calculations page 12 in Appendix 'B'

Wall Mk. 'B' Data:

$B := 2.0$ (feet) $h_{wall} := 10.0$ (feet) $t_{stem} := 1.00$ (feet)

$C := 3.25$ (feet) $W := 6.25$ (feet) $t_{base} := 1.50$ (feet)

Soil Data: $\gamma := 130$ (pcf) $\delta := 22\cdot deg$ $\phi := 32\cdot deg$

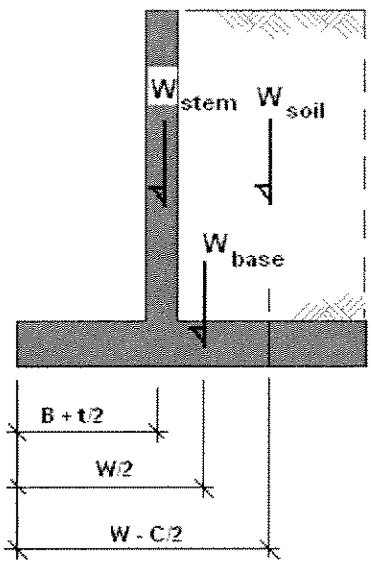


WALL STABILITY ANALYSIS

$EFP_{static} := 46$ (pcf)

$EFP_{AE} := 62$ (pcf)

$K_h := 0.09$



Stabilizing Forces

Weights: (kips.per foot)

$W_{stem} := (0.150) \cdot h_{wall} \cdot t_{stem}$ $W_{stem} = 1.500$

$W_{base} := (0.150) \cdot W \cdot t_{base}$ $W_{base} = 1.406$

$$W_{soil} := \frac{\gamma \cdot h_{wall} \cdot C}{1000} \qquad W_{soil} = 4.225$$

$H := h_{wall} + t_{base}$ $H = 11.5$ (feet)

Driving Forces:

$$P_{ST} := \frac{(EFP_{static}) \cdot \frac{1}{2} \cdot (H)^2}{1000} \qquad P_{ST} = 3.042 \quad \text{(kips)}$$

$$P_{SE} := \frac{(EFP_{AE}) \cdot \frac{1}{2} \cdot (H)^2}{1000} \qquad P_{SE} = 4.1 \quad \text{(kips)}$$

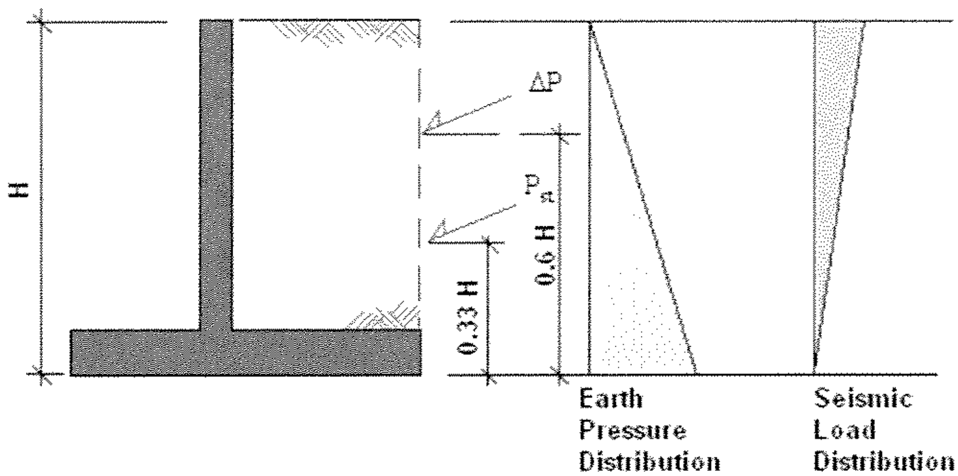
$$\Delta P_1 := P_{SE} - P_{ST} \qquad \Delta P_1 = 1.058 \quad \text{(kips)}$$

$$\Delta P_2 := \frac{K_h \cdot \gamma \cdot (H)^2}{1000} \qquad \Delta P_2 = 1.547 \quad \text{(kips)}$$

The larger value of either ΔP_1 or ΔP_2 is to be used in the seismic analysis

Let: $\Delta := \begin{pmatrix} \Delta P_1 \\ \Delta P_2 \end{pmatrix}$ $\Delta P := \max(\Delta)$ $\Delta P = 1.547$ (kips)

Driving Forces and Moments about the Toe:



Horizontal Driving Force (**HDF**) is the sum of P_{st} and ΔP in the horizontal direction:

$HDF := (P_{ST} + \Delta P) \cdot \cos(\delta)$ $\quad$ $HDF = 4.255$ (kips)

Driving Moment ($\mathbf{M_d}$) is the sum of the driving moments about the Toe.

$M_d := (P_{ST} \cdot 0.333 \cdot H) \cdot \cos(\delta) + (\Delta P \cdot 0.6 \cdot H) \cdot \cos(\delta)$ $\quad$ $M_d = 20.699$ (ft-kips)

Resisting Forces and Moments about the Toe:

Resisting Forces (**RF**) neglecting passive pressure, a conservative analysis:

$RF := \tan(\phi)(W_{stem} + W_{base} + W_{soil} + P_{ST} \cdot \sin(\delta) + \Delta P \cdot \sin(\delta))$

$RF = 5.53$ (kips)

"Factor of Safety" against sliding is the ratio of **RF** to **HDF**

$Ratio_{sliding} := \frac{RF}{HDF}$ $\quad$ $Ratio_{sliding} = 1.3$

Resisting Moments about the Toe M_r :

$$M_r := W_{stem}\cdot(B + t_{stem}) + W_{base}\cdot\left(\frac{W}{2}\right) + W_{soil}\cdot\left(W - \frac{C}{2}\right) + (P_{ST} + \Delta P)\cdot W\cdot\sin(\delta)$$

$M_r = 39.18$ (ft-kips)

"Factor of Safety" against overturning the ratio of $\mathbf{M_r}$ to $\mathbf{M_d}$

$Ratio_{OT} := \frac{M_r}{M_d}$ $Ratio_{OT} = 1.893$

Calculate Soil Bearing Pressurs:

Net Moment: $\Delta M := M_r - M_d$ $\Delta M = 18.48$ (ft-kips)

$$X := \frac{\Delta M}{(W_{stem} + W_{base} + W_{soil} + P_{ST}\cdot\sin(\delta) + \Delta P\cdot\sin(\delta))}$$ $X = 2.088$ (feet)

$R := (W_{stem} + W_{base} + W_{soil} + P_{ST}\cdot\sin(\delta) + \Delta P\cdot\sin(\delta))$ $R = 8.85$ (kips)

Eccentricity (e): $e := \frac{W}{2} - X$ $e = 1.037$ (feet) $\frac{W}{6} = 1.042$ (feet)

Eccentricity := | "OK Within Middle Third" if $e \le \frac{W}{6}$
| "Non in Middle one-third" otherwise

Eccentricity = "OK Within Middle Third"

$SP_2 := \frac{R}{W}\cdot\left(1 + \frac{e}{W}\right)$ $SP_2 = 1.651$ Maximum Soil Pearing Pressure (kips/ft^2)

$SP_1 := \frac{R}{W}\cdot\left(1 - \frac{e}{W}\right)$ $SP_1 = 1.181$ Minimum Soil Pearing Pressure (kips/ft^2)

Concrete Design:

The design on the concrete elements will be in accordance with ACI 318-02.

See Section 9.2 of ACI 319-02

$U_{DL} := 1.2 \qquad U_H := 1.6 \qquad U_E := 1.0$

$$R_{ult} := \left(U_{DL}\cdot W_{stem} + U_{DL}\cdot W_{base} + U_E\cdot W_{soil} + U_E\cdot P_{ST}\cdot \sin(\delta) + U_E\cdot \Delta P\cdot \sin(\delta)\right)$$

$$M_{d\_ult} := U_E\cdot\left[\left(P_{ST}\cdot 0.333\cdot H\right)\cdot\cos(\delta) + \left(\Delta P\cdot 0.6\cdot H\right)\cdot\cos(\delta)\right]$$

$$M_{r\_ult\_1} := U_{DL}\cdot W_{stem}\cdot\left(B + t_{stem}\right) + U_{DL}\cdot W_{base}\cdot\left(\frac{W}{2}\right) + U_{DL}\cdot W_{soil}\cdot\left(W - \frac{C}{2}\right)$$

$$M_{r\_ult\_2} := U_{DL}\cdot\left[\left(P_{ST} + \Delta P\right)\cdot W\cdot\sin(\delta)\right]$$

$$M_{r\_ult} := M_{r\_ult\_1} + M_{r\_ult\_2}$$

Net Ultimate Moment: $\Delta M_{ult} := M_{r\_ult} - M_{d\_ult}$ $\qquad \Delta M_{ult} = 26.316$ (ft-kips)

$X_{ult} := \dfrac{\Delta M_{ult}}{\left(R_{ult}\right)}$ $\qquad X_{ult} = 2.79$ (feet)

$R_{ult} = 9.432$ (kips)

Eccentricity (e): $e_{ult} := \dfrac{W}{2} - X_{ult}$ $\qquad e_{ult} = 0.335$ (feet) $\qquad \dfrac{W}{6} = 1.042$ (feet)

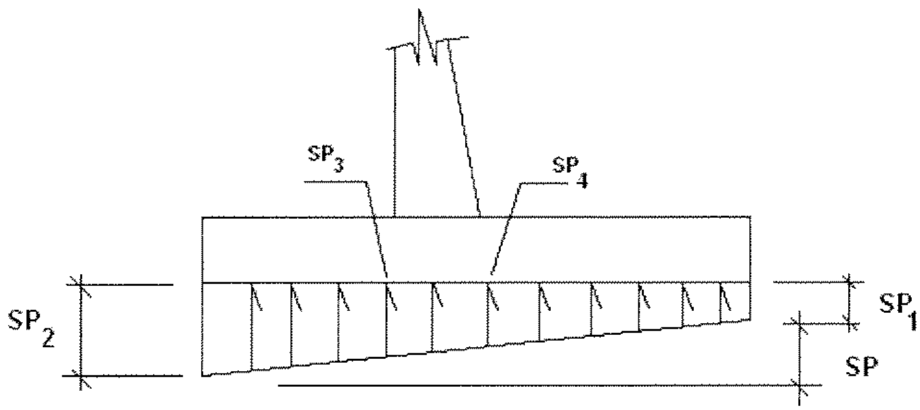
Eccentricity := | "OK Within Middle Third" if $e_{ult} \le \dfrac{W}{6}$
| "Non in Middle one-third" otherwise

Eccentricity = "OK Within Middle Third"

$SP_{2\_ult} := \dfrac{R_{ult}}{W}\cdot\left(1 + \dfrac{e_{ult}}{W}\right)$ $\qquad SP_{2\_ult} = 1.59$ Maximum Soil Pearing Pressure (kips/ft^2)

$SP_{1\_ult} := \frac{R_{ult}}{W} \cdot \left(1 - \frac{e_{ult}}{W}\right)$ $SP_{1\_ult} = 1.428$ Minimum Soil Pearing Pressure (kips/ft^2)

$\Delta SP_{ult} := SP_{2\_ult} - SP_{1\_ult}$ $\Delta SP_{ult} = 0.162$ (kips/ft^2)



Pressure Diagram - Toe & Heel

Soil Pressure at Front Face of Stem:

$SP_{3\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W} \cdot (B)$ $SP_{3\_ult} = 1.538$ (ksf)

Soil Pressure at Rear Face of Stem:

$SP_{4\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W} \cdot \left(B + t_{stem}\right)$ $SP_{4\_ult} = 1.512$ (ksf)

Moment at Front Face of Stem:

$$M_{toe} := SP_{3\_ult} \cdot \frac{B^2}{2} + \left(SP_{2\_ult} - SP_{3\_ult}\right) \cdot \frac{(B)}{2} \cdot \left(\frac{2}{3}\right) \cdot B - U_{DL} \cdot (0.150) \cdot t_{base} \cdot \left(\frac{B^2}{2}\right)$$

$M_{toe} = 2.605$ (ft-kips)

Concrete Data:

$f'_c := 3$ ksi $\quad f_y := 60$ ksi $\quad M_u := M_{toe}$ ft-kips

$b := 12$ inches $\quad d := (12)\cdot t_{base} - 4 \quad d = 14$ inches $\quad \phi_f := 0.90$

A_s calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7\cdot f'_c\cdot b\cdot d}{2\cdot f_y} - \frac{1}{2}\cdot\sqrt{\frac{2.89\cdot(f'_c\cdot b\cdot d)^2}{(f_y)^2} - \frac{6.8\cdot f'_c\cdot b\cdot M_u\cdot 12}{\phi_f\cdot(f_y)^2}}$$

$A_{s\_required} = 0.041$ Inches² $\quad \rho := \frac{A_{s\_required}}{12\cdot d} \quad \rho = 0.0002$

Shear in Toe:

Soil Pressure at d from front face:

$$SP_{31\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W}\cdot\left(B - \frac{d}{12}\right) \qquad SP_{31\_ult} = 1.568 \quad \text{(ksf)}$$

$$V_{toe} := SP_{31\_ult}\cdot\left(B - \frac{d}{12}\right) + \left(SP_{2\_ult} - SP_{31\_ult}\right)\cdot\left(\frac{1}{2}\right)\cdot\left(B - \frac{d}{12}\right)$$

$V_{toe} = 1.316$ (kips/foot)

$$\phi V_n := \frac{0.75\cdot 12\cdot d\cdot(2)\cdot\sqrt{f'_c\cdot 1000}}{1000} \qquad \phi V_n = 13.803 \quad \text{(kips/foot)}$$

Moment at Rear Face of Stem in the Heel:

$$M_{heel} := SP_{1\_ult}\cdot\frac{C^2}{2} + \left(SP_{4\_ult} - SP_{1\_ult}\right)\cdot\frac{(C)}{2}\cdot\left(\frac{1}{3}\right)\cdot C - U_{DL}\cdot(0.150)\cdot t_{base}\cdot\left(\frac{C^2}{2}\right)$$

$M_{heel} = 6.265$ (ft-kips) $\quad$ Let: $\quad M_u := M_{heel}$

A_s calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7 \cdot f'_c \cdot b \cdot d}{2 \cdot f_y} - \frac{1}{2} \cdot \sqrt{\frac{2.89 \cdot (f'_c \cdot b \cdot d)^2}{(f_y)^2} - \frac{6.8 \cdot f'_c \cdot b \cdot M_u \cdot 12}{\phi_f \cdot (f_y)^2}}$$

$A_{s\_required} = 0.1$ Inches² $\rho := \frac{A_{s\_required}}{12 \cdot d}$ $\rho = 0.0006$

Shear in Hell:

Soil Pressure at d from front rear face of stem:

$$SP_{41\_ult} := SP_{1\_ult} + \frac{\Delta SP_{ult}}{W} \cdot \left(C - \frac{d}{12}\right) \qquad SP_{41\_ult} = 1.482 \quad \text{(ksf)}$$

$$V_{heel} := SP_{1\_ult} \cdot \left(C - \frac{d}{12}\right) + \left(SP_{41\_ult} - SP_{1\_ult}\right) \cdot \left(\frac{1}{2}\right) \cdot \left(C - \frac{d}{12}\right)$$

$V_{heel} = 3.032$ (kips/foot)

$$\phi V_n := \frac{0.75 \cdot 12 \cdot d \cdot (2) \cdot \sqrt{f'_c \cdot 1000}}{1000} \qquad \phi V_n = 13.803 \quad \text{(kips/foot)}$$

Moments in Stem:

Driving Forces:

$$P_{ST} := \frac{(EFP_{static}) \cdot \frac{1}{2} \cdot (h_{wall})^2}{1000} \qquad P_{ST} = 2.3 \quad \text{(kips)}$$

$$P_{SE} := \frac{(EFP_{AE}) \cdot \frac{1}{2} \cdot (h_{wall})^2}{1000} \qquad P_{SE} = 3.1 \quad \text{(kips)}$$

$$\Delta P_1 := P_{SE} - P_{ST} \qquad \Delta P_1 = 0.8 \quad \text{(kips)}$$

$\Delta P_2 := \dfrac{K_h \cdot \gamma \cdot (h_{wall})^2}{1000}$ $\quad\quad \Delta P_2 = 1.17$ $\quad\quad$ (kips)

The larger value of either ΔP_1 or ΔP_2 is to be used in the seismic analysis

Let: $\Delta := \begin{pmatrix} \Delta P_1 \\ \Delta P_2 \end{pmatrix}$ $\quad\quad \Delta P := \max(\Delta)$ $\quad\quad \Delta P = 1.17$ $\quad\quad$ (kips)

$M_{stem} := U_E \cdot \left[\left(P_{ST} \cdot \cos(\delta) \cdot 0.333 h_{wall} \right) + \left(\Delta P \cdot 0.600 \cdot h_{wall} \right) \right]$

$M_{stem} = 14.121$ (ft-kips) $\quad$ Let: $\quad M_u := M_{stem}$ $\quad\quad d := 12 t_{stem} - 3.0$

$d = 9$ (inches)

$\mathbf{A_s}$ calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7 \cdot f'_c \cdot b \cdot d}{2 \cdot f_y} - \frac{1}{2} \cdot \sqrt{\frac{2.89 \cdot (f'_c \cdot b \cdot d)^2}{(f_y)^2} - \frac{6.8 \cdot f'_c \cdot b \cdot M_u \cdot 12}{\phi_f \cdot (f_y)^2}}$$

$A_{s\_required} = 0.363$ $\quad$ Inches² $\quad\quad \rho := \dfrac{A_{s\_required}}{12 \cdot d}$ $\quad\quad \rho = 0.0034$

WALL MK. 'C'

Loading Case	Overturning Ratio	Sliding Ratio	Maximum Soil Bearing Pressure	Controlling Case for Strength Design	Remarks
Normal	2.60	1.49	2920		
Seismic 1	2.13	1.22	3532		
Compaction Equipment	2.03	1.46	3640	4	
Seismic 2	1.92	1.29	2335		

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	15.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	51.0 psf/ft
Toe Active Pressure	=	51.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	3.00 ft
Heel Width	=	6.25
Total Footing Width	=	9.25
Footing Thickness	=	21.00 in
Key Width	=	15.00 in
Key Depth	=	18.00 in
Key Distance from Toe	=	3.00 ft
f'c = 3,000 psi	Fy =	60,000 psi
Footing Concrete Density	=	150.00 pcf
Min. As %	=	0.0018
Cover @ Top = 2.00 in	@ Btm.=	3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios			
Overturning	=	2.60	OK
Sliding	=	1.49	Ratio < 1.5!
Total Bearing Load	=	17,111 lbs	
...resultant ecc.	=	10.68 in	
Soil Pressure @ Toe	=	2,918 psf	OK
Soil Pressure @ Heel	=	782 psf	OK
Allowable	=	4,000 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	3,165 psf	
ACI Factored @ Heel	=	848 psf	
Footing Shear @ Toe	=	18.7 psi	OK
Footing Shear @ Heel	=	38.4 psi	OK
Allowable	=	82.2 psi	
Sliding Calcs (Vertical Component NOT Used)			
Lateral Sliding Force	=	7,025.3 lbs	
less 100% Passive Force	= -	379.7 lbs	
less 100% Friction Force	= -	10,053.5 lbs	
Added Force Req'd	=	0.0 lbs	OK
....for 1.5 : 1 Stability	=	104.7 lbs	NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem	2nd	3rd
		Stem OK	Stem OK	Stem OK
Design Height Above Ftg	ft =	10.00	3.75	0.00
Wall Material Above "Ht"	=	Concrete	Concrete	Concrete
Thickness	=	15.00	15.00	15.00
Rebar Size	=	# 7	# 7	# 9
Rebar Spacing	=	18.00	9.00	9.00
Rebar Placed at	=	Edge	Edge	Edge
Design Data				
fb/FB + fa/Fa	=	**0.081**	**0.480**	**0.716**
Total Force @ Section	lbs =	1,020.0	5,163.8	9,169.8
Moment....Actual	ft-# =	1,700.0	19,364.1	45,898.3
Moment.....Allowable	ft-# =	20,892.0	40,368.0	64,133.3
Shear.....Actual	psi =	7.1	35.9	63.7
Shear.....Allowable	psi =	82.2	82.2	82.2
Wall Weight	psf =	187.5	187.5	187.5
Rebar Depth 'd'	in =	12.00	12.00	12.00
LAP SPLICE IF ABOVE	in =	37.38	37.38	48.06
LAP SPLICE IF BELOW	in =	37.38	37.38	
HOOK EMBED INTO FTG	in =			17.25
Masonry Data				
f'm	psi =			
Fs	psi =			
Solid Grouting	=			
Special Inspection	=			
Modular Ratio 'n'	=			
Short Term Factor	=			
Equiv. Solid Thick.	=			
Masonry Block Type	=			
Concrete Data				
f'c	psi =	3,000.0	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0	60,000.0

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall 'C' H=15' Normal
Job # : E-05129 Dsgnr: JJF
Page: ______
Date: MAY 24,2005
Description....
Wall 'C" Height 'H' = 15'-0" Normal Loads EFP = 51 pcf

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

Retain Pro 2005 , 7-April-2005, (c) 1989-2005
www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	3,165	848 psf
Mu' : Upward	=	13,115	15,819 ft-#
Mu' : Downward	=	1,769	46,337 ft-#
Mu: Design	=	11,347	30,519 ft-#
Actual 1-Way Shear	=	18.74	38.44 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 9 @ 31.75 in	
Heel Reinforcing	=	# 5 @ 14.00 in	
Key Reinforcing	=	None Spec'd	

Other Acceptable Sizes & Spacings
Toe: #4@ 6.50 in, #5@ 10.00 in, #6@ 14.00 in, #7@ 19.25 in, #8@ 25.25 in, #9@ 31
Heel: #4@ 5.00 in, #5@ 7.50 in, #6@ 10.75 in, #7@ 14.50 in, #8@ 19.25 in, #9@ 24.
Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	7,154.3	5.58	39,945.1
Toe Active Pressure	=	-129.1	0.75	-96.8
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	7,025.3	**O.T.M.** =	39,848.3

Resisting/Overturning Ratio = **2.60**

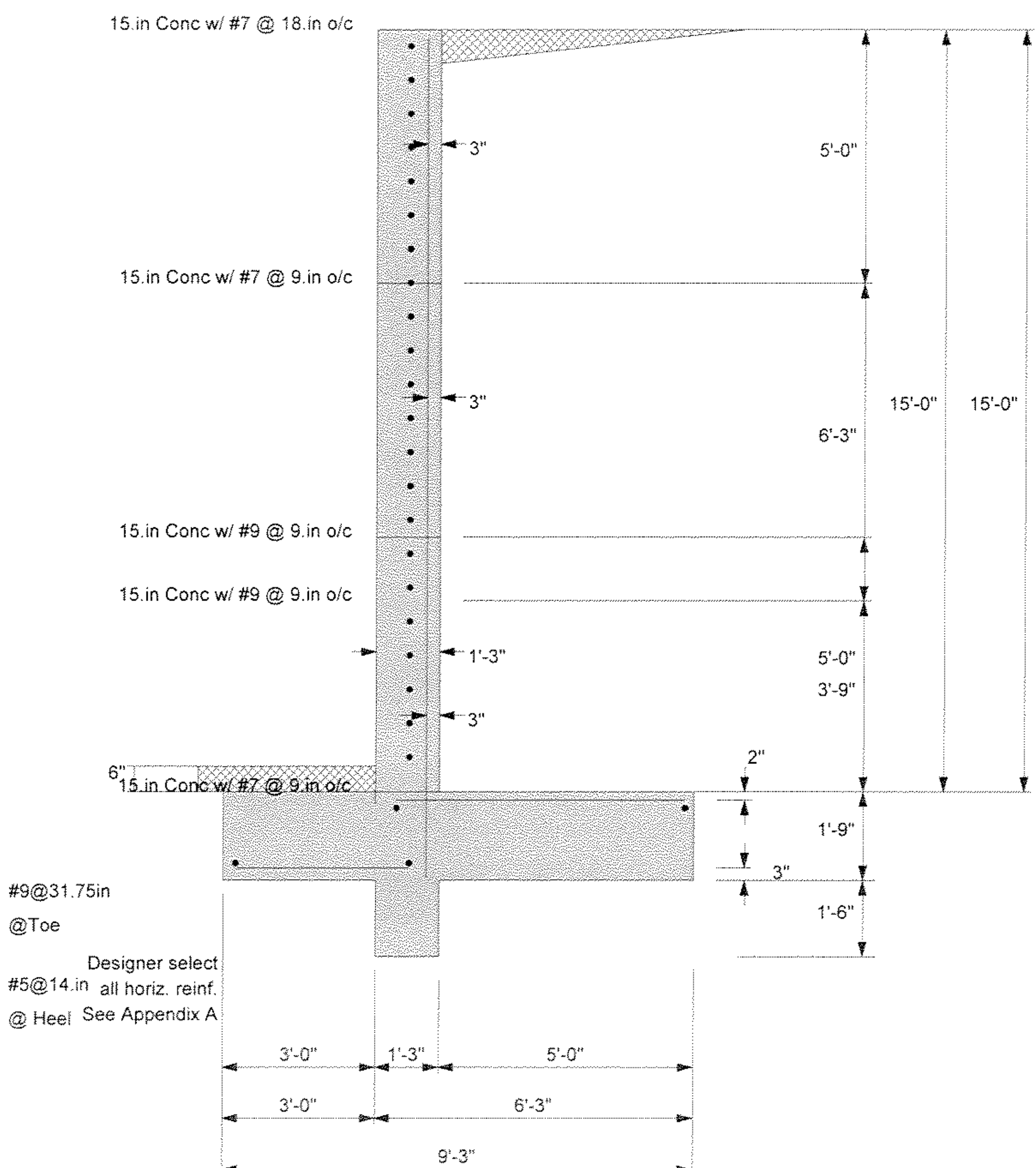
Vertical Loads used for Soil Pressure = 17,110.6 lbs

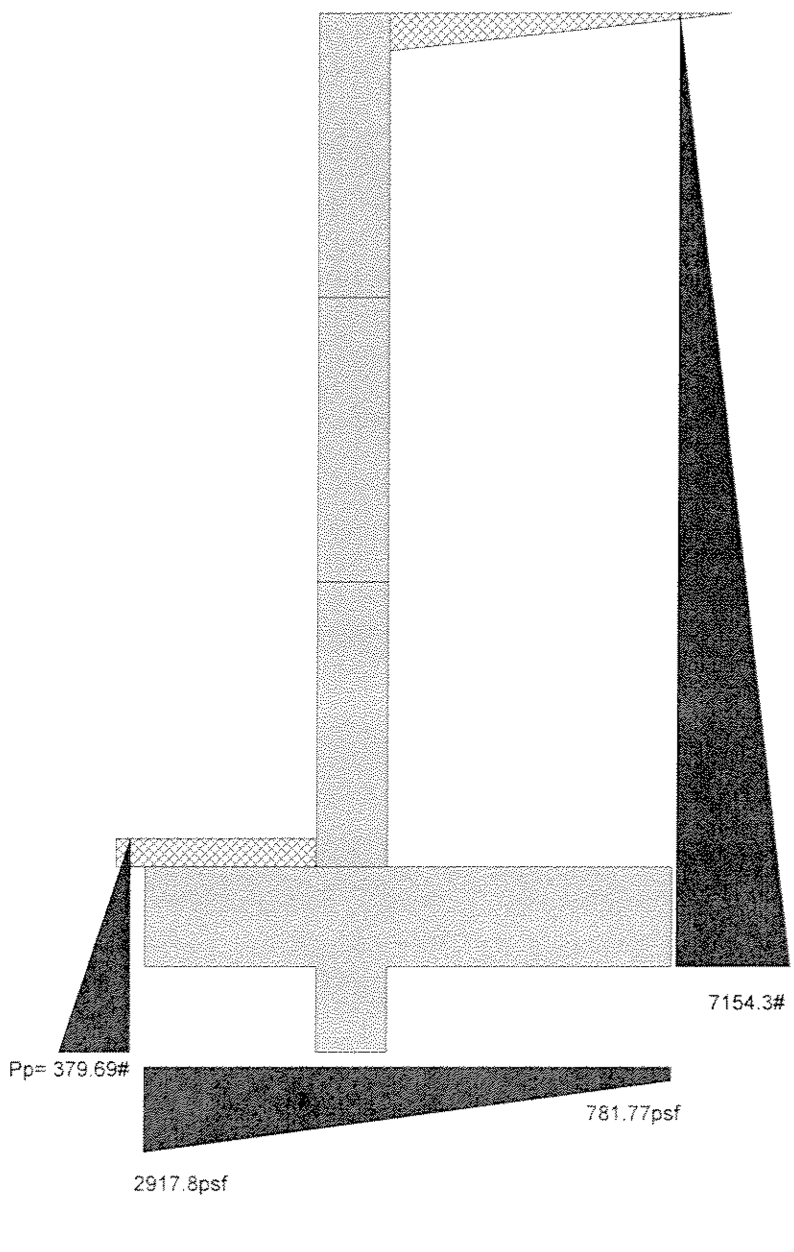
Vertical component of active pressure used for soil pressure

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	9,750.0	6.75	65,812.5
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	195.0	1.50	292.5
Surcharge Over Toe	=			
Stem Weight(s)	=	2,812.5	3.63	10,195.3
Earth @ Stem Transitions	=			
Footing Weight	=	2,428.1	4.63	11,230.1
Key Weight	=	281.3	3.63	1,019.5
Vert. Component	=	1,643.7	9.25	15,204.5
Total	=	17,110.6 lbs	**R.M.**=	103,754.4

DESIGNER NOTES:


15.in Conc w/ #7 @ 18.in o/c
3"
5'-0"
15.in Conc w/ #7 @ 9.in o/c
3"
6'-3"
15'-0"
15'-0"
15.in Conc w/ #9 @ 9.in o/c
15.in Conc w/ #9 @ 9.in o/c
1'-3"
5'-0"
3'-9"
3"
2"
6"
15.in Conc w/ #7 @ 9.in o/c
1'-9"
3"
1'-6"
#9@31.75in
@Toe
Designer select
all horiz. reinf.
See Appendix A
#5@14.in
@ Heel
3'-0"
1'-3"
5'-0"
3'-0"
6'-3"
9'-3"


7154.3#
Pp= 379.69#
781.77psf
2917.8psf

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall 'C' H= 15' Seismic
Job # : E-05129 Dsgnr: JJF
Page: ______
Date: MAY 25,2005
Description....
Wall 'C' Height (H) = 15'-0" Seismic Load , EFP = 61pcf

This Wall in File: C:\Program Files\RP2005\los alamos rw.rj

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www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	15.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	5,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	62.0 psf/ft
Toe Active Pressure	=	62.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	3.00 ft
Heel Width	=	6.25
Total Footing Width	=	9.25
Footing Thickness	=	21.00 in
Key Width	=	15.00 in
Key Depth	=	18.00 in
Key Distance from Toe	=	3.00 ft

f'c = 3,000 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top = 2.00 in @ Btm.= 3.00 in

Surcharge Loads

Surcharge Over Heel = 0.0 psf
Used To Resist Sliding & Overturning
Surcharge Over Toe = 0.0 psf
Used for Sliding & Overturning

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.13 OK
Sliding	=	1.22 Ratio < 1.5!
Total Bearing Load	=	17,059 lbs
...resultant ecc.	=	16.93 in
Soil Pressure @ Toe	=	3,532 psf OK
Soil Pressure @ Heel	=	157 psf OK
Allowable	=	5,000 psf

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	3,843 psf
ACI Factored @ Heel	=	170 psf
Footing Shear @ Toe	=	23.0 psi OK
Footing Shear @ Heel	=	45.1 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	8,540.5 lbs
less 100% Passive Force	= -	379.7 lbs
less 100% Friction Force	= -	10,053.5 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	2,377.6 lbs NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.400
Wind, W	1.600
Seismic, E	1.000

Stem Construction

			Top Stem	2nd	3rd
			Stem OK	Stem OK	Stem OK
Design Height Above Ftg	ft	=	10.00	3.75	0.00
Wall Material Above "Ht"		=	Concrete	Concrete	Concrete
Thickness		=	15.00	15.00	15.00
Rebar Size		=	# 7	# 7	# 9
Rebar Spacing		=	18.00	9.00	9.00
Rebar Placed at		=	Edge	Edge	Edge
Design Data					
fb/FB + fa/Fa		=	**0.087**	**0.510**	**0.761**
Total Force @ Section	lbs	=	1,085.0	5,492.8	9,754.2
Moment....Actual	ft-#	=	1,808.3	20,598.0	48,823.2
Moment.....Allowable	ft-#	=	20,892.0	40,368.0	64,133.3
Shear.....Actual	psi	=	7.5	38.1	67.7
Shear.....Allowable	psi	=	82.2	82.2	82.2
Wall Weight	psf	=	187.5	187.5	187.5
Rebar Depth 'd'	in	=	12.00	12.00	12.00
LAP SPLICE IF ABOVE	in	=	37.38	37.38	48.06
LAP SPLICE IF BELOW	in	=	37.38	37.38	
HOOK EMBED INTO FTG	in	=			17.25
Masonry Data					
f'm	psi	=			
Fs	psi	=			
Solid Grouting		=			
Special Inspection		=			
Modular Ratio 'n'		=			
Short Term Factor		=			
Equiv. Solid Thick.		=			
Masonry Block Type		=			
Concrete Data					
f'c	psi	=	3,000.0	3,000.0	3,000.0
Fy	psi	=	60,000.0	60,000.0	60,000.0

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	3,843	170 psf
Mu' : Upward	=	15,505	10,401 ft-#
Mu' : Downward	=	1,769	45,923 ft-#
Mu: Design	=	13,737	35,521 ft-#
Actual 1-Way Shear	=	22.98	45.08 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 5 @ 15.00 in	
Heel Reinforcing	=	# 5 @ 14.00 in	
Key Reinforcing	=	None Spec'd	

Other Acceptable Sizes & Spacings

Toe: #4@ 6.50 in, #5@ 10.00 in, #6@ 14.00 in, #7@ 19.25 in, #8@ 25.25 in, #9@ 31

Heel: #4@ 4.25 in, #5@ 6.50 in, #6@ 9.25 in, #7@ 12.50 in, #8@ 16.50 in, #9@ 20.7

Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	8,697.4	5.58	48,560.7
Toe Active Pressure	=	-156.9	0.75	-117.7
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	8,540.5	**O.T.M.** =	48,443.0

Resisting/Overturning Ratio = 2.13

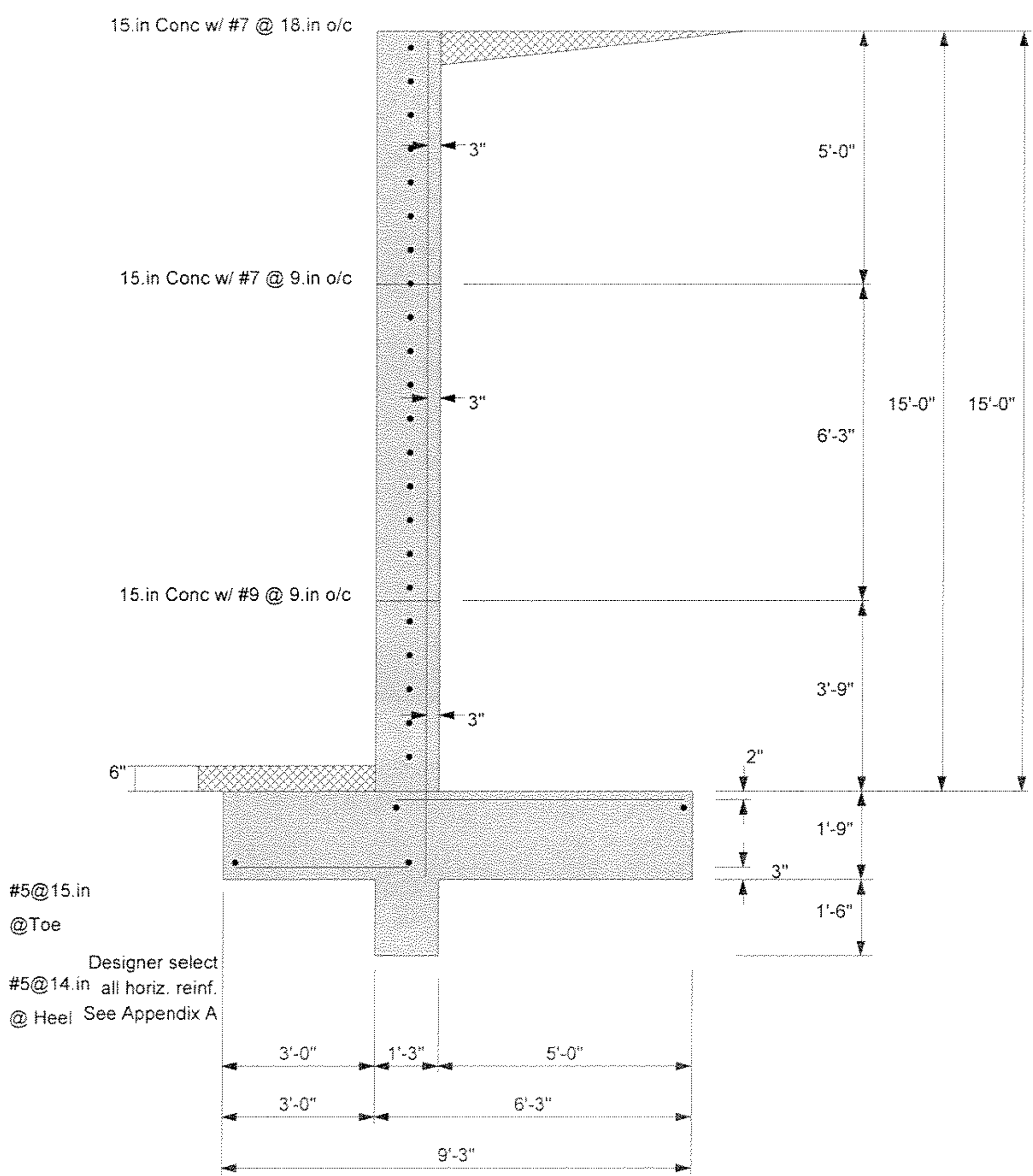
Vertical Loads used for Soil Pressure = 17,058.8 lbs

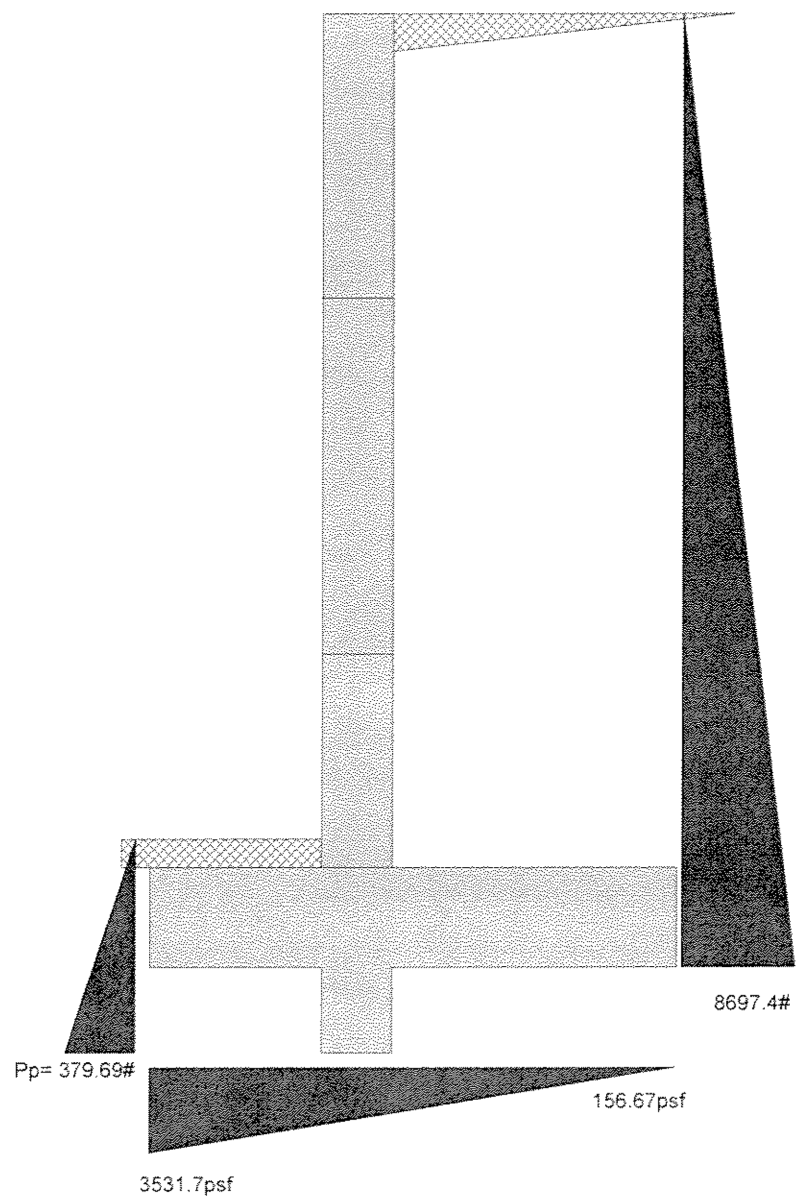
Vertical component of active pressure used for soil pressure

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	9,750.0	6.75	65,812.5
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	195.0	1.50	292.5
Surcharge Over Toe	=			
Stem Weight(s)	=	2,812.5	3.63	10,195.3
Earth @ Stem Transitions	=			
Footing Weight	=	2,428.1	4.63	11,230.1
Key Weight	=	281.3	3.63	1,019.5
Vert. Component	=	1,591.9	9.25	14,725.1
Total =		17,058.8 lbs	**R.M.**=	103,275.0

DESIGNER NOTES:


15.in Conc w/ #7 @ 18.in o/c
15.in Conc w/ #7 @ 9.in o/c
15.in Conc w/ #9 @ 9.in o/c
3"
3"
3"
5'-0"
6'-3"
3'-9"
15'-0"
15'-0"
6"
2"
1'-9"
3"
1'-6"
#5@15.in
@Toe
Designer select
all horiz. reinf.
See Appendix A
#5@14.in
@ Heel
3'-0"
1'-3"
5'-0"
3'-0"
6'-3"
9'-3"


8697.4#
Pp= 379.69#
156.67psf
3531.7psf

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall 'C' H=15' Equipment
Job # : E-05129 Dsgnr: JJF
Page: ______
Date: MAY 25,2005
Description....
Wall "C" Height (H) = 15'-0" Equipment Load EFP = 46

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

Retain Pro 2005 , 7-April-2005, (c) 1989-2005
www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	15.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	5,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	46.0 psf/ft
Toe Active Pressure	=	46.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	3.00 ft
Heel Width	=	6.25
Total Footing Width	=	9.25
Footing Thickness	=	21.00 in
Key Width	=	15.00 in
Key Depth	=	18.00 in
Key Distance from Toe	=	3.00 ft
f'c = 3,000 psi	Fy =	60,000 psi
Footing Concrete Density	=	150.00 pcf
Min. As %	=	0.0018
Cover @ Top = 2.00 in	@ Btm.=	3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	2,000.0 lbs
Footing Width	=	8.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	6.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.03 OK
Sliding	=	1.46 Ratio < 1.5!
Total Bearing Load	=	15,955 lbs
...resultant ecc.	=	20.45 in
Soil Pressure @ Toe	=	3,641 psf OK
Soil Pressure @ Heel	=	0 psf OK
Allowable	=	5,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	4,414 psf
ACI Factored @ Heel	=	0 psf
Footing Shear @ Toe	=	26.5 psi OK
Footing Shear @ Heel	=	36.7 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	7,387.1 lbs
less 100% Passive Force	= -	379.7 lbs
less 100% Friction Force	= -	10,370.5 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	330.4 lbs NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem	2nd	3rd
		Stem OK	Stem OK	Stem OK
Design Height Above Ftg	ft =	10.00	3.75	0.00
Wall Material Above "Ht"	=	Concrete	Concrete	Concrete
Thickness	=	15.00	15.00	15.00
Rebar Size	=	# 7	# 7	# 9
Rebar Spacing	=	18.00	9.00	9.00
Rebar Placed at	=	Edge	Edge	Edge
Design Data				
fb/FB + fa/Fa	=	**0.106**	**0.593**	**0.833**
Total Force @ Section	lbs =	1,370.8	5,977.6	9,866.1
Moment....Actual	ft-# =	2,211.9	23,950.7	53,398.9
Moment.....Allowable	ft-# =	20,892.0	40,368.0	64,133.3
Shear.....Actual	psi =	9.5	41.5	68.5
Shear.....Allowable	psi =	82.2	82.2	82.2
Wall Weight	psf =	187.5	187.5	187.5
Rebar Depth 'd'	in =	12.00	12.00	12.00
LAP SPLICE IF ABOVE	in =	37.38	37.38	48.06
LAP SPLICE IF BELOW	in =	37.38	37.38	
HOOK EMBED INTO FTG	in =			17.25
Masonry Data				
f'm	psi =			
Fs	psi =			
Solid Grouting	=			
Special Inspection	=			
Modular Ratio 'n'	=			
Short Term Factor	=			
Equiv. Solid Thick.	=			
Masonry Block Type	=			
Concrete Data				
f'c	psi =	3,000.0	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0	60,000.0

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	4,414	0 psf
Mu' : Upward	=	17,597	7,718 ft-#
Mu' : Downward	=	1,769	33,188 ft-#
Mu: Design	=	15,828	25,470 ft-#
Actual 1-Way Shear	=	26.48	36.69 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 9 @ 31.75 in	
Heel Reinforcing	=	# 5 @ 14.00 in	
Key Reinforcing	=	None Spec'd	

Other Acceptable Sizes & Spacings

Toe: #4@ 6.50 in, #5@ 10.00 in, #6@ 14.00 in, #7@ 19.25 in, #8@ 25.25 in, #9@ 31

Heel: #4@ 6.00 in, #5@ 9.00 in, #6@ 13.00 in, #7@ 17.50 in, #8@ 23.00 in, #9@ 29.

Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	6,452.9	5.58	36,028.9
Toe Active Pressure	=	-116.4	0.75	-87.3
Surcharge Over Toe	=			
Adjacent Footing Load	=	1,050.6	8.85	9,296.0
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	7,387.1	**O.T.M.** =	45,237.6

Resisting/Overturning Ratio = **2.03**

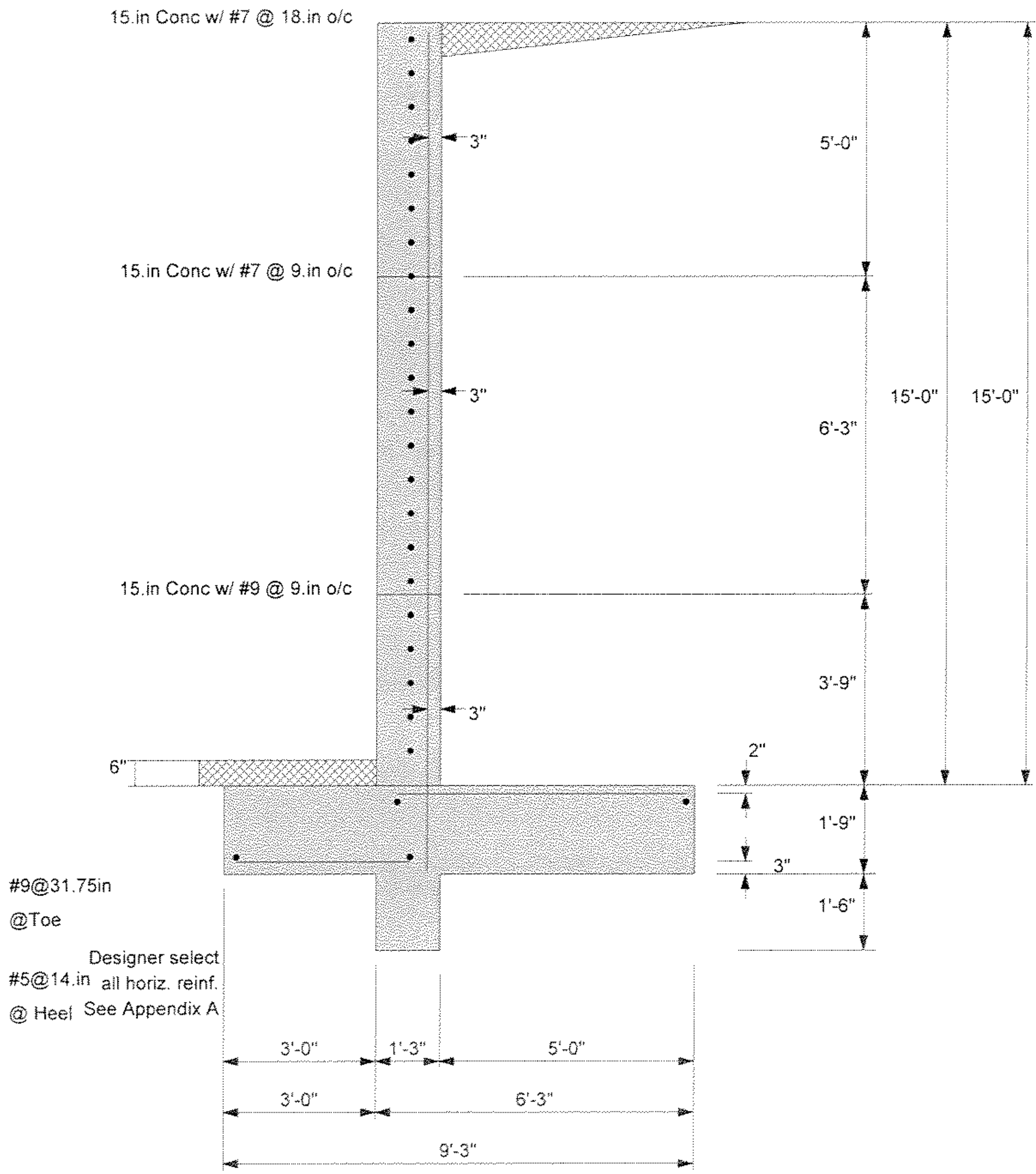
Vertical Loads used for Soil Pressure = 15,954.7 lbs

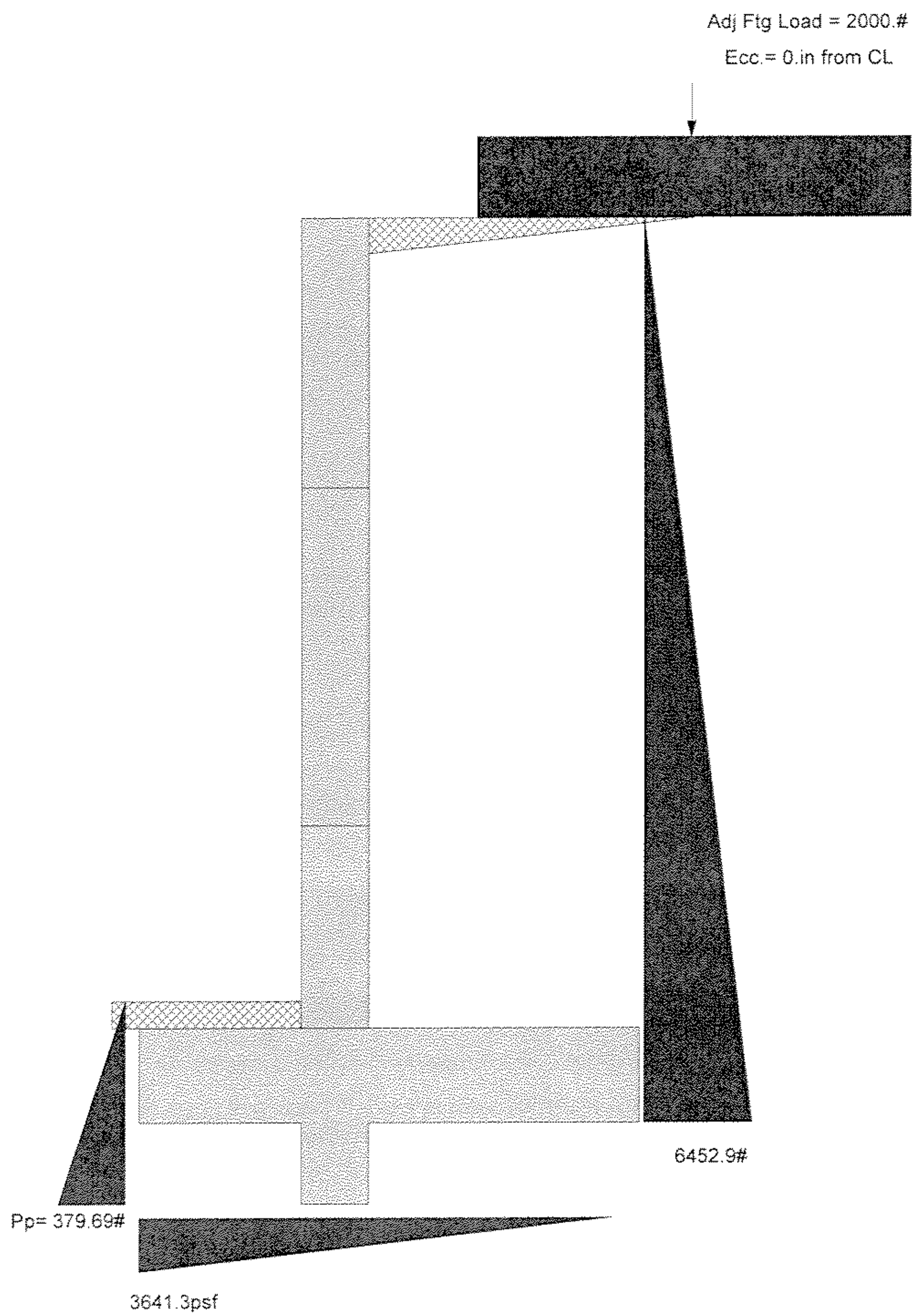
Vertical component of active pressure NOT used for soil pressure

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	9,750.0	6.75	65,812.5
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=	487.8	6.75	3,292.7
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	195.0	1.50	292.5
Surcharge Over Toe	=			
Stem Weight(s)	=	2,812.5	3.63	10,195.3
Earth @ Stem Transitions	=			
Footing Weight	=	2,428.1	4.63	11,230.1
Key Weight	=	281.3	3.63	1,019.5
Vert. Component	=			
Total =		15,954.7 lbs	**R.M.=**	91,842.6

DESIGNER NOTES:


15.in Conc w/ #7 @ 18.in o/c
15.in Conc w/ #7 @ 9.in o/c
15.in Conc w/ #9 @ 9.in o/c
3"
3"
3"
5'-0"
6'-3"
3'-9"
15'-0"
15'-0"
6"
2"
1'-9"
3"
1'-6"
#9@31.75in
@Toe
#5@14.in
@ Heel
Designer select
all horiz. reinf.
See Appendix A
3'-0"
1'-3"
5'-0"
3'-0"
6'-3"
9'-3"


Adj Ftg Load = 2000.#
Ecc.= 0.in from CL
6452.9#
Pp= 379.69#
3641.3psf

WALL Mark 'C' Seismic Loads

Definitions:

B = Width of Toe (feet)
C = Width of Heel (feet)
W = Width of Base (feet)

h wall = Height of Wall over base (feet)
t_{base} = thickness of Base (feet)
t_{stem} = Thickness of Stem (feet)

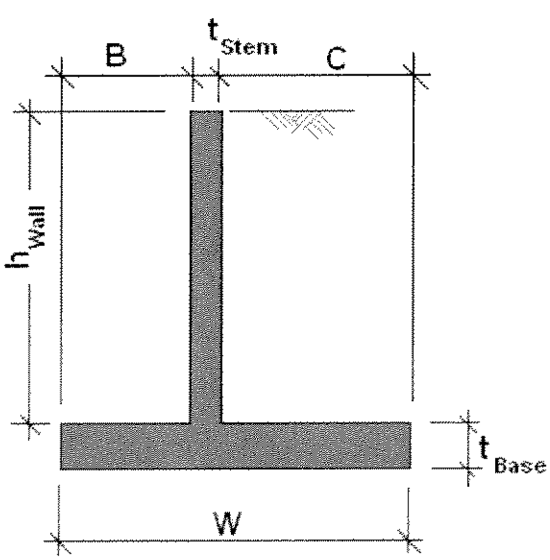
γ = density of backfill (pcf)
$\gamma_{concrete}$ density = 150 pcf
EFP_{static} = Design equivalent fluid pressure (pcf), static condition.
EFP_{AE} = Design equivalent fluid pressure (pcf), Active Earth pressure under seismic conditions..
ϕ = Internial angle of friction of the soil.
δ = Friction angle of soil to concrete wall.
K_h = Alternate seismic force developed from the Geotechnical Calculations page 12 in Appendix 'B'

Wall Mk. 'C' Data:

$B := 3.0$ (feet) $h_{wall} := 15.0$ (feet) $t_{stem} := 1.25$ (feet)

$C := 5.0$ (feet) $W := 9.25$ (feet) $t_{base} := 1.75$ (feet)

Soil Data: $\gamma := 130$ (pcf) $\delta := 22 \cdot deg$ $\phi := 32 \cdot deg$

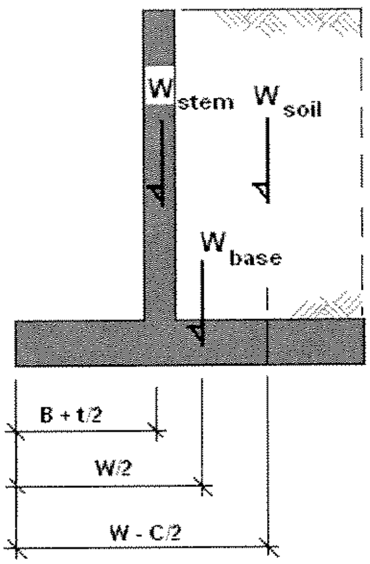


WALL STABILITY ANALYSIS

$EFP_{static} := 46$ (pcf)

$EFP_{AE} := 62$ (pcf)

$K_h := 0.09$



Stabilizing Forces

Weights: (kips.per foot)

$W_{stem} := (0.150)\cdot h_{wall}\cdot t_{stem}$ $W_{stem} = 2.813$

$W_{base} := (0.150)\cdot W\cdot t_{base}$ $W_{base} = 2.428$

$W_{soil} := \frac{\gamma\cdot h_{wall}\cdot C}{1000}$ $W_{soil} = 9.75$

$H := h_{wall} + t_{base}$ $H = 16.75$ (feet)

Driving Forces:

$P_{ST} := \frac{(EFP_{static})\cdot\frac{1}{2}\cdot(H)^2}{1000}$ $P_{ST} = 6.453$ (kips)

$P_{SE} := \frac{(EFP_{AE})\cdot\frac{1}{2}\cdot(H)^2}{1000}$ $P_{SE} = 8.697$ (kips)

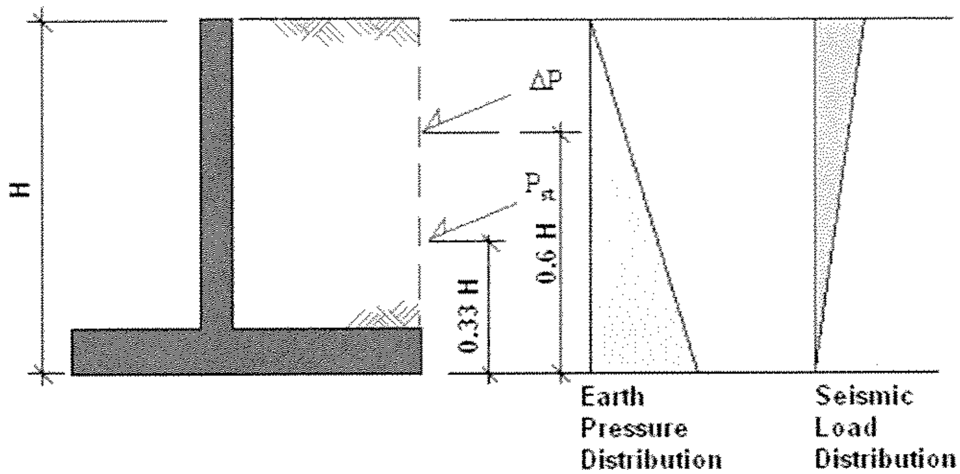
$\Delta P_1 := P_{SE} - P_{ST}$ $\Delta P_1 = 2.244$ (kips)

$\Delta P_2 := \frac{K_h\cdot\gamma\cdot(H)^2}{1000}$ $\Delta P_2 = 3.283$ (kips)

The larger value of either ΔP_1 or ΔP_2 is to be used in the seismic analysis

Let: $\Delta := \begin{pmatrix}\Delta P_1\\ \Delta P_2\end{pmatrix}$ $\Delta P := \max(\Delta)$ $\Delta P = 3.283$ (kips)

Driving Forces and Moments about the Toe:



Horizontal Driving Force (**HDF**) is the sum of P_{st} and ΔP in the horizontal direction:

$HDF := (P_{ST} + \Delta P)\cdot\cos(\delta)$ $HDF = 9.027$ (kips)

Driving Moment ($\mathbf{M_d}$) is the sum of the driving moments about the Toe.

$M_d := (P_{ST}\cdot 0.333\cdot H)\cdot\cos(\delta) + (\Delta P\cdot 0.6\cdot H)\cdot\cos(\delta)$ $M_d = 63.96$ (ft-kips)

Resisting Forces and Moments about the Toe:

Resisting Forces (**RF**) neglecting passive pressure, a conservative analysis:

$RF := \tan(\phi)(W_{stem} + W_{base} + W_{soil} + P_{ST}\cdot\sin(\delta) + \Delta P\cdot\sin(\delta))$

$RF = 11.646$ (kips)

"Factor of Safety" against sliding is the ratio of **RF** to **HDF**

$Ratio_{sliding} := \frac{RF}{HDF}$ $Ratio_{sliding} = 1.29$

Resisting Moments about the Toe M_r :

$$M_r := W_{stem} \cdot (B + t_{stem}) + W_{base} \cdot \left(\frac{W}{2}\right) + W_{soil} \cdot \left(W - \frac{C}{2}\right) + (P_{ST} + \Delta P) \cdot W \cdot \sin(\delta)$$

$M_r = 122.73$ (ft-kips)

"Factor of Safety" against overturning the ratio of $\mathbf{M_r}$ to $\mathbf{M_d}$

$Ratio_{OT} := \frac{M_r}{M_d}$ $Ratio_{OT} = 1.919$

Calculate Soil Bearing Pressurs:

Net Moment: $\Delta M := M_r - M_d$ $\Delta M = 58.771$ (ft-kips)

$$X := \frac{\Delta M}{(W_{stem} + W_{base} + W_{soil} + P_{ST} \cdot \sin(\delta) + \Delta P \cdot \sin(\delta))}$$ $X = 3.153$ (feet)

$$R := (W_{stem} + W_{base} + W_{soil} + P_{ST} \cdot \sin(\delta) + \Delta P \cdot \sin(\delta))$$ $R = 18.638$ (kips)

Eccentricity (e): $e := \frac{W}{2} - X$ $e = 1.472$ (feet) $\frac{W}{6} = 1.542$ (feet)

Eccentricity := | "OK Within Middle Third" if $e \le \frac{W}{6}$
| "Non in Middle one-third" otherwise

Eccentricity = "OK Within Middle Third"

$SP_2 := \frac{R}{W} \cdot \left(1 + \frac{e}{W}\right)$ $SP_2 = 2.335$ Maximum Soil Pearing Pressure (kips/ft^2)

$SP_1 := \frac{R}{W} \cdot \left(1 - \frac{e}{W}\right)$ $SP_1 = 1.694$ Minimum Soil Pearing Pressure (kips/ft^2)

Concrete Design:

The design on the concrete elements will be in accordance with ACI 318-02.

See Section 9.2 of ACI 319-02

$U_{DL} := 1.2$ $\quad U_H := 1.6$ $\quad U_E := 1.0$

$$R_{ult} := \left(U_{DL} \cdot W_{stem} + U_{DL} \cdot W_{base} + U_E \cdot W_{soil} + U_E \cdot P_{ST} \cdot \sin(\delta) + U_E \cdot \Delta P \cdot \sin(\delta)\right)$$

$$M_{d\_ult} := U_E \cdot \left[\left(P_{ST} \cdot 0.333 \cdot H\right) \cdot \cos(\delta) + \left(\Delta P \cdot 0.6 \cdot H\right) \cdot \cos(\delta)\right]$$

$$M_{r\_ult\_1} := U_{DL} \cdot W_{stem} \cdot \left(B + t_{stem}\right) + U_{DL} \cdot W_{base} \cdot \left(\frac{W}{2}\right) + U_{DL} \cdot W_{soil} \cdot \left(W - \frac{C}{2}\right)$$

$$M_{r\_ult\_2} := U_{DL} \cdot \left[\left(P_{ST} + \Delta P\right) \cdot W \cdot \sin(\delta)\right]$$

$$M_{r\_ult} := M_{r\_ult\_1} + M_{r\_ult\_2}$$

Net Ultimate Moment: $\Delta M_{ult} := M_{r\_ult} - M_{d\_ult}$ $\quad \Delta M_{ult} = 83.317$ (ft-kips)

$X_{ult} := \dfrac{\Delta M_{ult}}{\left(R_{ult}\right)}$ $\quad X_{ult} = 4.232$ (feet)

$R_{ult} = 19.686$ (kips)

Eccentricity (e): $e_{ult} := \dfrac{W}{2} - X_{ult}$ $\quad e_{ult} = 0.393$ (feet) $\quad \dfrac{W}{6} = 1.542$ (feet)

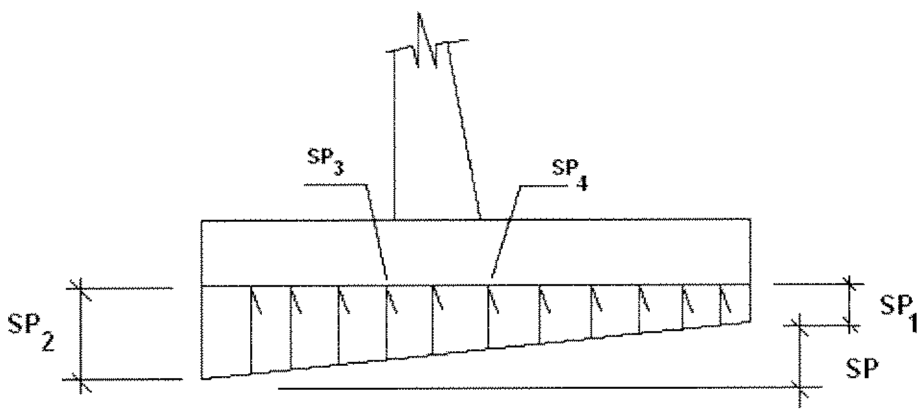
Eccentricity := | "OK Within Middle Third" if $e_{ult} \le \dfrac{W}{6}$
| "Non in Middle one-third" otherwise

Eccentricity = "OK Within Middle Third"

$SP_{2\_ult} := \dfrac{R_{ult}}{W} \cdot \left(1 + \dfrac{e_{ult}}{W}\right)$ $\quad SP_{2\_ult} = 2.219$ Maximum Soil Pearing Pressure (kips/ft²)

$SP_{1\_ult} := \frac{R_{ult}}{W}\cdot\left(1 - \frac{e_{ult}}{W}\right)$ $SP_{1\_ult} = 2.038$ Minimum Soil Pearing Pressure (kips/ft²)

$\Delta SP_{ult} := SP_{2\_ult} - SP_{1\_ult}$ $\Delta SP_{ult} = 0.181$ (kips/ft²)



Pressure Diagram - Toe & Heel

Soil Pressure at Front Face of Stem:

$SP_{3\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W}\cdot(B)$ $SP_{3\_ult} = 2.16$ (ksf)

Soil Pressure at Rear Face of Stem:

$SP_{4\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W}\cdot(B + t_{stem})$ $SP_{4\_ult} = 2.136$ (ksf)

Moment at Front Face of Stem:

$$M_{toe} := SP_{3\_ult}\cdot\frac{B^2}{2} + \left(SP_{2\_ult} - SP_{3\_ult}\right)\cdot\frac{(B)}{2}\cdot\left(\frac{2}{3}\right)\cdot B - U_{DL}\cdot(0.150)\cdot t_{base}\cdot\left(\frac{B^2}{2}\right)$$

$M_{toe} = 8.478$ (ft-kips)

Concrete Data:

$f'_c := 3$ ksi $\quad f_y := 60$ ksi $\quad M_u := M_{toe}$ ft-kips

$b := 12$ inches $\quad d := (12)\cdot t_{base} - 4 \quad d = 17$ inches $\quad \phi_f := 0.90$

$\mathbf{A_s}$ calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7\cdot f'_c\cdot b\cdot d}{2\cdot f_y} - \frac{1}{2}\cdot\sqrt{\frac{2.89\cdot(f'_c\cdot b\cdot d)^2}{(f_y)^2} - \frac{6.8\cdot f'_c\cdot b\cdot M_u\cdot 12}{\phi_f\cdot(f_y)^2}}$$

$A_{s\_required} = 0.112$ Inches² $\quad \rho := \frac{A_{s\_required}}{12\cdot d} \quad \rho = 0.0005$

Shear in Toe:

Soil Pressure at d from front face:

$$SP_{31\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W}\cdot\left(B - \frac{d}{12}\right) \qquad SP_{31\_ult} = 2.188 \quad \text{(ksf)}$$

$$V_{toe} := SP_{31\_ult}\cdot\left(B - \frac{d}{12}\right) + \left(SP_{2\_ult} - SP_{31\_ult}\right)\cdot\left(\frac{1}{2}\right)\cdot\left(B - \frac{d}{12}\right)$$

$V_{toe} = 3.488$ (kips/foot)

$$\phi V_n := \frac{0.75\cdot 12\cdot d\cdot(2)\cdot\sqrt{f'_c\cdot 1000}}{1000} \qquad \phi V_n = 16.76 \quad \text{(kips/foot)}$$

Moment at Rear Face of Stem in the Heel:

$$M_{heel} := SP_{1\_ult}\cdot\frac{C^2}{2} + \left(SP_{4\_ult} - SP_{1\_ult}\right)\cdot\frac{(C)}{2}\cdot\left(\frac{1}{3}\right)\cdot C - U_{DL}\cdot(0.150)\cdot t_{base}\cdot\left(\frac{C^2}{2}\right)$$

$M_{heel} = 21.943$ (ft-kips) $\quad$ Let: $\quad M_u := M_{heel}$

A_s calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7 \cdot f'_c \cdot b \cdot d}{2 \cdot f_y} - \frac{1}{2} \cdot \sqrt{\frac{2.89 \cdot (f'_c \cdot b \cdot d)^2}{(f_y)^2} - \frac{6.8 \cdot f'_c \cdot b \cdot M_u \cdot 12}{\phi_f \cdot (f_y)^2}}$$

$A_{s\_required} = 0.292$ Inches² $\rho := \frac{A_{s\_required}}{12 \cdot d}$ $\rho = 0.0014$

Shear in Hell:

Soil Pressure at d from front rear face of stem:

$$SP_{41\_ult} := SP_{1\_ult} + \frac{\Delta SP_{ult}}{W} \cdot \left(C - \frac{d}{12}\right) \qquad SP_{41\_ult} = 2.108 \quad \text{(ksf)}$$

$$V_{heel} := SP_{1\_ult} \cdot \left(C - \frac{d}{12}\right) + \left(SP_{41\_ult} - SP_{1\_ult}\right) \cdot \left(\frac{1}{2}\right) \cdot \left(C - \frac{d}{12}\right)$$

$V_{heel} = 7.428$ (kips/foot)

$$\phi V_n := \frac{0.75 \cdot 12 \cdot d \cdot (2) \cdot \sqrt{f'_c \cdot 1000}}{1000} \qquad \phi V_n = 16.76 \quad \text{(kips/foot)}$$

Moments in Stem:

Driving Forces:

$$P_{ST} := \frac{(EFP_{static}) \cdot \frac{1}{2} \cdot (h_{wall})^2}{1000} \qquad P_{ST} = 5.175 \quad \text{(kips)}$$

$$P_{SE} := \frac{(EFP_{AE}) \cdot \frac{1}{2} \cdot (h_{wall})^2}{1000} \qquad P_{SE} = 6.975 \quad \text{(kips)}$$

$$\Delta P_1 := P_{SE} - P_{ST} \qquad \Delta P_1 = 1.8 \quad \text{(kips)}$$

$$\Delta P_2 := \frac{K_h \cdot \gamma \cdot (h_{wall})^2}{1000} \qquad \Delta P_2 = 2.632 \qquad \text{(kips)}$$

The larger value of either ΔP_1 or ΔP_2 is to be used in the seismic analysis

Let: $\Delta := \begin{pmatrix} \Delta P_1 \\ \Delta P_2 \end{pmatrix}$ $\quad \Delta P := \max(\Delta) \quad \Delta P = 2.632$ (kips)

$$M_{stem} := U_E \cdot \left[\left(P_{ST} \cdot \cos(\delta) \cdot 0.333 h_{wall}\right) + \left(\Delta P \cdot 0.600 \cdot h_{wall}\right) \right]$$

$M_{stem} = 47.659$ (ft-kips) Let: $M_u := M_{stem}$ $\quad d := (12) \cdot t_{stem} - 3.0$

$d = 12$ (inches)

$\mathbf{A_s}$ calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7 \cdot f'_c \cdot b \cdot d}{2 \cdot f_y} - \frac{1}{2} \cdot \sqrt{\frac{2.89 \cdot (f'_c \cdot b \cdot d)^2}{(f_y)^2} - \frac{6.8 \cdot f'_c \cdot b \cdot M_u \cdot 12}{\phi_f \cdot (f_y)^2}}$$

$A_{s\_required} = 0.957$ Inches² $\qquad \rho := \frac{A_{s\_required}}{12 \cdot d} \qquad \rho = 0.0066$

WALL MK. 'D'

Loading Case	Overturning Ratio	Sliding Ratio	Maximum Soil Bearing Pressure	Controlling Case for Strength Design	Remarks
Normal	2.50	1.44	3990		
Seismic 1	2.04	1.18	4840		
Compaction Equipment	2.03	1.50	4720	✓	
Seismic 2	1.85	1.30	5360		

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	20.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	5,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	51.0 psf/ft
Toe Active Pressure	=	51.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	4.00 ft
Heel Width	=	8.00
Total Footing Width	=	12.00
Footing Thickness	=	27.00 in
Key Width	=	24.00 in
Key Depth	=	24.00 in
Key Distance from Toe	=	4.00 ft
f'c = 3,000 psi	Fy =	60,000 psi
Footing Concrete Density	=	150.00 pcf
Min. As %	=	0.0018
Cover @ Top = 2.00 in	@ Btm.=	3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.49 OK
Sliding	=	1.44 Ratio < 1.5!
Total Bearing Load	=	29,410 lbs
...resultant ecc.	=	15.05 in
Soil Pressure @ Toe	=	3,988 psf OK
Soil Pressure @ Heel	=	914 psf OK
Allowable	=	5,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	4,314 psf
ACI Factored @ Heel	=	988 psf
Footing Shear @ Toe	=	25.5 psi OK
Footing Shear @ Heel	=	50.6 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	12,431.3 lbs
less 100% Passive Force	= -	609.2 lbs
less 100% Friction Force	= -	7,231.5 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	806.2 lbs NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem	2nd	3rd
		Stem OK	Stem OK	Stem OK
Design Height Above Ftg	ft =	13.00	5.00	0.00
Wall Material Above "Ht"	=	Concrete	Concrete	Concrete
Thickness	=	24.00	24.00	24.00
Rebar Size	=	# 7	# 7	# 9
Rebar Spacing	=	15.00	7.50	7.50
Rebar Placed at	=	Edge	Edge	Edge
Design Data				
fb/FB + fa/Fa	=	**0.105**	**0.530**	**0.778**
Total Force @ Section	lbs =	1,999.2	9,180.0	16,309.8
Moment....Actual	ft-# =	4,664.8	45,900.0	108,798.3
Moment.....Allowable	ft-# =	44,340.5	86,641.9	139,872.0
Shear.....Actual	psi =	7.9	36.4	64.7
Shear.....Allowable	psi =	82.2	82.2	82.2
Wall Weight	psf =	300.0	300.0	300.0
Rebar Depth 'd'	in =	21.00	21.00	21.00
LAP SPLICE IF ABOVE	in =	37.38	37.38	48.06
LAP SPLICE IF BELOW	in =	37.38	37.38	
HOOK EMBED INTO FTG	in =			17.25
Masonry Data				
f'm	psi =			
Fs	psi =			
Solid Grouting	=			
Special Inspection	=			
Modular Ratio 'n'	=			
Short Term Factor	=			
Equiv. Solid Thick.	=			
Masonry Block Type =				
Concrete Data				
f'c	psi =	3,000.0	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0	60,000.0

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	4,314	988 psf
Mu' : Upward	=	31,553	27,767 ft-#
Mu' : Downward	=	3,864	91,294 ft-#
Mu: Design	=	27,689	63,527 ft-#
Actual 1-Way Shear	=	25.50	50.59 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 9 @ 9.00 in	
Heel Reinforcing	=	# 9 @ 12.00 in	
Key Reinforcing	=	# 7 @ 16.00 in	

Other Acceptable Sizes & Spacings

Toe: #4@ 4.75 in, #5@ 7.50 in, #6@ 10.50 in, #7@ 14.25 in, #8@ 18.75 in, #9@ 23.
Heel: #4@ 3.25 in, #5@ 4.75 in, #6@ 6.75 in, #7@ 9.25 in, #8@ 12.25 in, #9@ 15.50
Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	12,624.1	7.42	93,628.7
Toe Active Pressure	=	-192.8	0.92	-176.8
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	12,431.3	**O.T.M.** =	93,451.9

Resisting/Overturning Ratio = **2.49**

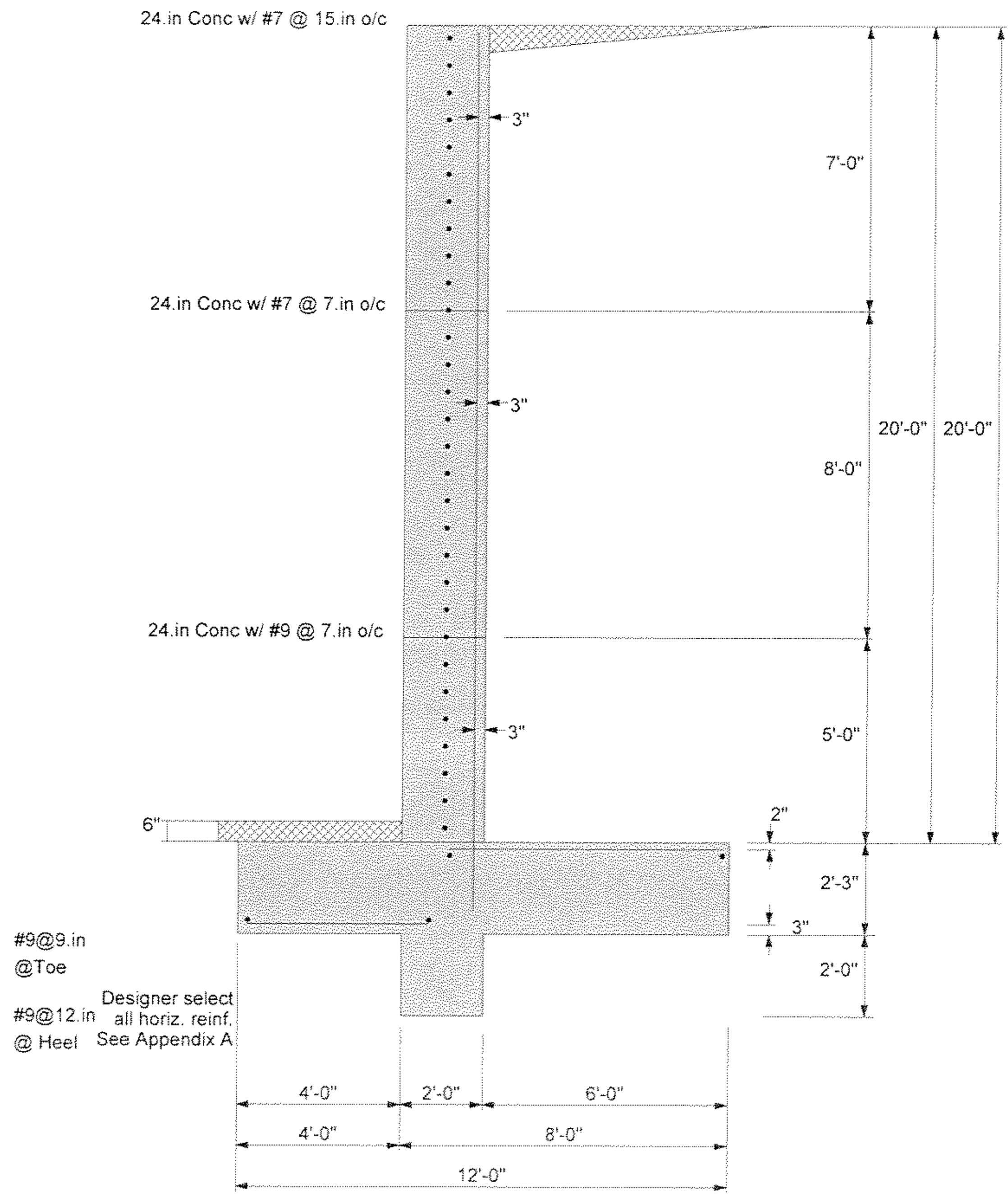
Vertical Loads used for Soil Pressure = 29,410.4 lbs

Vertical component of active pressure used for soil pressure

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	15,600.0	9.00	140,400.0
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	260.0	2.00	520.0
Surcharge Over Toe	=			
Stem Weight(s)	=	6,000.0	5.00	30,000.0
Earth @ Stem Transitions	=			
Footing Weight	=	4,050.0	6.00	24,300.0
Key Weight	=	600.0	5.00	3,000.0
Vert. Component	=	2,900.4	12.00	34,804.9
Total =		29,410.4 lbs	**R.M.**=	233,024.9

DESIGNER NOTES: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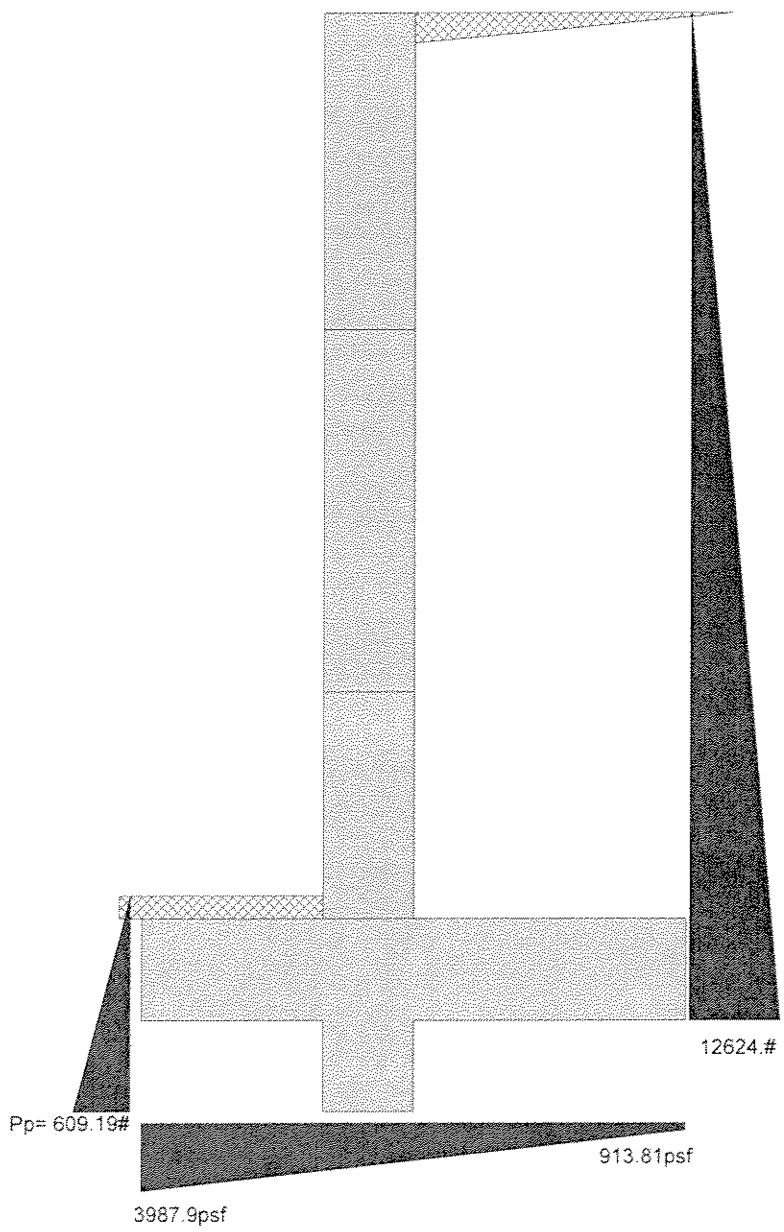
24.in Conc w/ #7 @ 7.in o/c
24.in Conc w/ #9 @ 7.in o/c
3"
3"
3"
7'-0"
8'-0"
5'-0"
20'-0"
20'-0"
6"
2"
2'-3"
3"
2'-0"
#9@9.in
@Toe
#9@12.in
@ Heel
Designer select
all horiz. reinf.
See Appendix A
4'-0"
2'-0"
6'-0"
4'-0"
8'-0"
12'-0"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Pp= 609.19#
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3987.9psf

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall "D" H= 20' Seismic
Job # : E-05129 Dsgnr: JJF
Description....
Wall 'D' Height (H) = 20'-0" Seismic Loads EFP = 62pcf

Page: ______
Date: MAY 25,2005

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

Retain Pro 2005 , 7-April-2005, (c) 1989-2005
www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	20.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	5,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	62.0 psf/ft
Toe Active Pressure	=	62.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	4.00 ft
Heel Width	=	8.00
Total Footing Width	=	12.00
Footing Thickness	=	27.00 in
Key Width	=	24.00 in
Key Depth	=	24.00 in
Key Distance from Toe	=	4.00 ft

f'c = 3,000 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top = 2.00 in @ Btm.= 3.00 in

Surcharge Loads

Surcharge Over Heel = 0.0 psf
Used To Resist Sliding & Overturning
Surcharge Over Toe = 0.0 psf
Used for Sliding & Overturning

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.04 OK
Sliding	=	1.18 Ratio < 1.5!
Total Bearing Load	=	29,319 lbs
...resultant ecc.	=	23.57 in
Soil Pressure @ Toe	=	4,843 psf OK
Soil Pressure @ Heel	=	43 psf OK
Allowable	=	5,000 psf

Soil Pressure Less Than Allowable

ACI Factored @ Toe	=	5,255 psf
ACI Factored @ Heel	=	47 psf
Footing Shear @ Toe	=	31.4 psi OK
Footing Shear @ Heel	=	59.7 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	15,112.5 lbs
less 100% Passive Force	= -	609.2 lbs
less 100% Friction Force	= -	17,231.5 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	4,828.1 lbs NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.100
Wind, W	1.600
Seismic, E	1.000

Stem Construction

			Top Stem	2nd	3rd
			Stem OK	Stem OK	Stem OK
Design Height Above Ftg	ft =		13.00	5.00	0.00
Wall Material Above "Ht"	=		Concrete	Concrete	Concrete
Thickness	=		24.00	24.00	24.00
Rebar Size	=		# 7	# 7	# 9
Rebar Spacing	=		15.00	7.50	7.50
Rebar Placed at	=		Edge	Edge	Edge
Design Data					
fb/FB + fa/Fa	=		**0.088**	**0.443**	**0.650**
Total Force @ Section	lbs =		1,670.9	7,672.5	13,631.5
Moment....Actual	ft-# =		3,898.8	38,362.5	90,931.9
Moment.....Allowable	ft-# =		44,340.5	86,641.9	139,872.0
Shear.....Actual	psi =		6.6	30.4	54.1
Shear.....Allowable	psi =		82.2	82.2	82.2
Wall Weight	psf =		300.0	300.0	300.0
Rebar Depth 'd'	in =		21.00	21.00	21.00
LAP SPLICE IF ABOVE	in =		37.38	37.38	48.06
LAP SPLICE IF BELOW	in =		37.38	37.38	
HOOK EMBED INTO FTG	in =				17.25
Masonry Data					
f'm	psi =				
Fs	psi =				
Solid Grouting	=				
Special Inspection	=				
Modular Ratio 'n'	=				
Short Term Factor	=				
Equiv. Solid Thick.	=				
Masonry Block Type =					
Concrete Data					
f'c	psi =		3,000.0	3,000.0	3,000.0
Fy	psi =		60,000.0	60,000.0	60,000.0

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel	
Factored Pressure	=	5,255	47	psf
Mu' : Upward	=	37,410	16,472	ft-#
Mu' : Downward	=	3,864	90,416	ft-#
Mu: Design	=	33,546	73,944	ft-#
Actual 1-Way Shear	=	31.39	59.69	psi
Allow 1-Way Shear	=	82.16	82.16	psi

Toe Reinforcing = # 5 @ 15.00 in
Heel Reinforcing = # 5 @ 14.00 in
Key Reinforcing = None Spec'd

Other Acceptable Sizes & Spacings
Toe: #4@ 4.75 in, #5@ 7.50 in, #6@ 10.50 in, #7@ 14.25 in, #8@ 18.75 in, #9@ 23.
Heel: #4@ 2.75 in, #5@ 4.25 in, #6@ 6.00 in, #7@ 8.00 in, #8@ 10.50 in, #9@ 13.25
Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	15,346.9	7.42	113,823.1
Toe Active Pressure	=	-234.4	0.92	-214.9
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	15,112.5	**O.T.M.** =	113,608.2

Resisting/Overturning Ratio = **2.04**

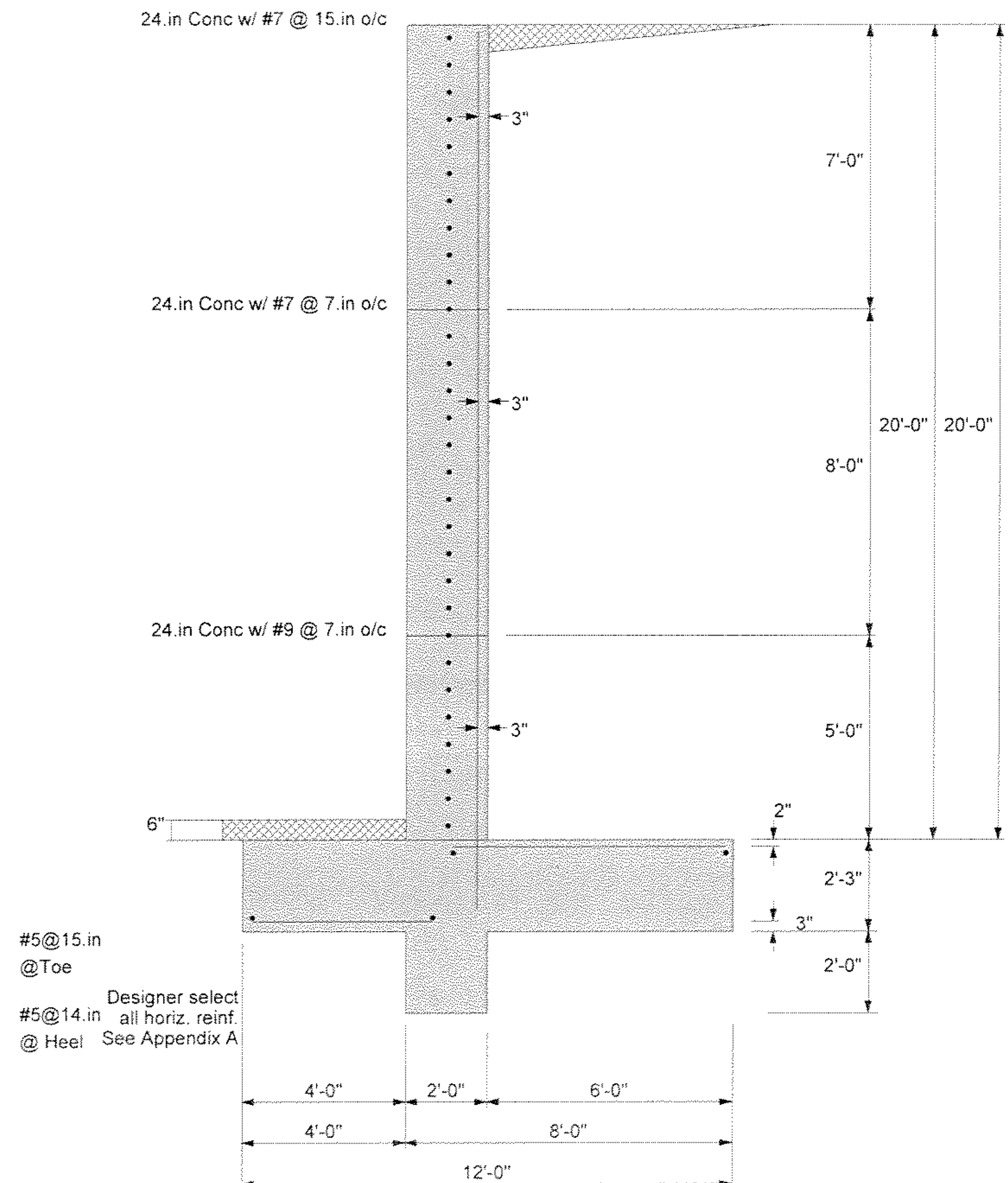
Vertical Loads used for Soil Pressure = 29,319.0 lbs

Vertical component of active pressure used for soil pressure

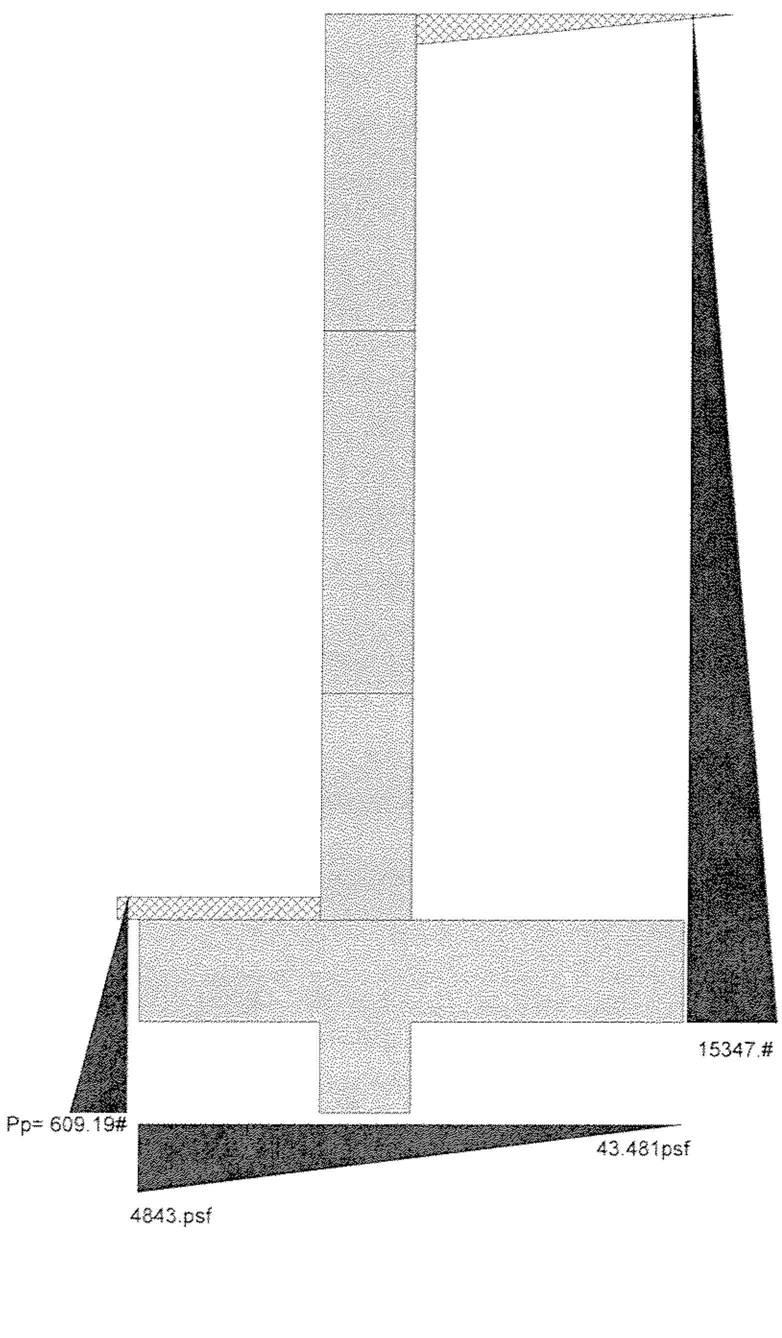
.....RESISTING.....

Item		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	15,600.0	9.00	140,400.0
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	260.0	2.00	520.0
Surcharge Over Toe	=			
Stem Weight(s)	=	6,000.0	5.00	30,000.0
Earth @ Stem Transitions	=			
Footing Weight	=	4,050.0	6.00	24,300.0
Key Weight	=	600.0	5.00	3,000.0
Vert. Component	=	2,809.0	12.00	33,707.6
Total =		29,319.0 lbs	**R.M.=**	231,927.6

DESIGNER NOTES:



24.in Conc w/ #7 @ 15.in o/c
24.in Conc w/ #7 @ 7.in o/c
24.in Conc w/ #9 @ 7.in o/c
3"
3"
3"
7'-0"
8'-0"
5'-0"
20'-0"
20'-0"
6"
2"
2'-3"
3"
2'-0"
#5@15.in
@Toe
#5@14.in
@ Heel
Designer select
all horiz. reinf.
See Appendix A
4'-0"
2'-0"
6'-0"
4'-0"
8'-0"
12'-0"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TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall 'D' H= 20' Equipment Load
Job # : E-05129 Dsgnr: JJF
Page: ______
Date: MAY 25,2005
Description....
Wall "D" Height (H) = 20'-0" withe Equipment Loads

This Wall in File: C:\Program Files\RP2005\los alamos rw.r|

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	20.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	6.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	5,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	46.0 psf/ft
Toe Active Pressure	=	46.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	4.00 ft
Heel Width	=	8.00
Total Footing Width	=	12.00
Footing Thickness	=	27.00 in
Key Width	=	24.00 in
Key Depth	=	24.00 in
Key Distance from Toe	=	4.00 ft
f'c = 4,000 psi	Fy =	60,000 psi
Footing Concrete Density	=	150.00 pcf
Min. As %	=	0.0018
Cover @ Top = 2.00 in	@ Btm.=	3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	2,000.0 lbs
Footing Width	=	8.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	6.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

*Design Summary

Wall Stability Ratios

Overturning	=	2.03 OK
Sliding	=	1.47 Ratio < 1.5!
Total Bearing Load	=	27,010 lbs
...resultant ecc.	=	26.22 in
Soil Pressure @ Toe	=	4,720 psf OK
Soil Pressure @ Heel	=	0 psf OK
Allowable	=	5,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	5,699 psf
ACI Factored @ Heel	=	0 psf
Footing Shear @ Toe	=	33.9 psi OK
Footing Shear @ Heel	=	46.8 psi OK
Allowable	=	94.9 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	12,366.4 lbs
less 100% Passive Force	= -	609.2 lbs
less 100% Friction Force	= -	17,556.5 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	383.9 lbs NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem	2nd	3rd
		Stem OK	Stem OK	Stem OK
Design Height Above Ftg	ft =	14.50	5.00	0.00
Wall Material Above "Ht"	=	Concrete	Concrete	Concrete
Thickness	=	24.00	24.00	24.00
Rebar Size	=	# 7	# 7	# 9
Rebar Spacing	=	15.00	7.50	7.50
Rebar Placed at	=	Edge	Edge	Edge
Design Data				
fb/FB + fa/Fa	=	**0.067**	**0.616**	**0.848**
Total Force @ Section	lbs =	1,649.3	9,875.3	16,504.0
Moment....Actual	ft-# =	2,966.1	53,400.5	118,668.4
Moment.....Allowable	ft-# =	44,340.5	86,641.9	139,872.0
Shear.....Actual	psi =	6.5	39.2	65.5
Shear.....Allowable	psi =	82.2	82.2	82.2
Wall Weight	psf =	300.0	300.0	300.0
Rebar Depth 'd'	in =	21.00	21.00	21.00
LAP SPLICE IF ABOVE	in =	37.38	37.38	48.06
LAP SPLICE IF BELOW	in =	37.38	37.38	
HOOK EMBED INTO FTG	in =			14.94
Masonry Data				
f'm	psi =			
Fs	psi =			
Solid Grouting	=			
Special Inspection	=			
Modular Ratio 'n'	=			
Short Term Factor	=			
Equiv. Solid Thick.	=			
Masonry Block Type =				
Concrete Data				
f'c	psi =	3,000.0	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0	60,000.0

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall 'D' H= 20' Equipment Load
Job # : E-05129 Dsgnr: JJF
Page: ______
Date: MAY 25,2005
Description....
Wall "D" Height (H) = 20'-0" withe Equipment Loads

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

Retain Pro 2005 , 7-April-2005, (c) 1989-2005
www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	5,699	0 psf
Mu' : Upward	=	40,283	13,392 ft-#
Mu' : Downward	=	3,864	63,450 ft-#
Mu: Design	=	36,419	50,058 ft-#
Actual 1-Way Shear	=	33.90	46.84 psi
Allow 1-Way Shear	=	94.87	94.87 psi

Toe Reinforcing = # 9 @ 9.00 in
Heel Reinforcing = # 9 @ 12.00 in
Key Reinforcing = # 7 @ 16.00 in

Other Acceptable Sizes & Spacings
Toe: #4@ 4.75 in, #5@ 7.50 in, #6@ 10.50 in, #7@ 14.25 in, #8@ 18.75 in, #9@ 23.
Heel: #4@ 4.00 in, #5@ 6.25 in, #6@ 8.75 in, #7@ 12.00 in, #8@ 15.50 in, #9@ 19.7
Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	11,386.4	7.42	84,449.4
Toe Active Pressure	=	-173.9	0.92	-159.4
Surcharge Over Toe	=			
Adjacent Footing Load	=	1,153.9	13.34	15,396.6
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	12,366.4	**O.T.M.** =	99,686.5

Resisting/Overturning Ratio = **2.03**

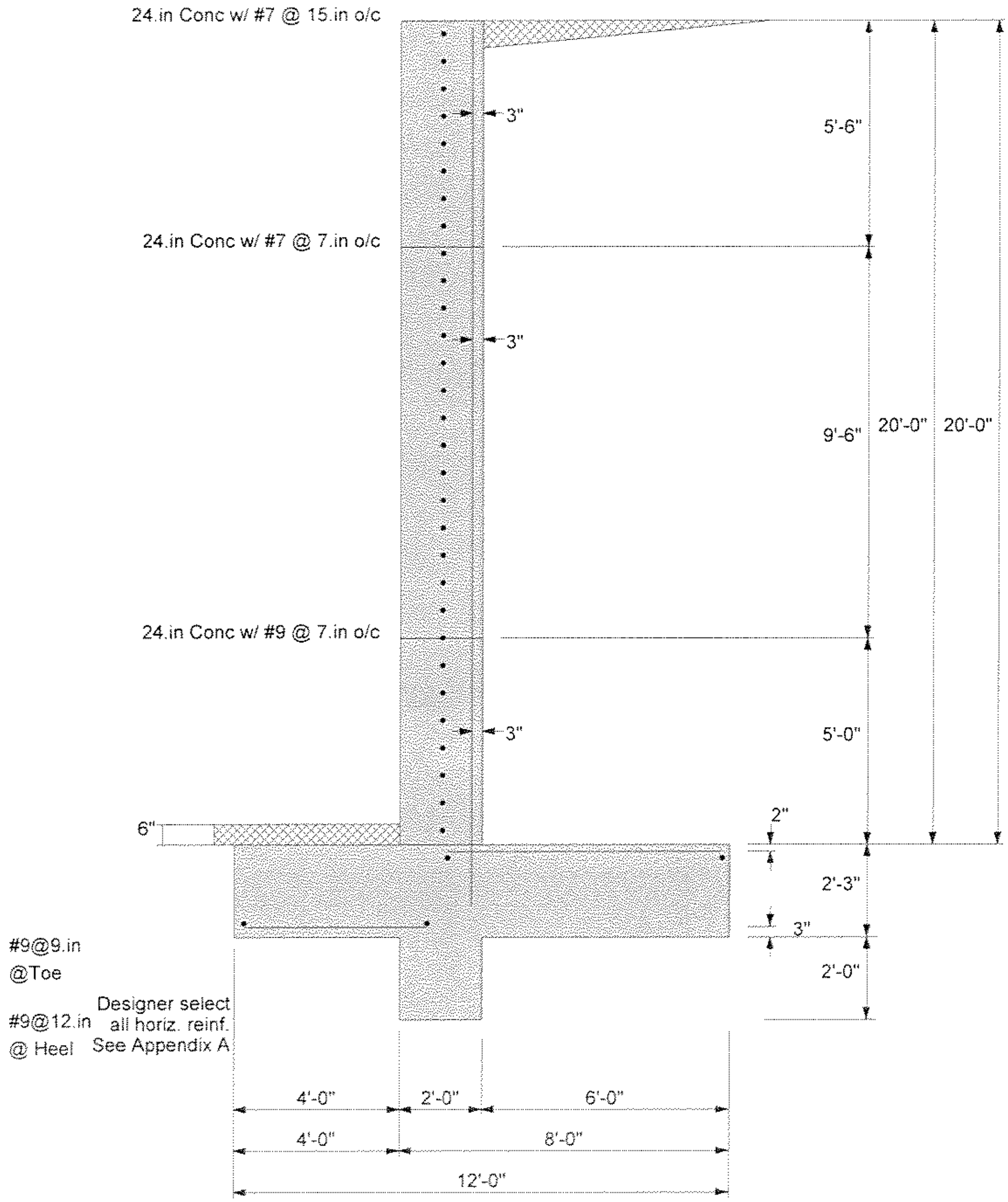
Vertical Loads used for Soil Pressure = 27,010.0 lbs

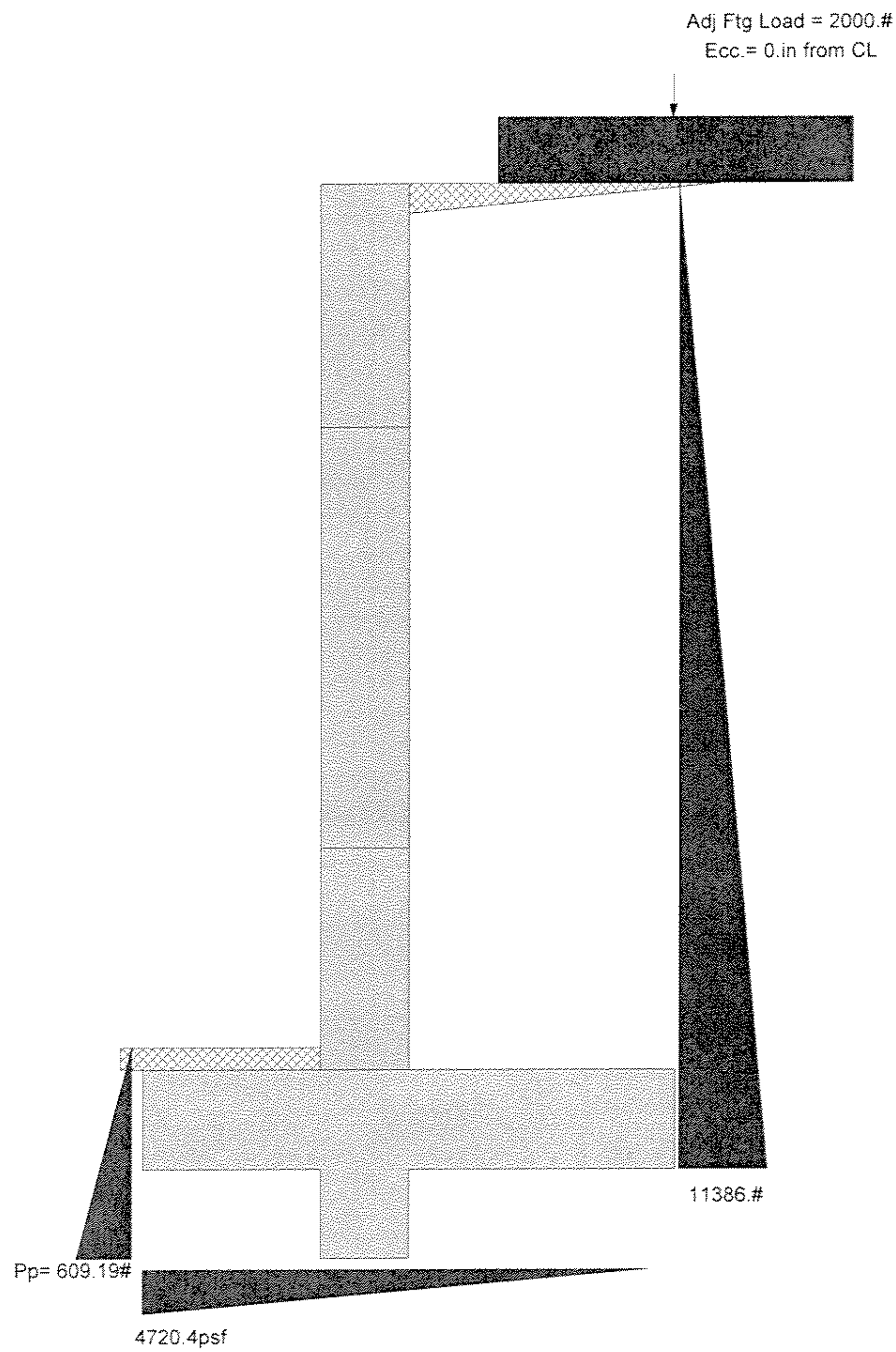
Vertical component of active pressure NOT used for soil pressure

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	15,600.0	9.00	140,400.0
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=	500.0	9.00	4,500.0
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=	260.0	2.00	520.0
Surcharge Over Toe	=			
Stem Weight(s)	=	6,000.0	5.00	30,000.0
Earth @ Stem Transitions	=			
Footing Weight	=	4,050.0	6.00	24,300.0
Key Weight	=	600.0	5.00	3,000.0
Vert. Component	=			
Total =		27,010.0 lbs	**R.M.**=	202,720.0

DESIGNER NOTES:


24.in Conc w/ #7 @ 15.in o/c
24.in Conc w/ #7 @ 7.in o/c
24.in Conc w/ #9 @ 7.in o/c
3"
3"
3"
5'-6"
9'-6"
5'-0"
20'-0"
20'-0"
6"
2"
2'-3"
3"
2'-0"
#9@9.in
@Toe
#9@12.in
@ Heel
Designer select
all horiz. reinf.
See Appendix A
4'-0"
2'-0"
6'-0"
4'-0"
8'-0"
12'-0"



Adj Ftg Load = 2000.#
Ecc.= 0.in from CL
11386.#
Pp= 609.19#
4720.4psf

WALL Mark 'D' Seismic Loads

Definitions:

B = Width of Toe (feet)
C = Width of Heel (feet)
W = Width of Base (feet)
h wall = Height of Wall over base (feet)
t_{base} = thickness of Base (feet)
t_{stem} = Thickness of Stem (feet)
γ = density of backfill (pcf)
$\gamma_{concrete}$ density = 150 pcf
EFP_{static} = Design equivalent fluid pressure (pcf), static condition.
EFP_{AE} = Design equivalent fluid pressure (pcf), Active Earth pressure under seismic conditions..
ϕ = Internial angle of friction of the soil.
δ = Friction angle of soil to concrete wall.
K_h = Alternate seismic force developed from the Geotechnical Calculations page 12 in Appendix 'B'

Wall Mk. 'D' Data:

$B := 4.0$ (feet) $h_{wall} := 20.0$ (feet) $t_{stem} := 2.00$ (feet)

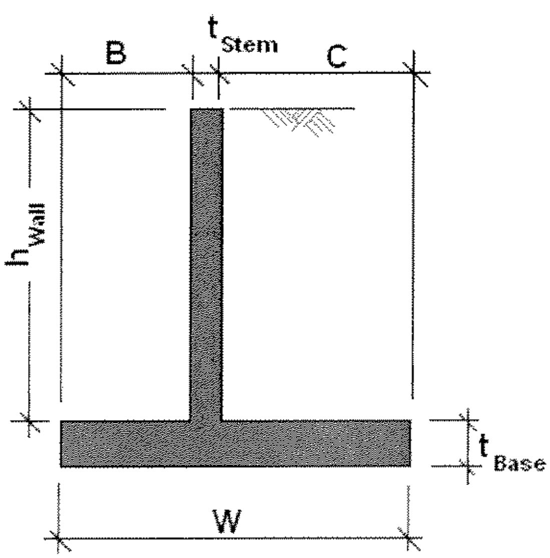
$C := 6.0$ (feet) $W := 12$ (feet) $t_{base} := 2.25$ (feet)

Soil Data: $\gamma := 130$ (pcf) $\delta := 22 \cdot deg$ $\phi := 32 \cdot deg$

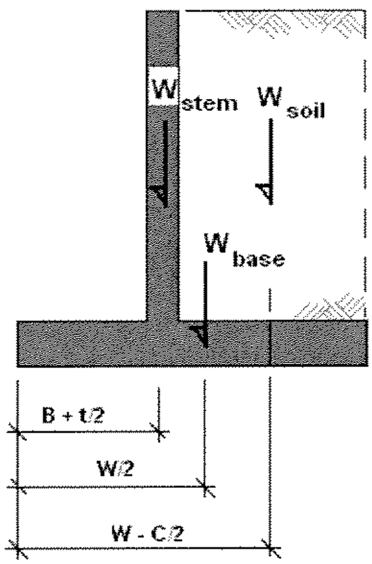
$EFP_{static} := 46$ (pcf)

$EFP_{AE} := 62$ (pcf)

$K_h := 0.09$



WALL STABILITY ANALYSIS



Stabilizing Forces

Weights: (kips.per foot)

$W_{stem} := (0.150)\cdot h_{wall}\cdot t_{stem}$ $W_{stem} = 6.000$

$W_{base} := (0.150)\cdot W\cdot t_{base}$ $W_{base} = 4.05$

$W_{soil} := \dfrac{\gamma\cdot h_{wall}\cdot C}{1000}$ $W_{soil} = 15.6$

$H := h_{wall} + t_{base}$ $H = 22.25$ (feet)

Driving Forces:

$P_{ST} := \dfrac{(EFP_{static})\cdot\frac{1}{2}\cdot(H)^2}{1000}$ $P_{ST} = 11.386$ (kips)

$P_{SE} := \dfrac{(EFP_{AE})\cdot\frac{1}{2}\cdot(H)^2}{1000}$ $P_{SE} = 15.347$ (kips)

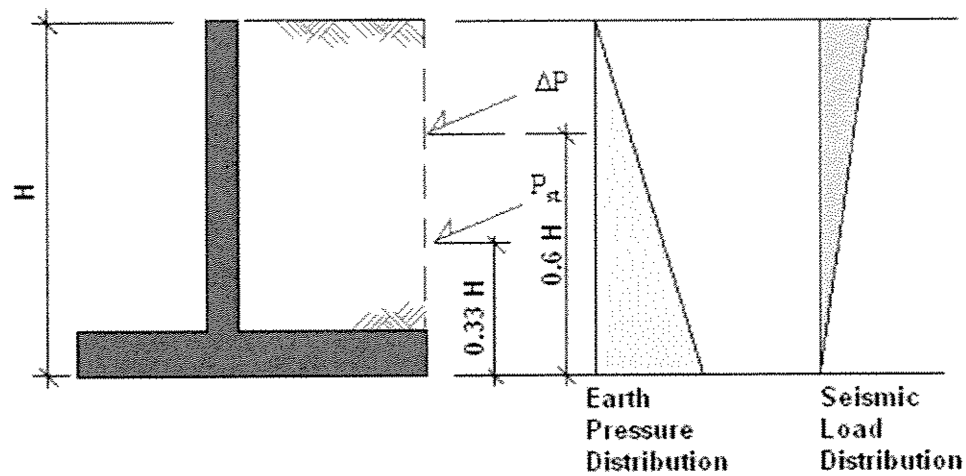
$\Delta P_1 := P_{SE} - P_{ST}$ $\Delta P_1 = 3.96$ (kips)

$\Delta P_2 := \dfrac{K_h\cdot\gamma\cdot(H)^2}{1000}$ $\Delta P_2 = 5.792$ (kips)

The larger value of either ΔP_1 or ΔP_2 is to be used in the seismic analysis

Let: $\Delta := \begin{pmatrix}\Delta P_1\\ \Delta P_2\end{pmatrix}$ $\Delta P := \max(\Delta)$ $\Delta P = 5.792$ (kips)

Driving Forces and Moments about the Toe:



Horizontal Driving Force (**HDF**) is the sum of P_{st} and ΔP in the horizontal direction:

$HDF := (P_{ST} + \Delta P)\cdot\cos(\delta)$ $\qquad$ $HDF = 15.928$ $\qquad$ (kips)

Driving Moment ($\mathbf{M_d}$) is the sum of the driving moments about the Toe.

$M_d := (P_{ST}\cdot 0.333\cdot H)\cdot\cos(\delta) + (\Delta P\cdot 0.6\cdot H)\cdot\cos(\delta)$ $\qquad$ $M_d = 149.918$ $\qquad$ (ft-kips)

Resisting Forces and Moments about the Toe:

Resisting Forces (**RF**) neglecting passive pressure, a conservative analysis:

$RF := \tan(\phi)(W_{stem} + W_{base} + W_{soil} + P_{ST}\cdot\sin(\delta) + \Delta P\cdot\sin(\delta))$

$RF = 20.049$ $\qquad$ (kips)

"Factor of Safety" against sliding is the ratio of **RF** to **HDF**

$Ratio_{sliding} := \frac{RF}{HDF}$ $\qquad$ $Ratio_{sliding} = 1.259$

Resisting Moments about the Toe M_r :

$$M_r := W_{stem} \cdot (B + t_{stem}) + W_{base} \cdot \left(\frac{W}{2}\right) + W_{soil} \cdot \left(W - \frac{C}{2}\right) + (P_{ST} + \Delta P) \cdot W \cdot \sin(\delta)$$

$M_r = 277.923$ (ft-kips)

"Factor of Safety" against overturning the ratio of $\mathbf{M_r}$ to $\mathbf{M_d}$

$Ratio_{OT} := \frac{M_r}{M_d}$ $\quad$ $Ratio_{OT} = 1.854$

Calculate Soil Bearing Pressurs:

Net Moment: $\Delta M := M_r - M_d$ $\quad$ $\Delta M = 128.005$ (ft-kips)

$$X := \frac{\Delta M}{(W_{stem} + W_{base} + W_{soil} + P_{ST} \cdot \sin(\delta) + \Delta P \cdot \sin(\delta))}$$ $X = 3.99$ (feet)

$$R := (W_{stem} + W_{base} + W_{soil} + P_{ST} \cdot \sin(\delta) + \Delta P \cdot \sin(\delta))$$ $R = 32.085$ (kips)

Eccentricity (e): $e := \frac{W}{2} - X$ $\quad$ $e = 2.01$ (feet) $\quad$ $\frac{W}{6} = 2$ (feet)

Eccentricity := | "OK Within Middle Third" if $e \le \frac{W}{6}$
| "Non in Middle one-third" otherwise

Eccentricity = "Non in Middle one-third"

$$SP_2 := \frac{2R}{3 \cdot (1.0) \cdot \left(\frac{W}{2} - e\right)}$$ $SP_2 = 5.362$ $\quad$ Maximum Soil Pearing Pressure (kips/ft^2)

$SP_1 := 0.0$ $\quad$ $SP_1 = 0$ $\quad$ Minimum Soil Pearing Pressure (kips/ft^2)

Effective Soil Bearing Width (W') :

$W' := 3 \cdot \left(\frac{W}{2} - e\right)$ $\quad$ $W' = 11.969$

Concrete Design:

The design on the concrete elements will be in accordance with ACI 318-02.

See Section 9.2 of ACI 319-02

$U_{DL} := 1.2 \qquad U_H := 1.6 \qquad U_E := 1.0$

$$R_{ult} := \left(U_{DL} \cdot W_{stem} + U_{DL} \cdot W_{base} + U_E \cdot W_{soil} + U_E \cdot P_{ST} \cdot \sin(\delta) + U_E \cdot \Delta P \cdot \sin(\delta)\right)$$

$$M_{d\_ult} := U_E \cdot \left[\left(P_{ST} \cdot 0.333 \cdot H\right) \cdot \cos(\delta) + \left(\Delta P \cdot 0.6 \cdot H\right) \cdot \cos(\delta)\right]$$

$$M_{r\_ult\_1} := U_{DL} \cdot W_{stem} \cdot \left(B + t_{stem}\right) + U_{DL} \cdot W_{base} \cdot \left(\frac{W}{2}\right) + U_{DL} \cdot W_{soil} \cdot \left(W - \frac{C}{2}\right)$$

$$M_{r\_ult\_2} := U_{DL} \cdot \left[\left(P_{ST} + \Delta P\right) \cdot W \cdot \sin(\delta)\right]$$

$$M_{r\_ult} := M_{r\_ult\_1} + M_{r\_ult\_2}$$

Net Ultimate Moment: $\Delta M_{ult} := M_{r\_ult} - M_{d\_ult}$ $\qquad \Delta M_{ult} = 183.59$ (ft-kips)

$X_{ult} := \dfrac{\Delta M_{ult}}{\left(R_{ult}\right)}$ $\qquad X_{ult} = 5.385$ (feet)

$R_{ult} = 34.095$ (kips)

Eccentricity (e): $e_{ult} := \dfrac{W}{2} - X_{ult}$ $\qquad e_{ult} = 0.615$ (feet) $\qquad \dfrac{W}{6} = 2$ (feet)

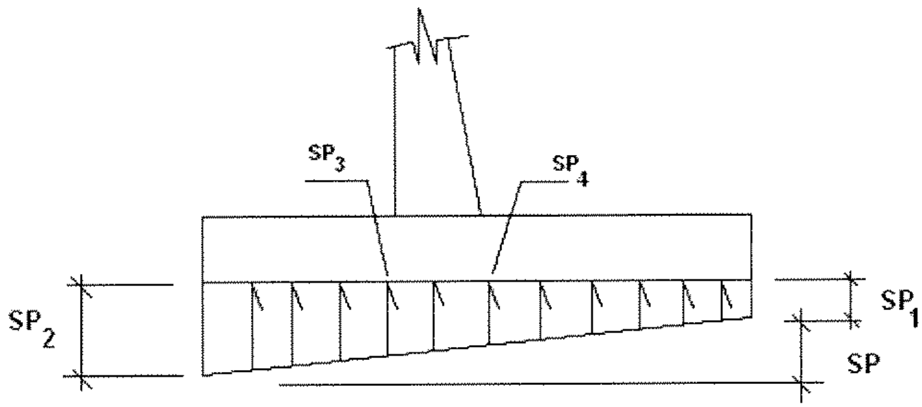
Eccentricity := | "OK Within Middle Third" if $e_{ult} \le \dfrac{W}{6}$
| "Non in Middle one-third" otherwise

Eccentricity = "OK Within Middle Third"

$SP2_{\_ult} := \dfrac{R_{ult}}{W} \cdot \left(1 + \dfrac{e_{ult}}{W}\right)$ $\qquad SP2_{\_ult} = 2.987$ Maximum Soil Pearing Pressure (kips/ft^2)

$SP_{1\_ult} := \frac{R_{ult}}{W} \cdot \left(1 - \frac{e_{ult}}{W}\right)$ $SP_{1\_ult} = 2.696$ Minimum Soil Pearing Pressure (kips/ft²)

$\Delta SP_{ult} := SP_{2\_ult} - SP_{1\_ult}$ $\Delta SP_{ult} = 0.291$ (kips/ft²)



Pressure Diagram - Toe & Heel

Soil Pressure at Front Face of Stem:

$SP_{3\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W} \cdot (B)$ $SP_{3\_ult} = 2.89$ (ksf)

Soil Pressure at Rear Face of Stem:

$SP_{4\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W} \cdot (B + t_{stem})$ $SP_{4\_ult} = 2.841$ (ksf)

Moment at Front Face of Stem:

$$M_{toe} := SP_{3\_ult} \cdot \frac{B^2}{2} + (SP_{2\_ult} - SP_{3\_ult}) \cdot \frac{(B)}{2} \cdot \left(\frac{2}{3}\right) \cdot B - U_{DL} \cdot (0.150) \cdot t_{base} \cdot \left(\frac{B^2}{2}\right)$$

$M_{toe} = 20.397$ (ft-kips)

Concrete Data:

$f'_c := 3$ ksi $\quad f_y := 60$ ksi $\quad M_u := M_{toe}$ ft-kips

$b := 12$ inches $\quad d := (12)\cdot t_{base} - 4 \quad d = 23$ inches $\quad \phi_f := 0.90$

A_s calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7\cdot f'_c\cdot b\cdot d}{2\cdot f_y} - \frac{1}{2}\cdot\sqrt{\frac{2.89\cdot(f'_c\cdot b\cdot d)^2}{(f_y)^2} - \frac{6.8\cdot f'_c\cdot b\cdot M_u\cdot 12}{\phi_f\cdot(f_y)^2}}$$

$A_{s\_required} = 0.199$ Inches² $\quad \rho := \frac{A_{s\_required}}{12\cdot d} \quad \rho = 0.0007$

Shear in Toe:

Soil Pressure at d from front face:

$$SP_{31\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W}\cdot\left(B - \frac{d}{12}\right) \qquad SP_{31\_ult} = 2.936 \quad \text{(ksf)}$$

$$V_{toe} := SP_{31\_ult}\cdot\left(B - \frac{d}{12}\right) + \left(SP_{2\_ult} - SP_{31\_ult}\right)\cdot\left(\frac{1}{2}\right)\cdot\left(B - \frac{d}{12}\right)$$

$V_{toe} = 6.17$ (kips/foot)

$$\phi V_n := \frac{0.75\cdot 12\cdot d\cdot(2)\cdot\sqrt{f'_c\cdot 1000}}{1000} \qquad \phi V_n = 22.676 \quad \text{(kips/foot)}$$

Moment at Rear Face of Stem in the Heel:

$$M_{heel} := SP_{1\_ult}\cdot\frac{C^2}{2} + \left(SP_{4\_ult} - SP_{1\_ult}\right)\cdot\frac{(C)}{2}\cdot\left(\frac{1}{3}\right)\cdot C - U_{DL}\cdot(0.150)\cdot t_{base}\cdot\left(\frac{C^2}{2}\right)$$

$M_{heel} = 42.104$ (ft-kips) $\quad$ Let: $\quad M_u := M_{heel}$

$\mathbf{A_s}$ calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7 \cdot f'_c \cdot b \cdot d}{2 \cdot f_y} - \frac{1}{2} \cdot \sqrt{\frac{2.89 \cdot (f'_c \cdot b \cdot d)^2}{(f_y)^2} - \frac{6.8 \cdot f'_c \cdot b \cdot M_u \cdot 12}{\phi_f \cdot (f_y)^2}}$$

$A_{s\_required} = 0.414$ Inches² $\rho := \frac{A_{s\_required}}{12 \cdot d}$ $\rho = 0.0015$

Shear in Hell:

Soil Pressure at d from front rear face of stem:

$$SP_{41\_ult} := SP_{1\_ult} + \frac{\Delta SP_{ult}}{W} \cdot \left(C - \frac{d}{12}\right)$$ $SP_{41\_ult} = 2.795$ (ksf)

$$V_{heel} := SP_{1\_ult} \cdot \left(C - \frac{d}{12}\right) + (SP_{41\_ult} - SP_{1\_ult}) \cdot \left(\frac{1}{2}\right) \cdot \left(C - \frac{d}{12}\right)$$

$V_{heel} = 11.209$ (kips/foot)

$$\phi V_n := \frac{0.75 \cdot 12 \cdot d \cdot (2) \cdot \sqrt{f'_c \cdot 1000}}{1000}$$ $\phi V_n = 22.676$ (kips/foot)

Moments in Stem:

Driving Forces:

$$P_{ST} := \frac{(EFP_{static}) \cdot \frac{1}{2} \cdot (h_{wall})^2}{1000}$$ $P_{ST} = 9.2$ (kips)

$$P_{SE} := \frac{(EFP_{AE}) \cdot \frac{1}{2} \cdot (h_{wall})^2}{1000}$$ $P_{SE} = 12.4$ (kips)

$\Delta P_1 := P_{SE} - P_{ST}$ $\Delta P_1 = 3.2$ (kips)

$\Delta P_2 := \dfrac{K_h \cdot \gamma \cdot (h_{wall})^2}{1000}$ $\quad \Delta P_2 = 4.68 \quad$ (kips)

The larger value of either ΔP_1 or ΔP_2 is to be used in the seismic analysis

Let: $\Delta := \begin{pmatrix} \Delta P_1 \\ \Delta P_2 \end{pmatrix}$ $\quad \Delta P := \max(\Delta) \quad \Delta P = 4.68 \quad$ (kips)

$M_{stem} := U_E \cdot [(P_{ST} \cdot \cos(\delta) \cdot 0.333 h_{wall}) + (\Delta P \cdot 0.600 \cdot h_{wall})]$

$M_{stem} = 112.97$ (ft-kips) Let: $M_u := M_{stem}$ $\quad d := (12) \cdot t_{stem} - 3.0$

$d = 21$ (inches)

$\mathbf{A_s}$ calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7 \cdot f'_c \cdot b \cdot d}{2 \cdot f_y} - \frac{1}{2} \cdot \sqrt{\frac{2.89 \cdot (f'_c \cdot b \cdot d)^2}{(f_y)^2} - \frac{6.8 \cdot f'_c \cdot b \cdot M_u \cdot 12}{\phi_f \cdot (f_y)^2}}$$

$A_{s\_required} = 1.271$ Inches² $\quad \rho := \dfrac{A_{s\_required}}{12 \cdot d} \quad \rho = 0.0050$

WALL MK. 'E'

Loading Case	Overturning Ratio	Sliding Ratio	Maximum Soil Bearing Pressure	Controlling Case for Strength Design	Remarks
Normal	2.70	1.40	4181		
Seismic 1	2.21	1.15	4700		
Compaction Equipment	2.27	1.46	4520	X	
Seismic 2	2.41	1.26	3380		

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall "E" H = 24' Normal
Job # : E-05129 Dsgnr: JJF
Page: ______
Date: MAY 24,2005
Description....
Wall "E" Height 'H' = 24'-0" Normal loads EFP = 51pcf

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	24.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	0.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	4,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	51.0 psf/ft
Toe Active Pressure	=	51.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	5.50 ft
Heel Width	=	9.50
Total Footing Width	=	15.00
Footing Thickness	=	27.00 in
Key Width	=	30.00 in
Key Depth	=	24.00 in
Key Distance from Toe	=	5.50 ft
f'c = 3,000 psi	Fy =	60,000 psi
Footing Concrete Density	=	150.00 pcf
Min. As %	=	0.0018
Cover @ Top = 2.00 in	@ Btm.=	3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.70 OK
Sliding	=	1.39 Ratio < 1.5!
Total Bearing Load	=	40,689 lbs
...resultant ecc.	=	12.78 in
Soil Pressure @ Toe	=	3,868 psf OK
Soil Pressure @ Heel	=	1,557 psf OK
Allowable	=	4,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	4,181 psf
ACI Factored @ Heel	=	1,683 psf
Footing Shear @ Toe	=	43.7 psi OK
Footing Shear @ Heel	=	66.8 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	17,442.0 lbs
less 100% Passive Force	= -	487.7 lbs
less 100% Friction Force	= -	13,824.1 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	1,851.2 lbs NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

			Top Stem	2nd	3rd	4th
			Stem OK	Stem OK	Stem OK	Stem OK
Design Height Above Ftg	ft	=	20.00	13.00	5.00	0.00
Wall Material Above "Ht"		=	Concrete	Concrete	Concrete	Concrete
Thickness		=	30.00	30.00	30.00	30.00
Rebar Size		=	# 5	# 5	# 7	# 9
Rebar Spacing		=	12.00	6.00	6.00	6.00
Rebar Placed at		=	Edge	Edge	Edge	Edge
Design Data						
fb/FB + fa/Fa		=	**0.023**	**0.246**	**0.669**	**0.820**
Total Force @ Section	lbs	=	652.8	4,936.8	14,728.8	23,500.8
Moment....Actual	ft-#	=	870.4	18,101.6	93,282.4	188,006.4
Moment.....Allowable	ft-#	=	37,239.8	73,629.0	139,428.0	229,237.5
Shear.....Actual	psi	=	2.0	15.2	45.5	71.4
Shear.....Allowable	psi	=	82.2	82.2	82.2	82.2
Wall Weight	psf	=	375.0	375.0	375.0	375.0
Rebar Depth 'd'	in	=	27.00	27.00	27.00	27.44
LAP SPLICE IF ABOVE	in	=	21.36	21.36	37.38	48.06
LAP SPLICE IF BELOW	in	=	21.36	21.36	37.38	
HOOK EMBED INTO FTG	in	=				17.25
Masonry Data						
f'm	psi	=				
Fs	psi	=				
Solid Grouting		=				
Special Inspection		=				
Modular Ratio 'n'		=				
Short Term Factor		=				
Equiv. Solid Thick.		=				
Masonry Block Type		=				
Concrete Data						
f'c	psi	=	3,000.0	3,000.0	3,000.0	3,000.0
Fy	psi	=	60,000.0	60,000.0	60,000.0	60,000.0

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	4,181	1,683 psf
Mu' : Upward	=	58,621	50,761 ft-#
Mu' : Downward	=	6,126	146,865 ft-#
Mu: Design	=	52,496	96,104 ft-#
Actual 1-Way Shear	=	43.72	66.80 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 9 @ 12.00 in	
Heel Reinforcing	=	# 9 @ 12.25 in	
Key Reinforcing	=	# 7 @ 12.50 in	

Other Acceptable Sizes & Spacings
Toe: #4@ 3.75 in, #5@ 5.75 in, #6@ 8.00 in, #7@ 10.75 in, #8@ 14.25 in, #9@ 18.0
Heel: #4@ 2.50 in, #5@ 4.00 in, #6@ 5.50 in, #7@ 7.50 in, #8@ 9.75 in, #9@ 12.25
Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	17,571.1	8.75	153,747.1
Toe Active Pressure	=	-129.1	0.75	-96.8
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	17,442.0	**O.T.M.** =	153,650.3

Resisting/Overturning Ratio = **2.70**

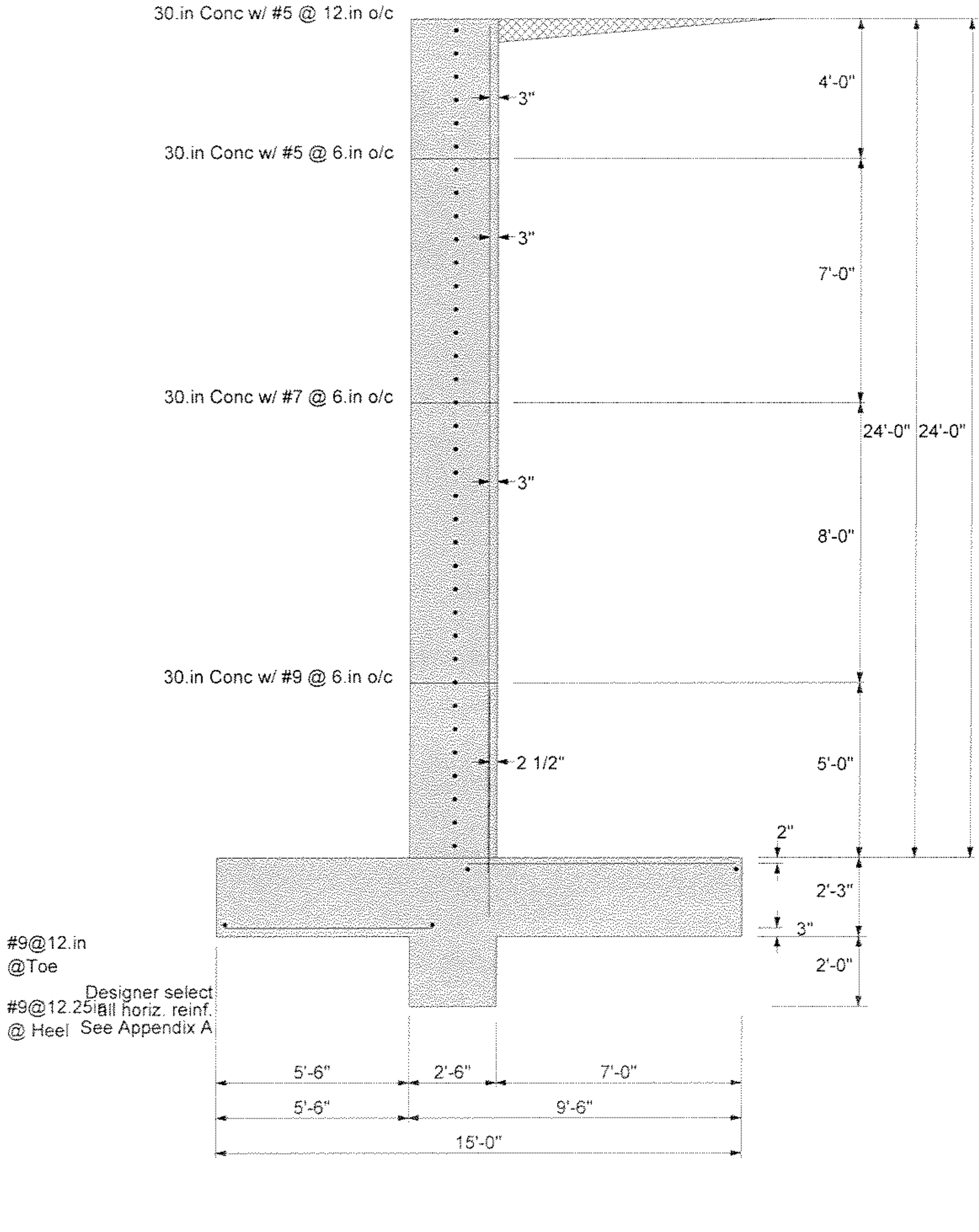
Vertical Loads used for Soil Pressure = 40,689.5 lbs

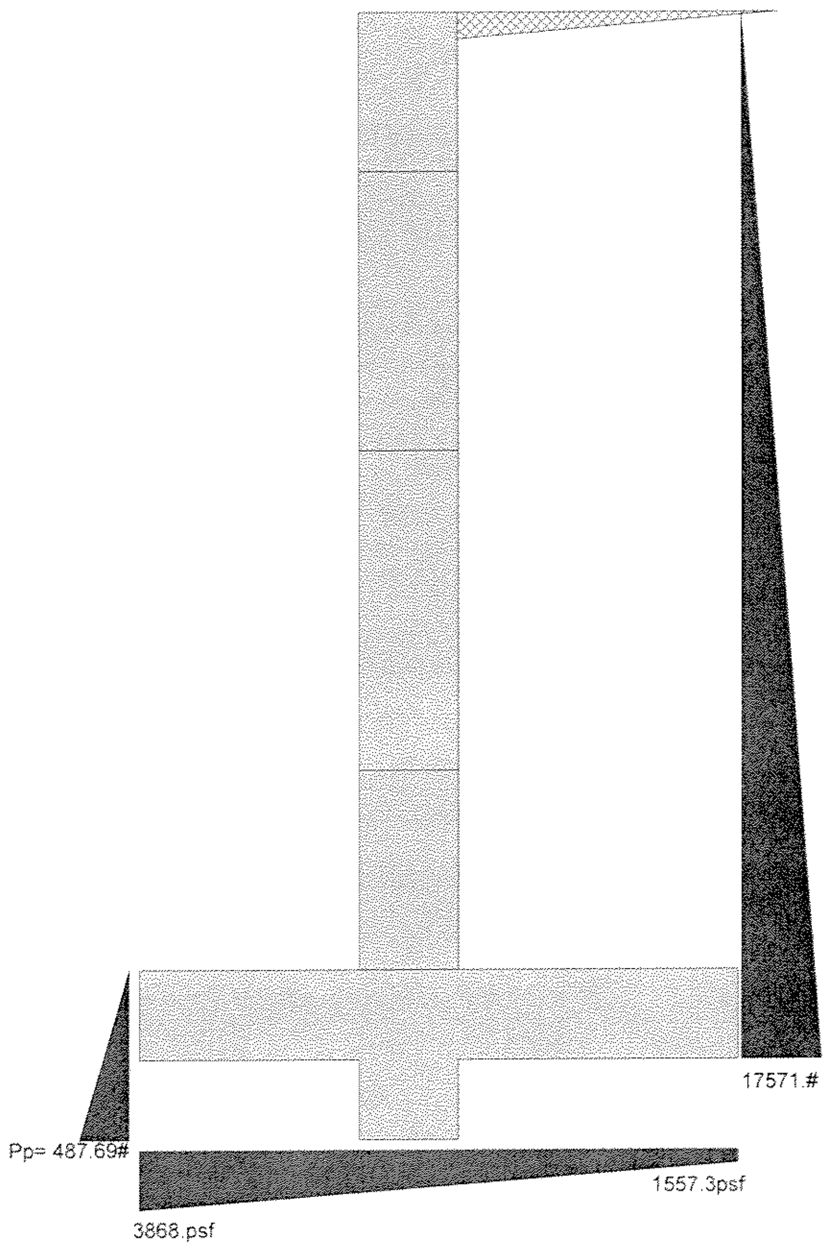
Vertical component of active pressure used for soil pressure

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	21,840.0	11.50	251,160.0
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=			
Surcharge Over Toe	=			
Stem Weight(s)	=	9,000.0	6.75	60,750.0
Earth @ Stem Transitions	=			
Footing Weight	=	5,062.5	7.50	37,968.8
Key Weight	=	750.0	6.75	5,062.5
Vert. Component	=	4,037.0	15.00	60,554.9
Total =		40,689.5 lbs	**R.M.**=	415,496.2

DESIGNER NOTES:


30.in Conc w/ #5 @ 12.in o/c
30.in Conc w/ #5 @ 6.in o/c
30.in Conc w/ #7 @ 6.in o/c
30.in Conc w/ #9 @ 6.in o/c
3"
3"
3"
2 1/2"
4'-0"
7'-0"
8'-0"
5'-0"
24'-0"
24'-0"
2"
2'-3"
3"
2'-0"
#9@12.in
@Toe
#9@12.25in
@ Heel
Designer select
all horiz. reinf.
See Appendix A
5'-6"
2'-6"
7'-0"
5'-6"
9'-6"
15'-0"



17571.#
Pp= 487.69#
1557.3psf
3868.psf

TCPI
436 Creamery Way, Suite 100
Exton, Pa 19341
Los Alamos Retaining Wall No. 1

Title : Wall 'E' H= 24 Seismic
Job # : E-05129 Dsgnr: JJF
Page: ______
Date: MAY 25,2005
Description....
Wall "E" Height (H) = 24'-0" Seismic EFP = 62 pcf

This Wall in File: C:\Program Files\RP2005\los alamos rw.r

Retain Pro 2005 , 7-April-2005, (c) 1989-2005
www.retainpro.com/support for latest release
Registration # : RP-1141385 2005001

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	24.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	0.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	5,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	62.0 psf/ft
Toe Active Pressure	=	62.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	5.50 ft
Heel Width	=	9.50
Total Footing Width	=	15.00
Footing Thickness	=	27.00 in
Key Width	=	30.00 in
Key Depth	=	24.00 in
Key Distance from Toe	=	5.50 ft
f'c = 3,000 psi	Fy =	60,000 psi
Footing Concrete Density	=	150.00 pcf
Min. As %	=	0.0018
Cover @ Top = 2.00 in	@ Btm.=	3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.21 OK
Sliding	=	1.15 Ratio < 1.5!
Total Bearing Load	=	40,562 lbs
...resultant ecc.	=	22.90 in
Soil Pressure @ Toe	=	4,769 psf OK
Soil Pressure @ Heel	=	640 psf OK
Allowable	=	5,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	5,171 psf
ACI Factored @ Heel	=	694 psf
Footing Shear @ Toe	=	53.2 psi OK
Footing Shear @ Heel	=	78.7 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	21,204.0 lbs
less 100% Passive Force	= -	487.7 lbs
less 100% Friction Force	= -	13,824.1 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	7,494.2 lbs NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.400
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem	2nd	3rd	4th
		Stem OK	Stem OK	Stem OK	Stem OK
Design Height Above Ftg	ft =	20.00	13.00	5.00	0.00
Wall Material Above "Ht"	=	Concrete	Concrete	Concrete	Concrete
Thickness	=	30.00	30.00	30.00	30.00
Rebar Size	=	# 5	# 5	# 7	# 9
Rebar Spacing	=	12.00	6.00	6.00	6.00
Rebar Placed at	=	Edge	Edge	Edge	Edge
Design Data					
fb/FB + fa/Fa	=	**0.025**	**0.262**	**0.712**	**0.872**
Total Force @ Section	lbs =	694.4	5,251.4	15,667.4	24,998.4
Moment....Actual	ft-# =	925.9	19,255.1	99,226.9	199,987.2
Moment.....Allowable	ft-# =	37,239.8	73,629.0	139,428.0	229,237.5
Shear.....Actual	psi =	2.1	16.2	48.4	75.9
Shear.....Allowable	psi =	82.2	82.2	82.2	82.2
Wall Weight	psf =	375.0	375.0	375.0	375.0
Rebar Depth 'd'	in =	27.00	27.00	27.00	27.44
LAP SPLICE IF ABOVE	in =	21.36	21.36	37.38	48.06
LAP SPLICE IF BELOW	in =	21.36	21.36	37.38	
HOOK EMBED INTO FTG	in =				17.25
Masonry Data					
f'm	psi =				
Fs	psi =				
Solid Grouting	=				
Special Inspection	=				
Modular Ratio 'n'	=				
Short Term Factor	=				
Equiv. Solid Thick.	=				
Masonry Block Type =					
Concrete Data					
f'c	psi =	3,000.0	3,000.0	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0	60,000.0	60,000.0

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	5,171	694 psf
Mu' : Upward	=	69,932	34,056 ft-#
Mu' : Downward	=	6,126	145,439 ft-#
Mu: Design	=	63,807	111,384 ft-#
Actual 1-Way Shear	=	53.22	78.68 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 9 @ 12.00 in	
Heel Reinforcing	=	# 9 @ 12.25 in	
Key Reinforcing	=	# 7 @ 12.50 in	

Other Acceptable Sizes & Spacings
Toe: #4@ 3.00 in, #5@ 4.75 in, #6@ 6.50 in, #7@ 8.75 in, #8@ 11.75 in, #9@ 14.75
Heel: #4@ 2.50 in, #5@ 3.75 in, #6@ 5.25 in, #7@ 7.00 in, #8@ 9.00 in, #9@ 11.50
Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	21,360.9	8.75	186,908.2
Toe Active Pressure	=	-156.9	0.75	-117.7
Surcharge Over Toe	=			
Adjacent Footing Load	=			
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	21,204.0	**O.T.M.** =	186,790.5

Resisting/Overturning Ratio = **2.21**

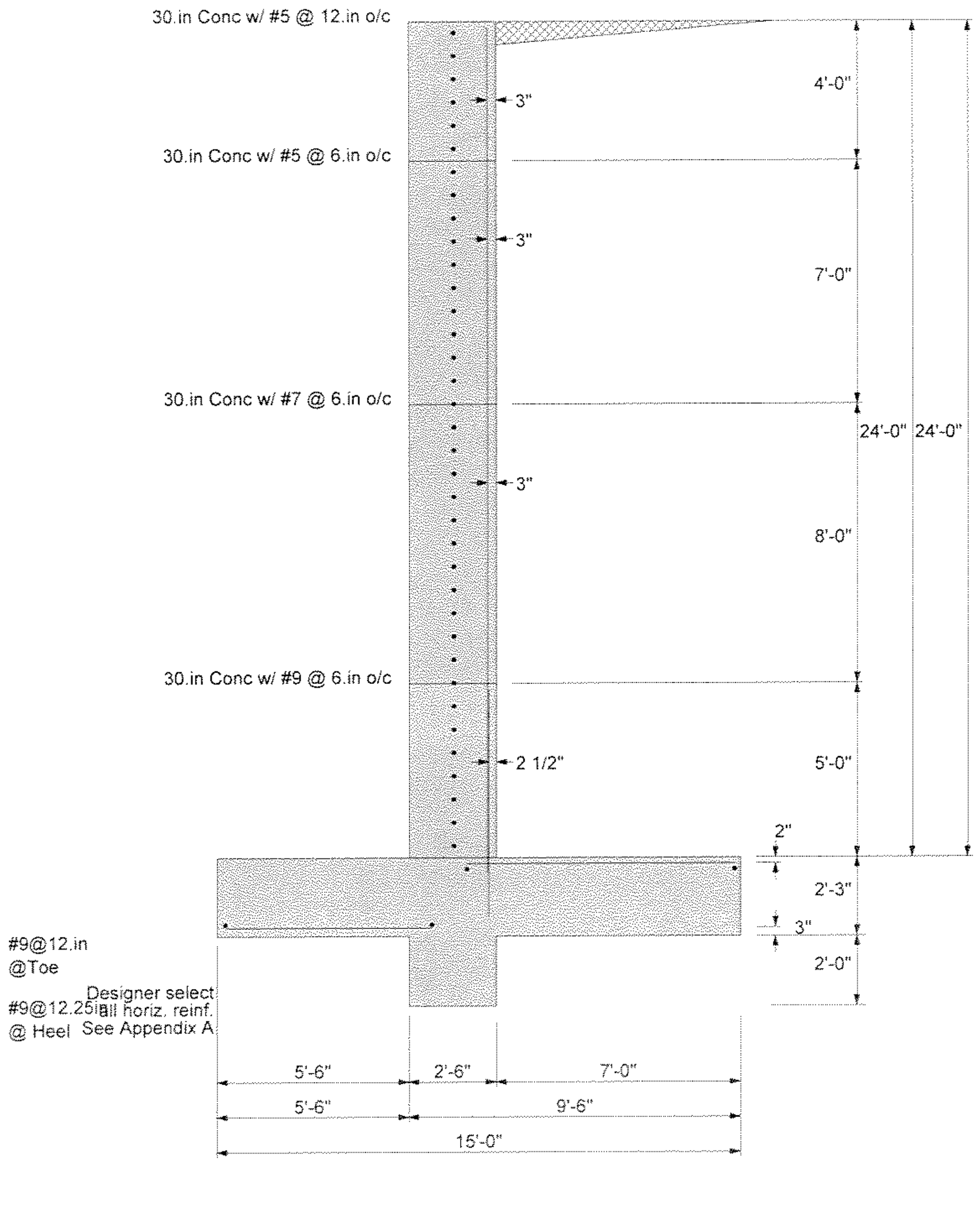
Vertical Loads used for Soil Pressure = 40,562.2 lbs

.....RESISTING.....

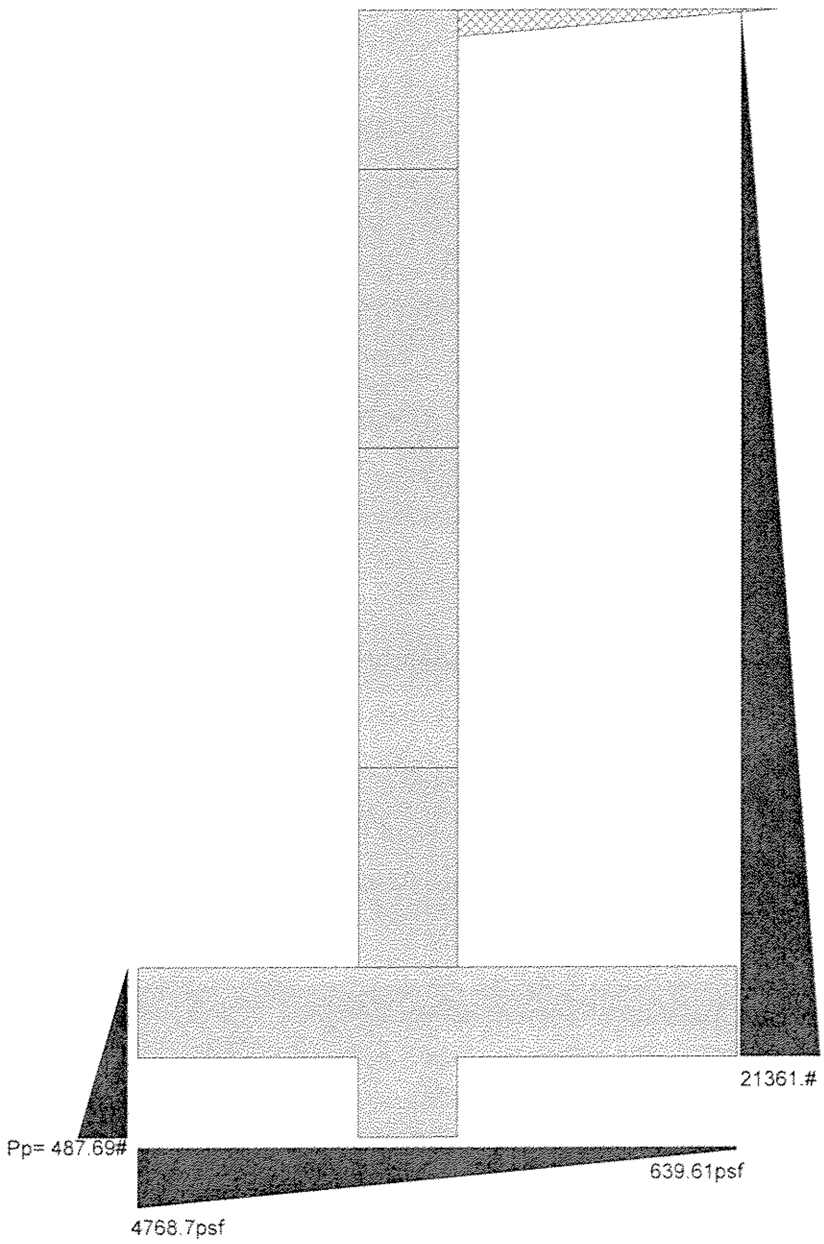
		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	21,840.0	11.50	251,160.0
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=			
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=			
Surcharge Over Toe	=			
Stem Weight(s)	=	9,000.0	6.75	60,750.0
Earth @ Stem Transitions	=			
Footing Weight	=	5,062.5	7.50	37,968.8
Key Weight	=	750.0	6.75	5,062.5
Vert. Component	=	3,909.7	15.00	58,645.8
Total =		40,562.2 lbs	**R.M.**=	413,587.0

Vertical component of active pressure used for soil pressure

DESIGNER NOTES:



30.in Conc w/ #5 @ 12.in o/c
30.in Conc w/ #5 @ 6.in o/c
30.in Conc w/ #7 @ 6.in o/c
30.in Conc w/ #9 @ 6.in o/c
3"
3"
3"
2 1/2"
4'-0"
7'-0"
8'-0"
5'-0"
24'-0"
24'-0"
2"
2'-3"
3"
2'-0"
#9@12.in
@Toe
#9@12.25in
@ Heel
Designer select
all horiz. reinf.
See Appendix A
5'-6"
2'-6"
7'-0"
5'-6"
9'-6"
15'-0"


21361.#
Pp= 487.69#
639.61psf
4768.7psf

Cantilevered Retaining Wall Design

Code: IBC 2003

Criteria

Retained Height	=	24.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	0.00 : 1
Height of Soil over Toe	=	0.00 in
Water height over heel	=	0.0 ft
Wind on Stem	=	0.0 psf

Soil Data

Allow Soil Bearing	=	5,000.0 psf
Equivalent Fluid Pressure Method		
Heel Active Pressure	=	46.0 psf/ft
Toe Active Pressure	=	46.0 psf/ft
Passive Pressure	=	54.0 psf/ft
Soil Density	=	130.00 pcf
Footing||Soil Friction	=	0.650
Soil height to ignore for passive pressure	=	0.00 in

Footing Dimensions & Strengths

Toe Width	=	5.50 ft
Heel Width	=	9.50
Total Footing Width	=	15.00
Footing Thickness	=	27.00 in
Key Width	=	30.00 in
Key Depth	=	24.00 in
Key Distance from Toe	=	5.50 ft
f'c = 3,000 psi	Fy =	60,000 psi
Footing Concrete Density	=	150.00 pcf
Min. As %	=	0.0018
Cover @ Top = 2.00 in	@ Btm.=	3.00 in

Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0 psf
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	0.00 ft
...Height to Bottom	=	0.00 ft

Adjacent Footing Load

Adjacent Footing Load	=	2,000.0 lbs
Footing Width	=	8.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	6.00 ft
Footing Type		
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

*Design Summary

Wall Stability Ratios

Overturning	=	2.27 OK
Sliding	=	1.46 Ratio < 1.5!
Total Bearing Load	=	37,162 lbs
...resultant ecc.	=	24.73 in
Soil Pressure @ Toe	=	4,520 psf OK
Soil Pressure @ Heel	=	435 psf OK
Allowable	=	5,000 psf
Soil Pressure Less Than Allowable		
ACI Factored @ Toe	=	5,448 psf
ACI Factored @ Heel	=	525 psf
Footing Shear @ Toe	=	56.0 psi OK
Footing Shear @ Heel	=	58.9 psi OK
Allowable	=	82.2 psi

Sliding Calcs (Vertical Component NOT Used)

Lateral Sliding Force	=	16,924.9 lbs
less 100% Passive Force	= -	487.7 lbs
less 100% Friction Force	= -	?4,155.0 lbs
Added Force Req'd	=	0.0 lbs OK
....for 1.5 : 1 Stability	=	744.6 lbs NG

Load Factors

Building Code	IBC 2003
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.600
Seismic, E	1.000

Stem Construction

		Top Stem	2nd	3rd	4th
		Stem OK	Stem OK	Stem OK	Stem OK
Design Height Above Ftg	ft =	20.00	13.00	5.00	0.00
Wall Material Above "Ht"	=	Concrete	Concrete	Concrete	Concrete
Thickness	=	30.00	30.00	30.00	30.00
Rebar Size	=	# 5	# 5	# 7	# 9
Rebar Spacing	=	12.00	6.00	6.00	6.00
Rebar Placed at	=	Edge	Edge	Edge	Edge
Design Data					
fb/FB + fa/Fa	=	**0.029**	**0.305**	**0.738**	**0.861**
Total Force @ Section	lbs =	873.3	5,748.8	15,048.6	23,074.3
Moment....Actual	ft-# =	1,096.8	22,485.6	102,892.0	197,460.5
Moment.....Allowable	ft-# =	37,239.8	73,629.0	139,428.0	229,237.5
Shear.....Actual	psi =	2.7	17.7	46.4	70.1
Shear.....Allowable	psi =	82.2	82.2	82.2	82.2
Wall Weight	psf =	375.0	375.0	375.0	375.0
Rebar Depth 'd'	in =	27.00	27.00	27.00	27.44
LAP SPLICE IF ABOVE	in =	21.36	21.36	37.38	48.06
LAP SPLICE IF BELOW	in =	21.36	21.36	37.38	
HOOK EMBED INTO FTG	in =				17.25
Masonry Data					
f'm	psi =				
Fs	psi =				
Solid Grouting	=				
Special Inspection	=				
Modular Ratio 'n'	=				
Short Term Factor	=				
Equiv. Solid Thick.	=				
Masonry Block Type	=				
Concrete Data					
f'c	psi =	3,000.0	3,000.0	3,000.0	3,000.0
Fy	psi =	60,000.0	60,000.0	60,000.0	60,000.0

Cantilevered Retaining Wall Design

Code: IBC 2003

Footing Design Results

		Toe	Heel
Factored Pressure	=	5,448	525 psf
Mu' : Upward	=	73,305	31,617 ft-#
Mu' : Downward	=	6,126	101,651 ft-#
Mu: Design	=	67,180	70,033 ft-#
Actual 1-Way Shear	=	56.04	58.94 psi
Allow 1-Way Shear	=	82.16	82.16 psi
Toe Reinforcing	=	# 9 @ 12.00 in	
Heel Reinforcing	=	# 9 @ 12.25 in	
Key Reinforcing	=	# 7 @ 12.50 in	

Other Acceptable Sizes & Spacings

Toe: #4@ 3.00 in, #5@ 4.50 in, #6@ 6.25 in, #7@ 8.50 in, #8@ 11.00 in, #9@ 14.00
Heel: #4@ 3.00 in, #5@ 4.50 in, #6@ 6.25 in, #7@ 8.50 in, #8@ 11.00 in, #9@ 14.00
Key:

Summary of Overturning & Resisting Forces & Moments

.....OVERTURNING.....

Item		Force lbs	Distance ft	Moment ft-#
Heel Active Pressure	=	15,848.4	8.75	138,673.8
Toe Active Pressure	=	-116.4	0.75	-87.3
Surcharge Over Toe	=			
Adjacent Footing Load	=	1,192.9	16.84	20,083.4
Added Lateral Load	=			
Load @ Stem Above Soil	=			
Total	=	16,924.9	**O.T.M.** =	158,669.9

Resisting/Overturning Ratio = **2.27**

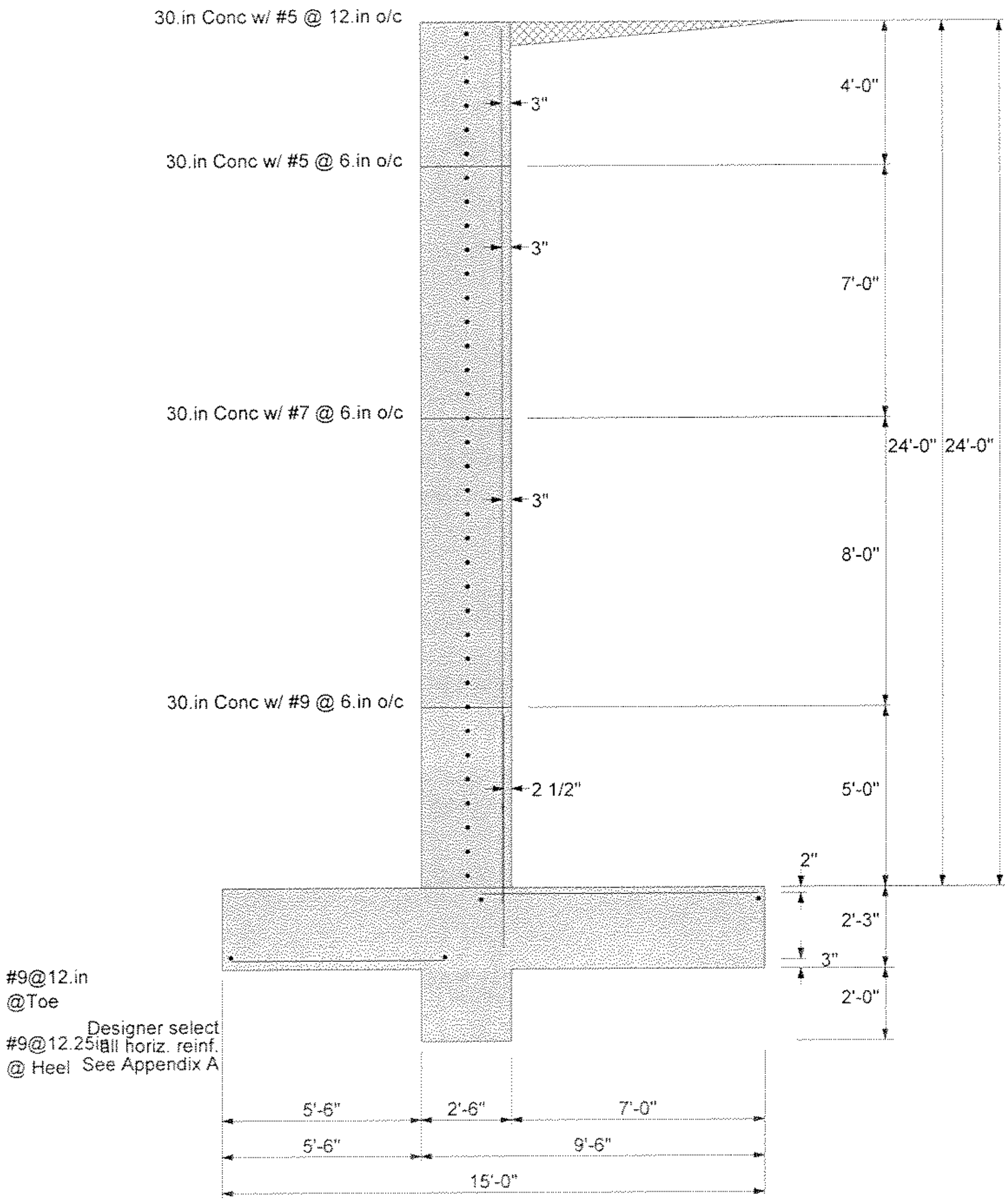
Vertical Loads used for Soil Pressure = 37,161.6 lbs

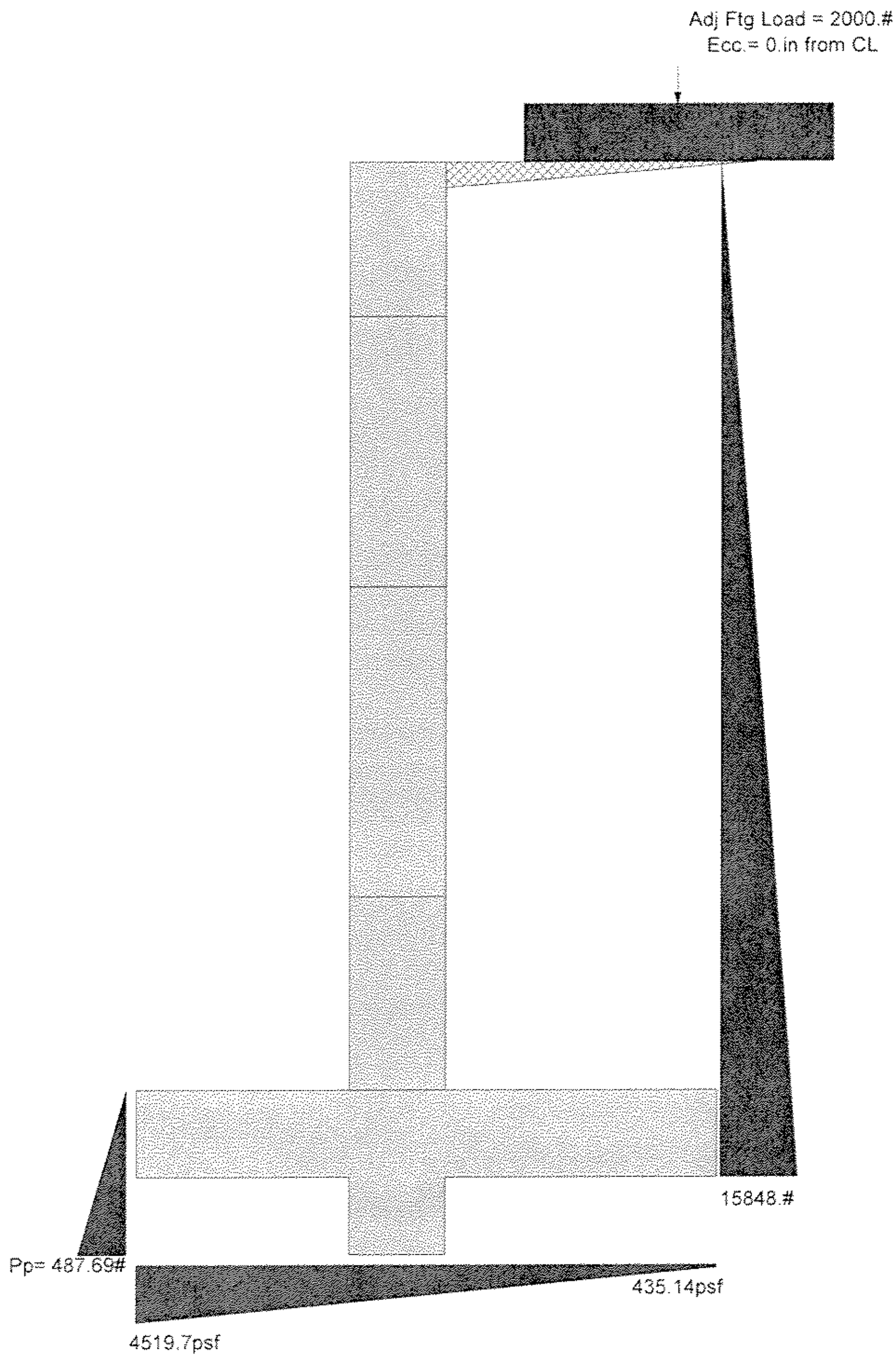
Vertical component of active pressure NOT used for soil pressure

.....RESISTING.....

		Force lbs	Distance ft	Moment ft-#
Soil Over Heel	=	21,840.0	11.50	251,160.0
Sloped Soil Over Heel	=			
Surcharge Over Heel	=			
Adjacent Footing Load	=	509.1	11.50	5,854.5
Axial Dead Load on Stem	=		0.00	
Soil Over Toe	=			
Surcharge Over Toe	=			
Stem Weight(s)	=	9,000.0	6.75	60,750.0
Earth @ Stem Transitions	=			
Footing Weight	=	5,062.5	7.50	37,968.8
Key Weight	=	750.0	6.75	5,062.5
Vert. Component	=			
Total	=	37,161.6 lbs	**R.M.**=	360,795.8

DESIGNER NOTES:


30.in Conc w/ #5 @ 12.in o/c
30.in Conc w/ #5 @ 6.in o/c
30.in Conc w/ #7 @ 6.in o/c
30.in Conc w/ #9 @ 6.in o/c
3"
3"
3"
2 1/2"
4'-0"
7'-0"
8'-0"
5'-0"
24'-0"
24'-0"
2"
2'-3"
3"
2'-0"
#9@12.in
@Toe
#9@12.25in
@ Heel
Designer select
all horiz. reinf.
See Appendix A
5'-6"
2'-6"
7'-0"
5'-6"
9'-6"
15'-0"



Adj Ftg Load = 2000.#
Ecc.= 0.in from CL
15848.#
Pp= 487.69#
435.14psf
4519.7psf

WALL Mark 'E' Seismic Loads

Definitions:

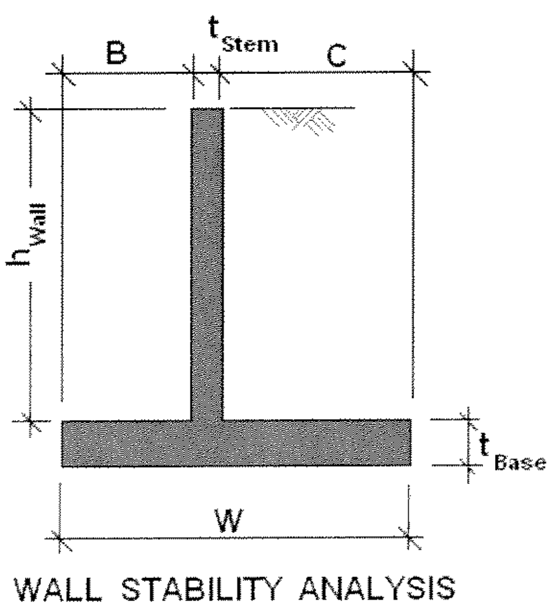
B = Width of Toe (feet)
C = Width of Heel (feet)
W = Width of Base (feet)
h wall = Height of Wall over base (feet)
t_{base} = thickness of Base (feet)
t_{stem} = Thickness of Stem (feet)
γ = density of backfill (pcf)
$\gamma_{concrete}$ density = 150 pcf
EFP_{static} = Design equivalent fluid pressure (pcf), static condition.
EFP_{AE} = Design equivalent fluid pressure (pcf), Active Earth pressure under seismic conditions..
ϕ = Internial angle of friction of the soil.
δ = Friction angle of soil to concrete wall.
K_h = Alternate seismic force developed from the Geotechnical Calculations page 12 in Appendix 'B'

Wall Mk. 'E' Data:

$B := 5.5$ (feet) $h_{wall} := 24.0$ (feet) $t_{stem} := 2.50$ (feet)

$C := 7.0$ (feet) $W := 15$ (feet) $t_{base} := 2.25$ (feet)

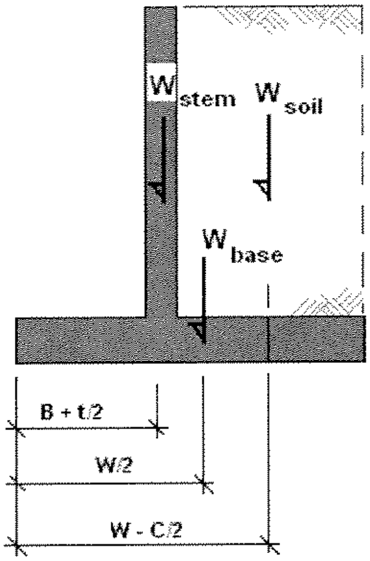
Soil Data: $\gamma := 130$ (pcf) $\delta := 22 \cdot deg$ $\phi := 32 \cdot deg$



$EFP_{static} := 46$ (pcf)

$EFP_{AE} := 62$ (pcf)

$K_h := 0.09$



Stabilizing Forces

Weights: (kips.per foot)

$W_{stem} := (0.150)\cdot h_{wall}\cdot t_{stem}$ $W_{stem} = 9.000$

$W_{base} := (0.150)\cdot W\cdot t_{base}$ $W_{base} = 5.063$

$W_{soil} := \frac{\gamma\cdot h_{wall}\cdot C}{1000}$ $W_{soil} = 21.84$

$H := h_{wall} + t_{base}$ $H = 26.25$ (feet)

Driving Forces:

$P_{ST} := \frac{\left(EFP_{static}\right)\cdot\frac{1}{2}\cdot(H)^2}{1000}$ $P_{ST} = 15.848$ (kips)

$P_{SE} := \frac{\left(EFP_{AE}\right)\cdot\frac{1}{2}\cdot(H)^2}{1000}$ $P_{SE} = 21.361$ (kips)

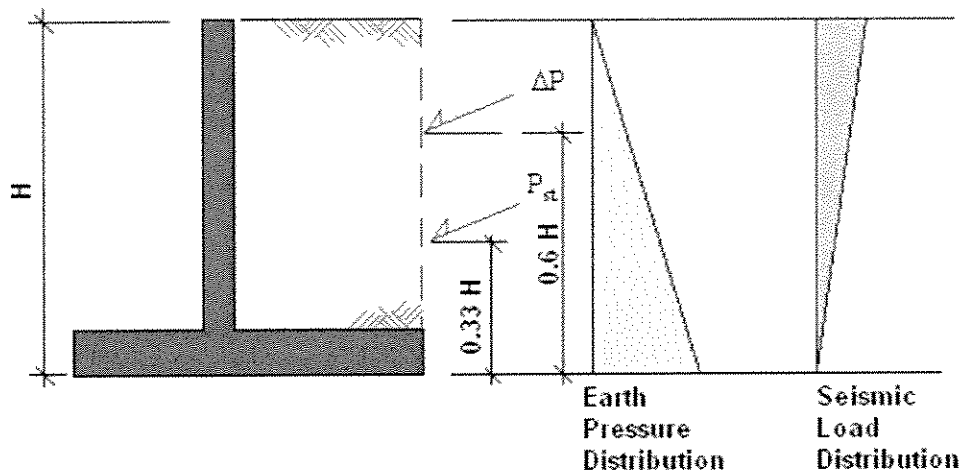
$\Delta P_1 := P_{SE} - P_{ST}$ $\Delta P_1 = 5.512$ (kips)

$\Delta P_2 := \frac{K_h\cdot\gamma\cdot(H)^2}{1000}$ $\Delta P_2 = 8.062$ (kips)

The larger value of either ΔP_1 or ΔP_2 is to be used in the seismic analysis

Let: $\Delta := \begin{pmatrix}\Delta P_1 \\ \Delta P_2\end{pmatrix}$ $\Delta P := \max(\Delta)$ $\Delta P = 8.062$ (kips)

Driving Forces and Moments about the Toe:



Horizontal Driving Force (**HDF**) is the sum of P_{st} and ΔP in the horizontal direction:

$HDF := (P_{ST} + \Delta P)\cdot\cos(\delta)$ $\quad HDF = 22.169$ (kips)

Driving Moment ($\mathbf{M_d}$) is the sum of the driving moments about the Toe.

$M_d := (P_{ST}\cdot 0.333\cdot H)\cdot\cos(\delta) + (\Delta P\cdot 0.6\cdot H)\cdot\cos(\delta)$ $\quad M_d = 246.179$ (ft-kips)

Resisting Forces and Moments about the Toe:

Resisting Forces (**RF**) neglecting passive pressure, a conservative analysis:

$RF := \tan(\phi)(W_{stem} + W_{base} + W_{soil} + P_{ST}\cdot\sin(\delta) + \Delta P\cdot\sin(\delta))$

$RF = 28.031$ (kips)

"Factor of Safety" against sliding is the ratio of **RF** to **HDF**

$Ratio_{sliding} := \frac{RF}{HDF}$ $\quad Ratio_{sliding} = 1.264$

Resisting Moments about the Toe M_r :

$$M_r := W_{stem} \cdot (B + t_{stem}) + W_{base} \cdot \left(\frac{W}{2}\right) + W_{soil} \cdot \left(W - \frac{C}{2}\right) + (P_{ST} + \Delta P) \cdot W \cdot \sin(\delta)$$

$M_r = 495.484$ (ft-kips)

"Factor of Safety" against overturning the ratio of $\mathbf{M_r}$ to $\mathbf{M_d}$

$$Ratio_{OT} := \frac{M_r}{M_d} \qquad Ratio_{OT} = 2.013$$

Calculate Soil Bearing Pressurs:

Net Moment: $\Delta M := M_r - M_d$ $\Delta M = 249.305$ (ft-kips)

$$X := \frac{\Delta M}{(W_{stem} + W_{base} + W_{soil} + P_{ST} \cdot \sin(\delta) + \Delta P \cdot \sin(\delta))} \qquad X = 5.557 \quad \text{(feet)}$$

$$R := (W_{stem} + W_{base} + W_{soil} + P_{ST} \cdot \sin(\delta) + \Delta P \cdot \sin(\delta)) \qquad R = 44.86 \quad \text{(kips)}$$

Eccentricity (e): $e := \frac{W}{2} - X$ $e = 1.943$ (feet) $\frac{W}{6} = 2.5$ (feet)

Eccentricity := | "OK Within Middle Third" if $e \le \frac{W}{6}$
| "Non in Middle one-third" otherwise

Eccentricity = "OK Within Middle Third"

$SP_2 := \frac{R}{W} \cdot \left(1 + \frac{e}{W}\right)$ $SP_2 = 3.378$ Maximum Soil Pearing Pressure (kips/ft²)

$SP_1 := \frac{R}{W} \cdot \left(1 - \frac{e}{W}\right)$ $SP_1 = 2.603$ Minimum Soil Pearing Pressure (kips/ft²)

Concrete Design:

The design on the concrete elements will be in accordance with ACI 318-02.

See Section 9.2 of ACI 319-02

$U_{DL} := 1.2 \qquad U_H := 1.6 \qquad U_E := 1.0$

$$R_{ult} := \left(U_{DL}\cdot W_{stem} + U_{DL}\cdot W_{base} + U_E\cdot W_{soil} + U_E\cdot P_{ST}\cdot \sin(\delta) + U_E\cdot \Delta P\cdot \sin(\delta)\right)$$

$$M_{d\_ult} := U_E\cdot\left[\left(P_{ST}\cdot 0.333\cdot H\right)\cdot\cos(\delta) + \left(\Delta P\cdot 0.6\cdot H\right)\cdot\cos(\delta)\right]$$

$$M_{r\_ult\_1} := U_{DL}\cdot W_{stem}\cdot\left(B + t_{stem}\right) + U_{DL}\cdot W_{base}\cdot\left(\frac{W}{2}\right) + U_{DL}\cdot W_{soil}\cdot\left(W - \frac{C}{2}\right)$$

$$M_{r\_ult\_2} := U_{DL}\cdot\left[\left(P_{ST} + \Delta P\right)\cdot W\cdot\sin(\delta)\right]$$

$$M_{r\_ult} := M_{r\_ult\_1} + M_{r\_ult\_2}$$

Net Ultimate Moment: $\Delta M_{ult} := M_{r\_ult} - M_{d\_ult}$ $\qquad \Delta M_{ult} = 348.402$ (ft-kips)

$X_{ult} := \dfrac{\Delta M_{ult}}{\left(R_{ult}\right)}$ $\qquad X_{ult} = 7.308$ (feet)

$R_{ult} = 47.672$ (kips)

Eccentricity (e): $e_{ult} := \dfrac{W}{2} - X_{ult}$ $\qquad e_{ult} = 0.192$ (feet) $\qquad \dfrac{W}{6} = 2.5$ (feet)

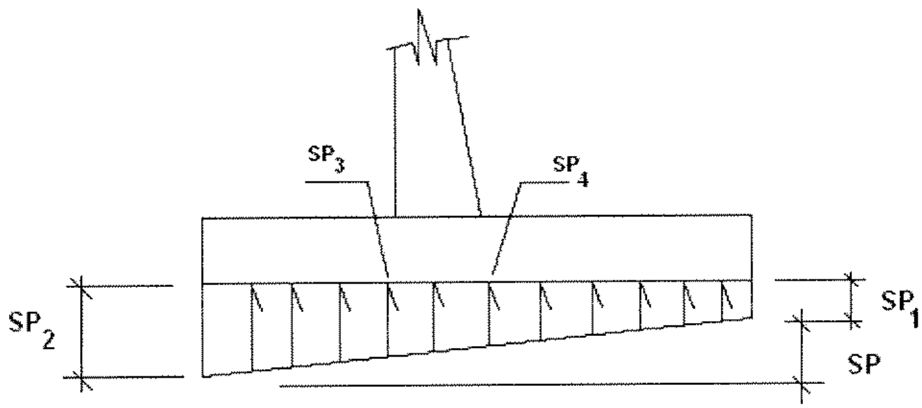
Eccentricity := | "OK Within Middle Third" if $e_{ult} \le \dfrac{W}{6}$
| "Non in Middle one-third" otherwise

Eccentricity = "OK Within Middle Third"

$SP_{2\_ult} := \dfrac{R_{ult}}{W}\cdot\left(1 + \dfrac{e_{ult}}{W}\right)$ $\qquad SP_{2\_ult} = 3.219$ Maximum Soil Pearing Pressure (kips/ft^2)

$SP_{1\_ult} := \frac{R_{ult}}{W} \cdot \left(1 - \frac{e_{ult}}{W}\right)$ $SP_{1\_ult} = 3.138$ Minimum Soil Pearing Pressure (kips/ft²)

$\Delta SP_{ult} := SP_{2\_ult} - SP_{1\_ult}$ $\Delta SP_{ult} = 0.081$ (kips/ft²)



Pressure Diagram - Toe & Heel

Soil Pressure at Front Face of Stem:

$SP_{3\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W} \cdot (B)$ $SP_{3\_ult} = 3.189$ (ksf)

Soil Pressure at Rear Face of Stem:

$SP_{4\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W} \cdot (B + t_{stem})$ $SP_{4\_ult} = 3.175$ (ksf)

Moment at Front Face of Stem:

$$M_{toe} := SP_{3\_ult} \cdot \frac{B^2}{2} + (SP_{2\_ult} - SP_{3\_ult}) \cdot \frac{(B)}{2} \cdot \left(\frac{2}{3}\right) \cdot B - U_{DL} \cdot (0.150) \cdot t_{base} \cdot \left(\frac{B^2}{2}\right)$$

$M_{toe} = 42.408$ (ft-kips)

Concrete Data:

$f'_c := 3$ ksi $f_y := 60$ ksi $M_u := M_{toe}$ ft-kips

$b := 12$ inches $d := (12)\cdot t_{base} - 4$ $d = 23$ inches $\phi_f := 0.90$

A_s calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7\cdot f'_c\cdot b\cdot d}{2\cdot f_y} - \frac{1}{2}\cdot\sqrt{\frac{2.89\cdot(f'_c\cdot b\cdot d)^2}{(f_y)^2} - \frac{6.8\cdot f'_c\cdot b\cdot M_u\cdot 12}{\phi_f\cdot(f_y)^2}}$$

$A_{s\_required} = 0.417$ Inches² $\rho := \frac{A_{s\_required}}{12\cdot d}$ $\rho = 0.0015$

Shear in Toe:

Soil Pressure at d from front face:

$$SP_{31\_ult} := SP_{2\_ult} - \frac{\Delta SP_{ult}}{W}\cdot\left(B - \frac{d}{12}\right) \qquad SP_{31\_ult} = 3.199 \quad \text{(ksf)}$$

$$V_{toe} := SP_{31\_ult}\cdot\left(B - \frac{d}{12}\right) + (SP_{2\_ult} - SP_{31\_ult})\cdot\left(\frac{1}{2}\right)\cdot\left(B - \frac{d}{12}\right)$$

$V_{toe} = 11.499$ (kips/foot)

$$\phi V_n := \frac{0.75\cdot 12\cdot d\cdot(2)\cdot\sqrt{f'_c\cdot 1000}}{1000} \qquad \phi V_n = 22.676 \quad \text{(kips/foot)}$$

Moment at Rear Face of Stem in the Heel:

$$M_{heel} := SP_{1\_ult}\cdot\frac{C^2}{2} + (SP_{4\_ult} - SP_{1\_ult})\cdot\frac{(C)}{2}\cdot\left(\frac{1}{3}\right)\cdot C - U_{DL}\cdot(0.150)\cdot t_{base}\cdot\left(\frac{C^2}{2}\right)$$

$M_{heel} = 67.256$ (ft-kips)   Let: $M_u := M_{heel}$

A_s calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7 \cdot f'_c \cdot b \cdot d}{2 \cdot f_y} - \frac{1}{2} \cdot \sqrt{\frac{2.89 \cdot (f'_c \cdot b \cdot d)^2}{(f_y)^2} - \frac{6.8 \cdot f'_c \cdot b \cdot M_u \cdot 12}{\phi_f \cdot (f_y)^2}}$$

$A_{s\_required} = 0.669$ Inches² $\rho := \frac{A_{s\_required}}{12 \cdot d}$ $\rho = 0.0024$

Shear in Hell:

Soil Pressure at d from front rear face of stem:

$$SP_{41\_ult} := SP_{1\_ult} + \frac{\Delta SP_{ult}}{W} \cdot \left(C - \frac{d}{12}\right) \qquad SP_{41\_ult} = 3.165 \quad \text{(ksf)}$$

$$V_{heel} := SP_{1\_ult} \cdot \left(C - \frac{d}{12}\right) + \left(SP_{41\_ult} - SP_{1\_ult}\right) \cdot \left(\frac{1}{2}\right) \cdot \left(C - \frac{d}{12}\right)$$

$V_{heel} = 16.019$ (kips/foot)

$$\phi V_n := \frac{0.75 \cdot 12 \cdot d \cdot (2) \cdot \sqrt{f'_c \cdot 1000}}{1000} \qquad \phi V_n = 22.676 \quad \text{(kips/foot)}$$

Moments in Stem:

Driving Forces:

$$P_{ST} := \frac{(EFP_{static}) \cdot \frac{1}{2} \cdot (h_{wall})^2}{1000} \qquad P_{ST} = 13.248 \quad \text{(kips)}$$

$$P_{SE} := \frac{(EFP_{AE}) \cdot \frac{1}{2} \cdot (h_{wall})^2}{1000} \qquad P_{SE} = 17.856 \quad \text{(kips)}$$

$$\Delta P_1 := P_{SE} - P_{ST} \qquad \Delta P_1 = 4.608 \quad \text{(kips)}$$

$\Delta P_2 := \dfrac{K_h \cdot \gamma \cdot (h_{wall})^2}{1000}$ $\Delta P_2 = 6.739$ (kips)

The larger value of either ΔP_1 or ΔP_2 is to be used in the seismic analysis

Let: $\Delta := \begin{pmatrix} \Delta P_1 \\ \Delta P_2 \end{pmatrix}$ $\Delta P := \max(\Delta)$ $\Delta P = 6.739$ (kips)

$M_{stem} := U_E \cdot \left[\left(P_{ST} \cdot \cos(\delta) \cdot 0.333 h_{wall} \right) + \left(\Delta P \cdot 0.600 \cdot h_{wall} \right) \right]$

$M_{stem} = 195.213$ (ft-kips) Let: $M_u := M_{stem}$ $d := (12) \cdot t_{stem} - 3.0$

$d = 27$ (inches)

$\mathbf{A_s}$ calculation is from CRSI Handbook

$$A_{s\_required} := \frac{1.7 \cdot f'_c \cdot b \cdot d}{2 \cdot f_y} - \frac{1}{2} \cdot \sqrt{\frac{2.89 \cdot (f'_c \cdot b \cdot d)^2}{(f_y)^2} - \frac{6.8 \cdot f'_c \cdot b \cdot M_u \cdot 12}{\phi_f \cdot (f_y)^2}}$$

$A_{s\_required} = 1.713$ Inches² $\rho := \dfrac{A_{s\_required}}{12 \cdot d}$ $\rho = 0.0053$

APPENDIX "A"

List of References

LIST OF REFERENCES;

1.0 International Building Code (IBC) 2003 edition
2.0 Building Code Requirements for Structural Concrete (ACI 318-02)
3.0 *Basics of Retaining Wall Design - A Guide for the Practicing Engineer*, 6th Edition, April 2005 by Hugh Brooks, HBA Publications, Inc. www.retainpro.com
4.0 CRSI Design Handbook 1996 Edition.

APPENDIX "B"

Geotechnical Calculations

(By WESTON Solutions)

WESTON SOLUTIONS

SUBJECT TA-73 Airport Landfill SHEET 1 of 18
TASK DESCRIPTION Lateral Earth Pressure Coefficients W.O. NO. 13104.002.001
PREPARED BY WCD DEPT Consult. DATE 5/19/05 TASK NO. 7000
MATH CHECK BY ______ DEPT ______ DATE ______ APPROVED BY
METHOD REV. BY ______ DEPT ______ DATE ______ DEPT ______ DATE ______

Develop Seismic Design Criteria For Concrete & MSE Wall Design

- criteria to be developed consistent with IBC 2003:

  - Chapter 16 (Structural Design) Section 1615 (Earthquake Loads - Site Ground Motion) & Section 1616 (Earthquake Loads - Criteria Selection) are relevant.

- From Section 1615.1 (Genl. Proc. for determining seismic design parameters)

$S_s = (33.85\%) g \rightarrow S_s = .3385g$

$S_1 = (9.76\%) g \rightarrow S_1 = .0976g$

(see pg 2 from USGS Earthquake Hazards Program web site for Zip Code 87544 (Los Alamos, NM).

↳ S_s = 5% Prob of Exceedance (PE) value in 50 yrs for .2 sec period

S_1 = 5% Prob. of Exceedance (PE) value

(2)

USGS
Earthquake Hazards Program

```
The input zip-code is 87544. - Los Alamos, NM
ZIP CODE                          87544
LOCATION                          35.8678 Lat. -106.2682 Long.
DISTANCE TO NEAREST GRID POINT    4.5840 kms
NEAREST GRID POINT                35.9 Lat. -106.3 Long.
Probabilistic ground motion values, in %g, at the Nearest Grid point are:
```

	10%PE in 50 yr	5%PE in 50 yr	2%PE in 50 yr
PGA	8.963270	14.212500	26.153641
0.2 sec SA	20.231220	33.854210 S_s	59.950050
0.3 sec SA	18.002939	28.778629	54.664909
1.0 sec SA	5.927866	9.756920 S_1	18.967649

The input zip-code is .
Zip code is zero and we go to the end and stop.

PROJECT INFO: Home Page
SEISMIC HAZARD: Hazard by Zip Code

WESTON SOLUTIONS

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- Per "Table 1615.1.1" (Site Class Definition)
  - 25' high concrete wall
    - wall footing will bear on parent bedrock
    - wall footing will be embedded into rock + likely poured "back to back" ⟵ ∴ At-rest (ie. K_o) LEP condition relevant @ base of wall
    - However, top of wall will be free to rotate outward ⟶ ∴ Active (ie. K_A) LEP condition relevant @ top of wall
    - Also, from Table 1615.1.1, "Site Class B" (rock) is appropriate for this design
  - MSE wall atop backfill of concrete wall
    - wall will bear on combination of structural fill, rock + C&D waste
    - From Table 1615.1.1,

      Site Class D (stiff soil profile) is appropriate for

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WESTON SOLUTIONS

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I.) Concrete Wall

- Site Class B
- $S_S = .3385g$

  $S_1 = .0976g$
- From Section 1615.1.2:

  $F_a = 1.0$ ⇝ Table 1615.1.2(1)

  $F_V = 1.0$ ⇝ Table 1615.1.2(2)

$\therefore \quad S_{MS} = F_a S_s = (1.0)(.3385g)$

$= .3385g$

$S_{M1} = F_V S_1 = (1.0)(.0976g)$

$= .0976g$

- From Section 1615.1.3:

  $S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3}(.3385g)$

  $= .226g$

  $S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3}(.0976g)$

  $= .065g$

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- From Section 1616.1
  - A "Seismic Design Category" must be assigned for this wall
- From Section 1616.2
  - A "Seismic Use Group" must be assigned for the wall based on Table 1604.5
  - Retaining wall is appropriately classified as "Category II" structure
  - As noted in footnote to Table 1604.5, "Category II" structures are classified as "Seismic Use Group I" for determining the "Seismic Design Category" of the structure for structural design purposes.

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DEPT DATE

- From Section 1616.3:
  - For "Seismic Use Group I" & S_{DS} = .226g
    ↓
    structure is classified as "Seismic Design Category B"
  - For "Seismic Use Group I" & S_{D1} = .065g
    ↓
    structure is classified as "Seismic Design Category A"

More Critical (severe) of these is "Seismic Design Category B"

* which is the assumption to be used for structural design of the concrete wall.

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Determine the Lateral Earth Pressures to be used to check the global stability condition (i.e. sliding, overturning, etc.) of the wall, as well as for structural design of the wall:

1.) STATIC STABILITY CONDITION

Consistent with discussion on pg 3 (i.e. K_o condition @ base of wall / K_A condition @ top of wall), develop lateral earth pressure diagram assuming ~~that the~~ appropriate lateral earth pressure coefficient (K_{ST}) is the average of the 2 values:

$$\therefore \quad K_{ST} = \frac{K_o + K_A}{2}$$

& assuming New Mexico Type I Aggregate (see App A for gradation data) which is a well graded sand/gravel structural fill soil will be used as the wall backfill:

ϕ (Type I) $\approx 34°$ $\quad W_{opt} = 5\% \pm$

includes water content wt necessary for compaction

γ_{Dmax} (Type I) $\approx$ 130 pcf

$\hookrightarrow \therefore 95\% \, \gamma_{Dmax} \approx$ 123.5 pcf

& γ_T @ 95% DOC = 123.5 pcf (1+.05) $\approx$ 130 pcf

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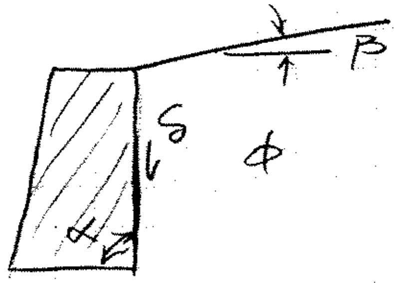
$\therefore K_0 = 1 - \sin\phi$ (granular soils)

$= 1 - \sin 34^\circ$

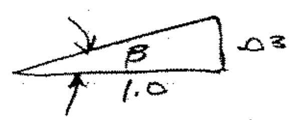
$= .441$

& $K_A = \dfrac{\sin^2(\alpha+\phi)}{\sin^2\alpha \sin(\alpha-\delta)\left[1+\sqrt{\dfrac{\sin(\phi+\delta)\sin(\phi-\beta)}{\sin(\alpha-\delta)\sin(\alpha+\beta)}}\right]^2}$

where



$\beta = 1.72^\circ$ for 3% grade →



$\beta = \tan^{-1}\left(\frac{.03}{1}\right) = 1.72^\circ$

$\alpha = 90^\circ$

$\delta = 22^\circ \pm$ for silty sandy gravel mixture to gravel/sand mix; Ref. Bowles, 2nd ed. Fnd Analysis + Design Table 11-6

$\phi = 34^\circ$

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– From spreadsheet on pg 10

$K_A = .259$

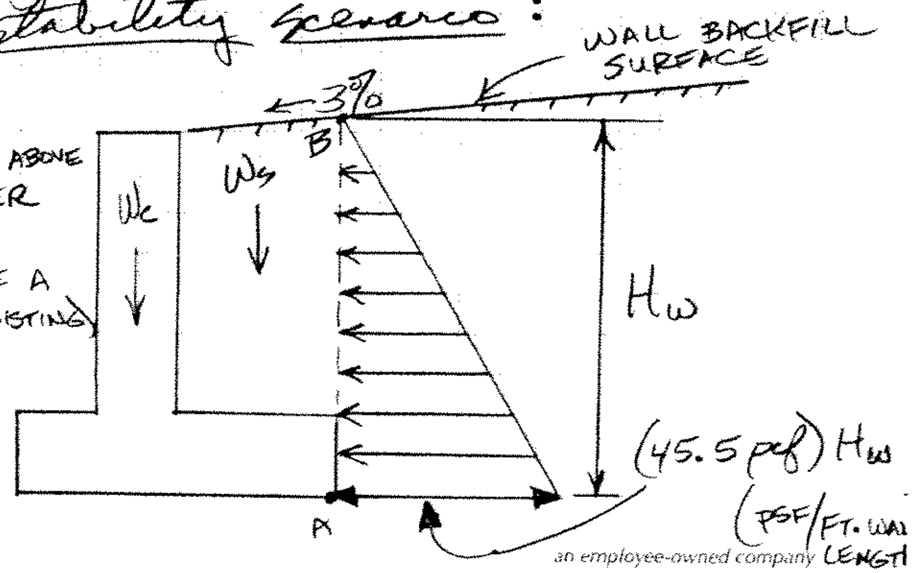
$$\therefore \quad K_{ST} = \frac{K_0 + K_A}{2} = \frac{.441 + .259}{2} = .350$$

$$\& \quad \gamma_{E_{ST}} = K_{ST}\gamma_T = .350\,(130\ \text{pcf}) = 45.5\ \text{pcf}$$

← equiv fluid wt. of soil (static conditions)

∴ For global stability analyses & structural design of concrete wall under <u>static stability scenario</u>:

NOTE: WT. OF SOIL ABOVE HEEL OF CANTILEVER WALL (W_S) CAN BE CONSIDERED TO BE A STABILIZING (i.e. RESISTING) FORCE FOR WALL GLOBAL STABILITY ANALYSES



TCPI
436 Creamery Way Suite 100
Exton, PA 19341
610-524-1357

Standard Calculation Sheet
Subject:
Los Alamos Retaining Wall
M-O Equation

Date: 5/24/2005 5:20 PM
Coulomb Ka Calculation.mcd

$\phi := 34 \cdot deg \quad \beta := 1.72 \cdot deg \quad \delta := 22 \cdot deg \qquad \alpha := 90 \cdot deg$

$$K_a := \frac{(\sin(\alpha + \phi))^2}{(\sin(\alpha))^2 \cdot \sin(\alpha - \delta) \cdot \left(1 + \sqrt{\frac{\sin(\phi + \delta) \cdot \sin(\phi - \beta)}{\sin(\alpha - \delta) \cdot \sin(\alpha + \beta)}}\right)^2} \qquad K_a = 0.259$$

The Mononobe-Okabe Equation

$K_h := .090 \quad \theta := \mathrm{atan}(K_h) \quad \theta = 0.09 \quad \theta' := \theta \cdot deg \quad \theta' := \theta \cdot \frac{1}{deg} \quad \theta' = 5.143$

$\theta' := \theta$

$$K_{AE} := \frac{(\sin(\alpha + \theta' - \phi))^2}{(\sin(\alpha))^2 \cdot \sin(\alpha + \theta' + \delta) \cdot \left(1 + \sqrt{\frac{\sin(\phi + \delta) \cdot \sin(\phi - \theta' - \beta)}{\sin(\alpha + \delta + \theta') \cdot \sin(\alpha - \beta)}}\right)^2 \cdot \cos(\theta')} \qquad K_{AE} = 0.317$$

$\Delta K_{AE} := K_{AE} - K_a \qquad \Delta K_{AE} = 0.058$

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& $FS_{STATIC} \geq 1.50$ for both sliding & overturning global stability analyses (Ref: IBC 2003 Section 1806.1)

2.) SEISMIC STABILITY CONDITION

Also consistent with discussion on pg 3, develop lateral earth pressure diagram for this case assuming that the appropriate lateral earth pressure coefficient (K_{SE}) is the average of the K_0 & K_A values under seismic loads.

i.e. $$K_{SE} = \frac{K_{OE} + K_{AE}}{2}$$

where K_{OE} = at-rest LEP coefficient under seismic load

K_{AE} = active LEP coefficient under seismic load

K_{AE} is calculated from the Mononobe Okabe eqn. as follows (See App B, REF. #1):

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$$K_{AE} = \frac{\sin^2(\alpha - \phi + \theta')}{\sin^2\alpha \cos\theta' \sin(\alpha + \theta' + \delta)\left[1 + \sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\theta'-\beta)}{\sin(\alpha+\delta+\theta')\sin(\alpha-\beta)}}\right]}$$

where α, ϕ, δ + β are defined as above, &

$$\theta' = \tan^{-1}\left(\frac{K_H}{1-K_V}\right) = \tan^{-1}(K_H)$$

for $K_V = 0$ as typically assumed

& $K_H = \frac{S_{DS}}{2.5} = .40 S_{DS} = .40(.226g) = .09g$

SEE APP. B, REF. #2 (→ 2.5)

+ K_H (MONOTOBE OKABE EQN) $= \frac{.09g}{g} = .09$

$\therefore \theta' = \tan^{-1}(.09) = 5.14°$

& from spreadsheet on pg 10:

$K_{AE} = .317$ (incr from .259)

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Also $K_{OE} \approx 2 K_{AE}$ for retaining walls founded on rock with soil backfill (See App C (FEMA document))

$\therefore K_{OE} = 2(.317) = .634$ (incr. from .44)

& $K_{SE} = \frac{K_{AE} + K_{OE}}{2} = \frac{.317 + .634}{2}$

$= .476$ (incr. from .350)

& $\gamma_{E_{SE}} = K_{SE}\gamma_T = .476(130 \text{ pcf})$

$= 61.9$ pcf

Say 62 pcf

($\gamma_{E_{SE}}$ ← equiv. fluid wt. of soil (seismic conditions))

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WESTON SOLUTIONS

SHEET 14 of ____

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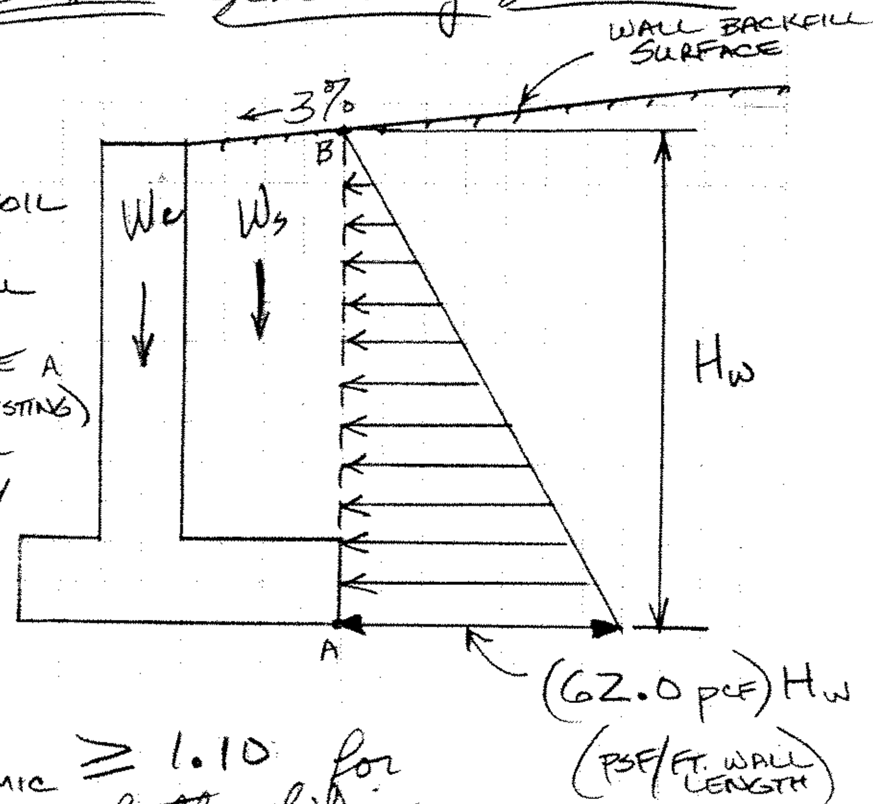
∴ For global stability analyses & structural design of concrete wall under seismic stability scenario:



NOTE: WT. OF SOIL ABOVE HEEL OF CANTILEVER WALL (W_s) CAN BE CONSIDERED TO BE A STABILIZING (i.e. RESISTING) FORCE FOR WALL GLOBAL STABILITY ANALYSES

& $FS_{SEISMIC} \geq 1.10$ for both sliding & overturning global stability analyses

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Above equivalent fluid pressure values should be used to quantify the seismic stability condition as follows:

1.) Resolve triangular pressure diagram of pg. 9 based on a 45.5 pcf equivalent fluid weight into a resultant force for the static stability condition (P_{ST}).

2.) Resolve the triangular pressure diagram of pg. 14 based on a 62.0 pcf equivalent fluid weight into a resultant force for the seismic stability condition (P_{SE}).

3.) Calculate $\Delta P_1 = P_{SE} - P_{ST}$

4.) Calculate $\Delta P_2 = K_H \gamma H_w^2$ (see App E Ref #2)

where $K_H = .09$ (see pg 12)

$\gamma = 130$ pcf

5.) Select ΔP = greater of ΔP_1 + ΔP_2

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6.) P_{ST} is applied to the back of the cantilever wall (i.e. line AB on pg. 9 + 14 sketches) at an angle $\delta = 22°$ above horizontal at a distance $H_w/3$ above bottom of wall footing for sliding + overturning analyses, and:

7.) ΔP is applied to the back of the cantilever wall (i.e. line AB on pg 9 + 14 sketches) at an angle $\delta = 22°$ above horizontal at a distance 0.6H above bottom of wall footing for sliding + overturning stability analyses.

That is:

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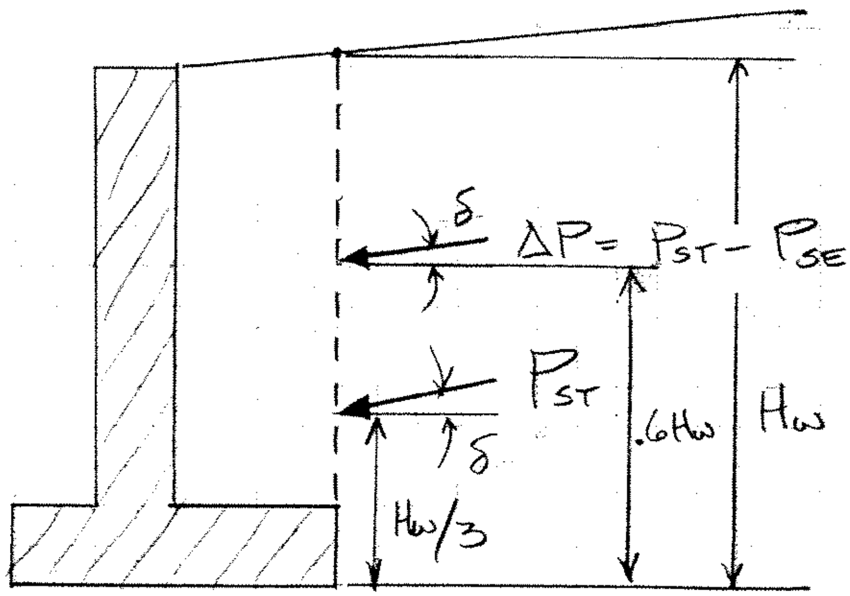

Also, more conservative wall geometry parameters (e.g. stem + footing thicknesses etc.) as determined from static and seismic global stability analyses (sliding, overturning, etc.) shall be selected for wall construction.

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II.) MSE Wall

- wall to be designed by Contractor selected Engineer via a performance specification ~~consultant~~ with established MSE wall design procedures + protocol. ~~Both~~ static and seismic internal + external stability conditions shall be considered and satisfied using appropriate + acceptable FS values. Seismic stability condition shall be evaluated assuming

see App D. for calcs. $\left\langle \begin{array}{l} K_H = .138g \\ K_V = 0g \end{array} \right.$

WLD 5/25/05

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APPENDIX A

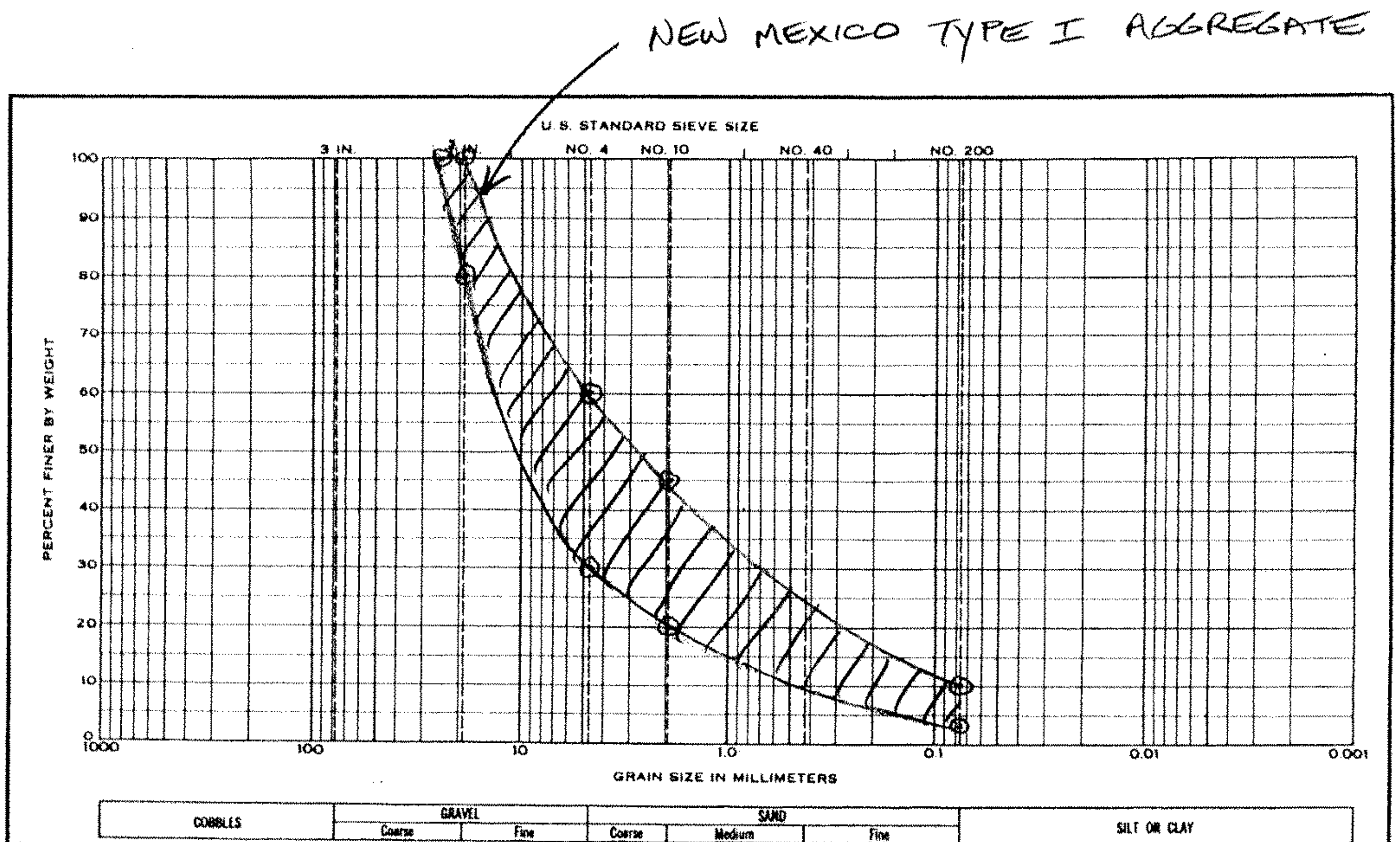
Sieve Sizes	Percent Passing		
	I	II	OGBC
25 mm (1 in.)	100	100	100
19 mm (3/4 in.)	80–100	85–100	90–100
9.5 mm (3/8 in.)	—	—	20–55
4.75 mm (No. 4)	30–60	40–70	0–10
2.0 mm (No. 10)	20–45	30–55	—
75 µm (No. 200)	3–10	4–12	0–2
2FF*	50% or More	50% or More	100%

* Fractured faces tests shall be perfomed on the material retained on the 4.75-mm (No. 4) sieve. The retained material shall have at least two fractured faces as evaluated by NMSHTD Method FF-1, "Fractured Face Determination for Coarse Aggregate."

Type I and Type II aggregate shall have an Aggregate Index of 35 or less when calculated in accordance with Section 910. The liquid limit shall be 25 or less and the plastic index shall be six or less.

OGBC shall have an Aggregate Index of 35 or less when calculated in accordance with Section 910.

When RAP is used, the requirements for the Aggregate Index shall apply to the extracted aggregate. When RAP is used in combination with untreated aggregate, the Aggregate Index shall be determined separately for each and each shall comply with the specification requirements.



Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI	

Project

Date

GRADATION CURVES

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APPENDIX B

7. EARTHQUAKE (SEISMIC) DESIGN

Earthquake (Seismic) Loading

Texts that address seismic design of retaining walls (e.g. Bowles, Kramer) acknowledge that seismic design of retaining walls is a highly complex issue, compounded by the assumptions that must be made to establish reasonable design guidelines. This is still an emerging science and geotechnical reports usually give only the peak ground acceleration applicable to the location and leave the application of this information to the designer.

Even the necessity of seismic design of retaining walls is arguable, considering compensating safety factors (e.g. 1.5 overturning safety factor). Earthquake caused retaining wall failures from which to obtain mode-of-failure lessons are very rare (waterfront structures excepted). It is also argued that since retaining walls are often at a distance from structures that would be affected by their failure and thus are not a life-safety issue. However, these arguments are moot considering the mandatory language of IBC and ASCE 7.

IBC 2003, Section 1622.1.2, refers to and modifies ASCE 7 to read as follows:

> ' . . . This section applies to all earth retaining walls. The applied seismic forces shall be determined in accordance with Section 9.7.5.1 [*This section states that "... the owner shall submit to the authority having jurisdiction a written report that includes an evaluation of the items in Section 9.7.4.1 and the lateral pressures on basement and retaining walls due to earthquake motions". Section 9.7.4.1identifies items to be included in the geotechnical report to be submitted ", when required by the authority having jurisdiction"]*

This clearly requires a seismic analysis of "earth retaining structures", based upon a geotechnical report, but implies some discretionary latitude by the "authority having jurisdiction".

The Uniform Building Code (UBC '97) and the California Building Code (CBC '01) do not appear to specifically require seismic design of "earth retaining structures" unless the requirements for "non-buildng structures" in CBC '01 could be so interpreted.

REF. # 1

Check applicable local and state codes that may have specific seismic design requirements for retaining walls.

The Mononobe-Okabe equations

Of the many investigations of dynamic forces on retaining walls, one of the most important and influential is an ASCE paper titled *Design of Earth Retaining Structures for Dynamic Loads,* by Seed and Whitman, delivered at a 1970 Cornell University conference. In this paper they cited the pioneering studies by Mononobe (1929) and Okabe (1926), widely referenced today. Another contribution was a subsequent ASCE paper by Robert Whitman titled, *Seismic Design and Behavior of Gravity Retaining Walls,* 1990. They considered this lateral force to be an inverted triangular wedge of soil behind the wall. Seed-Whitman proposed a simplified formula, based upon the Mononobe-Okabe theory, for the combined static and seismic factor, which they termed K_{AE}, to be applied to this wedge acting against the wall. This was an adaptation of the Coulomb formula to calculate the total (seismic and static) pressure and introduced the variable θ, which is defined as the angle whose tangent is the ground acceleration ($\theta = \tan^{-1} k_h$).

This equation is presented in **Figure 7-1.**

K_{AE} = active earth pressure coefficient

$$= \frac{\sin^2(\alpha + \theta - \phi')}{\cos\theta' \sin^2\alpha \sin(\alpha + \theta' + \delta)\left[1 + \sqrt{\frac{\sin(\phi + \delta)\sin(\phi - \theta' - \beta)}{\sin(\alpha + \delta + \theta')\sin(\alpha - \beta)}}\right]^2}$$

Where $\theta = \tan^{-1} K_h$, α = wall slope to horiz. (90° for a vertical face), ϕ = angle of internal friction, β = backfill slope, and δ = wall friction angle.
The horizontal component is $K_{AE} \cos\delta$.

For a vertical wall face and δ assumed to be $\phi/2$, this becomes:

$$K_{AE} = \frac{\sin^2(90 + \theta - \phi)}{\cos\theta \sin^2(90 + \theta + \phi/2)\left[1 + \sqrt{\frac{\sin 1.5\phi \sin(\phi - \theta - \beta)}{\sin(90 + \phi/2 + \theta)\sin(90 + \beta)}}\right]^2}$$

The total force (active and earthquake), $P_{AE} = \frac{1}{2}(\gamma) K_{AE} H^2$ where γ = soil density and H = retained height.

Figure 7-1. ***Mononobe-Okabe Equation***

When the acceleration is zero, $k_h = 0$, and K_{AE} becomes the familiar Coulomb K_A formula.

Also, note that passive the pressure coefficient decreases under seismic conditions.

The passive earth pressure coefficient, K_{PE} is:

$$K_{PE} = \frac{\sin^2(\alpha - \theta + \phi')}{\cos\theta' \sin^2\alpha \sin(\alpha + \theta' + \delta)\left[1 + \sqrt{\frac{\sin(\phi + \delta)\sin(\phi - \theta' + \beta)}{\sin(\alpha + \delta + \theta')\sin(\alpha - \beta)}}\right]^2}$$

K_{AE} is thus two components (seismic and static). The seismic component (K_{AE} - K_A) is assumed to be an inverted, near-triangular trapezoid force (maximum at the ground surface) acting at a height of 0.6 H. For stem design, H is the height from top of footing to retained height. For overturning and sliding, H is the height at the back face of the footing, along a virtual vertical plane from the bottom of the footing to its intersection with the backfill grade.

The K_A component is the familiar triangular distribution acting at H / 3.

The height to the combined resultant can be obtained by the formula:

$$\bar{x} = \frac{P_A (H/3) + (P_{AE} - P_A)\, 0.6H}{P_{AE}}$$

The direction of force application, per the Coulomb formula, is assumed to be inclined at an angle (from horizontal) equal to the friction angle at the back face of the stem, δ, which is often assumed to be $\phi/2$. Therefore, the horizontal components can be assumed to be

$$P_{AE\,horiz.} = \cos\left(\phi/2\right) P_{AE}.$$

A simple approach to the design for seismic is suggested by the overlapping force triangles, which tend to combine into a nearly uniform load over the height of the wall, if the height of the resultant is 0.5H.

Therefore, $w = \dfrac{K_{AE}\,\gamma\,H^2}{2H} = 0.5\,K_{AE}\,\gamma\,H$, where w is the equivalent uniform lateral static plus seismic force. This simplification, while approximate, is particularly helpful for checking stem moments and shears at various heights.

Seed and Whitman suggest an approximation of $K_{AE} = K_A + 0.75\,k_h$. If, for example, k_h is 0.30 and $K_A = 0.27$, then K_{AE} approximate would be 0.495. This would suggest an 83% increase over static K_A. However, the stem moments and overturning are greatly increased since 0.75 k_h act at an assumed height of 0.60H. Some geotechnical engineers use this method to give an added uniform seismic force over the full retained height with resultant acting at 0.6H. Such a requirement, therefore, might read "for seismic design add a uniform lateral force = 20 H^2 with the resultant applied at 0.6H.

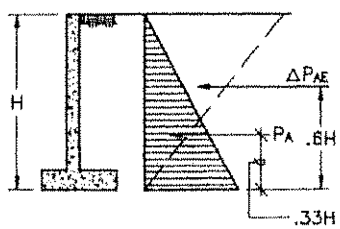

Figure 7-2. *Application of Seed Whitman Method*

Seed and Whitman's paper commented that few building codes (at that time) required seismic provisions for retaining walls, and concluded that the factors of safety for static design, which are generally around 1.5, are adequate to protect the wall for short term seismic forces, since such forces would merely reduce the safety factor to an acceptable value greater than 1.0.

NAVFAC for Seismic Zone 4 (UBC '97) requires, in addition to static force, 20% of the total active pressure and 20% of the wall weight, acting at 2/3 the height. It further comments that the one-third stress increase for short-term loading should more than compensate for the added seismic stresses.

AASHTO contains seismic design guidance for retaining walls in their Section 6 of Division I-A.

Determining k_h

k_h is the ground acceleration factor used in the Mononobe-Okabe (M-O) equation to compute lateral seismic earth pressure in cantilevered retaining walls.

This is a design value and not necessarily the most severe acceleration that could occur at the site. Unless an arbitrarily reduced value of k_h is used, one-third to one-half the peak ground acceleration is often used (see Kramer and others).

i.e. .33 → .50 (PGA) → $\frac{1}{2.5}$ = .40 IS WITHIN THIS RANGE

The starting point is to determine the peak acceleration applicable to your design. Assuming your code is IBC 2003, or ASCE 7-02, which has identical charts (UBC '97 will be discussed later), select from the contours the Maximum Considered Earthquake (MCE) ground motion for 0.2 second, spectral response acceleration at 5% of critical damping. Note that retaining walls are "short period", hence the 0.2 second selection.

There is an easier way. Go to http://eqhazmaps.usgs.gov This is a U.S. Geological Survey address. Just enter your zip code (but latitude and longitude is more accurate). For example, Newport Beach, California, zip code 92660, gives 127.4 percent "g", or 1.274. These maps are somewhat different from IBC maps and the latter are preferred and a zoom-capable CD is available from IBC.

Here is an example procedure for obtaining a design K_h using the USGS Hazard Maps:

From charts, $S_s = 1.274$
(All terms defined in referenced codes)

$S_{MS} = F_a\, S_s$

* $F_a = 1.0$ (This is a function of soil characteristics and value of S_s. See Table 1615.1.2 in IBC).

$\therefore\ S_{MS} = 1.0 \times 1.274 = 1.274$

$S_{DS} = \beta\, S_{MS} = 0.667 \times 1.274 = 0.85$

Per ASCE 7.02 Provisions Sec. 7.5.3:

$$K_h = \frac{S_{SD}}{2.5} = 0.40 \times 0.85 = 0.34$$

(Note that this is about one-fourth MCE) Note also that the above example value of k_h is nearly the same as could be obtained using simplified base shear equation 16-56 with R = 3.0.

Alternately, using UBC '97 and/or CBC '01:

Derive K_h from base shear, V, for non-building structure. (Terms defined in UBC '97 and CBC '01).

$$V = \frac{2.5\,C_a I}{R} W \qquad \text{Assume } R = 3.0$$

For example design: $C_a = 0.40$, $I = 1.0$

$$\therefore\ V = \frac{2.5 \times 0.40 \times 1.0}{3.0} W = 0.33\ W$$

This suggests $K_h = 0.33 \cong 0.34$ per IBC.

Simplified Seismic Force Application

The NEHRP 2000 Part 2 –Commentary states Seed and Whitman's proposed simpler approximation:

$\Delta K_{AE} \sim (3/4)\, k_h \qquad \therefore\ \Delta P_{AE} \sim (1/2)\gamma H^2 (3/4) k_h \sim (3/8) k_h \gamma H^2$

k_h is the peak ground acceleration modified per Provisions Sec. 7.5.3:

where $k_h = S_{DS} / 2.5$

Base moments, using this simplification, are therefore:

$$M_{AEbase} = P_A (H/3) + (\Delta P_{AE}) (0.6\ H)$$
$$= \gamma H^3 (0.17\ K_a + 0.225\ k_h)$$

An observation from this is that the base moments from static and dynamic (seismic) are equal when $k_h \sim 0.75\ K_A$

An arguable issue: If the seismic component is considered a factored force, and since overturning and soil pressure are based upon un-factored forces (E/1.4), should the seismic component be reduced by 0.71?

Vertical Distribution of Seismic Force on Stem

Here is a simplified method for assuming a uniformly applied force to the stem:

Since $P_{AE} = P_A + \Delta P_{AE}$

$$P_{AE} \cong \frac{\gamma H^2}{2} (.75\ k_h) \cong .375\ k_h\ \gamma H^2$$

$$P_A = \frac{K_a \gamma H^2}{2}$$

Total force on stem: $P_A + \Delta P_{AE} = .5K_a\ \gamma H^2 + .375\ k_h\ \gamma H^2$

If resultant acts at 0.5 H, the uniform lateral on stem

$$= \frac{.5K_a\ \gamma\ H^2 + .375\ K_h\ \gamma\ H^2}{H} = (.5\ K_a + .375\ k_h)\ (\gamma H)$$

For design example, assuming $K_a = 0.35$, $k_h = .34$, $\gamma = 120$

$F_P = 36H$

Note that this simplified formula is <u>not valid</u> if there is a <u>sloped backfill</u> that will significantly increase seismic forces.

Seismic for Stem Self-weight

This is an arguable issue: whether to include the seismic force due to self-weight of the wall acting simultaneously with the seismic due to earth pressure. It does not appear to be defined in the codes. AASHTO, however, in 5.5.4 states: "*...seismic design forces should account for wall inertia forces in addition to the equivalent static force, where a wall supports a bridge structure...*". But section 5.6.4, referring to flexible cantilever walls, states that "*Forces resulting from wall inertia effects may be ignored in estimating the seismic lateral earth pressure*".

Judgment indicates that seismic self-weight should be applied simultaneously with seismic due to earth pressure.

Using ASCE 7-02, Section 9.6.1.3:

F_P in equation 9.6.1.3-1, for cantilevered wall and assuming Ip = 1.0,

Reduces to: $Fp = 0.4\ S_{DS}\ W_p$

Per above design example where $S_{DS} = 0.85$,:

$F_P \quad = \quad 0.4 \times 0.85 \times 1.0\ W_P = 0.34\ W_p$

Using the UBC '97 method:

$$F_P \quad = \quad \frac{a_P C_a I_P}{R_p}\left(1 + \frac{h_x}{h_r}\right) W_P$$

$a_p \quad = \quad 1.0,\ R_P = 3.0,\ \frac{h_x}{h_r} = 0$ at bottom and 1.0 at top.

F_p minimum is $0.7\ C_a\ I_p\ W_p$

F_p for design is average between top and bottom

$\therefore F_P \quad = \quad (1.33 + 0.70) / 2 = 1.015 * [\ C_a I_P W_P\ ]$

For example design, $C_a = 0.44$, $I_P = 1.0$

$\therefore F_P \quad = \quad 0.45\ W_P$

to provide a displacement ductility of approximately 4. Beyond the potential plastic hinge region, the curvature ductility demand is not considered to exceed that provided by the nominal moment capacity of the section for non-earthquake loads.

7.4.4.4 Precast (non-prestressed) concrete piles. For precast concrete piles, the longitudinal reinforcement is specified to extend the full length of the pile so there is no need to determine the flexural length. Transverse reinforcement spacing within the potential plastic hinge zone is required for the length of three pile diameters at the bottom of pile cap. Particular attention should be taken where piles cannot be driven to or are overdriven beyond the anticipated end bearing point elevation. The transverse reinforcement size and spacing in this region is the same as the uncased concrete pile. Transverse reinforcement spacing outside the potential plastic hinge zone is specified to be no greater than 8 inches to conform with current building code minimums for this pile type.

7.4.4.5 Precast-prestressed piles. The transverse reinforcement requirements are primarily taken from the PCI Committee Report (1993) on precast prestressed concrete piling for geographic regions subject to low to moderate ground motions. The amount of transverse reinforcement was relaxed for the pile region greater than 20 feet (6m) below the pile cap to one-half of that required above. It was judged that the reduced transverse reinforcement would be sufficient to resist the reduced curvature demands at that point. Particular attention should be taken where piles cannot be driven to or are overdriven beyond the anticipated end bearing point elevation so that the length of the confining transverse reinforcement is maintained.

Equation (7.4-1), originally from ACI 318, has always been intended to be a lower bound spiral transverse reinforcement ratio for larger diameter columns. It is independent of the member section properties and can therefore be applied to large or small diameter piles. For cast-in-place piles and prestressed concrete piles, the resulting spiral reinforcement ratios from this formula are considered to be sufficient to provide moderate ductility capacities.

High strength hard drawn wire with higher yield strengths is permitted to be used for transverse circular spiral reinforcement of precast prestressed concrete piles. Pile test specimens using this type of transverse reinforcement include the research done by Park and Hoat Joen (1990). High strength hard drawn wire has yield strengths between 150 and 200 ksi. f_{yh} is conservatively limited to 85 ksi for this steel because hard drawn wire has limited ductility.

7.5 SEISMIC DESIGN CATEGORIES D, E, AND F

For Seismic Design Category D, E, or F construction, all the preceding provisions for Seismic Design Category C applies for the foundations, but the earthquake detailing is generally more severe and demanding.

7.5.1 Investigation. In addition to the potential site hazards discussed in *Provisions* Sec. 7.4.1, consideration of lateral pressures on earth retaining structures shall be included in investigations for Seismic Design Categories D, E, and F.

Earth retaining structures. Increased lateral pressures on retaining structures during earthquakes have long been recognized; however, design procedures have not been prescribed in U.S. model building codes. Waterfront structures often have performed poorly in major earthquake due to excess pore water pressure and liquefaction conditions developing in relatively loose, saturated granular soils. Damage reports for structures away from waterfronts are generally limited with only a few cases of stability failures or large permanent movements (Whitman, 1991). Due to the apparent conservatism or overstrength in static design of most walls, the complexity of nonlinear dynamic soil-structure interaction, and the poor understanding of the behavior of retaining structures with cohesive or dense granular soils, Whitman (1991) recommends that "engineers must rely primarily on a sound understanding of fundamental principles and of general patterns of behavior."

REF. #2

Seismic design analysis of retaining walls is discussed below for two categories of walls: "yielding" walls that can move sufficiently to develop minimum active earth pressures and "nonyielding" walls that do not satisfy this movement condition. The amount of movement to develop minimum active pressure is very small. A displacement at the top of the wall of 0.002 times the wall height is typically sufficient to develop the minimum active pressure state. Generally, free-standing gravity or cantilever walls are considered to be yielding walls (except massive gravity walls founded on rock), whereas building basement walls restrained at the top and bottom are considered to be nonyielding.

KA WALLS

Yielding walls. At the 1970 Specialty Conference on Lateral Stresses in the Ground and Design of Earth Retaining Structures, Seed and Whitman (1970) made a significant contribution by reintroducing and reformulating the Monobe-Okabe (M-O) seismic coefficient analysis (Monobe and Matsuo, 1929; Okabe, 1926), the earliest method for assessing the dynamic lateral pressures on a retaining wall. The M-O method is based on the key assumption that the wall displaces or rotates outward sufficiently to produce the minimum active earth pressure state. The M-O formulation is expressed as:

$$P_{AE} = (1/2)\gamma H^2 (1-k_v) K_{AE} \quad \text{(C7.5-1)}$$

where: P_{AE} is the total (static + dynamic) lateral thrust, γ is unit weight of backfill soil, H is height of backfill behind the wall, k_V is vertical ground acceleration divided by gravitational acceleration, and K_{AE} is the static plus dynamic lateral earth pressure coefficient which is dependent on (in its most general form) angle of friction of backfill, angle of wall friction, slope of backfill surface, and slope of back face of wall, as well as horizontal and vertical ground acceleration. The formulation for K_{AE} is given in textbooks on soil dynamics (Prakash, 1981; Das, 1983; Kramer, 1996) and discussed in detail by Ebeling and Morrison (1992).

Seed and Whitman (1970), as a convenience in design analysis, proposed to evaluate the total lateral thrust, P_{AE}, in terms of its static component (P_A) and dynamic incremental component (ΔP_{AE}):

$$P_{AE} = P_A + \Delta P_{AE} \quad \text{(C7.5-2a)}$$

or

$$K_{AE} = K_A + \Delta K_{AE} \quad \text{(C7.5-2b)}$$

or

$$\Delta P_{AE} = (1/2)\gamma H^2 \Delta K_{AE} \quad \text{(C7.5-2c)}$$

Seed and Whitman (1970), based on a parametric sensitivity analysis, further proposed that for practical purposes:

$$\Delta K_{AE} = (3/4)K_h \quad \text{(C7.5-3a)}$$

$$\Delta P_{AE} = (1/2)\gamma H^2 (3/4)k_h = (3/8)k_h \gamma H^2 \quad \text{(C7.5-3b)}$$

*

where k_h is horizontal ground acceleration divided by gravitational acceleration. It is recommended that k_h be taken equal to the site peak ground acceleration that is consistent with design earthquake ground motions as determined in *Provisions* Sec. 7.5.2 (that is, $k_h = S_{DS}/2.5$). Eq. C7.5-3a and C7.5-3b generally are referred to as the simplified M-O formulation.

Since its introduction, there has been a consensus in geotechnical engineering practice that the simplified M-O formulation reasonably represents the dynamic (seismic) lateral earth pressure increment for yielding retaining walls. For the distribution of the dynamic thrust, ΔP_{AE}, Seed and Whitman (1970) recommended that the resultant dynamic thrust act at $0.6H$ above the base of the wall (that is, inverted trapezoidal pressure distribution).

Using the simplified M-O formulation, a yielding wall may be designed using either a limit-equilibrium force approach (conventional retaining wall design) or an approach that permits movement of the wall up to tolerable amounts. Richards and Elms (1979) introduced a method for seismic design analysis of yielding walls considering translational sliding as a failure mode and based on tolerable permanent displacements for the wall. There are a number of empirical formulations for estimating permanent displacements under a translation mode of failure; these have been reviewed by Whitman and Liao (1985). Nadim (1980) and Nadim and Whitman (1984) incorporated the failure mode of wall tilting as well as sliding by employing coupled equations of motion, which were further formulated by Siddharthan et al. (1992) as a design method to predict the seismic performance of retaining walls taking into account both sliding and tilting. Alternatively, Prakash and others (1995) described design procedures and presented design charts for estimating both sliding and rocking displacements of rigid retaining walls. These design charts are the results of analyses for which the backfill and foundation soils were modeled as nonlinear viscoelastic materials. A simplified method that considers rocking of a wall on a rigid foundation about the toe was described by Steedman and Zeng (1996) and allows the determination of the threshold acceleration beyond which the wall will rotate. A simplified procedure for evaluating the critical threshold accelerations for sliding and tilting was described by Richards and others (1996).

Application of methods for evaluating tilting of yielding walls has been limited to a few case studies and back-calculation of laboratory test results. Evaluation of wall tilting requires considerable engineering judgment. Because the tilting mode of failure can lead to instability of a yielding retaining wall, it is suggested that this mode of failure be avoided in the design of new walls by proportioning the walls to prevent rotation in order to displace only in the sliding mode.

Ko WALLS

Nonyielding walls. Wood (1973) analyzed the response of a rigid nonyielding wall retaining a homogeneous linear elastic soil and connected to a rigid base. For such conditions, Wood established that the dynamic amplification was insignificant for relatively low-frequency ground motions (that is, motions at less than half of the natural frequency of the unconstrained backfill), which would include many or most earthquake problems.

For uniform, constant k_h applied throughout the elastic backfill, Wood (1973) developed the dynamic thrust, ΔP_E, acting on smooth rigid nonyielding walls as:

$$\Delta P_E = F k_h \gamma H^2 \qquad \text{(C7.5-4a)}$$

The value of F is approximately equal to unity (Whitman, 1991) leading to the following approximate formulation for a rigid nonyielding wall on a rigid base:

$$\Delta P_E = k_h \gamma H^2 \qquad \text{(C7.5-4b)}$$

As for yielding walls, the point of application of the dynamic thrust is taken typically at a height of $0.6H$ above the base of the wall.

It should be noted that the model used by Wood (1973) does not incorporate any effect on the pressures of the inertial response of a superstructure connected to the top of the wall. This effect may modify the interaction between the soil and the wall and thus modify the pressures from those calculated assuming a rigid wall on a rigid base. The subject of soil-wall interaction is addressed in the following sections. This section also provides further discussion on the applicability of the Wood and the M-O formulations.

7.5.2 **Soil-structure-interaction approach and modeling for wall pressures.** Lam and Martin (1986), Soydemir and Celebi (1992), Veletsos and Younan (1994a and 1994b), and Ostadan and White (1998), among others, argue that the earth pressures acting on the walls of embedded structures during earthquakes are primarily governed by soil-structure interaction (SSI) and, thus, should be treated differently from the concept of limiting equilibrium (that is, M-O method). Soil-structure interaction includes both a kinematic component—the interaction of a massless rigid wall with the adjacent soil as modeled by Wood (1973)—and an inertial component—the interaction of the wall, connected to a responding superstructure, with the adjacent soil. Detailed SSI analyses incorporating kinematic and inertial interaction may be considered for the estimation of seismic earth pressures on critical walls.

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APPENDIX C

C4. Foundations and Geotechnical Hazards (Systematic Rehabilitation)

C4.1 Scope

The fundamental reason for including consideration of foundations and geotechnical hazards in seismic rehabilitation of existing buildings is to improve the overall performance of the buildings. The geotechnical engineer and engineering geologist should work directly with the structural engineer and the building owner or the owner's representative, when necessary, to achieve the optimum rehabilitation strategy for the desired Rehabilitation Objective.

Typically, foundations have performed reasonably well on sites where ground displacement has not occurred because of surface faulting, landsliding, or liquefaction. Furthermore, modifying foundations to improve their performance during anticipated earthquake loading can be very costly because of the limited working space, as well as the presence of the building. Therefore, it is desirable to undertake costly foundation modifications only when they are essential to meeting seismic Rehabilitation Objectives for the building.

In addition to addressing building foundation capacities and deformations during earthquakes, the guidelines address other potential geologic hazards associated with earthquakes that may affect the performance of buildings on some sites.

C4.2 Site Characterization

In gathering data for site characterization, the following should be included:

- Visual inspection of the structure and its foundation
- Review of geotechnical reports, drawings, test results, and other available documents directly related to the building
- Review of regional or local reports related to geologic and seismic hazards, and subsurface conditions
- Site exploration, including borings and test pits
- Field and laboratory tests

The scope of the documentation program for a building depends upon specific deficiencies and the Rehabilitation Objective. In some cases, the cost of extensive analysis and testing can be justified by producing results that will allow the use of more accurately determined material properties than the conservative default values prescribed by the *Guidelines*.

Geotechnical information will be required to establish the subsurface conditions that exist beneath the building, to describe the building foundations, and to assess potential earthquake-related hazards that may affect the performance of the site. The general procedure for evaluating foundations and geotechnical information is outlined on Figure C4-1. In many instances, existing data may be sufficient to characterize the site. However, a detailed site assessment may be required for:

- Structures that require an enhanced level of seismic performance
- Facilities that are supported upon deep foundations
- Facilities that are located within areas that may be subjected to fault rupture, liquefaction, lateral spreading, differential compaction, and landsliding

Such detailed site assessments may be conducted with existing information or with new subsurface data. The following text discusses data sources that should be reviewed in the site characterization, along with the requirements for defining the subsurface conditions and describing the existing foundations.

Data Sources. Information required to adequately characterize a site will likely be derived from a combination of several sources, including existing data, a site reconnaissance, and site-specific studies. Potential data sources include the following:

- geological maps
- topographical maps
- hazard maps
- geotechnical reports
- design/construction drawings

to develop between a footing and the soil. This is considered to be analogous to tension yielding in bending of a structural element where the estimate of inelastic displacements assumes that the beam remains elastic. Even if the seismic overturning moment is equal to the maximum resisting moment due to gravity, this situation changes quickly with seismic load reversal. Experience with past earthquakes does not indicate that gross overturning is a problem for buildings. If the calculated displacements do not result in adverse behavior in the structure, there is no need to limit foundation displacements.

However, the situation for the Immediate Occupancy Performance Level is different, since foundation displacements may result in damage that impedes the use of the facility. For this reason, fixed-base conditions should not be assumed for structures sensitive to base movement.

C4.4.3.3 Nonlinear Procedures

The assumption that the base of the structure is rigid in nonlinear procedures is acceptable, provided that the resulting forces do not exceed upper-bound component capacities. The rationale for this limitation is similar to that for linear procedures.

If the foundation is modeled with appropriate nonlinear force-displacement relationships, the acceptability of geotechnical components for Collapse Prevention or Life Safety Performance is analogous to that for linear procedures. For Immediate Occupancy, the amount of the total structural displacement due to foundation movement must be calculated. Some percentage of this foundation-related movement is assumed to be permanent, and the effects of this must be included in considering whether the building can remain functional. Permanent foundation movement is controlled by foundation soil type and thickness, and foundation system characteristics (footing dimensions and geometry).

C4.5 Retaining Walls

The equation in the *Guidelines* for the seismic increment of earth pressure acting on a building retaining wall is a rounded-off form of the equation developed by Seed and Whitman (1970). (In their equation, the fraction 3/8 rather than the rounded-off decimal 0.4 is used. In view of the uncertainty in these pressures, the rounding off is justified.) This equation was developed as an approximation of a seismic earth pressure formulation presented by Seed and Whitman ("Mononobe-Okabe method," 1970) for yielding (free-standing) retaining walls. Because building walls retaining soil (e.g., basement walls) are relatively nonyielding due to the restraint provided by the interior floors, the applicability of these equations to building walls is a matter of some debate. Alternative elastic solutions for seismic wall pressures have been proposed. The most widely used elastic solution is that of Wood (1973), which provides seismic pressures of the order of twice those given by the Seed and Whitman expression. The argument for the lower values of the Seed and Whitman expression is that a limited number of dynamic finite element analyses and one case history (Chang et al., 1990) have found that the calculated and observed seismic earth pressures were of the same order of magnitude as those given by the Mononobe-Okabe formulations and lower than those of the Wood elastic solutions. In a state-of-the-art paper, Whitman (1991) concluded that the Mononobe-Okabe equation should suffice for nonyielding walls, except for the case where a structure, founded on rock, has walls retaining soil. Other publications that discuss seismic lateral earth pressures include Martin (1993), Soydemir (1991), and the *ASCE Standard 4* (ASCE, 1986; under revision).

If building retaining walls are required to be utilized as part of the foundation system to resist seismically-induced structure inertia forces, then higher pressures may be required to be developed on the walls. The maximum pressures that can be mobilized by the soil are passive earth pressures. Because of uncertainty regarding the direction or significance of soil inertia forces affecting the passive pressure capacity, it is suggested that passive pressures be obtained using conventional static earth pressure formulations.

C4.6 Soil Foundation Rehabilitation

Foundation enhancements may be required because of inadequate capacity of existing foundations to resist overturning effects (inadequate footing bearing capacities) or inadequate shear resistance of the foundations. Additionally, foundation enhancements may be required to support structural improvements, such as new shear walls or strengthening of existing shear walls. In either event, the foundation enhancements may be accomplished by a combination of one or several of the following schemes:

- Soil improvement

WESTON SOLUTIONS

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APPENDIX D

WESTON SOLUTIONS

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MSE Wall

- seismic design parameters
- From pg 3, MSE wall foundation conditions is "Site Class D" (stiff soil profile) based on IBC 2003, Table 1615.1.1.

- $S_S = .3385g$ \
  $S_1 = .0976g$ > see pg 4

- From Section 1615.1.2 (IBC 2003):

by interpolation <
$F_a = 1.529 \rightarrow$ Table 1615.1.2(1)
$F_v = 2.40 \rightarrow$ Table 1615.1.2(2)

- $\therefore S_{MS} = F_A S_S = 1.529(.3385g) = .518g$

  $S_{M1} = F_v S_S = 2.40(.0976g) = .234g$

- $S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3}(.518g) = .345g$

  $S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3}(.234g) = .156g$

$\& \frac{K_H}{g} = \frac{S_{DS}}{2.5} = \frac{.345g}{2.5} = \frac{.138g}{g} = .13$

APPENDIX "C"

Geotechnical Calculations of Surcharge effects from MSE Walls on Wall No. 1

(By WESTON Solutions)

WESTON SOLUTIONS

CLIENT/SUBJECT TA-73 LOS ALAMOS AIRPORT LANDFILL CLOSURE W.O. NO 13104.002.001

TASK DESCRIPTION Setback Requirements for Wall No.2 TASK NO. 7000

PREPARED BY K. Moser / A. Harpur DEPT 1495 DATE 6/17/05

MATH CHECK BY K. Moser DEPT 1495 DATE 6/17/05

METHOD REV. BY A. Harpur DEPT 1495 DATE 6/17/05

BACKGROUND

The reinforced concrete wall (Wall No. 1) was not designed to support any permanent surcharge loads. If Wall No. 2 is constructed too close to Wall No. 1 it will act as a surcharge on Wall No. 1. Therefore it is critical to ensure that Wall No. 2 is setback sufficiently far such that it does not act as a surcharge on Wall No.1.

ANALYSIS

An initial assess of the required setback distance was completed using the Culmann graphical procedure. This analysis was completed for a 26.5 feet high wall (25-foot stem with a 1.5-foot footing) conservatively assuming the use of backfill material with an internal friction angle (ϕ) of 32°. This analysis indicated that for a 26.5 ft high wall a setback distance, measured from the back of the footing was 18.67 feet, say 18.7 feet. A setback distance of 7.85 feet was determined using the Culmann procedure for a 11.5-ft high wall. To confirm these setback requirement distances were determined using Rankine theory.

Using Rankine theory, the failure plane forms an angle of $45 + \phi/2$ degrees with the horizontal. Assuming $\phi = 32°$, the failure plane forms an angle of 61° with the horizontal. Based on this angle and a wall height of 26.5 feet the failure plane would intersect the ground surface at a distance of 14.7 feet. This value is about 20% less than the value determined using the Culmann procedure. The Rankine procedure resulted in a setback distance of 6.37 feet, about 20% less than the 7.85 feet determined using the Culmann procedure.

The following table summarizes the required setback distances for various wall heights. The setback distances were calculated using Rankine theory and increased by 20% consistent with the results obtained for the 26.5-foot high wall. A more realistic value of 34° for the internal friction angle of the structural backfill was used in the calculations.

These setback requirements are shown on the design drawings.

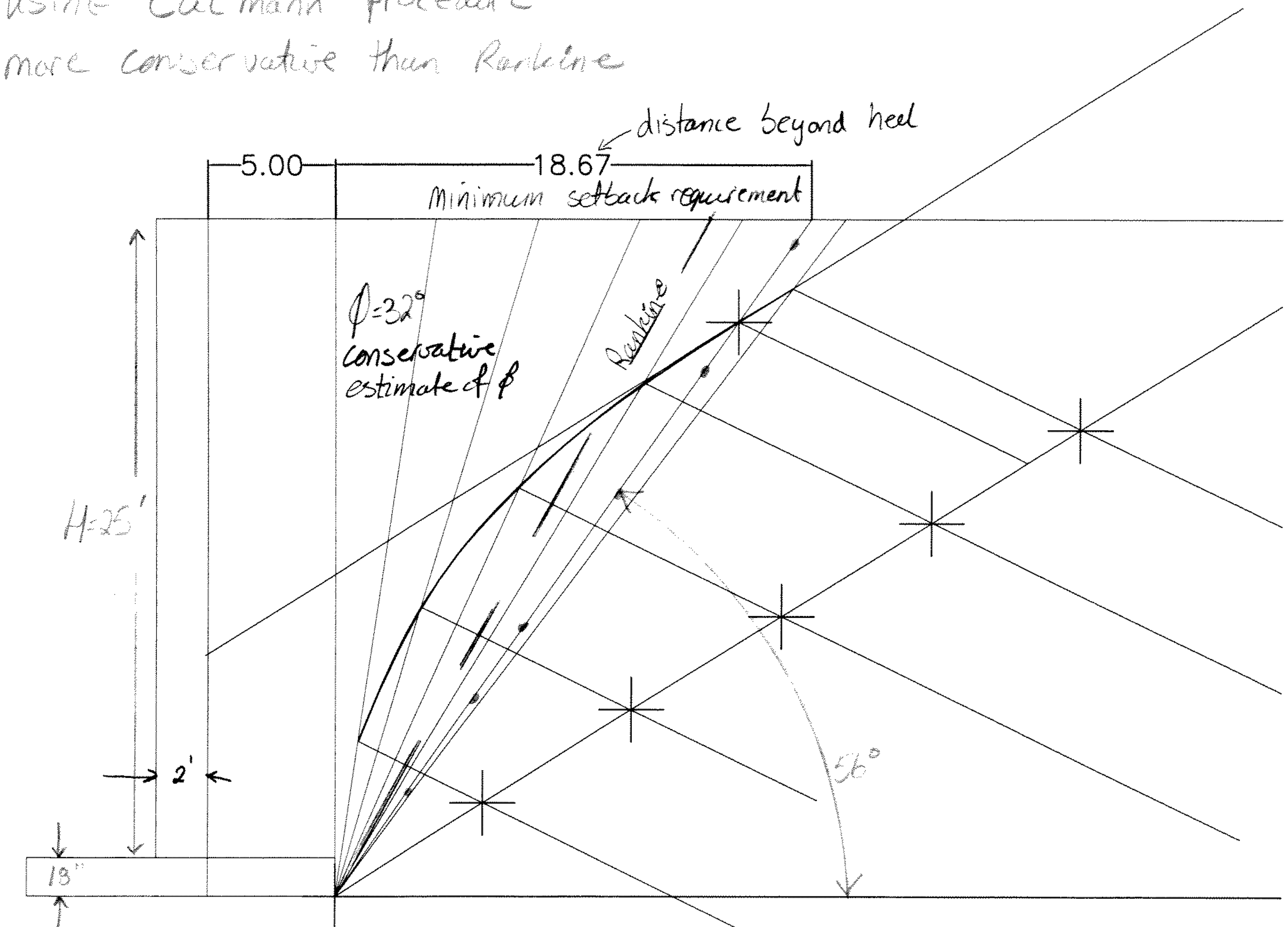
WALL SETBACK REQUIREMENTS

Wall Section	Starting Station	Wall Height (ft)	Footing Thickness (ft)	Total Length/Height (ft)	Internal Friction Angle of Backfill Soil	Rankine Setback from rear edge of heel(ft)	F.S. (20%)	Required Setback from end of heel (ft)	Wall 1 footing (heel) length (ft)	Wall 1 stem width (ft)	Required Setback from front face to front face (ft)	Required Setback from rear face to front face (ft)
A1	3+56	3	1.25	4.25	34	2.26	0.45	2.71	1.92	0.83	5.46	4.63
	3+50	5	1.25	6.25	34	3.32	0.66	3.99	1.92	0.83	6.74	5.90
B1	3+42	6	1.5	7.5	34	3.99	0.80	4.79	3.25	1.00	9.04	8.04
	3+34	8	1.5	9.5	34	5.05	1.01	6.06	3.25	1.00	10.31	9.31
	3+30	10	1.5	11.5	34	6.11	1.22	7.34	3.25	1.00	11.59	10.59
C1	3+24	10	1.75	11.75	34	6.25	1.25	7.50	5.00	1.25	13.75	12.50
	3+20	12	1.75	13.75	34	7.31	1.46	8.77	5.00	1.25	15.02	13.77
D1	3+08	14	2.25	16.25	34	8.64	1.73	10.37	6.00	2.00	18.37	16.37
	3+04	16	2.25	18.25	34	9.70	1.94	11.64	6.00	2.00	19.64	17.64
	3+00	18	2.25	20.25	34	10.77	2.15	12.92	6.00	2.00	20.92	18.92
E	2+96	20	2.25	22.25	34	11.83	2.37	14.20	7.00	2.50	23.70	21.20
	2+80	22	2.25	24.25	34	12.89	2.58	15.47	7.00	2.50	24.97	22.47
	2+50	24	2.25	26.25	34	13.96	2.79	16.75	7.00	2.50	26.25	23.75
	2+05	22	2.25	24.25	34	12.89	2.58	15.47	7.00	2.50	24.97	22.47
D2	2+00	20	2.25	22.25	34	11.83	2.37	14.20	6.00	2.00	22.20	20.20
	1+83	19	2.25	21.25	34	11.30	2.26	13.56	6.00	2.00	21.56	19.56
	1+64	17	2.25	19.25	34	10.24	2.05	12.28	6.00	2.00	20.28	18.28
	1+60	15	2.25	17.25	34	9.17	1.83	11.01	6.00	2.00	19.01	17.01
C2	1+53	15	1.75	16.75	34	8.91	1.78	10.69	5.00	1.25	16.94	15.69
	1+45	14	1.75	15.75	34	8.37	1.67	10.05	5.00	1.25	16.30	15.05
	1+30	12	1.75	13.75	34	7.31	1.46	8.77	5.00	1.25	15.02	13.77
B2	1+26	10	1.5	11.5	34	6.11	1.22	7.34	3.25	1.00	11.59	10.59
	1+22	8	1.5	9.5	34	5.05	1.01	6.06	3.25	1.00	10.31	9.31
	1+15	6	1.5	7.5	34	3.99	0.80	4.79	3.25	1.00	9.04	8.04
A2	1+07	5	1.25	6.25	34	3.32	0.66	3.99	1.92	0.83	6.74	5.90
	1+00	3	1.25	4.25	34	2.26	0.45	2.71	1.92	0.83	5.46	4.63

Notes:

1) FS of 20 % determined from comparison between Culmann and Rankine theory.

ACTIVE FAILURE WEDGE ANALYSIS
using Culmann procedure
more conservative than Rankine



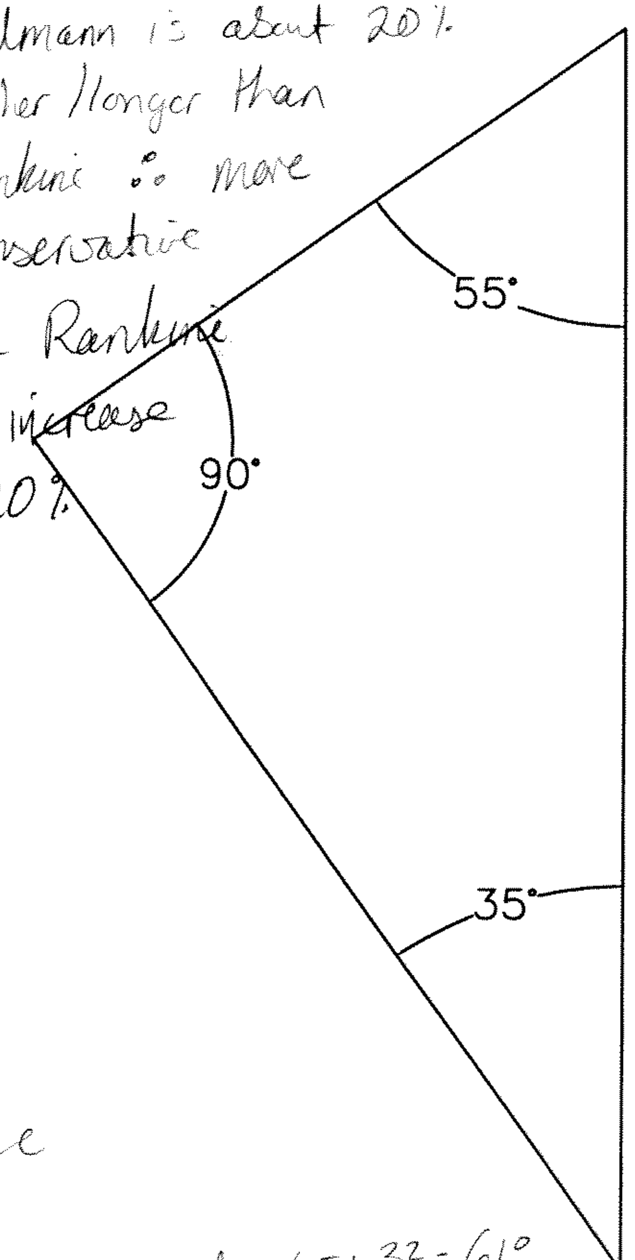
Minimum Surcharge set back distance for 26.5 ft high wall, as measured from base of footing, is approx. 24 feet. This set back distance is measured from the rear face of the wall.

$\frac{18.7 - 14.7}{18.7} = 21.4\%$

say 20%

Culmann is about 20% higher/longer than Rankine ∴ more conservative

Use Rankine but increase say 20%



Rankine

29°

$\theta = \tan 45 + \frac{\phi}{2} = 45 + \frac{32}{2} = 61°$

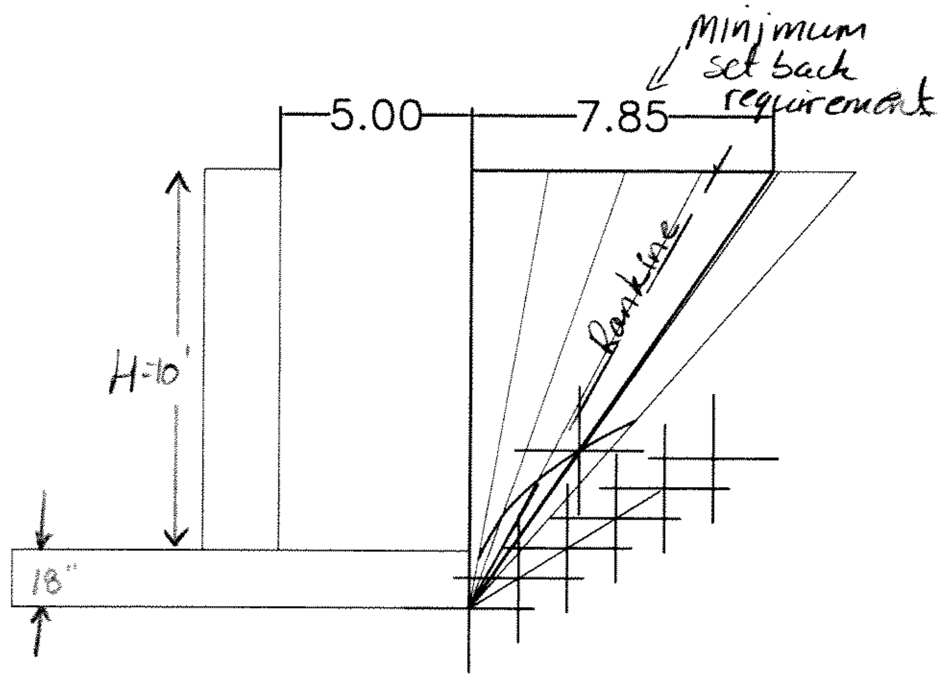
61°

$25 + 1.5 = 26.5\text{ ft} = H$

L=

$\tan 61° = \frac{H}{L} = \frac{26.5}{L}$

$L = \frac{26.5}{\tan 61°} = 14.7\text{ ft}$

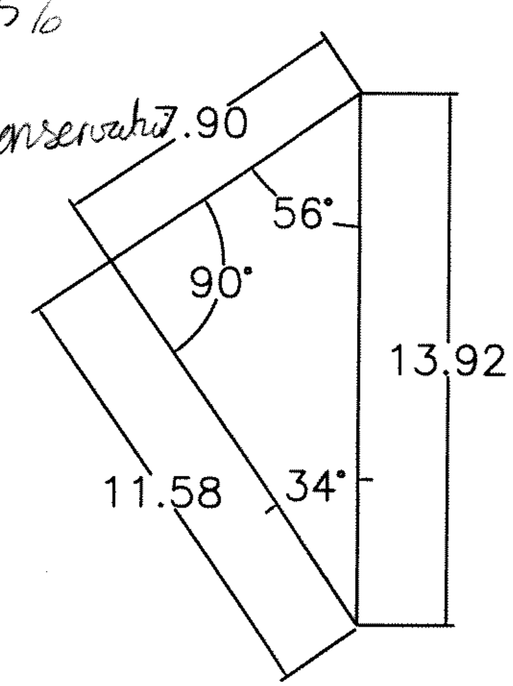


$H_{wall} = 10 + 1.5 = 11.5$

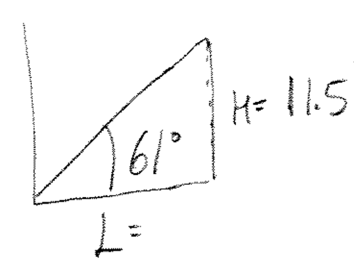
Set Back = 5 + 7.85 = 12.85 from rear face of wall

$\frac{7.85 - 6.4}{7.85} = 18.5\%$

Culmann is more conservative than Rankine.



Rankine



$\tan 45 + \frac{32}{2} = 61°$

$\tan 61 = \frac{11.5}{L}$

$L = \frac{11.5}{\tan 61°} = 6.4\ ft$

APPENDIX "D"

Chapter 7 "Earthquake (Seismic) Design

From ***Basics of Retaining Wall Design - A Guide for the Practicing Engineer,*** 6th Edition, April 2005, by Hugh Brooks, HBA Publications, Inc.
www.retainpro.com

7. EARTHQUAKE (SEISMIC) DESIGN

Earthquake (Seismic) Loading

Texts that address seismic design of retaining walls (e.g. Bowles, Kramer) acknowledge that seismic design of retaining walls is a highly complex issue, compounded by the assumptions that must be made to establish reasonable design guidelines. This is still an emerging science and geotechnical reports usually give only the peak ground acceleration applicable to the location and leave the application of this information to the designer.

Even the necessity of seismic design of retaining walls is arguable, considering compensating safety factors (e.g. 1.5 overturning safety factor). Earthquake caused retaining wall failures from which to obtain mode-of-failure lessons are very rare (waterfront structures excepted). It is also argued that since retaining walls are often at a distance from structures that would be affected by their failure and thus are not a life-safety issue. However, these arguments are moot considering the mandatory language of IBC and ASCE 7.

IBC 2003, Section 1622.1.2, refers to and modifies ASCE 7 to read as follows:

> ' . . . This section applies to all earth retaining walls. The applied seismic forces shall be determined in accordance with Section 9.7.5.1 [*This section states that "... the owner shall submit to the authority having jurisdiction a written report that includes an evaluation of the items in Section 9.7.4.1 and the lateral pressures on basement and retaining walls due to earthquake motions". Section 9.7.4.1identifies items to be included in the geotechnical report to be submitted ", when required by the authority having jurisdiction"]*

This clearly requires a seismic analysis of "earth retaining structures", based upon a geotechnical report, but implies some discretionary latitude by the "authority having jurisdiction".

The Uniform Building Code (UBC '97) and the California Building Code (CBC '01) do not appear to specifically require seismic design of "earth retaining structures" unless the requirements for "non-buildng structures" in CBC '01 could be so interpreted.

Check applicable local and state codes that may have specific seismic design requirements for retaining walls.

The Mononobe-Okabe equations

Of the many investigations of dynamic forces on retaining walls, one of the most important and influential is an ASCE paper titled *Design of Earth Retaining Structures for Dynamic Loads,* by Seed and Whitman, delivered at a 1970 Cornell University conference. In this paper they cited the pioneering studies by Mononobe (1929) and Okabe (1926), widely referenced today. Another contribution was a subsequent ASCE paper by Robert Whitman titled, *Seismic Design and Behavior of Gravity Retaining Walls,* 1990. They considered this lateral force to be an inverted triangular wedge of soil behind the wall. Seed-Whitman proposed a simplified formula, based upon the Mononobe-Okabe theory, for the combined static and seismic factor, which they termed K_{AE}, to be applied to this wedge acting against the wall. This was an adaptation of the Coulomb formula to calculate the total (seismic and static) pressure and introduced the variable θ, which is defined as the angle whose tangent is the ground acceleration ($\theta = \tan^{-1} k_h$).

This equation is presented in **Figure 7-1.**

K_{AE}= active earth pressure coefficient

$$= \frac{\sin^2(\alpha + \theta - \phi')}{\cos\theta' \sin^2 \alpha \sin(\alpha + \theta' + \delta)\left[1 + \sqrt{\dfrac{\sin(\phi + \delta)\sin(\phi - \theta' - \beta)}{\sin(\alpha + \delta + \theta')\sin(\alpha - \beta)}}\right]^2}$$

Where $\theta = \tan^{-1} K_h$, α = wall slope to horiz. (90° for a vertical face), ϕ = angle of internal friction, β = backfill slope, and δ = wall friction angle.
The horizontal component is $K_{AE} \cos\delta$.

For a vertical wall face and δ assumed to be $\phi/2$, this becomes:

$$K_{AE} = \frac{\sin^2(90+\theta-\phi)}{\cos\theta \sin^2(90+\theta+\phi/2)\left[1+\sqrt{\dfrac{\sin 1.5\phi \sin(\phi-\theta-\beta)}{\sin(90+\phi/2+\theta)\sin(90+\beta)}}\right]^2}$$

The total force (active and earthquake), $P_{AE} = \frac{1}{2}(\gamma) K_{AE} H^2$ where γ = soil density and H = retained height.

Figure 7-1. ***Mononobe-Okabe Equation***

When the acceleration is zero, $k_h = 0$, and K_{AE} becomes the familiar Coulomb K_A formula.

Also, note that passive the pressure coefficient decreases under seismic conditions.

The passive earth pressure coefficient, K_{PE} is:

$$K_{PE} = \frac{\sin^2(\alpha-\theta+\phi')}{\cos\theta' \sin^2\alpha \sin(\alpha+\theta'+\delta)\left[1+\sqrt{\dfrac{\sin(\phi+\delta)\sin(\phi-\theta'+\beta)}{\sin(\alpha+\delta+\theta')\sin(\alpha-\beta)}}\right]^2}$$

K_{AE} is thus two components (seismic and static). The seismic component (K_{AE} - K_A) is assumed to be an inverted, near-triangular trapezoid force (maximum at the ground surface) acting at a height of 0.6 H. For stem design, H is the height from top of footing to retained height. For overturning and sliding, H is the height at the back face of the footing, along a virtual vertical plane from the bottom of the footing to its intersection with the backfill grade.

The K_A component is the familiar triangular distribution acting at H / 3.

The height to the combined resultant can be obtained by the formula:

$$\bar{x} = \frac{P_A(H/3) + (P_{AE} - P_A)\,0.6H}{P_{AE}}$$

The direction of force application, per the Coulomb formula, is assumed to be inclined at an angle (from horizontal) equal to the friction angle at the back face of the stem, δ, which is often assumed to be $\phi/2$. Therefore, the horizontal components can be assumed to be

$$P_{AE\ horiz.} = \cos\left(\phi/2\right) P_{AE}.$$

A simple approach to the design for seismic is suggested by the overlapping force triangles, which tend to combine into a nearly uniform load over the height of the wall, if the height of the resultant is 0.5H.

Therefore, $w = \dfrac{K_{AE}\,\gamma\,H^2}{2H} = 0.5\,K_{AE}\,\gamma\,H$, where w is the equivalent uniform lateral static plus seismic force. This simplification, while approximate, is particularly helpful for checking stem moments and shears at various heights.

Seed and Whitman suggest an approximation of $K_{AE} = K_A + 0.75\,k_h$. If, for example, k_h is 0.30 and $K_A = 0.27$, then K_{AE} approximate would be 0.495. This would suggest an 83% increase over static K_A. However, the stem moments and overturning are greatly increased since 0.75 k_h act at an assumed height of 0.60H. Some geotechnical engineers use this method to give an added uniform seismic force over the full retained height with resultant acting at 0.6H. Such a requirement, therefore, might read "for seismic design add a uniform lateral force = 20 H^2 with the resultant applied at 0.6H.

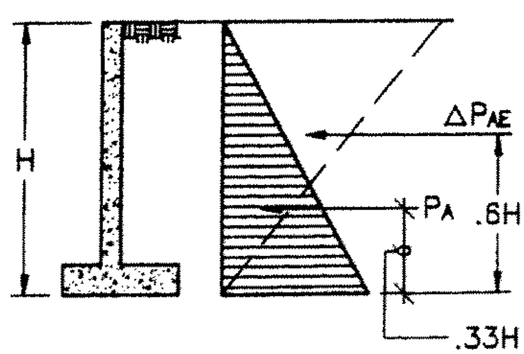


Figure 7-2. ***Application of Seed Whitman Method***

Seed and Whitman's paper commented that few building codes (at that time) required seismic provisions for retaining walls, and concluded that the factors of safety for static design, which are generally around 1.5, are adequate to protect the wall for short term seismic forces, since such forces would merely reduce the safety factor to an acceptable value greater than 1.0.

NAVFAC for Seismic Zone 4 (UBC '97) requires, in addition to static force, 20% of the total active pressure and 20% of the wall weight, acting at 2/3 the height. It further comments that the one-third stress increase for short-term loading should more than compensate for the added seismic stresses.

AASHTO contains seismic design guidance for retaining walls in their Section 6 of Division I-A.

Determining k_h

k_h is the ground acceleration factor used in the Mononobe-Okabe (M-O) equation to compute lateral seismic earth pressure in cantilevered retaining walls.

This is a design value and not necessarily the most severe acceleration that could occur at the site. Unless an arbitrarily reduced value of k_h is used, one-third to one-half the peak ground acceleration is often used (see Kramer and others).

The starting point is to determine the peak acceleration applicable to your design. Assuming your code is IBC 2003, or ASCE 7-02, which has identical charts (UBC '97 will be discussed later), select from the contours the Maximum Considered Earthquake (MCE) ground motion for 0.2 second, spectral response acceleration at 5% of critical damping. Note that retaining walls are "short period", hence the 0.2 second selection.

There is an easier way. Go to http://eqhazmaps.usgs.gov This is a U.S. Geological Survey address. Just enter your zip code (but latitude and longitude is more accurate). For example, Newport Beach, California, zip code 92660, gives 127.4 percent "g", or 1.274. These maps are somewhat different from IBC maps and the latter are preferred and a zoom-capable CD is available from IBC.

Here is an example procedure for obtaining a design K_h using the USGS Hazard Maps:

From charts, $S_s = 1.274$
(All terms defined in referenced codes)

$S_{MS} = F_a\, S_s$

$F_a = 1.0$ (This is a function of soil characteristics and value of S_s. See Table 1615.1.2 in IBC).

$\therefore\ S_{MS} = 1.0 \times 1.274 = 1.274$

$S_{DS} = \beta\, S_{MS} = 0.667 \times 1.274 = 0.85$

Per ASCE 7.02 Provisions Sec. 7.5.3:

$$K_h = \frac{S_{SD}}{2.5} = 0.40 \times 0.85 = 0.34$$

(Note that this is about one-fourth MCE) Note also that the above example value of k_h is nearly the same as could be obtained using simplified base shear equation 16-56 with R = 3.0.

Alternately, using UBC '97 and/or CBC '01:

Derive K_h from base shear, V, for non-building structure. (Terms defined in UBC '97 and CBC '01).

$$V = \frac{2.5 C_a I}{R} W \quad \text{Assume } R = 3.0$$

For example design: $C_a = 0.40$, $I = 1.0$

$$\therefore\ V = \frac{2.5 \times 0.40 \times 1.0}{3.0} W = 0.33\ W$$

This suggests $K_h = 0.33 \cong 0.34$ per IBC.

Simplified Seismic Force Application

The NEHRP 2000 Part 2 –Commentary states Seed and Whitman's proposed simpler approximation:

$\Delta K_{AE} \sim (3/4)\, k_h \qquad \therefore\ \Delta P_{AE} \sim (1/2)\gamma H^2 (3/4) k_h \sim (3/8) k_h \gamma H^2$

k_h is the peak ground acceleration modified per Provisions Sec. 7.5.3:

where $k_h = S_{DS} / 2.5$

Base moments, using this simplification, are therefore:

$$M_{AEbase} = P_A (H/3) + (\Delta P_{AE}) (0.6 H)$$
$$= \gamma H^3 (0.17 K_a + 0.225 k_h)$$

An observation from this is that the base moments from static and dynamic (seismic) are equal when $k_h \sim 0.75 K_A$

An arguable issue: If the seismic component is considered a factored force, and since overturning and soil pressure are based upon un-factored forces (E/1.4), should the seismic component be reduced by 0.71?

Vertical Distribution of Seismic Force on Stem

Here is a simplified method for assuming a uniformly applied force to the stem:

Since $P_{AE} = P_\Delta + \Delta P_{AE}$

$$P_{AE} \cong \frac{\gamma H^2}{2} (.75 k_h) \cong .375 k_h \gamma H^2$$

$$P_A = \frac{K_a \gamma H^2}{2}$$

Total force on stem: $P_A + \Delta P_{AE} = .5K_a \gamma H^2 + .375 k_h \gamma H^2$

If resultant acts at 0.5 H, the uniform lateral on stem

$$= \frac{.5K_a \gamma H^2 + .375 K_h \gamma H^2}{H} = (.5 K_a + .375 k_h)(\gamma H)$$

For design example, assuming $K_a = 0.35$, $k_h = .34$, $\gamma = 120$

$F_P = 36H$

Note that this simplified formula is <u>not valid</u> if there is a <u>sloped backfill</u> that will significantly increase seismic forces.

Seismic for Stem Self-weight

This is an arguable issue: whether to include the seismic force due to self-weight of the wall acting simultaneously with the seismic due to earth pressure. It does not appear to be defined in the codes. AASHTO, however, in 5.5.4 states: "*...seismic design forces should account for wall inertia forces in addition to the equivalent static force, where a wall supports a bridge structure...*". But section 5.6.4, referring to flexible cantilever walls, states that "*Forces resulting from wall inertia effects may be ignored in estimating the seismic lateral earth pressure*".

Judgment indicates that seismic self-weight should be applied simultaneously with seismic due to earth pressure.

Using ASCE 7-02, Section 9.6.1.3:

F_P in equation 9.6.1.3-1, for cantilevered wall and assuming Ip = 1.0,
Reduces to: $F_p = 0.4\ S_{DS}\ W_p$

Per above design example where $S_{DS} = 0.85$,:

$$F_P = 0.4 \times 0.85 \times 1.0\ W_P = 0.34\ W_p$$

Using the UBC '97 method:

$$F_P = \frac{a_P C_a I_P}{R_p}\left(1 + \frac{h_x}{h_r}\right) W_P$$

a_p = 1.0, $R_P = 3.0$, $\frac{h_x}{h_r} = 0$ at bottom and 1.0 at top.

F_p minimum is $0.7\ C_a\ I_p\ W_p$

F_p for design is average between top and bottom

$$\therefore F_P = (1.33 + 0.70) / 2 = 1.015 * [\ C_a I_P W_P\ ]$$

For example design, $C_a = 0.44$, $I_P = 1.0$

$$\therefore F_P = 0.45\ W_P$$

USER'S MANUAL

Retain Pro 2005

for Windows™ 95/98/NT/2000/ME/XP

Design & Analysis of Cantilevered and Restrained Retaining Walls

Retain Pro Software
Div. HBA Publications, Inc.
P.O. Box 826
Corona del Mar, CA 92625
(949) 721-4099

NOTE: Any errata for this manual will be posted on www.retainpro.com/support

Table Of Contents

CAUTION!!

Retain Pro is intended to be a design aid for persons already having the technical ability to design retaining walls in accordance with accepted structural engineering principles and applicable building codes. Design criteria used, input values, and all results from this program should be verified. The final design and/or analysis shall be the responsibility of the person(s) using the program and its results. Program developers ENERCALC Engineering Software, and Retain Pro Software/HBA Publications, Inc., their owners, and employees, are not responsible for anything resulting from the use of this program or its calculated values or drawings. Your acceptance of these conditions is a condition for its use. If you do not agree to accept these conditions and responsibility, you should return the program disk and accompanying documentation, retaining no copies and with a statement that it has not been installed on your computer, within 30 days of receipt and receive a refund of purchase price excluding shipping charges.

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Welcome!

Now you have a powerful, timesaving tool to help you design or analyze nearly any retaining wall you're likely to encounter. It will transform one of the most tedious structural design tasks from hours to minutes - and give you full documentation both on-screen and on printouts.

We welcome you to our family of many thousands of Retain Pro users nationwide, and on our part, we are dedicated to provide you with the finest retaining wall design software available.

We want to stay in touch with you, to know how you like the program, and to hear any suggestions you have for further improvements or new features. Remember to check our website, www.Retain Pro.com, often for news and announcements, and you can email us with any comments or suggestions at hbrooks@retainpro.com.

Just a Minute! Please Read This First...

We know you want to jump right in, but even if you are upgrading from a previous version, please read through this User's Manual first. True, you may not need to, especially since the program is quite intuitive and helpful prompts are everywhere, but a read-through will be an excellent investment of 30 minutes of your time.

We assure you that you will save time by doing this - and perhaps an unnecessary phone call to us. Nearly all of the entries are explained, and in particular, you should read the section *Design/Analysis and Methodology*.

And again, a reminder to check our Website often at www.retainpro.com. You can e-mail us from the site, and you will also be alerted to any technical bulletins (yes, we do occasionally find bugs). With version 2005 you will have automatic maintenance updates, via the Internet, and you will be asked whenever they are available. This manual is also available in pdf format under the Help Menu.

You can access our online User's Forum using your email address and password, to post questions and comments, and top read announcements from us.

If you change your email address you MUST notify us at www.retainpro.com/support, or you will not receive our bulletins and announcements.

Caution:

AGAIN WE NEED TO REMIND YOU THAT THIS PROGRAM IS INTENDED FOR THE PRACTICING ENGINEER WHO HAS THE TRAINING AND CAPABILITY TO DESIGN RELATIVELY COMPLEX RETAINING WALLS "BY HAND," AND IS FAMILIAR WITH SUCH DESIGN PRINCIPLES. THIS PROGRAM SHOULD BE USED ONLY BY THOSE WITH THESE PREREQUISITES, SINCE A LACK OF UNDERSTANDING OF TERMINOLOGY AND DESIGN PRINCIPLES COULD LEAD TO ERRONEOUS INPUT AND INACCURATE RESULTS.

About Retain Pro™

This new Version 2005 is our tenth upgrade since Version 1.0 was introduced in the summer of 1989. We've come a long way since then, and Retain Pro is now used in thousands of design offices, governmental agencies, and plan review agencies nationwide, and has become the #1 choice for retaining wall design and analysis software.

The Retain Pro program was written by Michael Brooks, founder and president of Enercalc Engineering Software, and portions of Retain Pro are included in their *Structural Engineering Library*. Since 1991 Retain Pro Software has been an independent company acquired by Hugh Brooks, SE, as a division of HBA Publications, Inc., Corona del Mar, California.

What You Can Do With Retain Pro 2005

This is a powerful program that you can use to design or check nearly any configuration or loading conditions for cantilevered or restrained retaining walls. The design methodology follows accepted engineering practice, as described in later sections, and is in accordance with applicable provisions of ACI 318-02, ACI 530-02, IBC 2003, NEHRP 2000, ASCE 7-02, UBC '97, and CBC '01.

Here is a listing of design capabilities contained in Retain Pro 2005:

- Cantilevered Stem wall can have up to five different stem sections, of either masonry or concrete, each with a different thickness and/or reinforcing size and spacing. You may also include a weightless fence on top of the wall. Concrete stem can be tapered on inside face (cantilevered walls only).
- Selects applicable building code and program automatically inserts load factors, all of which can be changed or set as default
- Restrained walls with lateral support near top and base either fixed or pinned.
- Designs gravity walls.
- Surcharges on either side of the wall.
- Sloped backfill.
- Axial dead and live load applied to the top of the wall, with eccentricity.
- Wind acting on a wall projection above grade.
- Wall Wizard for quick-start data entry.

- Optional Visual Input data entry screen.
- Add lateral loads against the stem -- uniform or concentrated (impact) loads.
- Effect of an adjacent footing behind the wall.
- Water table conditions (two levels of active pressure).
- Option to use user-defined active and passive pressure or input angle of internal friction and program will compute pressures using the Rankine or Coulomb Formulas.
- Add seismic forces per Mononobe-Okabe equations, including wall self-weight and restrained walls.
- Wall tilt calculations.
- Specify percent passive and frictional resistance to be used to prevent sliding.
- Specify sliding resistance using cohesion, in lieu of friction.
- With the built-in AutoCAD® utility you can create a .DXF file of your design to import to your CAD program (AutoCAD®, AutoCAD® LT, QuickCAD, and others) to create a to scale drawing for inclusion in your drawings, or print on your laser printer.
- On-screen graphics to view input loading conditions and wall geometry.
- Database files to keep track of your designs, with capability to add, edit, delete, copy, or print a file. Print directory lists.
- Automatic sizing of footing
- Customize your title block for printouts. Even add your logo.
- Over 70 values (wall weights, factors, stresses, and dimensions) can be modified or set as default values.
- Extensive on-line Help System and access to online User's Forum.
- Warning messages for overstress conditions.
- Select either U.S. or SI units.
- Comprehensive two page 8.5" x 11" calculation printouts.

What's New In Version 2005 ?

You'll experience a new look and feel, with an easier-on-the-eyes background color, improved printouts, and lots of tidying-up enhancements to make your work even easier.

There's this new User's Manual with more explanations, and it's also accessible within the program, in pdf format.

We've added a QuickHelp button to give you instant explanations of all entries, including tips, and it's accessible from every screen.

You'll never be out-of-date with any missed patches. Every time you open Retain Pro 2005 you'll be asked if you want to install a maintenance update (provided one becomes necessary). And it's all automatic.

You'll be assured of continuing technical support. Personalized, either fax, email or talking to Hugh.

If you're upgrading from version 6.1x, you will, of course, have all the patches issued up through 6.1f, in case you missed any.

If you're upgrading from version 6.0, you'll also find that we've updated to all current codes, added editable load factors, added seismic design for restrained walls and wall self-weight, and other improvements. We also introduced assigning you a Product Activation Code (PAC) which lets you install Retain Pro on multiple computers without a CD (Internet connection is required).

If you're upgrading from version 5.x or earlier, you'll also find a whole new array of features, including gravity walls, seismic design, and many other technical improvements throughout.

We doubt whether anyone is still using version 3 or earlier, but it should be noted that in version 4 we switched from DOS to Windows.

Before You Begin

First, read the license agreement contained herein, and review our cautionary notes about **only qualified personnel using the software**. When you install and use the software you will be accepting and bound by all the conditions stated therein.

Second, understand the operation of the Microsoft Windows version you are using, (95, 98, NT, 2000, ME, or XP) that must be installed on your computer before using Retain Pro. Be sure your display is set for either 800x600-pixel or 1024 x 768, and set for small fonts.

Third, review the hardware requirements outlined below. The software must be installed from the CD onto your hard drive, or downloaded from www.retainpro.com/downloads, using your Product Activation code to activate from demonstration mode.

Fourth, read through this User's Manual so you will know how to navigate and what all the entries mean. If you have downloaded this software, the User's Manual is on the file and should be viewed, read, and printed (Adobe Acrobat).

Lastly, go ahead and run the "SETUP.EXE" program from the installation CD.

System Requirements

Here's what you will need to use this software:

- Pentium 4 processor.
- RAM: 16 MB recommended.
- Windows 95, 98, NT, 2000, ME, 2000, or XP.
- 16 MB of hard disk space.
- A standard 1024 x 768 monitor, or 800 x 600
- Access to the Internet is required since it will be the source of downloads and give you access to the online User's Forum.

Installation Procedure

For Windows 95, 98, NT, 2000, ME, or XP

- From your desktop, click the **START** button and select **RUN**.
- Type **D:SETUP.EXE** in the box to the right of the word "Open". (Or select the correct drive for inserting the CD). Then click the ***OK*** button.
- The setup program will begin. All you need to do is specify the drive and directory location to install Retain Pro 2005 (for example "RP2005").

If you're downloading, go to www.retainpro.com/downloads, and follow the instructions. Your download will be in the Demo mode, and when prompted you will need to enter your 12-character Program Activation Code (PAC), which will be on your email order acknowledgement, to activate the program.

Here are instructions for installing Retain Pro on a server:
Install Retain Pro into its own subdirectory off of the root. Start Retain Pro up on the server and enter your Product Activation Code (PAC). This will store the PAC on the server. On the client, create a shortcut to the executable program file. Be sure that on your shortcut the startup directory is set to the installation directory on the server.

To create a Retain Pro icon for your desktop, right click on the desktop, choose New, choose Shortcut. On Create Shortcut dialogue box choose Browse, then double-click on the Retain Pro directory you installed. Double-click RP6.1.exe, which will then appear on the Command Line in the Create Shortcut box. Click Next, then Finish. An icon will be on your desktop. To rename it, Right-click and choose Rename.

Write down or remember your personal password for access to the online User's Forum and Message Board. You'll also need the email address you used for ordering – you can change it later by going to www.retainpro.com/support.

Technical Support

If you need technical support, go to www.retainpro.com/support. You will find an email form for technical support, fax number, and voice contact information. Please include your name, company, and phone number, and a brief description of the problem you are experiencing. If you question a computational result you must include your hand-calc showing your alleged discrepancy. Please first review the Frequently Asked Technical Questions on our website Support page.
Providing technical support and/or reviewing your design input SHALL NOT be construed as approval of your final design – **responsibility of the final design rests with the Engineer of Record.**

Program Limitations

These are a few conditions that Version 2005 will not currently handle:

- Computation of horizontal reinforcing for shrinkage and temperature. This is at the designer's option due to a wide divergence of opinion and practice. As a guide, please refer to Appendix A for suggestions.
- Water table calculation is not valid for a fluid other than water, nor is this feature available for restrained walls.
- Restrained walls can be of only one material (concrete or masonry) and only be 100% fixed at base, or assumed pinned at base – no intermediate degrees of fixity.
- .DXF files created for restrained walls show only a to-scale depiction of the wall, without reinforcing. The program will display reinforcing selected from the design, however, the designer and CAD person will need to insert and detail the reinforcing per his/her specific design intent. Similarly, details at the top of the wall will need to be input, since conditions are too numerous (e.g. ledgers, connections for concentrated loads, architectural details). Horizontal reinforcing must also be chosen and input.

Feedback and Suggestions

We always want to know how you like Retain Pro, what problems you encounter, and suggestions for new features and other improvements. We want to serve you as best we can!

Just email us at hbrooks@retainpro.com.

Because this software may be used to design components of structures that protect property and human life, it is CRITICALLY important that you fully understand the intended use and capabilities of this program. Only experienced (and preferably licensed) professional engineers should use this software. The authors of this software have tried, to the best of their ability, to correctly combine the principles of structural mechanics, provisions of building codes, and typical analysis processes. Regardless of how thoroughly any software is tested, errors may occasionally —and likely will—occur, and the engineer-of-record for a project should thoroughly review the results and must take responsibility for the use of the final calculations. No software can possibly account for the multitude of factors influencing sound structural design; therefore this software should be considered only an aid to performing numerical calculations. In no event will HBA Publications, Inc., Retain Pro Software, or ENERCALC Engineering Software, its officers, owners, or employees be liable to anyone for any unfavorable conditions occurring from the use of this software. If you do not agree with the terms of this disclaimer or the terms of the License Agreement, return this User's Manual and uninstalled program disk to Retain Pro Software within 30 days of purchase for a full refund of software cost, excluding shipping.
Installation of the software by you indicates your acceptance of this Disclaimer and License Agreement.

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This is a legal agreement between you (either an individual or an entity) and Retain Pro Software, div. of HBA Publications, Inc., wherein by installing this software on a computer or network server, you agree to be bound by the terms of this agreement. If you do not agree to the terms of this agreement, promptly return the uninstalled software and accompanying items to us for a refund.

Definitions:

License -- The conditions of use of this software to which you agree to adhere.

Program Activation Code (PAC) -- This is a 24 digit character assigned to you when you ordered, and is on your email order acknowledgement receipt. These are the specific characters to enter when initializing the program in order to change it from a demonstration mode to full use. It contains encrypted information about your use of the software and authorized number of seats.

Registration Number (RN) -- This replaces the originally used four digit order number. It is now a seven digit number following RP. For example, RP2345678. Keep this number handy since it will help us retrieve information about your order if necessary.

Software – Retain Pro 2005.

Password -- This is a 4 to 8 digit password you assigned to yourself, or your company, for access to our online Forums and Message Board.

Email Address -- This is the email address you used when ordering and is the **only way** we can contact you. If you want to change it, such as from the purchasing department to your personal email, you may do so online at www.retainpro.com/support.

User ID – This is the same as your email address, and used for access to online Forum and Message Boards.

Seat(s) -- This defines the number of simultaneous users of the Software under the License Agreement

Grant of License

Retain Pro currently offers two classes of license:

Small Office License – Permits installation of the Software on several office computers, including a home computer and a laptop, however, only one simultaneous user is permitted.

Site License – Is intended for larger offices where the Software is installed on a network server allowing unlimited simultaneous users. However, a Site License is for one physical location only. For example, for a branch office another Small Office or Site license would be required.

Retain Pro is considered in "use" on a computer when it is loaded into temporary memory (i.e. RAM) or installed into permanent memory (e.g. hard disk or other storage device) of that computer, except that a copy installed on a network server for the sole purpose of usage access by other computers is not "in use".

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It is the responsibility of the licensee to keep Retain Pro informed of any change of address, email address, or contact individual. Changes can be made at www.retainpro.com/support.

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QUICK-START Overview Tutorial

The program is designed to be intuitive, that is, lead you through the design of a retaining wall, just as you would do it by "hand calcs." But save you lots of number-crunching time!

As we'll describe below, you design the wall by steps—using the tabs at the top of each screen to lead you – from left to right -- from criteria input through the design process. On the right side of your screen you can access Summary, Construction Drawing, Loading Diagram, or Moment/shear diagrams.

You'll start with the WELCOME TO RETAIN PRO 2005 screen, where you choose what you want to do. You'll have many options, such as using Wall Wizard or the graphical data entry screen. Soon you'll learn it's easiest to start with CRITERIA.

To navigate between or within the screens, use your mouse to position the cursor, or use the TAB key to advance the cursor to succeeding entries (don't use the ENTER key after entering date—use the TAB key!). Spin buttons and drop-down menus are also available.

HELP gives you access to Tutorials, and the "QuickHelp" button on the Task Bar displays the related page from the User's Manual for entry explanations. And when your cursor is on an entry, its description is on the Entry Description Bar at the bottom of your screen.

There is a SETTINGS screen tab where you enter your title block information—and even import your logo, which will then appear on all your printouts.

It's easy to change input and manipulate your design to optimize the result you want, and meets your design criteria. (For example, the program doesn't choose the stem reinforcing for you—there are too many options the program can't predict for you—so you play with the bar sizes and spacings until the Stress Ratio (which appears after every entry) approaches 1.0, indicating an efficient design (but not <u>over</u> 1.0, or the Overstress warning should flash on!)

When you're done click PRINT to get a two-page printout of your design. You can also click the Print Preview icon alongside the Print button to preview the printout.

When you've finished a design you can make a DXF file to import into nearly all CAD programs (such as AutoCAD®, AutoCAD® LT or QuickCAD). You'll still need to do some editing, but most of your drawing will be done for you.

Here is a quick tour of the steps to design -- or analyze -- a retaining wall:

1. From the Opening Screen, "WHAT DO YOU WANT TO DO?," choose your path. If you are just starting the program, you will want to choose CREATE PROJECT FILE and perhaps call it "Testing" to become familiar with the program. Afterwards, you can give specific names such as a project name or the name of a client.
2. After you have chosen CREATE PROJECT FILE and given it a name, click SAVE. This will lead you to a WALLS IN PROJECT FILE directory. Click ADD WALL, then choose the type of wall you want to design: cantilevered, restrained, tapered stem, or gravity wall. You can also choose WALL WIZARD to help you.
3. If you choose WALL WIZARD you will be led step by step with questions to answer regarding the criteria you want to use for your design. When you have finished entering data, it will be automatically inserted into the next screen, CRITERIA, ready for you to continue with your design.
4. If you skip WALL WIZARD and instead choose, for example, ADD CANTELEVERED WALL you will be first prompted to enter the information for this design (job title, number, designer, etc.).
5. To continue with your design you proceed from left to right with the tabs at the top of your screen, proceeding from CRITERIA to LOADS to STEM and finally to FOOTING. You will note that for each 'tab' there are 'sub-tabs' asking you for additional criteria input. Pay particular attention to the OPTIONS sub-tab.
6. When you complete your design you can also click tabs on the right side of your screen for a schematic construction drawing of your design, a wall loading diagram, stem moment and shear envelope curves. You can click Save to put your design into the Walls In Project File directory, or Exit to return you to the WALLS IN PROJECT FILE screen. You may also click PRINT to print your calculations, or SAVE to place it in the WALLS IN PROJECT FILE directory.

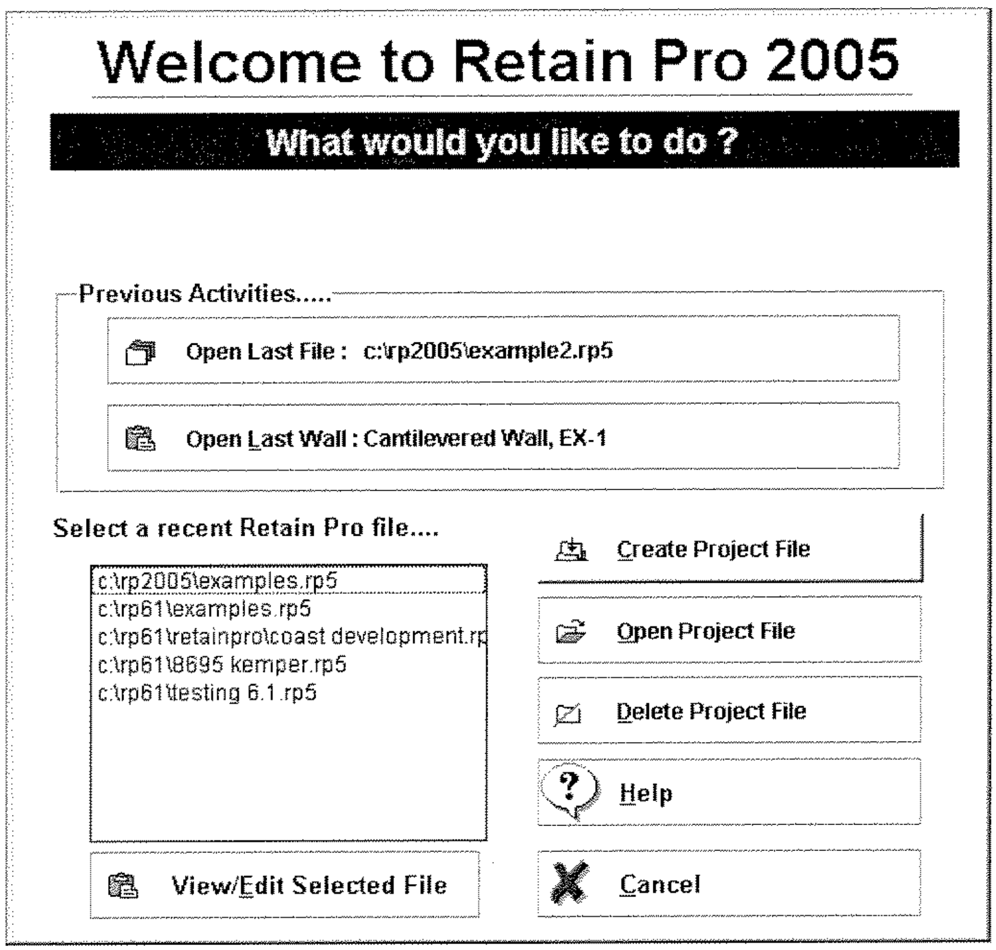
Remember that for help you can click on QuickHelp (on the Task Bar) to get explanations of entries.

To make a DXF file, select Make DXF from the task bar. It will prompt you for additional information, such as a file name. When imported to CAD, some editing will be required.

Remember that HELP can also be selected from the tool bar, where you have choices of the Topic Index and Tutorial. The tutorial topics can be particularly helpful as you learn.

Note that the Construction Drawing and Diagrams will initially show only a default image and will not display completely until you have finished your design, since it does not have enough data. We suggest you do not access these tabs until you have finished a design.

The START MENU Screen



When you start the program you will first see a Welcome To Retain Pro 2005 screen (shown above) subtitled "What Would You Like To Do?" This will be the initial screen from which you choose the design paths you wish to follow. You will be offered a number of choices:

Previous Activities will offer these choices:

Open Last File enables you to quickly go to the last project file you were working on.

Open Last Wall enables you to pick up where you left off with your last wall design.

Select a Recent Retain Pro File will give you a listing of recent project files you have used. By highlighting any one of them and clicking **View / Edit Selected File** below you can access it.

Create Project File is used to create a Project File which will contain one or more walls designed for that project folder.

Open Project File will display a complete list of project files from which you can make a selection.

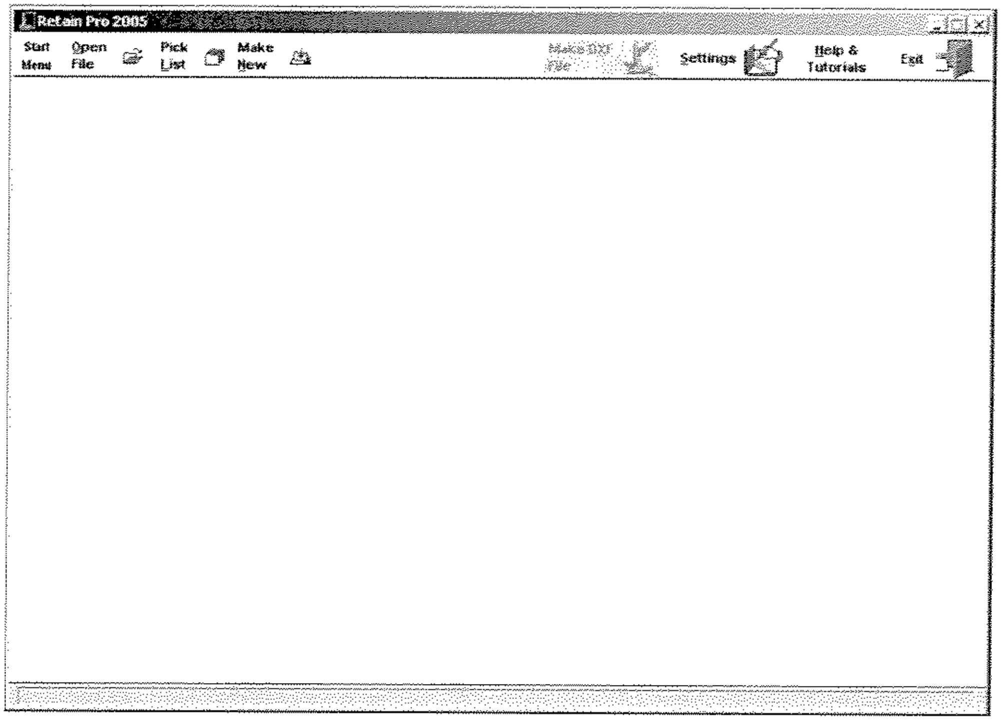
Delete Project File will delete the highlighted file.

Help will lead you to four choices for getting help.

Cancel will return you to the TOOL BAR.

Each of these procedures will be described later.

The Tool Bar



Across the top of all screens will be the **Tool Bar**, which will offer nine choices. Some of the choices may be dimmed for certain screens when they are not applicable or available.

Start Menu returns you to the Welcome / start-up screen.

Open File is to access a project file you have already created.

Pick List offers you a quick way to view and select recently used project files.

Make New is for creating a new project file (such as for a client or a specific project). Choosing this leads to the Create New Retain Pro Project File window.

Save As allows you to save the currently open to a file with a different name. This will be dimmed except on the Walls in Project Files screen.

Save Defaults is dimmed except when working on a wall design. This button saves the input values in the current wall design as default values for subsequent new wall designs.

Make DXF File leads to the dialog box Select DXF File Options.

Settings leads to a Global Settings screen, which allows you to create or change your title block and/or logo.

Help & Tutorials offers seven choices:

Topic Index, where you can scroll to select a topic that you'd like explained.

Tutorial, where you can scroll through a list of get-started topics.

FAQs directs you to www.retainpro.com/support where common technical FAQs are accessible, and updated frequently.

Email Support will connect you to the Internet and give you a ready-to-use screen where you can ask a technical support question and email it to our staff.

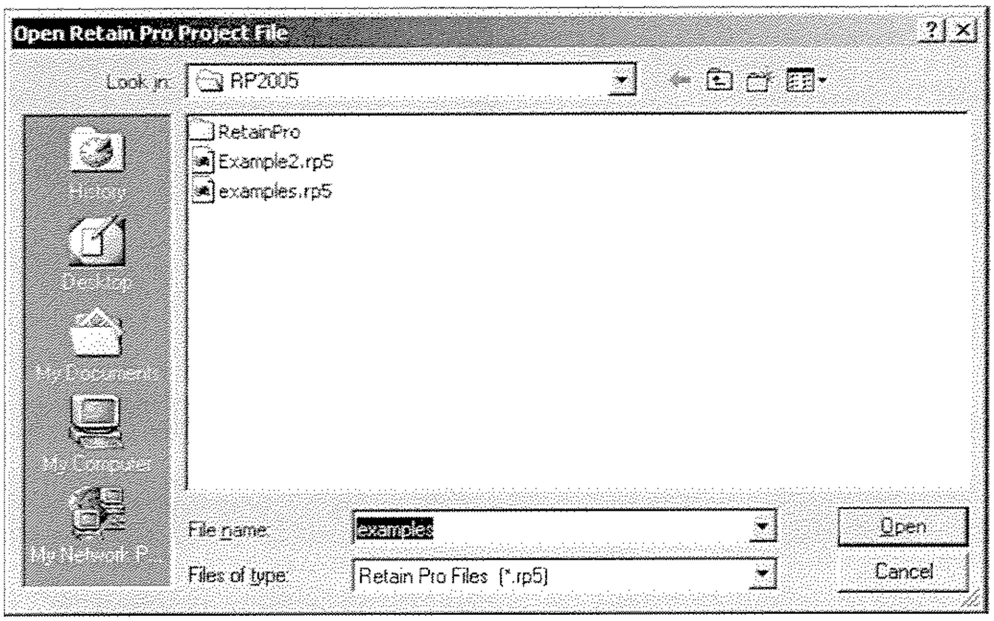
FAX Support gives you a form ready for you to fill out, print, and FAX to our support staff.

This Version will give you information about the Retain Pro version you are currently using.

Access User's Manual allows you to download the complete User's Manual (in Adobe Acrobat .pdf format) for viewing and printing. Pertinent sections of this manual will also be accessed from each screen via the QuickHelp tab..

Open Project File / Make New Project File

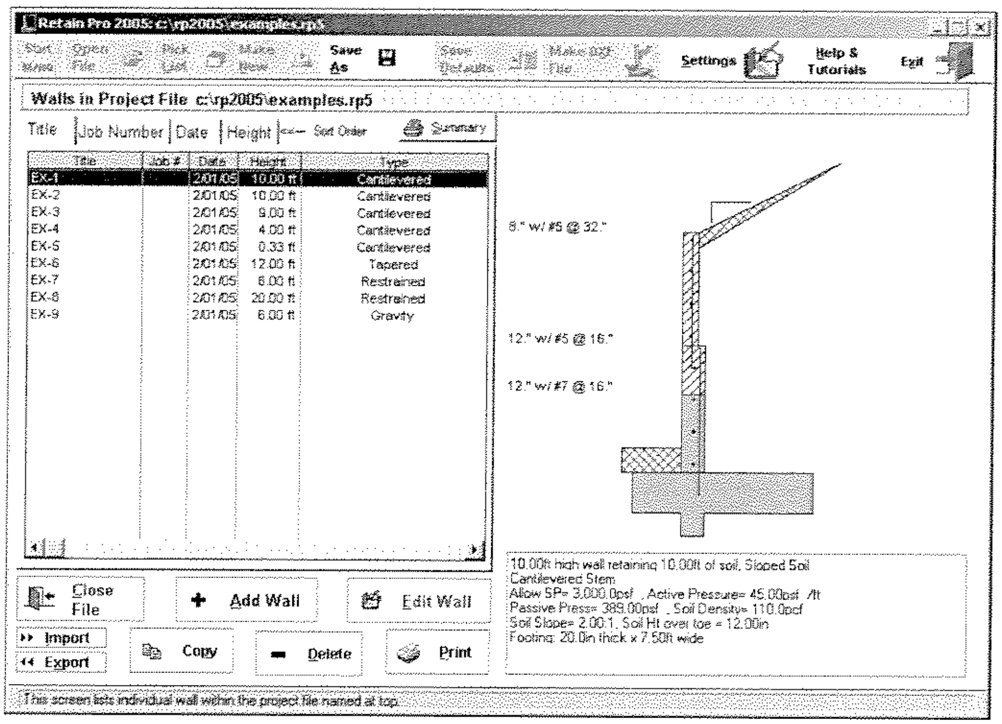
Choosing **Open File** from the Task Bar will display the Open Retain Pro Project file window selection dialog, shown below. Use it to access a project file you have previously created. All Retain Pro for Windows files use a file extension of "rp5". No other index files are required. Here's an image of the Windows file dialog ready to choose "Open" to load the "examples.rp5" file from the C:\rp2005 location:



Use **LOOK IN** to select the sub-directory you are using. Typically it will say "RP2005". Select any of the project files listed and click OPEN. The installation disk comes with the file **examples.rp5** (the extension .rp5 is for compatibility with files you convert from earlier versions of Retain Pro) which contains nine example problems for your review and reference. We suggest you do not alter them. They are the same as the Sample Calculations and Printouts at the end of this User's Manual.

If you had chosen **Make New**, you would see a similar dialog window, but with other project files dimmed. You would then type in the name of the new file in **File Name**, for example, "Baywood Development." You do not need to type the .rp2005 extension—the program will add it automatically.
When you click Save (for a New Project File name) or Open to access an existing file, you will next see the **Walls in Project File** window.

This screen is the central control screen for working with the wall designs in a Retain Pro project file directory.



The left side of the screen lists walls that were already completed and stored in the file RP2005/EXAMPLES. The right side shows a schematic drawing of the highlighted wall, for your reference, and below, basic data about the wall below the sketch.

If you had started a new project file, say BAYWOOD DEVELOPMENT per the earlier sample, this screen would have no entries until you click the Add Wall button, filled in the new job information, then clicked OK to place the wall into this file list.

Along the top are a series of "Tabs" that control the sorting of the walls listed. This way, you can view the walls in order of Title, Job Number, Date, or Height for faster access to the wall you wish to use.

The Bottom Buttons

At the bottom of the Walls In Project File window are the following buttons:

Close File Add Wall Edit Wall
Import/Export Copy Wall Delete Wall Print

They perform the following functions:

Close File returns you to a blank screen with just the TOOL BAR displayed.

Add Wall is used to add a new retaining wall design in the Retain Pro project file you have highlighted. Description of this entry follows

Edit Wall displays the design criteria for the highlighted wall.

Import allows you to choose another Retain Pro file, browse the walls in that file, and select one to bring into the file you are now using. This is a fast and easy way to a previous wall design copied to a new job file.

Export allows you to put the highlighted wall design into another Retain Pro file. When you press Export you will be prompted for a Retain Pro file to export into with the standard Windows file selection dialog. After selecting a file, the currently highlighted wall will be placed into that file.

Copy copies the complete file you are using to a new file name. After choosing the Copy button, you will be prompted to enter a new file name. Retain Pro will place all walls from the current file (showing near the top of the window) to the name you've entered. To copy just one wall design, use the Import button.

Delete deletes the highlighted wall design from the file (you will be asked to verify first).

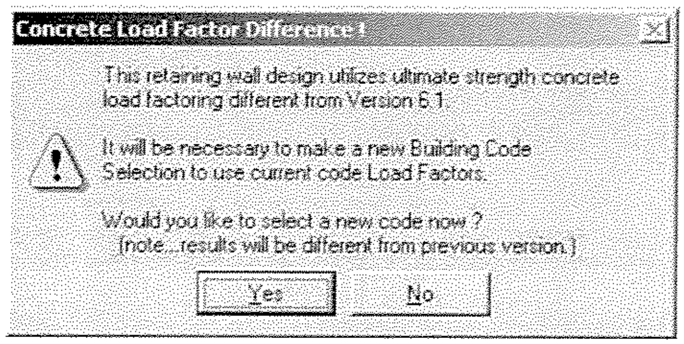
Print the currently highlighted wall to the Windows printer of your choice. You can also choose to preview your calculation print-out page.

Summary Button will print a summary of designs in the Walls in Project File directory.

Updating Load Factors

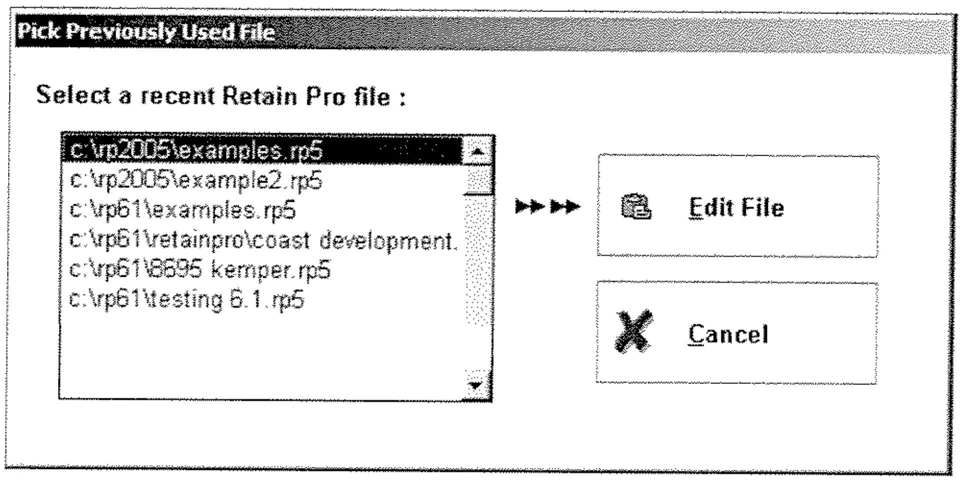
When a specific wall is selected from a Version 6.0 Project Directory, a pop-up window will ask whether you want to update the wall design, which used load factors from version 6.0, to new version 2005 load factors. If you click Yes, you will be prompted to select a building code. The design will then be updated for strength design factors based upon the code you selected. If you want to change load factors, click on CalcInfo and select another code (for example, IBC to AASHTO), or go to the Load Factors tab and change factors.

Always check the Load Factors since you may have edited them differently from the default values.

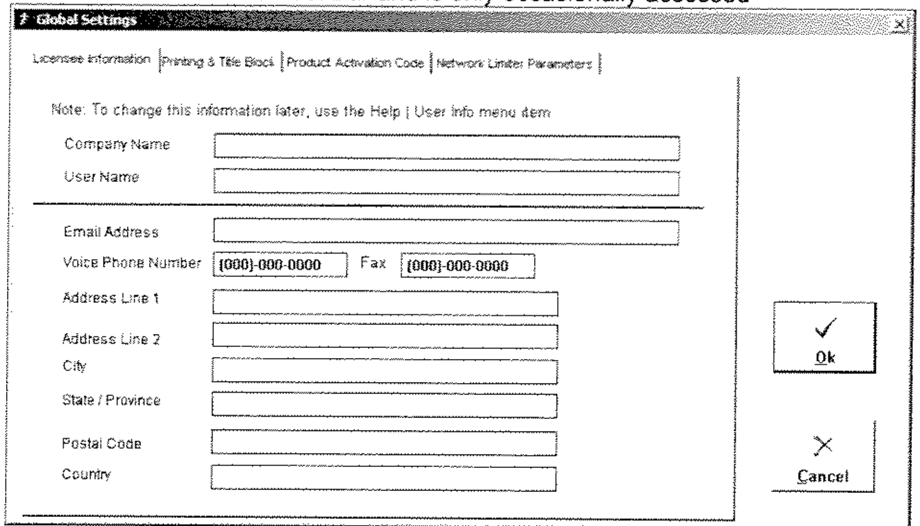


Pick List

This screen is a quick way to jump to any Retain Pro file, and then pick a Project file to edit or add a new wall design. Highlight the project file and click Edit File, or just double-click the highlighted file.



This tab is located on the Tool Bar and is only occasionally accessed



License Information

This is license information for you to fill in about your company, for your reference.

Printing and Title Block:

Use these five lines for your company name, address, and phone number which will appear on your calculation printouts. You can also enter your logo which will print on the title block. Files supported include BMP, JPEG, GIF, PIX and WMF files.

Product Activation Code (PAC)

Enter your Product Activation Code here. Your Registration Number and the number of authorized licenses (seats) will also be displayed.

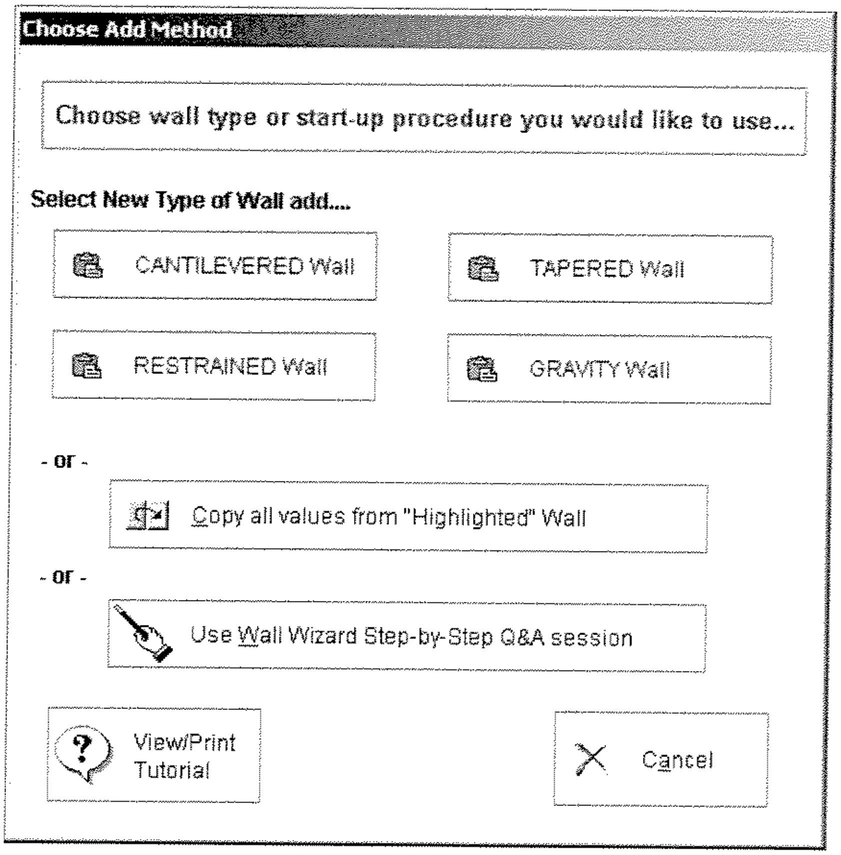
Network Limiter Parameters

Displays information about your network use.

Updates This tab (not shown above) has prompts to set "days between update checks" and other criteria for managing Retain Pro 2005's auto update utility.

Choose Add Method Window

This screen appears when you select a wall in the WALLS IN PROJECT FILE, and press Add Wall



On this screen you select the type of wall you would like to design, or copy values from a previously designed wall, or use Wall Wizard

After selecting **Cantilevered**, **Restrained**, **Tapered**, or **Gravity** Wall, you will jump to the start of your wall design, where you add the Wall Specific Title Block Information. Having selected the type of wall you would like to design, the subsequent criteria and Stem Design Screens will automatically be set for this type of wall design.

If you select **Copy All Values from Highlighted Wall**, you will start with all the values from the currently highlighted wall and modify them as necessary for your new wall design. This is handy, for example, if you're making a series of designs for changing heights or conditions along a long length of wall (e.g., retaining 12', 10', 8', 6', and 4').

Selecting **Wall Wizard** will open a series of questions to answer about your specific design. The answers will be input to the Criteria awaiting your finishing the design. When you become familiar with Retain Pro you will probably not use Wall Wizard.

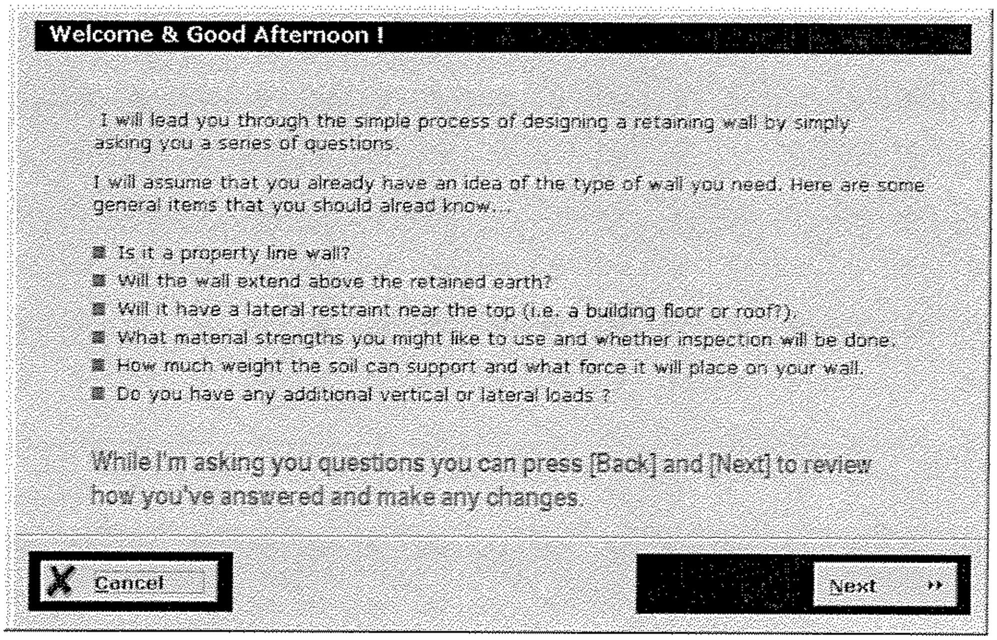
Clicking **View/Print Tutorial** will display a drop-down menu to select a topic to help you get started. The Tutorials are also available from the Help tab.

Clicking **Cancel** will return you to the WALLS IN PROJECT FILE screen.

Note that if you are starting a **New Project file** this window will also appear if you are starting a wall design in a new project file. However, in this case there will be no previous walls in the Project File, so the Copy From Selected Wall option will not appear, and your only option is to choose Use Default Values.

Using Wall Wizard

From the CHOOSE ADD METHOD if you select **Use Wall Wizard Step-By-Step Q & A Session** you will be led through a series of questions regarding the wall you are designing. This feature will be especially helpful for new users.



You can answer the questions and at any time press **Back** and **Next** to review how you have answered and make any changes.

The first screen you get will prompt you for information that will appear on your title block such as job title, job number, designer, date, and description. This screen is essentially the same as the WALL DESIGN TITLE INFORMATION, which will be described in the next section

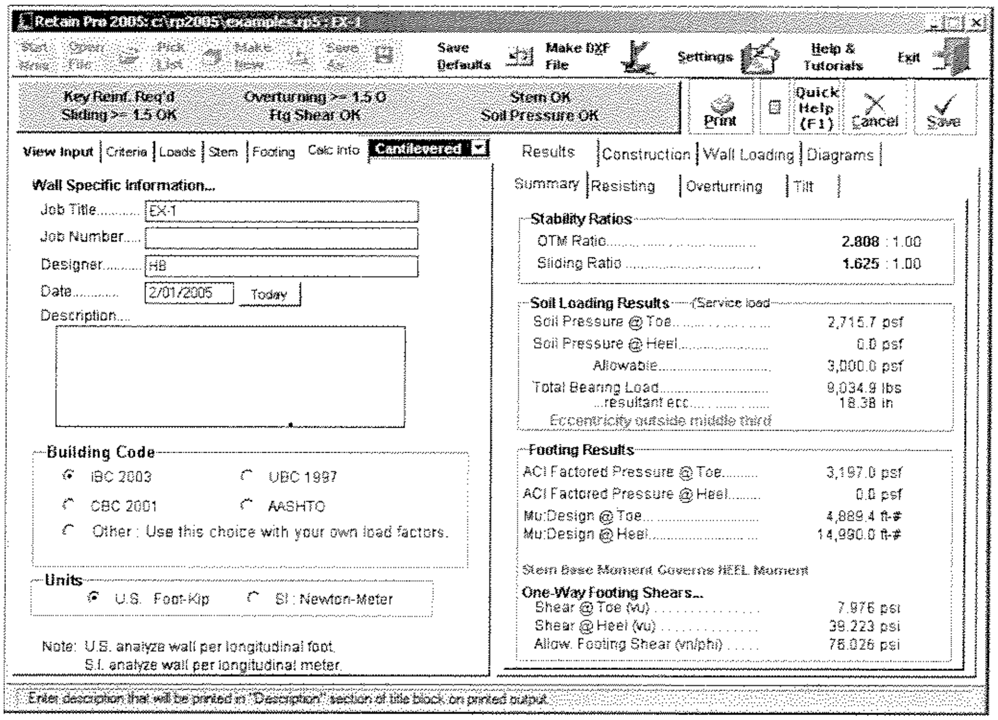
After entering the wall title information, you will be shown seven icons for selection for the type of wall you will be designing. For example, a property line wall on the toe side, a restrained wall, or a gravity wall.

This will lead you through a series of questions such as whether there is a soil slope behind the wall, height of soil over the footing, soil bearing value, weight of the soil, design method (equivalent fluid pressure, Couloumb, for Rankine method) lateral loads on the wall, axial loads, adjacent footing loads, material allowable stresses, and other design option questions.

When you are done, click FINISH and this information will be put into the proper places for the wall that you will proceed to design.

Wall Specific Information (CalcInfo)

This CalcInfo tab is where you enter information about your wall design. It is the first screen in the Sequence Tabs which appears after choosing from the **Choose Add Method** box, or using **Wall Wizard.** Enter specific information about the wall that you are currently designing. "Job Title" will also appear on the **Project Walls File** listing.



The Wall Design Title Information you enter will appear on your printouts.

The information you enter here will appear on your **Walls In Project File** screen. Ignore warning messages and data on the right side, which may be carried over from an earlier or uncompleted design. At the bottom of the screen you can select either U.S. or S.I. units that will apply to this wall only.

Select the applicable building code for your project and the proper load factors will be applied (for Strength Design). Check the load factors since you may have edited them differently.

The tabs across the top of your worksheet screens can be called the Design Sequence Tabs.

You will use them in sequence—left to right—as you proceed with your design (An exception is the Calc Info tab at right. It will contain the Wall Specific Information you entered earlier, or you can change it here.

Each of these tab contents will be described later, but here is a brief description of each, and of their sub-tabs:

Visual Input

On this screen, which is optional -- you may prefer to skip right to Criteria to enter your data -- you can enter data so you can see what you are doing. This drawing will not change as you enter data, however, the Construction Drawing (tab on right side of screen) will reflect your changes. Your input on this screen will be automatically placed on the following Criteria screen, ready for you to proceed with your design.

Then the following left-to-right tabs and sub-tabs:

Criteria

General Data	For entering basic design criteria
Material Data	Enter/change material data
Options	Check boxes for design procedure options
Load Factors	Select building code and review or change load factors.

Loads

Vertical Loads	Enter all applicable vertical loads
Lateral Loads	Enter all applicable lateral loads
Seismic Loads	Enter seismic design criteria, if applicable

Stem (will be set to type of wall below, based upon what you previously selected).

Cantilevered	Wall not restrained at top—free to rotate
Tapered	Battered inside face (for concrete stems only)
Restrained	"Basement" or tieback walls with restraint at or near top.
Gravity	Battered on both faces and usually unreinforced, dependent upon bulk weight to resist overturning.

Footing

Footing Dimensions	Enter trial toe, heel, thickness
Key Dimensions and Sliding	Sliding design, if required

Calc Info For entering your Wall Specific Information (Usually already completed).

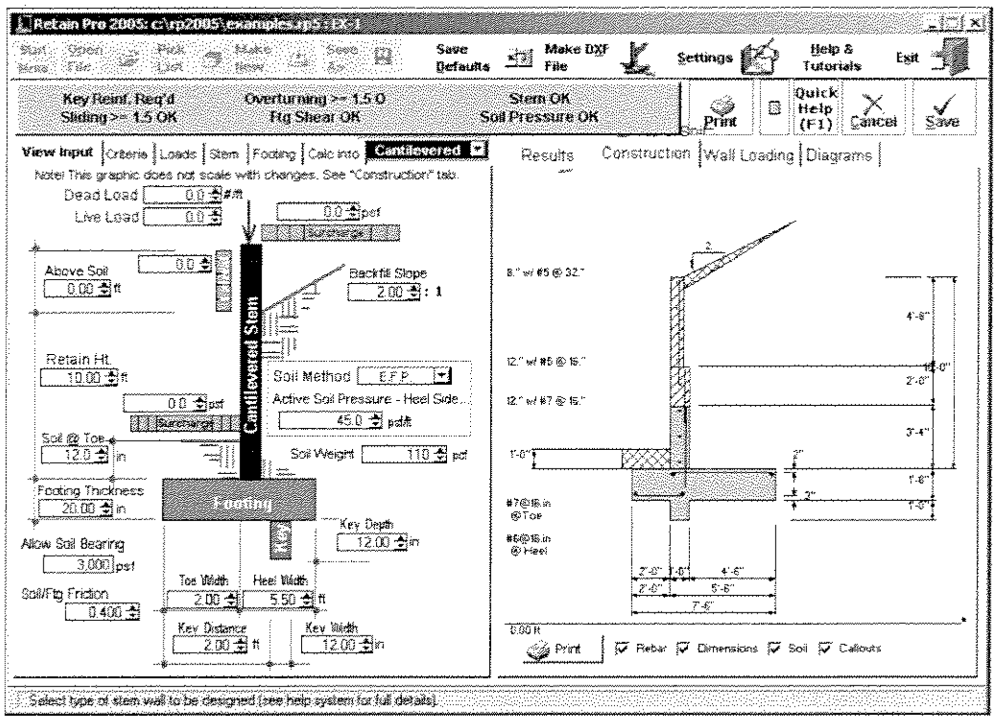
On the right side of your screen these tab and sub-tabs:

Results

Summary	Displays the basis design results
Resisting	Tabular listing of resisting forces
Overturning	Tabular listing of overturning forces
Wall Tilt	Enter soil modulus to calculate tilt of wall.

Construction	Displays to scale a drawing of the data you hav entered.
Wall Loading	Graphically displays the forces on the wall.
Diagrams	Shows envelope curves of moments and shears.

The use of this screen is optional, and will be primarily helpful to novices. You can enter most of the input for your specific wall design here. The information you enter will be automatically transferred to the next tab, CRITERIA, ready for you to proceed with your design. Conversely, info entered on criteria screen will be displayed here.

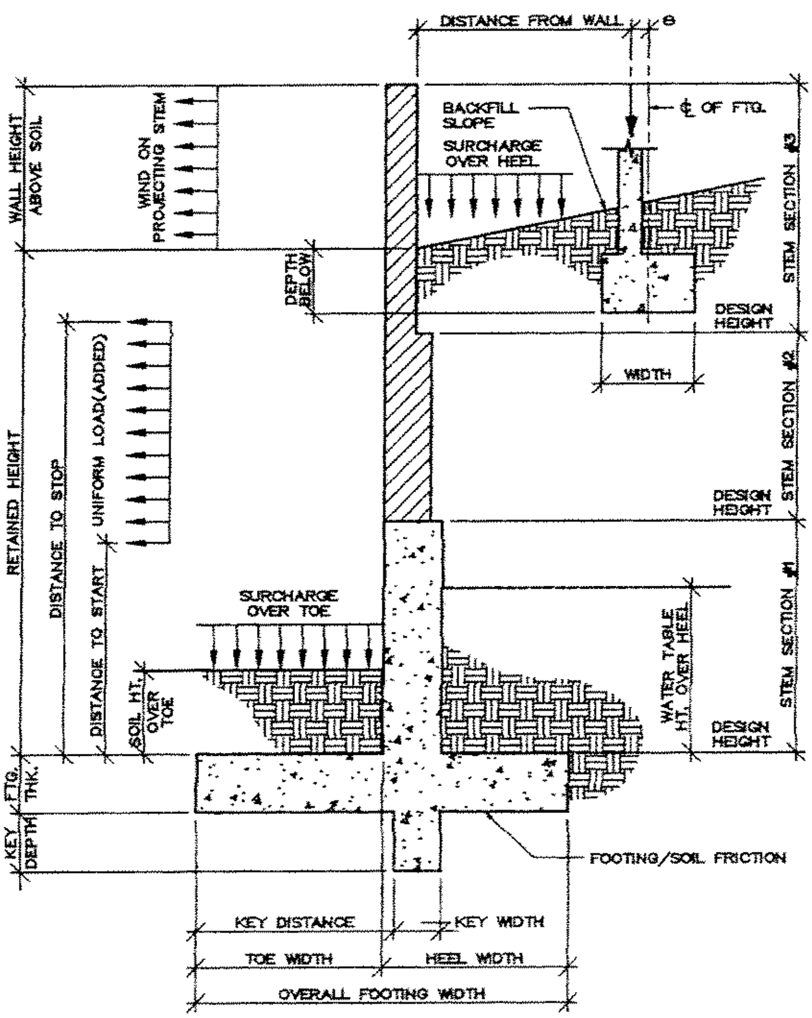


Please note that as you enter dimensions the displayed wall will not change. However, if you click Construction Drawing, you will notice a changing after each entry. Initial value displayed will be Default Values.

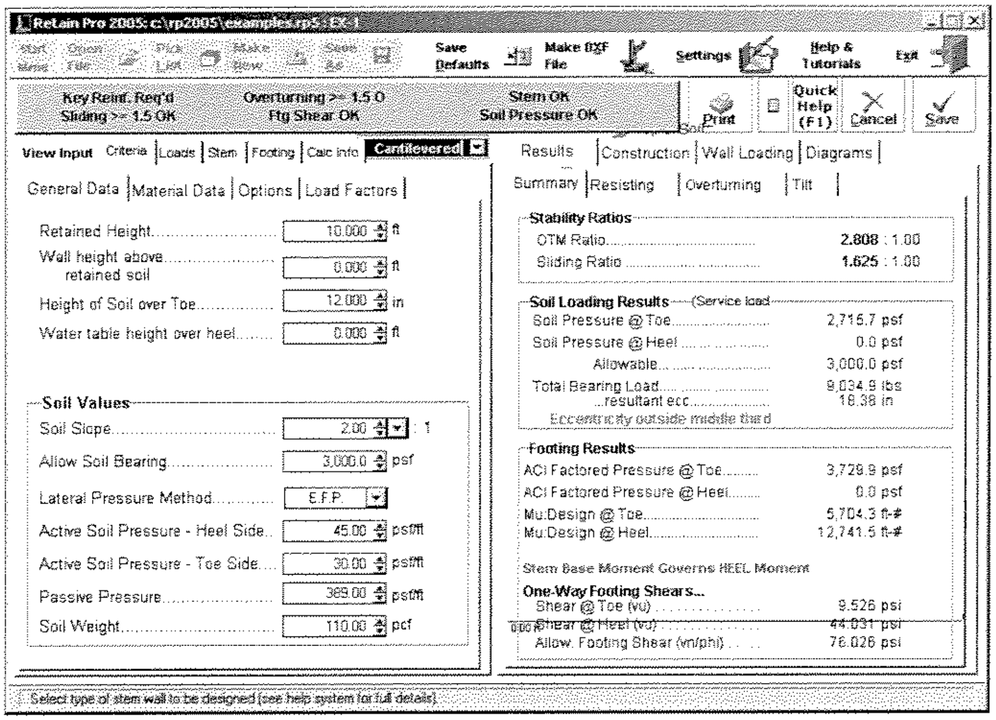
Warning messages and data on right side of screen can be ignored when starting your input, since it may have carried over from a previous or uncompleted design.

Reference Diagram For Dimensional Conventions Used

To assist you in referencing the entries in Retain Pro's data entry locations, here is a drawing of a typical wall with the major entries shown.



On this sub-tab of CRITERIA you enter the basic design criteria.



✍ Retained Height:

This is the height of retained earth measured from top of footing to the top of soil behind the stem (over the heel). When the backfill is sloped, the soil will slope away and upwards from this height.

The actual retained height used for overturning and soil pressure calculations will be the retained height projected at the vertical plane of the back of the heel, but for stem moments, no such increase will be made.

Using the spin-buttons you can vary this in 3-inch increments (you can type in any number). **After each entry you can press the tab key to advance to the next entry, or use your mouse to position the cursor.**

✍ Wall Height Above Retained Soil

Use this entry to specify if the wall extends above the retained height. This entry is typically used to define a "screen wall" projection above the soil retained. This extension can be used as a weightless "Fence" or a concrete or masonry stem section without any soil retained behind it. You can enter wind load on this projection using the entry "Load @ stem above soil" on the "Loads" tab. We'll handle the fence when we get to the STEM design screen. TOTAL HEIGHT OF WALL = "RETAINED HEIGHT" + WALL HEIGHT ABOVE RETAINED SOIL".

✍ Height of Soil Over Toe

Measured from top of footing to top of soil on toe side, this may vary from a few inches to a few feet (it is input in inches) depending upon site conditions. It is used to calculate passive soil resistance (but its effective depth can be modified by the "Ht. to Neglect" entry on the Footing > Key Dimensions & Sliding tab). This depth of soil is also used to calculate a counter-overturning moment, and reduce net lateral sliding force. You can negate the latter effects on the Options screen.

✍ Water Table Height Over Footing

If you want to design for a water table condition, enter the maximum height from top of footing to water table level. The program will then compute the added pressures for saturated soil on the heel side of the footing, including buoyancy effect, to calculate increased moments and shears on the stem, and overturning. Don't enter a height more than the retained height, nor a liquid other than water. If the water table is near the top of the retained height, suggest using saturated soil density and active pressure for the full retained height.

✍ Soil Slope

You may enter any backfill slope behind the wall. Use the drop-down menu or type the slope ratio as Horiz/Vert. The soil must be level or slope upward. Negative backfill slopes (grade sloping downward, away from the wall) are not allowed.

The program will use this slope to 1) include the weight of a triangular wedge of soil over the heel as vertical load, and 2) compute overturning based upon an assumed vertical plane at the back face of the footing extending from the bottom of the footing to ground surface – a steeper slope will result in a higher overturning moment. We suggest not using a slope steeper than 1.5 to 1.0 unless approved by the geotechnical engineer. The program will not accept a backfill slope steeper than the angle of internal friction.

✍ Allowable Soil Bearing

The maximum allowable soil bearing pressure for static conditions. Using the spin buttons you can increment in 50 psf steps. Usual values for this vary from 1,000 psf to 4,000 psf or more.

✍ Lateral Pressure Method

Here you can choose between E.F.P. or Rankine formula or Coulomb formula. EFP means "Equivalent Fluid Pressure," where you can enter a lateral soil pressure in psf per foot of depth. "Rankine" or "Coulomb" instructs Retain Pro to use the Rankine or Coulomb Method to calculate active and passive soil pressures using an entered angle of internal friction for the soil. When Rankine or Coulomb is chosen, the Ka*Density value for active pressure is computed.

✍ Active Soil Pressure - Heel Side (EFP Method Chosen)
Active Pressure: Ka * Gamma (Rankine or Coulomb Method Chosen)

Enter the equivalent fluid pressure (EFP), or the angle of internal friction if Rankine or Coulomb is chosen, for the soil being retained that acts to overturn and slide the wall toward the toe side. This pressure acts on the stem for stem section calculations, and on the total footing+wall+slope height for overturning, sliding, and soil pressure calculations.

Commonly used values, assuming an angle of internal friction of 34°, are 30 pcf for a level backfill; 35 pcf for a 4:1 slope; 38 pcf for a 3:1 slope; 43 pcf for a 2:1 slope; and 55 pcf for a 1.5:1 slope. These values are usually provided by the geotechnical engineer. If the Rankine or Coulomb method had been chosen, these values will be computed using those formulas.

When the retained soil is sloped, a vertical component of the lateral earth pressure over the heel can be applied vertically downward in the plane of the back of the footing. You can choose to apply this force for overturning resistance, sliding resistance, and/or for soil pressure calculations, by checking the boxes on the CRITERIA > Option screen. It is recommended to use the vertical component only to resist overturning.

✍ Angle of Internal Friction (Rankine or Coulomb Method Chosen)

This value is entered in degrees and is the angle of internal friction of the soil. This value is usually provided by a geotechnical engineer from soils tests, but can also be found in reference books or building codes for various typical soil classifications. This value is used along with Soil Density within the standard Rankine and Coulomb equations to determine "K_a" and "K_p" multipliers of density to give active and passive soil pressure values.

✍ Active Soil Pressure - Toe Side

If the EFP method is chosen, enter the active pressure to be used on the toe side of the wall. This active pressure is used along with the "Soil Height over Toe" value (entered on the Sliding tab) to calculate a stabilizing soil force on the wall. This front side of the wall is assumed to be level.

When either the Rankine or Coulomb method is chosen, the angle of internal friction is used in the Rankine formula with an assumed level toe-side slope.

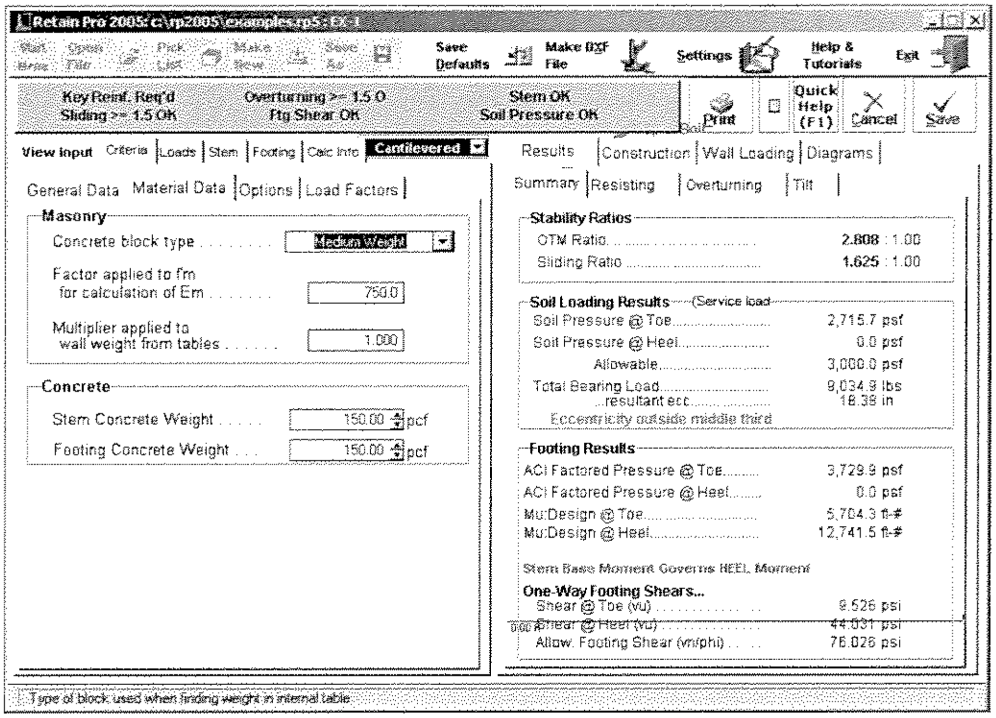
The active pressure from soil over the toe counteracts the heel-side active pressure to reduce net overturning and net sliding force.

✍ Passive Pressure (EFP Method Chosen)
Passive Pressure: Kp * Gamma (Rankine or Coulomb Method Chosen)

This is the <u>resistance of the soil in front of the wall to being pushed against</u> to resist sliding. Its value is in psf per foot of depth (pcf). For the E.F.P. method, you input this value, which is usually obtained from the geotechnical engineer. If the Rankine or Coulomb method is chosen, it will be computed and entered for you. Its value usually varies from 100 pcf to about 350 pcf.

✍ Soil Density

Enter the soil density for all earth above the toe and heel of the footing. This weight is used to calculate overturning resistance forces and soil pressures using the weight of the soil block over the projecting toe and heel of the footing. When surcharges are applied over the soil, the surcharges are transformed to equivalent uniform lateral loads acting on the wall by the ratio force = (Surcharge/ Density)*Lateral Load. Input this value in lbs. per cubic foot. Usual values are 110 pcf to 120 pcf. More if saturated soil.



On this screen you can change properties of masonry and concrete.

For Masonry:

✍ Concrete Block Type

This allows you to select Lightweight, Medium weight, or Normal weight concrete masonry units.

✍ Factor Applied to f'_m for Calculation of E_m

The modulus of elasticity for masonry is 750 f'_m per UBC '97 2106.12.1 and 900 f'_m per IBC '03. This entry allows you to select the desired multiplier.

✍ **Multiplier Applied to Wall Weight from Tables**

This entry allows you to increase or decrease the internal default values of stem weights, as displayed on the STEM screen.

For Concrete

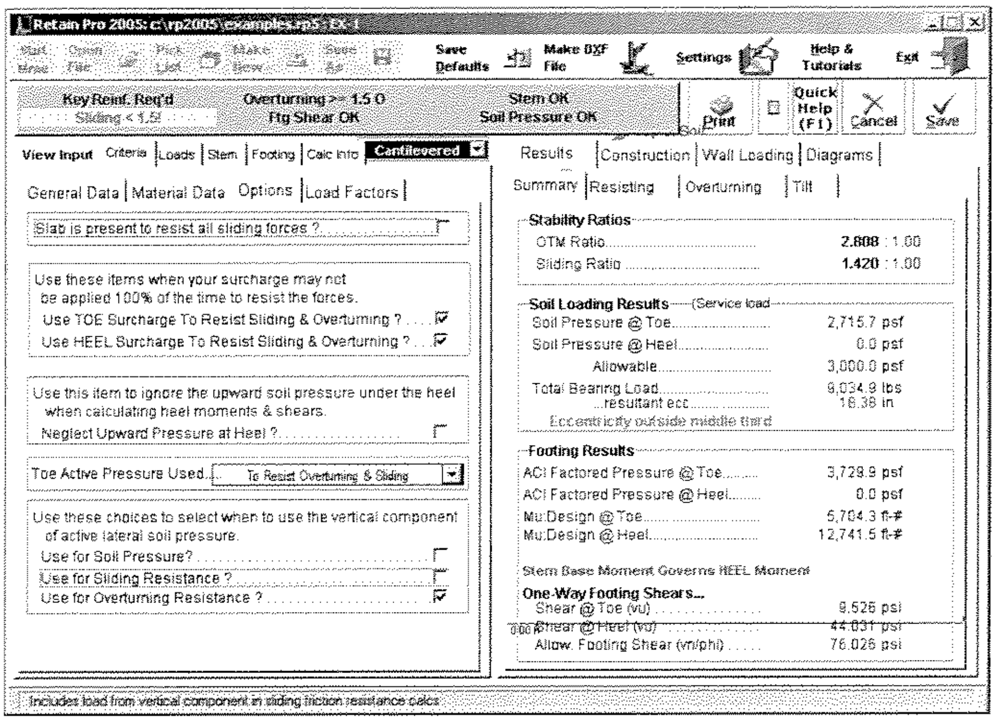
✍ **Stem concrete weight**

This is usually 145-150 pcf, but may be changed with this entry.

✍ **Footing concrete weight**

This option is necessary since if there is any buoyancy effect, this will reduce the effective weight of the footing concrete.

This screen is critical to your design, since many subsequent calculation results will be affected. Review and check these boxes carefully.



☑ Slab is Present to Resist all Sliding Forces

Check this box when a slab is in front of the wall to resist lateral sliding.. When this box is checked, sliding is not a design issue – passive and friction resistance are ignored -- but the lateral sliding force is displayed for checking the resistance offered by the slab.

It has a similar effect for restrained walls. allow it to be placed higher—if this condition occurs, append your printout with hand-calcs,

The slab is assumed to be at the top of the footing – not higher.

☑ **Use Toe Surcharge to Resist Sliding and Overturning**

Checking this box will include the weight of soil overburden on the toe to resist overturning and add to its weight for frictional resistance.

☑ **Use Heel Surcharge to Resist Sliding and Overturning**

Checking this box will include heel surcharge. If surcharge is live load and its use would be non-conservative, don't check this box.

☑ **Neglect Upward Pressure at Heel**

For heel calculations you may choose to neglect the upward soil pressure, typically resulting in greater heel moment. If this box is checked the M_u for upward loads will be zero.

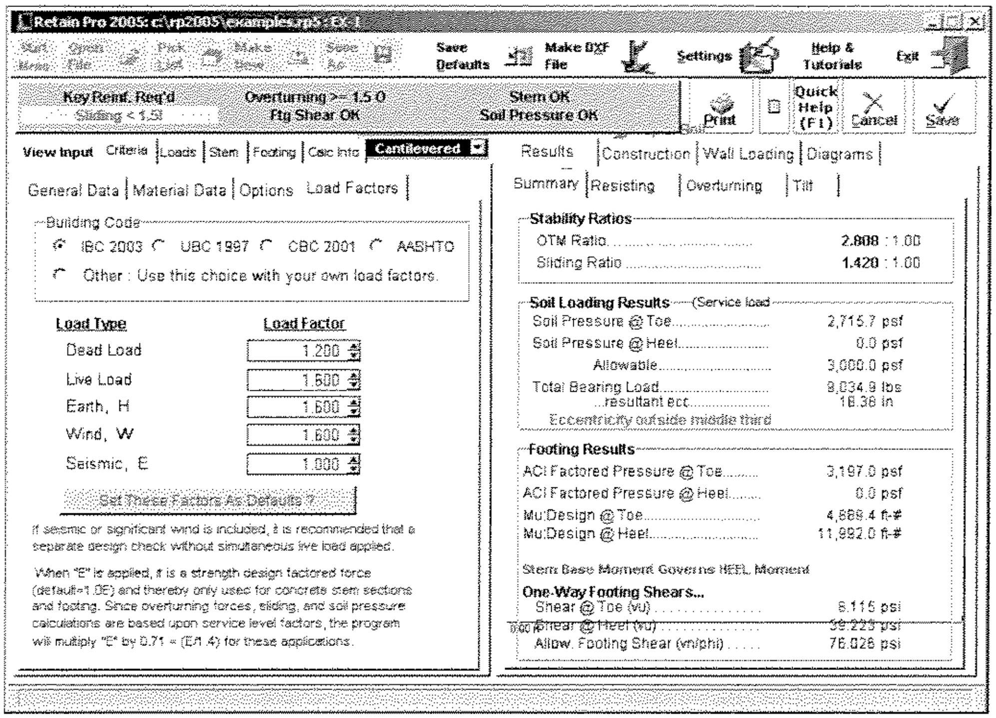
☑ **Toe Active Pressure Used**

Checking this box will apply the toe side active pressure to reduce overturning moment and reduce sliding force to a net sliding force to be resisted.

☑ **Choices for Use of Vertical Component of Active Pressure**

The vertical component of the lateral pressure is applied at a vertical plane at the back of the footing. You can optionally use this to resist overturning, sliding, or for soil pressure calculations. (For the latter it can make a considerable difference). Checking these boxes applies the options. For a level backfill, this option will back-solve the EFP method to find the equivalent internal friction angle, then apply this vertical component equal to $\tan\beta$. If either the Rankine or Coulomb method had been chosen, this vertical component would be tangent of $\phi/2$.

Note that most texts suggest using the vertical component only to resist overturning. For a level backfill these options are usually not used. .



Building Code

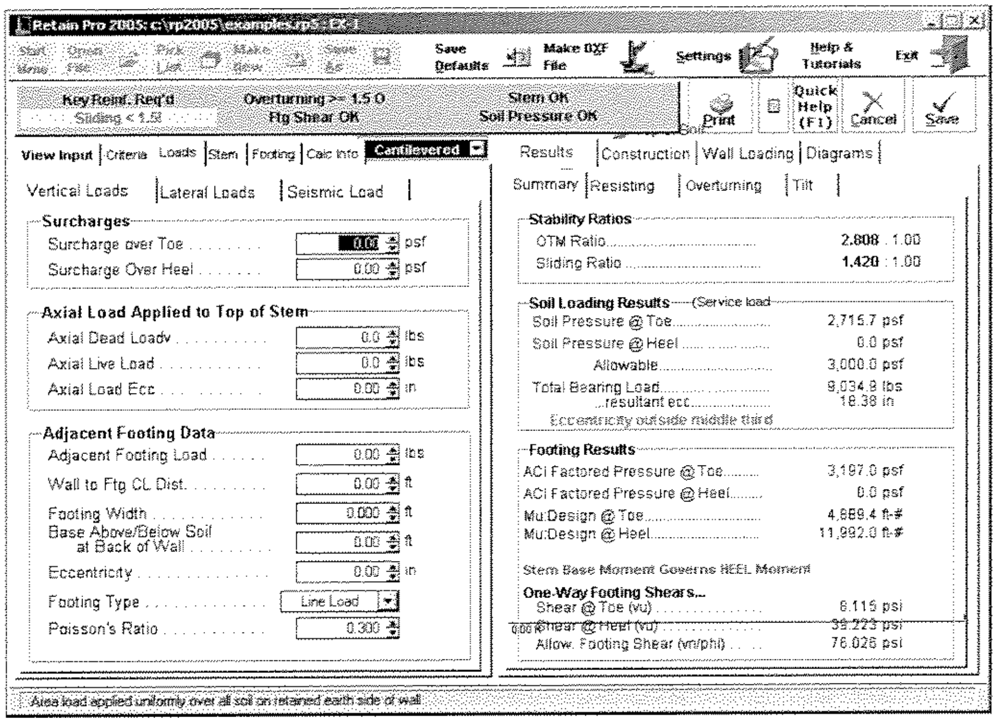
Select from IBC 2003, UBC '97, CBC '02, AASHTO, or "Other". When "Other" is selected you can enter load factors you choose for a specific design.

Load Type / Load Factor

For each type of load (DL, LL, etc) the default factor will be displayed. You can change them and set new defaults, but remember to review them for a new design..

NOTE: The above factors apply to Strength Design (concrete stem sections and footing). For Allowable Strength Design, used for masonry, all factors are set at 1.0 except earthquake (E) is 1/1.4 = 0.71, to convert strength-based E to a service load.

Additional loads on the wall are entered on these sub-tabs.



✍ Surcharge Over Toe

This surcharge is treated as additional soil weight – if the surcharge is 240 psf and the density is 120 pcf, then the program uses two feet of additional soil. Similarly, if 50 psfsf is added for the weight of a slab over the footing, this will be equivalent to 0.41 feet of soil (50 / 120). This surcharge will affect sliding resistance and active toe pressure. Consider this if modeling a point load toe surcharge.

✍ Surcharge Over Heel

This surcharge is considered uniformly applied to the top surface of the soil over the heel. It may be entered whether or not the ground surface is sloped, but it is unlikely a surcharge could apply to a sloped backfill. This surcharge is always taken as a vertical force. This surcharge is divided by the soil density and multiplied by the Active Pressure to create a uniform lateral load applied to the wall. You can choose to use this surcharge to resist sliding and overturning by clicking the box on the CRITERIA > Options sub-tab.

✍ Axial Loads Applied to Top of Stem

These loads are considered uniform load along the length of the wall. They are applied to the top of the topmost stem section and affect the design of masonry stems only. The dead and live loads are used to calculate stem design values and factored soil reaction pressures used for footing design. Only the dead load is used to resist overturning and sliding of the retaining wall. AVOID A HIGH AXIAL LOAD (say over 3 kips plf – DL + LL) SINCE IT COULD CAUSE A REVERSAL OF BENDING IN THE HEEL.

✍ Axial Load Eccentricity

This is the eccentricity of the axial load with respect to the centerline of the uppermost stem section. The eccentricity moves the load toward the toe, causing bending moments that are additive to those caused by the lateral soil pressure over the heel. Negative eccentricities are not accepted.

✍ Adjacent Footing Load

This entry gives you the option of placing a footing (line, strip, or square) adjacent and parallel to the back face of the wall, and have its affect on the wall included in both the vertical and horizontal forces on the wall and footing. Refer to the General Reference Diagram for locations where input measurements should be taken.

For "Line (Strip) Load" the entry is the total load per ft.parallel to the wall (not psf).

If the adjacent footing is specified as "Square Footing" (not line load), the load entered should be the adjacent footing load divided by its dimension parallel to the wall, giving a pounds per lineal foot value, as for a continuous (line) footing.

A Boussinesq analysis is used to calculate the vertical and lateral pressures acting on the stem and footing. The program uses equation (11-20a) in Bowles' *Foundation Analysis and Design*, 5th Edition, McGraw-Hill, pages 630.

When the Boussinesq analysis is used, the program may require additional computing time (hundreds of internal calculations are done after each entry), depending upon the speed of your computer. To avoid this delay (which occurs any time any entry is changed) we suggest you use a vertical load of zero until your data entry is nearly finalized. Then enter the actual footing load and modify your final values.

For adjacent truck or highway loading, it may be preferable to use a heel surcharge (uniform) of 250 psf (or more!) instead of treating it as an "adjacent footing."

Do not use this feature if the adjacent footing load is farther from the stem than the retained height, less the depth of the adjacent footing below the retained height, since at this distance it will not have significant effect on the wall.

✍ Footing Width

Width of the adjacent footing measured perpendicular to the wall. This is necessary to create a one-foot long by Width wide area over which the load is applied.

✍ Footing Eccentricity

This entry is provided in case the soil pressure under the adjacent footing is not uniform. Enter the eccentricity of the resultant force under the adjacent footing from the centerline of the footing. Positive eccentricity is toward the toe, resulting in greater pressure at the side of the adjacent footing closest to the stem. The program will use the vertical load and eccentricity and create a trapezoidal pressure distribution under the adjacent footing for use with the Boussinesq analysis of vertical and lateral pressures.

✍ Wall to Footing Centerline Distance

This is the distance from the center of the adjacent footing to the back face of the stem at the retained height. The nearest edge of the footing should be at least a foot away from the wall face – otherwise suggest using an equivalent heel surcharge instead. Do not use a horizontal distance greater than the vertical distance from the top of the footing to the bottom of the adjacent footing, since the effect on the wall will be insignificant.

✍ Footing Type

This drop down menu selection allows you to enter either an isolated footing using the "Square Footing" selection, or a continuous footing using the "Line Load" selection.

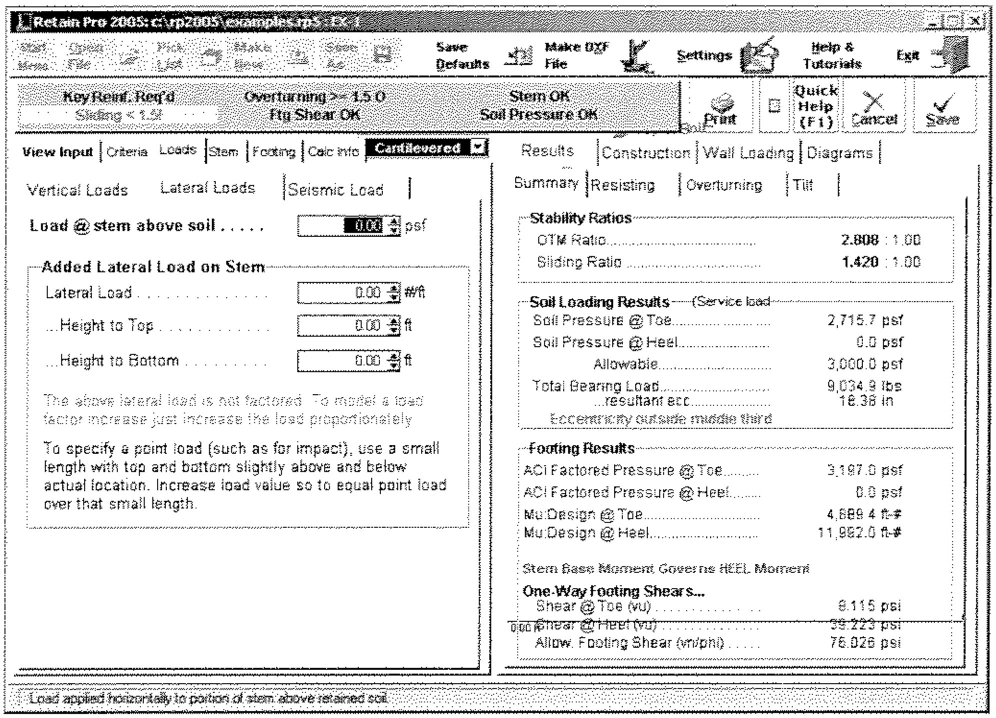
✍ Base Above/Below Soil at Back of Wall

Use this entry to locate the bottom of the footing with respect to the Retained Height. Entering a negative number places the footing below the soil. A positive entry would typically only be used when the soil is sloped and the footing resides "uphill". To insert a negative number, first type the number then press the "-" (minus) sign.

Note: If the "Adjacent Footing" is another retaining wall at a higher elevation, the Boussenesq analysis may be used for the vertical load applied to the soil from the wall, however the design must also consider the lateral (sliding) loads from that adjacent wall. This load could be applied as "Added Lateral Load", however this is at the discretion of the designer and is not within the scope of the program. Caution is urged for this condition. See discussion in the companion book: Basics of Retaining Wall Design.

- **Poisson's Ratio**

  Since the resulting pressures are sensitive to Poisson's Ratio, there is an entry allowing you to select a ratio from 0.30 to 0.55. This value should be provided by the geotechnical engineer. A value of 0.50 is often assumed.



✍ Load @ Stem Above Soil

This load (typically a wind load) will be applied to that part of the stem projecting above the retained height defined by the entry "Wall height above retained soil." It is used to calculate overturning moment and shear, stem design moment and shear, and soil pressures. Customary values are 10 psf or higher. Only a positive "+" value can be entered (i.e., the force may only be applied in a direction to add overturning, in the direction of the active soil pressure).

✍ Added Lateral Load

This input allows you to specify an additional uniformly distributed lateral load applied to the stem.

This for an impact point load, such as due to an impact of a car or similar force, enter the load as a one foot high increment, separating the "Height to Bottom" and "Height to Top" by one-half foot (or meter).

This load is not factored! To apply a load factor (such as for an impact load), increase the applied load proportionately (e.g. an impact load of 1000 lbs requiring a load factor of 2.0 would be entered as 2,000 lbs).

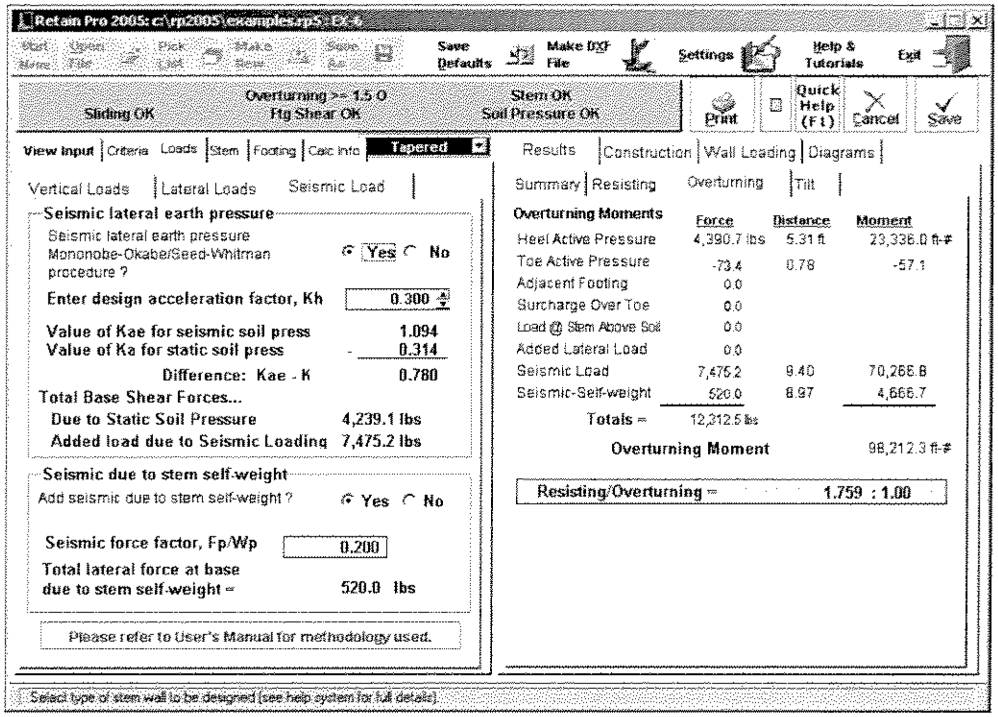
A point lateral load can be reduced for the effect of its spreading horizontally at levels below the point of application..

✍ Height to Top

This dimension defines the upper limit of the added lateral load measured from the top of the footing. Do not enter a dimension higher than the top of the wall ("retained height" plus "Wall height above retained soil").

✍ Height to Bottom

This dimension defines the beginning (or bottom) of the added lateral load measured from the top of the footing.



You can choose to apply seismic force from either lateral earth pressure or for wall self-weight, by selecting Yes / No for these options.

✍ Seismic Lateral Earth Pressure

Entering Yes, then entering k_h will activate the calculation of K_{AE} and K_A using the Mononobe-Okabe/Seed-Whitman equations if for a yielding wall (cantilevered). If it is a non-yielding wall (restrained) the added lateral force per square foot is computed using $F_w = k_h$(density)(retained height), in psf. Common k_h values range from 0.05 to 0.30, depending upon area seismicity.

Displayed will be both the static component soil pressure, and the added seismic.

✍ Seismic due to Self-Weight

Entering Yes, then Fp/Wp will apply a uniform seismic force in psf (k_h x (wall weight). If the wall has multiple stem sections, each will be calculated separately and accumulated for the base shear and moment.

NOTE: The k_h values entered are the <u>design</u> accelerations (not necessarily peak ground acceleration as may be given in a geotechnical report) and must be determined per procedures in the applicable code. They are then factored per Load Factors (generally 1.0 for concrete and 1/1.4 for masonry (for ASD).

The resultant is assumed to act at approximately 0.6 x retained height.

Methodology

The program computes K_{AE} (coefficient for combined active and earthquake forces) per the Coulomb formula, modified by Mononobe-Okabe/Seed-Whitman, to account for earthquake loading, where the term θ is the angle whose tangent is the horizontal ground acceleration. (Note that if $K_h = 0$, $\theta = 0$, then $K_{AE} = K_A$). Vertical acceleration is neglected, resulting in a more conservative K_{AE}.

K_{AE} = active earth pressure coefficient

$$= \frac{\sin^2(\phi + \alpha - \theta')}{\cos\theta' \sin^2 \alpha \sin(\alpha - \theta' - \delta\left[1 + \sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\theta'-\beta)}{\sin(\alpha-\delta-\theta')\sin(\alpha+\beta)}}\right]^2}$$

Where $\theta = \tan^{-1} K_h$, α = wall slope to horiz., ϕ = angled internal friction,

β = backfill slope, and δ = wall friction angle.

For a vertical wall face and δ assumed to be $\phi/2$, becomes:

$$K_{AE} = \frac{\sin^2(\phi + 90 - \theta)}{\cos\theta \sin(90 - \theta - \phi/2 \quad \left[1 + \sqrt{\frac{\sin 1.5\phi \sin(\phi - \theta - \beta)}{\sin(90 - \phi/2 - \theta)\sin(\beta + 90)}}\right]^2}$$

The values K_{AE} and K_A are displayed.

Total force (active and earthquake) - $P_{AE} = \frac{1}{2} (\gamma) K_{AE} H^2$ where γ = soil density

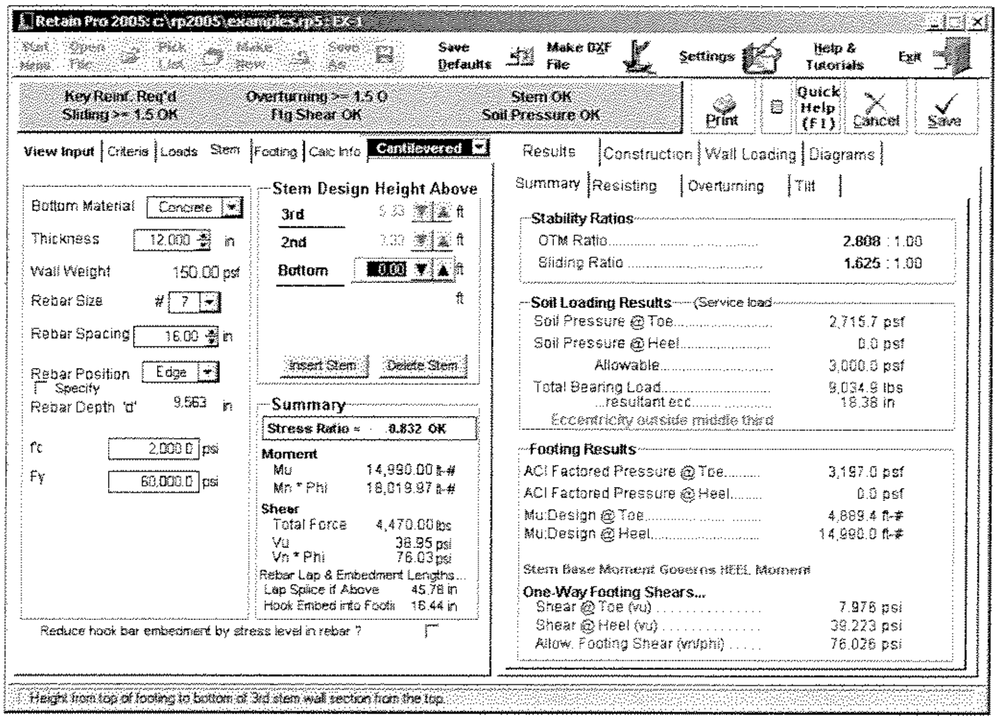
and H = retained height.
Since the total force consists of two components, static (P_A, as previously computed for static forces) with triangular distribution and the earthquake (P_{AE} - P_A) with an inverted semi-triangular distribution with an assumed point of application at 0.60 x height, the combined (static and EQ) point of application is determined by

$$\bar{x} = \frac{P_A(H/3) + (P_{AE} - P_A)0.6H}{P_{AE}},$$

which is displayed as "Ht. to static + EQ point of appl."

Total base shear for both static force and added seismic force are displayed.

The layout of this screen will change depending upon whether you previously chose a conventional cantilevered wall, a tapered stem wall (earth side battered), or a gravity wall. This screen is for a straight stem non-battered wall.



✍ Material

Use the drop down menu to select Masonry, Concrete, Fence, or None. Fence is only allowed on top of the wall, higher than the Retained Height, and is considered weightless. Use None to disable the stem section.

✍ Thickness

Use the drop down menu to input the wall thickness. If masonry is chosen, you will be given standard masonry thickness (e.g. 6", 8", 12"). If concrete is chosen, you can increment in one-inch steps. If Fence had been chosen, this entry is unavailable since the fence is assumed to be weightless.

✍ **Wall Weight**

This displayed value is based upon the wall data entered earlier. The industry standard values used by the program may be modified on the CRITERIA > Materials Screen. See Appendix C for masonry wall weights.

✍ **Rebar Size**

Make your selection from the pull-down menu for bar sizes #3 to #10. "Soft Metric" sizes will be displayed in parentheses alongside.

✍ **Rebar Position**

Chose between Center and Edge. If Center is chosen, the rebar d distance will be 1/2 the actual wall thickness. If Edge is chosen it will be located at the heel side of the stem.

For masonry design, the program contains a table of the appropriate "d" values to use for various block sizes and center/edge locations, as shown in the table below. These may be modified from the CRITERIA > Material screen.

Rebar Position Depth for Masonry, Default Values.

Thickness	**Rebar Depth (in)**	
	Center	**Edge**
6"	**2.75"**	**2.75"**
8"	**3.75"**	**5.25"**
10"	**4.75"**	**7.25"**
12"	**5.75"**	**9.0"**
14"	**6.75"**	**11.0"**
16"	**7.75"**	**13.0"**

For concrete, the "edge" rebar depth is always stem thickness less 1.5" for #5 and smaller bars (or 2" for #6 or larger), less one-half the bar diameter. You can modify the rebar depths on the CRITERIA > Material screen.

✍ **Specify Position Box**

Click this box to change the default "d" value.

✍ f'_m

Enter f'_m for masonry stems to be designed. This value is not visible when a concrete wall has been specified. Spin button changes this value in 250 psi increments.

✍ F_s

Enter the allowable steel stress, based on working stress design, which should be used for design of the masonry stem section. Spin button changes this value in increments, and is not visible when a concrete wall has been specified.

✍ **Short Term**

This is used for masonry design only and UBC '97/CBC '01 is selected. It indicates the allowable overstress multiplier (1.33 for wind and seismic; higher for impact). Use it with caution if earth pressure contributes significantly to total moment and shear since the stress increase may then be unwarranted.

✍ **Special Inspection**

This is applicable to masonry stems only using the UBC or CBC code. If checked, the full allowable f'_m used in flexure, shear, and axial stress will be used. If not checked, the allowable values will be reduced by one-half if Special Inspection provisions are not specified.

✍ **Solid Grout**

This applies to masonry only, and if this box is checked the weight of the wall will be based upon industry standard solid-grout weight for either lightweight, medium weight, or normal weight. If this box is not checked, the program will calculate the weight based upon grouting of only cells containing reinforcing. This also affects equivalent solid thickness for stem shear calculations, and area for axial stress calculations (combined with moment for masonry stems).

Modular Ratio "n"

This is the multiplier used on f'_m to calculate the modulus of elasticity of masonry. The 1997 UBC specifies $E_m = 750 * f'_m$, which is the default value in the program. ACI 530-02, Table 5.5.1.3, lists higher values, which result in lower "n" values, hence the allowance for the user to modify it by using the CRITERIA > Material screen.

Equivalent Solid Thickness

If partially grouted (not solid grout) this value is generated from an internal database as shown below:

Masonry Equivalent Solid Thickness (inches)

	Grout Spacing					
Thickness (inches)	8"	16"	24"	32"	40"	48"
6	5.6	4.5	4.1	3.9	3.8	3.7
8	7.6	5.8	5.2	4.9	4.7	4.6
10	9.6	7.2	6.3	5.9	5.7	5.5
12	11.6	8.5	7.5	7.0	6.7	6.5
14	13.6	9.9	8.7	8.1	7.6	7.4
16	15.6	11.6	10.1	9.5	8.6	8.3

✍ Stem Design Heights

IMPORTANT! The term "Stem Design Height" used in this program is the height <u>above the top of the footing</u> (i.e. above the base of the stem). It is the height above the bottom of the stem where you want the program to compute moments and shears <u>above</u> that height.

You can divide the stem into up to five sections (increments of height). Each increment represents either a different material (concrete, masonry, or fence), thickness, or a change in reinforcing size or spacing.

For most walls, only two or three changes in stem sections are used, for example, at the top of the dowels projecting into the stem from the footing and perhaps further up the wall where a more economical section is desired.

✍ Bottom

<u>You must start your stem design here</u>, at the base (height above footing = 0.00), where the stem moment and shear is maximum. As you manipulate the bar sizes, spacing, and position (you first, of course, will have selected a wall material and trial thickness) until the Summary box shows you an acceptable stress ratio (the higher and closer to 1.0, the more efficient).

<u>To check the wall at a higher Design Height</u>, such as at least the LAP REQ'D IF ABOVE distance, where reinforcing or thickness can be reduced, click the **Insert Stem** button and enter the next higher section. Advance the spin button to the desired height above the top of the footing or enter it by typing. This will move (and dim) the Bottom Section and you can now design this "2nd" section.

Continue this way, clicking Insert Stem after each stem section design is completed, up to a maximum of five heights. A new Design Height should only be entered when you want to change the material, thickness, or reinforcing, and should never be less than about two foot intervals.

Summary -- Overall Stress Ratio

For masonry, this is the computed ratio of $f_a/F_a + M_{actual}/M_{allowable}$. For concrete it is $M_{actual}/M_{allowable}$.

The weight of the stem will be included only if there is added axial load. For masonry stems, F_a is calculated by considering the wall as unsupported with "K" = 2.0. Since even a very small axial load will activate the unsupported height/slenderness calculation for masonry stems, we suggest you do not enter an axial load unless it is significant (e.g. greater than, say, 3000 plf.).

Actual Moment

This is the maximum moment due to the lateral pressures and applied loads above the "Design Height" location entered. Note that when concrete is used, all soil pressures and loads are factored per default Load Factors for evaluation of moments and shears.

Allowable Moment

This is the allowable moment capacity, using working stress for masonry and ultimate strength for concrete. For masonry, both steel and masonry stresses are checked (and half stresses used for no Special Inspection). For concrete strength design, and steel percentage is limited to 0.75*rho balanced.

Total Force

This is the total lateral force from loads applied above the "Check Design at Height" location entered. Note that when concrete is used the forces acting will be factored. (Forces applied to compute overturning, sliding, and soil pressure are not factored.).

Actual Shear

For masonry, the effective thickness based on the actual "d" distance for the moment applied is used, considering partial or full grouting, to determine the unit shear produced by the total lateral force of the stem cross section (equivalent solid thickness is not used). Half stresses are used for no special inspection. Shears are calculated at the "Design height" location entered, not at distance "d" above design height. Concrete stems use a distance "d" x 12" for the shear area, and masonry stems use "jd" x 12" (with proper calculations for partial grouted cells) as the shear area.

Allowable Shear

For masonry, this equals (f'_m * short term increase)* ½ with a maximum of 50 psi.

For concrete, this equals 0.85*2* $f'_c{}^{½}$.

Lap Required If Above / Below

This displays the required lap length if a splice occurs above (or below) the Design Height. They are not cumulative, either make the lap above or below the Design Height for the minimum distance displayed.

The laps required above and below will be different if you are changing from concrete to masonry, or bar size.

For concrete stems, a Class B lap splice is assumed (see ACI 318-02, 12.15), therefore the lap length is the bar development length x 1.3. No reduction for stress level is permitted for lap splice lengths. Concrete is assumed to be normal weight, and bars not epoxy coated.

Concrete development lengths are computed per ACI 12.2.3, equation (12-1).

For masonry stems, the development length is set at 48 bar diameter, for F_s = 24,000 psi and 40 diameters for F_s = 20,000 psi. No reduction is made for stress level.

Bond stress is not calculated for concrete, since it is incorporated into the development length formula. The same is considered tru for masonry where bars are embedded in code specified 2000 psi grout.

Assumes bars are embedded in 2000 psi grout (specified by code) and therefore bond is not a significant concern.

Bar Embedment into Footing

For the bottom Design Height only (Ht. = 0.00), this displays the required hook bar embedment into the footing. It assumes a bar with a 90° bend and at lest a 12 diameter extension. This embedment must be at least 6" or 8 bar diameters.

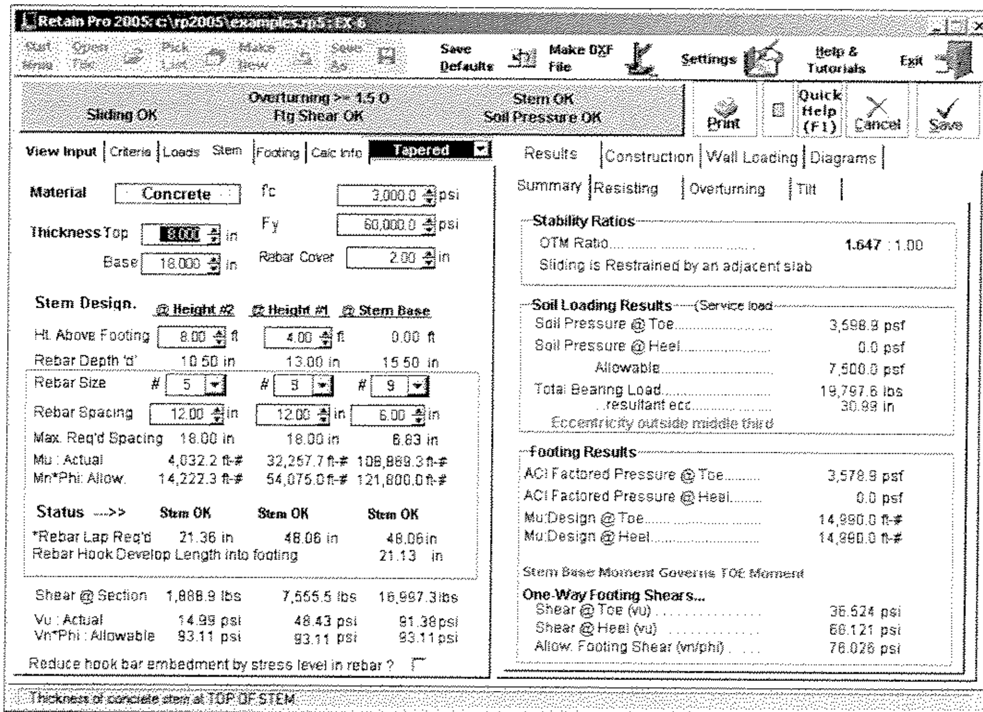
The minimum footing thickness required is based upon this embedment depth plus the clearance you have specified below the bar (usually 3 inches). If this totals less than the footing thickness you have chosen, a warning message will be displayed.

Note that if the bar extends straight down into a key, it must go the development length, and is not reduced by level of stress. For this condition, refer to the table in Appendix B, and multiply by the displayed Stress Level to get the required embedment.

The program does not reduce embedment length by stress level unless the Reduce Hook Bar Embedment for Stress Level box is checked. This is a code arguable issue.

Wall Type

If tapered (battered) stem is selected, entry and data descriptions are described below. Taper can only apply to the inside face (the face against the soil).



Material

The default will be Concrete, since masonry cannot be tapered.

Thickness: Top and Base

Enter the thickness at the bottom of the stem and at the top.

✍ **f'c and Fy**

Enter concrete strength and rebar yield stress.

✍ **Rebar Cover**

Select the clearance you want. Against earth or exposed to weather and where formed, #5 and smaller bars are 1½" and 2" for #6 and larger (per ACI).

Stem Design

You can select two heights above the base to check moments and shears. These are identified as "@ Height #2" and "@ Height #1." The latter is the lower, and the default height at the base is 0.00 ft.

✍ **Ht. Above Footing**

Select the two heights above the footing where rebar will be reduced for economy. Height #2 is highest and height at stem base will be fixed at 0.00. The #1 height should be at least the lap distance required above the stem top and base of the stem.

Rebar Depth "d".

This will be computed based upon the heights you have chosen and the amount of wall taper. One-half inch will be automatically added to rebar clearance to determine "d".

✍ **Rebar Size**

Use the drop down menu to select #3 through #10 bar.

✍ **Rebar Spacing**

Use the above data as a guide, but you will not be able to enter a spacing greater than 18 inches, which is the ACI permitted maximum.

Max. Allow. Spacing

This is the maximum permitted spacing, which per ACI is 18 inches.

Actual Moment (M_u)

These are factored (by 1.7) moments at the heights you have selected.

Compare this value with Allowable Moment, indicated below, to verify adequacy of your design at the selected height location.

Allowable Moment (M_n x ϕ)

This will be based upon the bar sizes and spacings you select.

Status

This indicates whether your stem design is OK at the selected height—or at the base—or displays M_u > Phi * M_n or A_s < min or A_s > max.

Rebar Lap Splice Above / Below

This is the lap distance required above or below the Design Height. It is the development length multiplied by 1.3 (assuming a Class B splice) and without adjustment for stress level.

Rebar Embed Length into Footing

This is the same as for the Cantilevered (non-tapered) stem, and assumes the bar is hooked into the footing with a 90° bend and minimum 12 d_b bar extension.

Shear at Section

This is the total factored shear at the indicated height.

Actual Shear

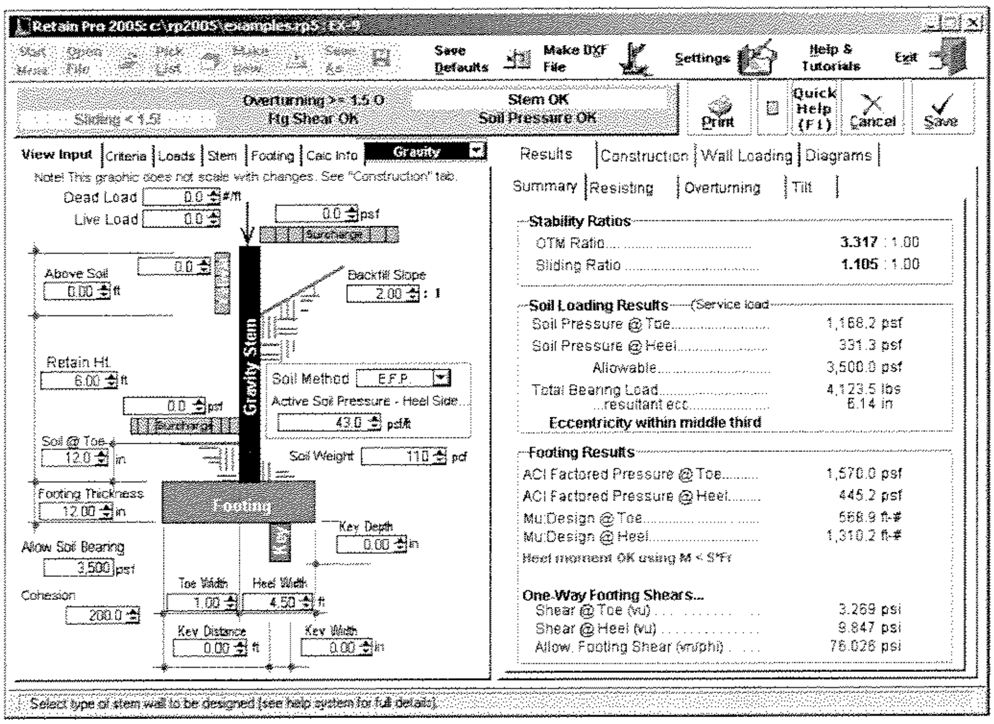
Unfactored shear stress at designated height computed by area = 12 * "d".

Allowable Shear

Based upon 0.85 * 2 * $(f'_c)^{1/2}$ for concrete.

Gravity walls may have one or both sides tapered and are assumed to be proportioned such that no reinforcing is required since every section is primarily in compression. Any solid homogeneous material may be used. Reinforcing can be added if there is any tension in the cross section, but the program does not compute this requirement.

Although the program only permits straight tapered sides (no crooks), changes in batter on either face, or even curved surfaces, can be modeled with reasonably close results.



Material

This entry displays "Gravity" and is not editable since any homogeneous material with compressive capacity can be used.

✍ **Wall Weight**

Enter the weight of the wall material in pcf. Generally this will be the weight of rubble, or approximately 145 pcf.

✍ **Front Batter Distance**

Enter the offset of the top of the wall from the front face at the base.

✍ **Thickness at Top**

Enter the thickness of the top of the wall.

✍ **Back Batter Distance**

Enter the offset of the top of the wall from the back face of the base.

✍ **Applied Load Factor**

Enter the load factor to be applied, 1.6 for concrete, 1.0 for masonry ASD, or other.

✍ **F'c Max. Compression Allowed**

Enter your criteria. Usually varies from 100 psi to over 700 psi.

✍ **F_t Max. Tension Allowed**

Enter your criteria. Usually varies from about 15 psi to 40 psi. Generally gravity walls are designed such that there is no tension – the full cross section is in compression.

✍ **Height Above Footing**

You can check stresses in the cross section at two heights above the footing. The Height Above Footing at the base will by default be zero.

Wall Thickness @ Height

This displays the wall thickness at the heights you have selected for analysis.

Section Modulus

This displays the computed section modulus at the heights selected for analysis.

Moment @ Height

This displays the moment at the designated height above the base.

Vertical Load @ Height

Summation of the vertical loads above designated height.

Maximum Tension / Compression

Interaction formulas displays compression and tension stresses.

Status

Indicates OK or NG for resulting stresses compared with designated maximums allowable.

Shear @ Section

Total shear at designated height.

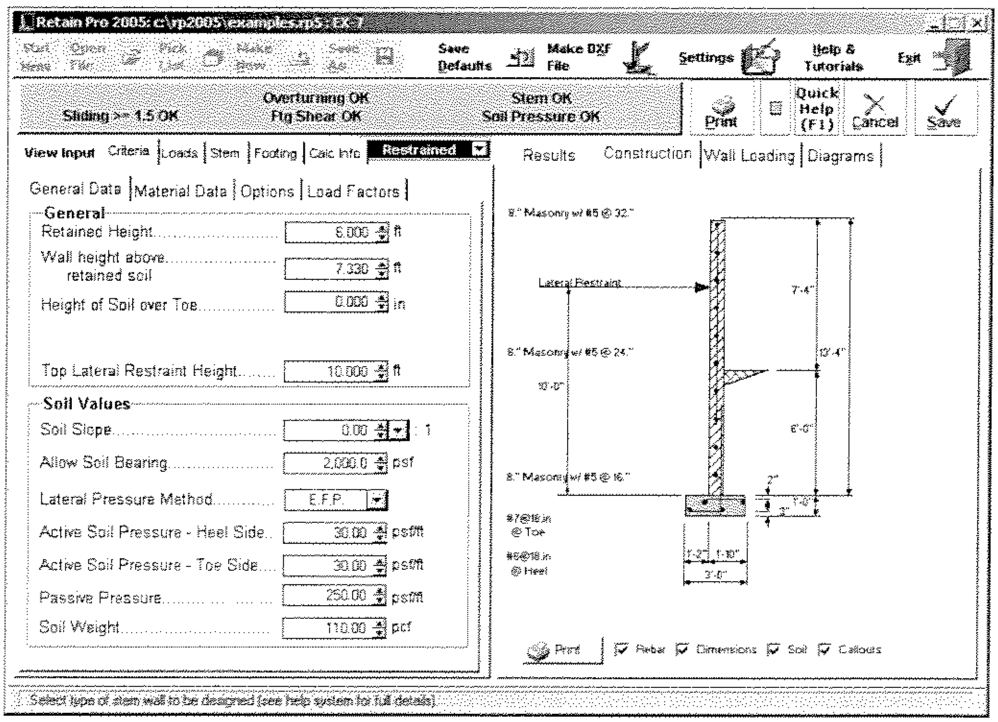
Actual Unit Shear

Calculated unit shear at designated height. Compare this with the allowable shear for the material you have selected.

NOTE: Entries for Criteria similar to cantilevered walls. Recommend "wall height above retained soil," not exceed about ¼ support height.

✍ Wall Type

If Restrained Stem is selected, you may have a lateral support (such as an abutting roof, slab-on-grade over backfill, or tiebacks). The lateral support should be near the top of the wall, although some extension of the wall above the support is permitted. You have the option of fixing the base (as for a cantilevered wall) or assuming it pinned. Intermediate degrees of fixity are not permitted. The program will compute moments, shears, and stresses at three locations: base (negative moment if fixed; zero moment if pinned), maximum positive moment between base and support, and at the point of support.



✍ **Material**

Select Masonry or Concrete. Only one material can be used, and must be of constant thickness.

✍ **Support Height**

Use the spin buttons (or type the value) for height from base to level of support. To check the overall wall height that you had input (retained height plus height above soil) just click the CRITERIA tab.

✍ **Thickness**

The program only permits a constant thickness throughout the height of the wall. Use the spin button (or type) the choice for thickness. If Masonry was chosen, the drop down menu will give you modular choices.

✍ **Fix Stem @ Base**

Clicking this box will check footing and stem for 100% fixity at base. If unchecked, pin condition will be assumed.

✍ **f'_m or f'_c**

Enter choice for masonry or concrete.

✍ **F_s or F_y**

Enter choice for masonry or concrete.

✍ **Rebar Cover**

This appears if a concrete stem is chosen and lets you enter desired cover on toe and earth side.

✍ **Inspection**

This is applicable to masonry stems only using UBC or CBC code. If checked, the full allowable f'_m used in flexure, shear, and axial stress will be used. If not checked, the allowable values will be reduced by one-half. The UBC and CBC codes require this reduction if Special Inspection is not specified.

✍ **Solid Grout**

This applies to masonry only, and if this box is checked the weight of the wall will be based upon industry standard solid-grout weight for either lightweight, medium weight, or normal weight. If this box is not checked, the program will calculate the weight based upon grouting of only cells containing reinforcing. This also affects equivalent solid thickness for stem shear calculations

✍ **Short Term**

This is used for masonry design only, and indicates the allowable overstress multiplier (1.33 for wind and seismic).It should only be used when wind or seismic induced stresses comprise most of the total stress (i.e. earth pressure is insignificant). For a concrete wall this does not apply since strength design is used, and this entry should be 1.0.

Stem Design

This allows you to design or check wall moment and shear at three locations: @ Top Support, @ M_{max} Between Ends, and @ Stem Base. If base is pinned, the entries under @ Stem Base will be zero or dimmed.

Ht. Above Footing

This displays, from left to right, the distance up to lateral support, height to point of maximum positive moment, and at the base of the stem.

Rebar Depth "d"

From the thickness and center/edge condition, the program determines the d" to be used for design (using internal tables and default modifications). See Rebar Position, above. For concrete, the program automatically adds to cover chosen one-inch allowance for one-half bar diameter, for determining "d" to be used.

✍ **Rebar Size**

Select from the drop-down menu.

✍ **Rebar Location**

Click the button for Center or Edge.

✍ **Rebar Spacing**

Enter your trial choice, or for masonry, select from the drop-down menu.

Actual Moment

This will show moments at the indicated locations with (+) and (-) as applicable. For concrete the moments will be factored by 1.7.

Allowable Moment

This will be calculated based upon the data you have entered. For concrete, it will be based upon strength design (factored by 1.7).

Status

This indicates whether your stem design is OK at the selected height—or at the base—or displays M_u > Phi * M_n or A_s < min or A_s > max.

Rebar Lap Req'd Above / Below

For masonry, the lap required is 48 bar diameters for F_s = 24,000 psi and 40 diameters for F_s = 20,000 psi.

For concrete, a Class B splice is assumed, which multiplies the development length by 1.3 (See ACI 12.15.2), and excludes reduction for stress level.

Note: The program does not compute or display bar cut-off points, which must be done manually, or extend positive reinforcing so it is acceptable.

Shear at Section

This is the total shear at the indicated height (factored for concrete).

Actual Shear

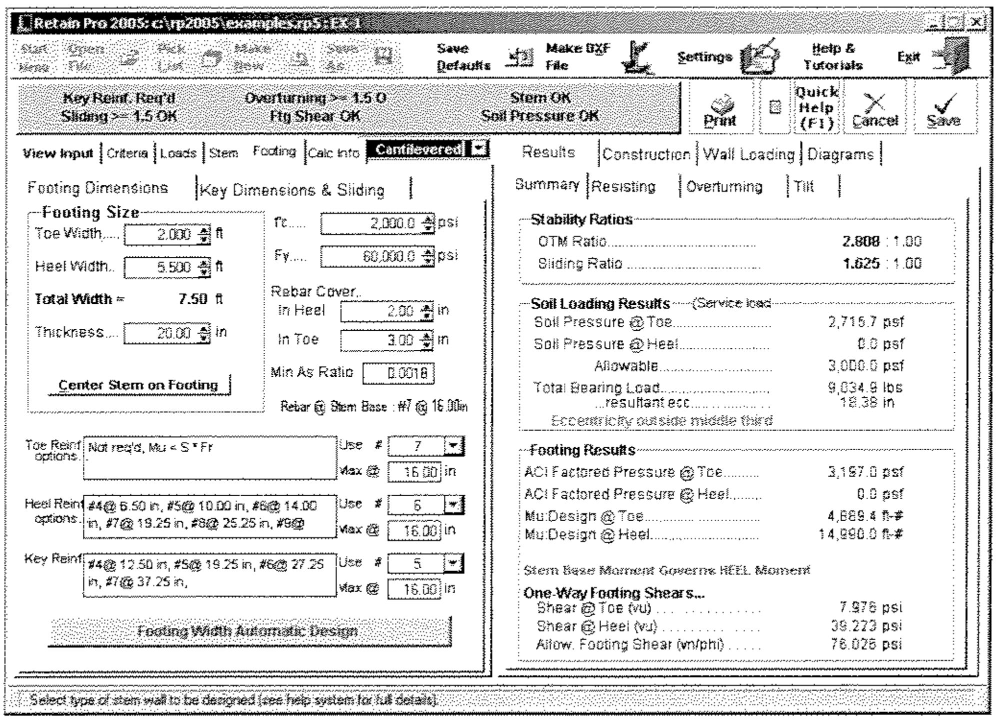
Unit shear stress at designated height computed by area = 12 * "d".

Allowable Shear

Based upon 0.85 * 2 * $(f'_c)^{1/2}$ for concrete and $(f'_m)^{1/2}$ for masonry, reduced one-half for no special inspection per UBC/CBC, and not to exceed 50 psi.

See Methodology, for further discussion of restrained walls.

This is the screen where you design the footing, by manipulating the heel and toe widths so the actual soil pressure is less than allowable, or you can use the Automatic Footing Design button (described below) to size the footing. This screen also gives you choices for toe and heel reinforcing, or indicates if it is theoretically not required. It also suggests key reinforcing, if applicable.



Toe Width

This is the width of the Toe of the footing, and is measured from the front edge of the footing to the front face of the stem. Can be set to 0.00 for a property line condition. All overturning and resisting moments are taken about the bottom-front edge of the toe.

✍ Heel Width

Distance from front face of stem to back of heel projection. If a dimension is entered that is less than the stem width at the base, the program will automatically reset the heel dimension to at least the stem width. For a property line at the rear face of the stem, this dimension would be the stem width.

Total Footing Width

The calculated width of the footing, Toe Width + Heel Width.

✍ Footing Thickness

Total footing thickness, NOT including the key depth (if used). For bending and shear design of the footing, the rebar depth "d" is taken as Footing Depth - Rebar Cover - ½" (to account for the rebar radius). If footing thickness is inadequate for shear capacity a red warning indicator will appear.

The footing thickness must be greater than the rebar embedment length required for the bottom stem reinforcing + rebar cover. If you enter a dimension less than required for stem bar embedment, a red message will appear at the top of the screen. The program adds the calculated hooked bar embedment from the STEM screen and adds it to the rebar cover you have chosen for the bottom of the footing (usually 3"). This will trigger the red warning. If inadequate thickness, increase the thickness, or change the stem dowels, until this message disappears.

Center Stem on Footing

Clicking this bar will adjust the toe and heel widths you have entered so stem is centered on the footing but overall width remains the same.

✍ f'_c

Enter concrete compressive stress for footing.

✍ F_y

Allowable rebar yields stress to be used for design of footing bending reinforcement.

✍ **Rebar Cover in Heel/Toe**

Distance from the face of concrete to edge of rebar. The program will add 1/2" to this value and subtract the result from the footing thickness to determine the bending "d" distance.

✍ **Minimum A_s Rebar Ratio**

Enter the absolute minimum steel percentage to be used to calculate rebar spacing requirements (commonly 0.0018 Ag for F_y=60,000 psi, but code applicability for footings is arguable). If the % steel required by stress analysis is less that $200/F_y$, the minimum of ($200/F_y$ -or- 1.333 * bending percentage required) is calculated and compared with the Minimum A_s% entered here, and the greater of the two used to calculate rebar spacing requirements.

Rebar at Stem Base

This is a reminder of the size and spacing of the bottom stem reinforcing, to make it easier for you to select toe reinforcing to match (toe reinforcing is usually the bottom stem dowel bars bent toward the toe).

Toe Reinforcing Options

This list gives you choices for reinforcing sizes and spacing for the bottom toe bars. Typically the toe bars are extensions of the stem dowels, which are bent out toward the toe. Therefore, you will probably want only to verify that the stem dowel bar size and spacing do not exceed the selections offered.

NOTE: If "No reinf' req'd" message appears, it means the flexural capacity of the footing (modulus of rupture times the section modulus, with 2" deducted from the thickness for crack allowance per code) is adequate to resist the applied moment. However, the designer in some cases may consider it prudent to add reinforcing regardless of the theoretical flexural capacity.

Heel Reinforcing Options

This list gives you choices for acceptable sizes and spacing of top heel bars. It is desirable to select a spacing that is modular with the stem dowel bars for ease of construction. Note: The program does not calculate the heel bar development length inward from the back face of the stem (where the moment is maximum). You can refer to Appendix B for development lengths in concrete, which can be adjusted for the stress level in the heel bars. When detailing footing reinforcing it is important to consider and specify development lengths for both toe and heel bars.

NOTE: If "No reinf req'd" message appears, it means the flexural capacity of the footing (modulus of rupture times the section modulus, with 2" deducted from the thickness for crack allowance per code) is adequate to resist the applied moment. However, the designer in some cases may consider it prudent to add reinforcing regardless of the theoretical flexural capacity.

Rebar Selections

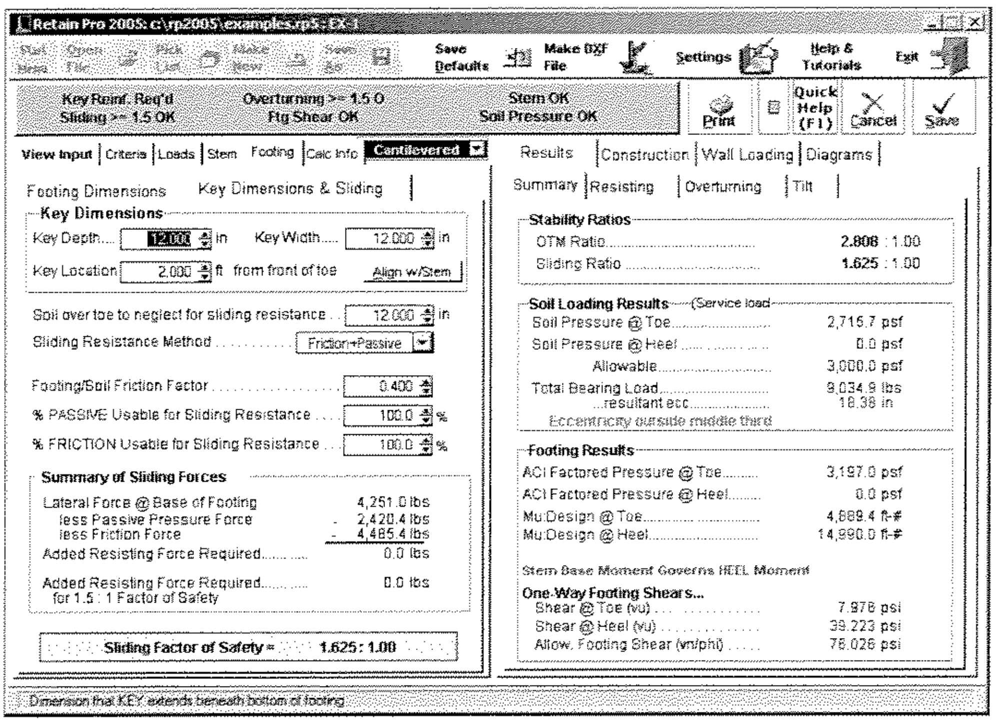
Use these three entries to pick your toe, heel, and if applicable, key reinforcing. The "Max @" message tells you the maximum spacing allowed for the bar selected. Since the dowels into the stem are usually bent toward the toe, a reminder is displayed for the bar size and spacing used for the stem dowels.

Footing Width Automatic Design

Clicking this button will cause the program to iterate footing widths until the soil pressure, overturning stability, and sliding stability ratios are acceptable. You can select either a fixed toe or heel distance, or balance the toe and heel dimensions. You can also select whether the resultant must be within the middle third of the footing. After clicking "Design," the widths required will be displayed.

Automatic footing design is not available for Restrained Walls.

This screen tells you whether passive soil resistance plus friction resistance is adequate to resist sliding with at least a 1.5 safety factor. If inadequate, you can design a key. If a key is used, the previous footing screen will check whether reinforcing is required by first checking the plain concrete flexural capacity (for computing section modulus, 2" is deducted from the key width per Code). If the key depth to width ratio is less than about 2:1, it's usually adequate.



✍ Key Depth

Depth of the key below the bottom of footing. The bottom of the key is used as the lower horizontal plane for determining the size of the passive pressure block from the soil in front of the footing. Adjust this depth so the sliding safety factor is acceptable, but not less than 1.5. A depth greater than three feet or one-half the footing width is not recommended.

✍ **Key Width**

Width of the key, measured along the same direction as the footing width. This is usually 12"-14", but generally not less than one-half the key depth so flexural stress in the key is usually adequate.

✍ **Key Location**

Enter the distance from the front edge of the toe to the beginning of the key. Do not enter a distance greater than the footing width minus key width.

✍ **Align with Stem**

Click this button to set front edge of key aligned with front of stem. If the key is then made the same width as the stem, the stem bars could extend down into the key to achieve development.

✍ **Soil Over Toe to Neglect for Sliding Resistance**

Since the soil over the toe of the footing is usually loose and uncompacted, it may have little or no passive resistance. This entry gives you the option of neglecting any or all of the Height of Soil Over Toe that you had entered in the CRITERIA screen. You can neglect the soil over toe plus the footing thickness, if desired.

✍ **Footing/Soil Friction Factor**

Enter this friction factor here, which is generally provided by the geotechnical engineer. It usually varies from 0.25 to 0.45.

✍ **% Passive Usable for Sliding Resistance**

This may be a stated restriction in the geotechnical report. Enter a value from zero to 100%.

✍ **% Friction Usable for Sliding Resistance**

This may be a stated restriction in the geotechnical report. Enter a value from zero to 100%.

Lateral Pressure @ Base of Footing

This is the total lateral force against the stem and footing which causes the wall to slide and which must be resisted. It is the total active pressure on the heel side less the active pressure on the toe side. The latter will be excluded if you choose to delete it on the OPTIONS screen.

Less Passive Pressure Force

This uses the allowable passive pressure in pcf and the available depth (soil above toe less height to neglect plus footing thickness) to compute the total passive resistance, again multiplied by the percent usable you selected. Weight due to toe surcharge, if applicable, will also be added. If a key is used, the available passive pressure depth will be to the bottom of the key.

Less Friction Force

This is the total vertical reaction multiplied by the friction factor, again multiplied by the percent usable you selected

Added Resisting Force Required

If this is 0.0 lbs., the forces balance, but there may be no safety factor. Watch the Sliding Factor of Safety for an adequate value (usually 1.5). Add a key as required.

Added Resisting Force Required for 1.5:1 Safety Factor

This is the additional force required to be resisted by a key to achieve a 1.5 safety factor. If zero, no key is required.

Key Reinforcing

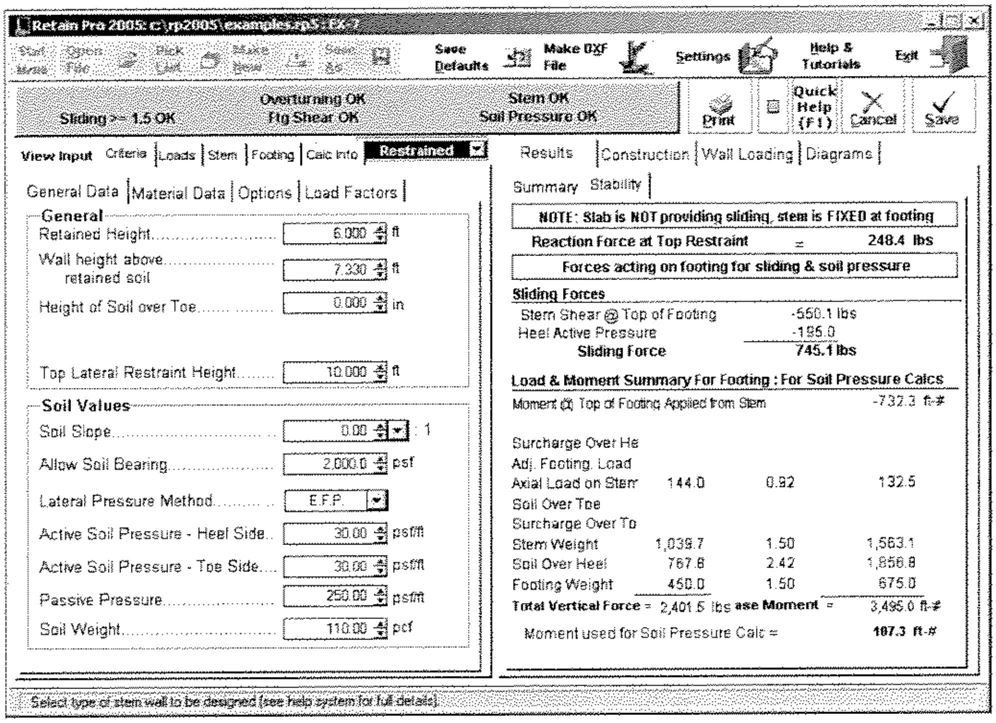
If flexural tension is insufficient to resist bending in key, a message will appear indicating reinforcing required. You can vary the width of the key until the message disappears. Or you can manually calculate reinforcing required. Also see *Methodology.*

Sliding Factor of Safety

This gives you the ratio of passive and friction resistance to the total lateral force. This should be at least 1.5.

NOTE: If lateral restraint is provided by an abutting floor slab (by checking the box on the CRITERIA > OPTIONS screen), the sliding factor of safety displays will be deleted, but the "Lateral Force @ Base of Footing" will be displayed for checking restraint adequacy of the slab.

For Restrained Walls the STABILITY screen will appear differently, summarizing the conditions you have set regarding base fixity and base lateral restraint.



A banner will display whether a slab is present to resist base sliding (box checked on CRITERIA > OPTIONS screen) and whether fixed or pinned at base, as previously selected on the STEM screen.

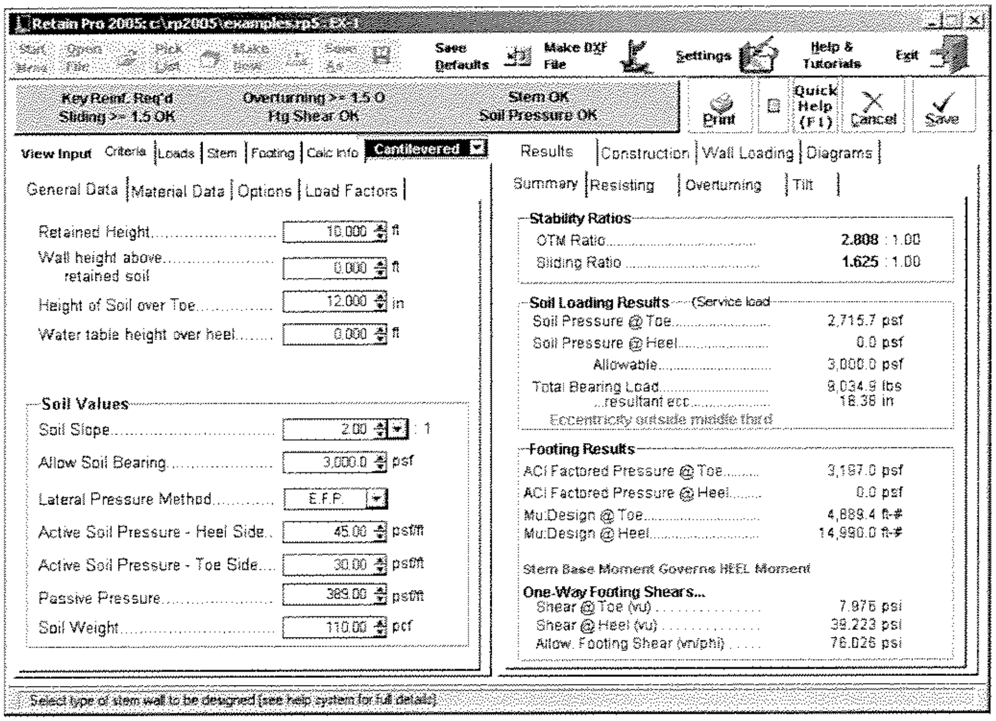
The reaction at the top restraint will be displayed.

The Sliding forces will be displayed, and indicate counteracting active pressure on toe side, if this option was selected on the Options screen.

For analyzing the stem, if it is assumed "pinned" at the bottom (checkbox choice is made on the Stem screen), and a slab is not present to resist sliding, then the theoretical overturning of the footing due to the reaction at the base of the stem, is the reaction at the bottom of the stem times the depth of the footing. In actual practice the footing will be constructed integrally with the stem (not a true "pin") therefore the displayed "moment at top of footing applied from stem" (shown on Stability tab) will be compared to the moment capacity at the stem base (shown on Stem screen) and an overstress shown if the stem base moment capacity is inadequate.

If slab restraint is provided, the moment applied to the footing is the total vertical load times its eccentricity from the center of the footing. This moment is displayed (Stability screen) and used to compute soil pressure. The moment capacity at the stem-footing interface (shown on Stem screen) must exceed the moment applied to the footing

This screen summarizes the footing/soil bearing results obtained from previous screens, including a message whether the resultant is within or outside the middle third of the footing. <u>This is not an input screen. It's strictly for your review</u>.



Stability Ratios

These are displayed for both overturning and sliding.

Soil Pressure @ Toe and Heel

This is the resulting unfactored soil pressure for both the toe and heel. If the eccentricity is outside the middle third, the heel pressure will show 0.00. (Note: when the resultant is outside the middle-third, the program calculates the toe pressure assuming no "tension" at heel).

Allowable Soil Pressure

This is for your reference as input on the Criteria input Screen

Total Bearing Load

This is the sum of all vertical forces.

Resultant Eccentricity

Distance from center of footing to resultant soil pressure.

Eccentricity Within/Outside Middle Third

The resultant is outside the middle third of the footing width if the eccentricity is greater than one-sixth the footing width. (If outside the middle third, the program computes the toe soil pressure assuming no "tension" at heel.)

ACI Factored Soil Pressure @ Toe and Heel

ACI or AASHTO load factors are applied to all dead and live loads to determine total vertical load for soil pressure used in calculating footing moments and shears. This load is then applied at the same eccentricity calculated for service load soil pressures to yield the actual factored soil pressures for footing design using ultimate strength design principles. Note that since only factored vertical loads are applied at the non-factored resultant eccentricity, a true 1.6 load factor applied to lateral earth pressure is not used for footing design. If resultant vertical load eccentricity were to be calculated using factored loads, the distance would not truly represent a correct state of stress in the soil. ACI load factors are intended to give conservative results for stress. Calculation of a factored load eccentricity would give soil pressure diagrams that would not always represent the actual soil pressure distribution under the footing, and yield unreasonable results. Factored lateral earth pressure, however, is always used for concrete stem design.

M_u Design @ Toe/Heel

These are the factored (by 1.2) moments at face of stem for toe and heel moments. Since neither can be greater than the stem base moment (factored if concrete stem), the latter may govern. These moments will be reduced if you choose to neglect the upward soil pressure on the Criteria > Options tab.

A message will indicate which controls.

Shear @ Toe and Heel

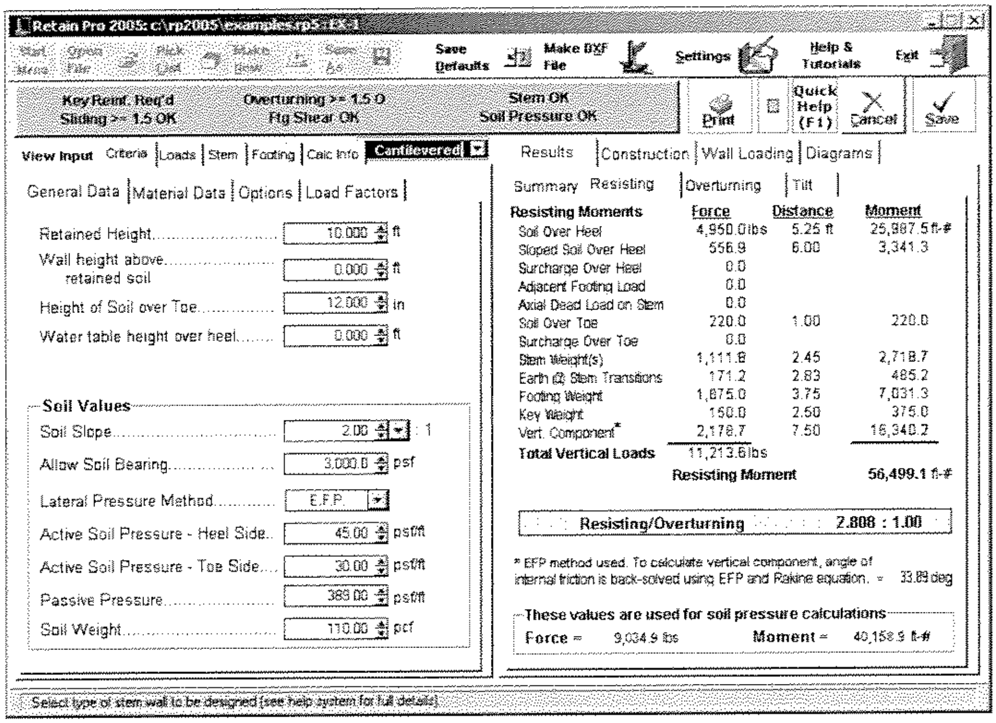
The actual shear is calculated from the one-way action in the footing at a distance "d" (footing thickness - rebar cover) from the toe side of the bottom stem section, and at the face of the stem on the heel side. If "d" is greater than the projecting toe or heel length, then the one-way shear is zero.

Allowable Footing Shear

The allowable unit shear equals ($0.85 * 2 * f_c'^{1/2}$).

Stability ratios are re-displayed.

This screen presents in tabular form each component contributing to resisting moment, giving weights and lever arms from the front edge of the toe to the centroid of the weight.

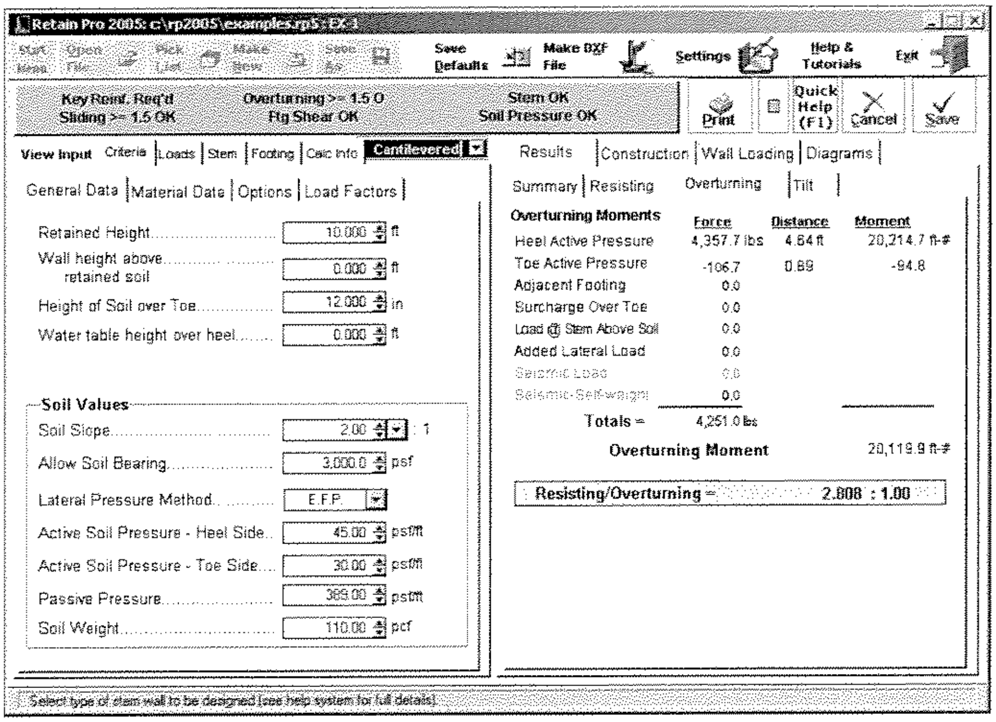


Resisting/Overturning ratio is displayed.

For calculating the vertical component, if checked on the OPTIONS screen, and if the EFP method was chosen, the program will back-solve using the Rankine formula to obtain an equivalent internal friction angle.

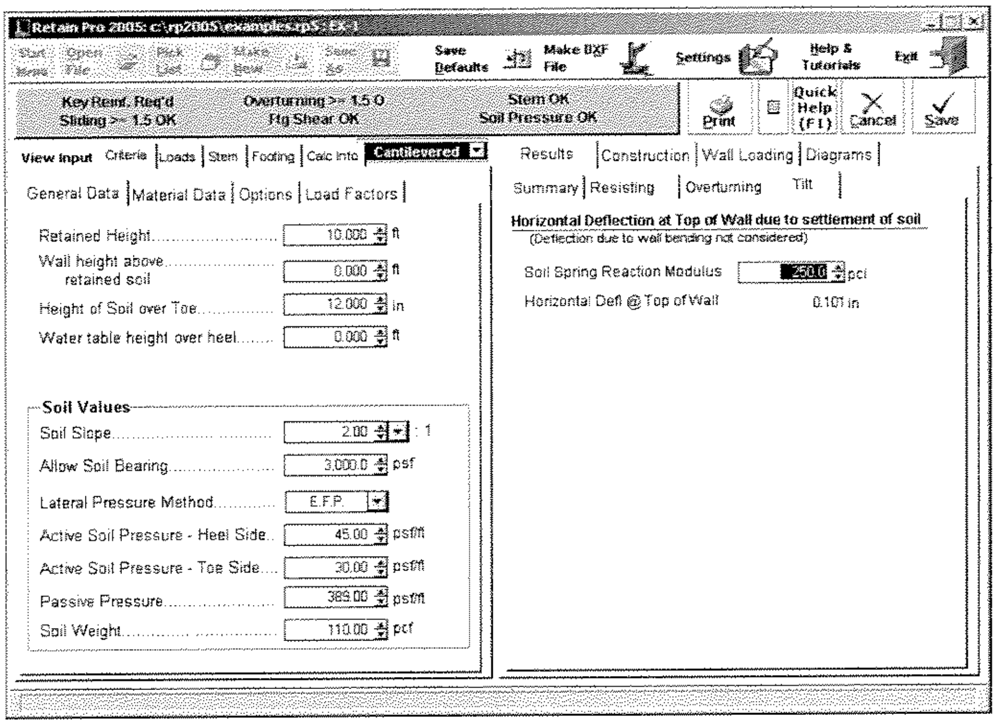
The force and moment displayed at the bottom accounts for deduction of effect of vertical component, if box on CRITERIA > OPTIONS box has been checked.

This screen presents in tabular form each component acting horizontally to overturn the wall/footing system. The centroid of each force is multiplied by its distance up from the bottom of the footing. The Heel Active Pressure includes the effect of surcharges and water table, if applicable, and its Distance is to the centroid of the total lateral force.



The total overturning moment is displayed, and the Resisting/Overturning ratio. The overturning moment is reduced by the toe side active pressure, if this option is selected on the Options screen.

This computes the rotation of the wall due to compression of the soil under the toe.

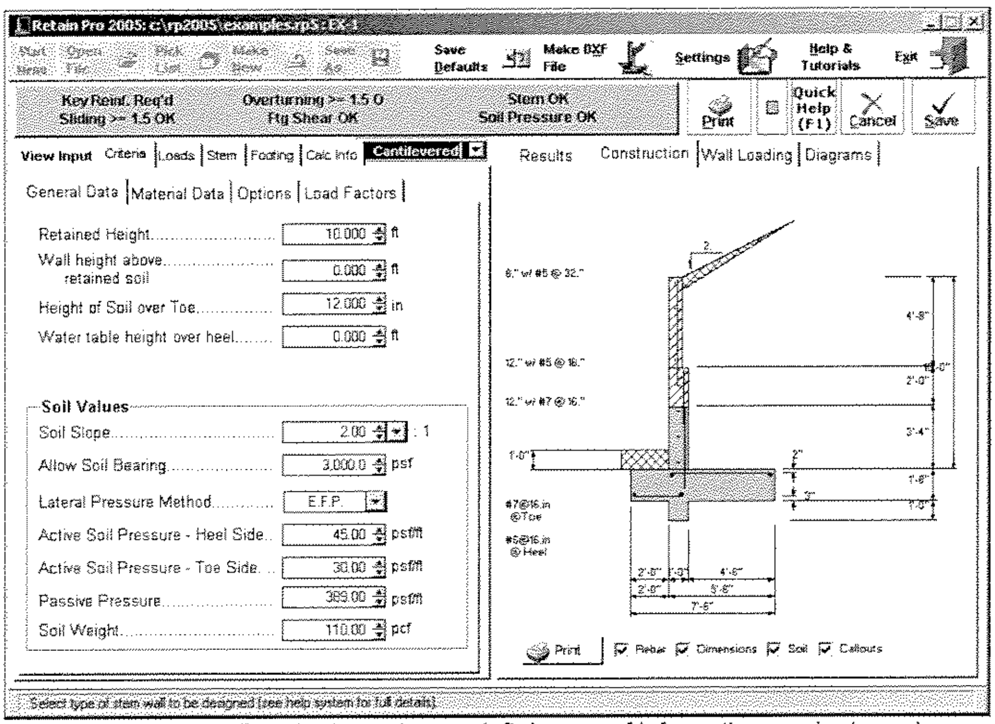


You must enter the modulus of subgrade reaction (determined by the geotechnical engineer). The program divides the soil bearing stress in psi by the soil modulus (psi/inch) to obtain Δ. Then, assuming the wall and footing rigid, the out-of-plane tilt at top = $\Delta H / W$, where H = overall height of wall and footing, and W is width of footing.

Note: This is approximate due to variation in soil pressure under the footing, and does not include deflection of the stem due to lateral earth pressures. (The latter is usually less than the "tilt" deflection, and if desired, must be done by hand calculation, requiring investigation of cracked and uncracked moments of inertia.) To mobilize the soil wedge, deflection at top is often considered 0.005 x H_{total}

CONSTRUCTION Tab

This graphics screen displays a construction drawing showing the pertinent construction data for the wall as you have entered it. It can be printed, copied to the Windows clipboard, or a DXF file can be generated for importing to your CAD software. This graphic is not editable and is intended as a check of your input. We do not recommend printing and editing it (by hand) for an actual construction drawing. Instead, use the DXF to CAD feature.



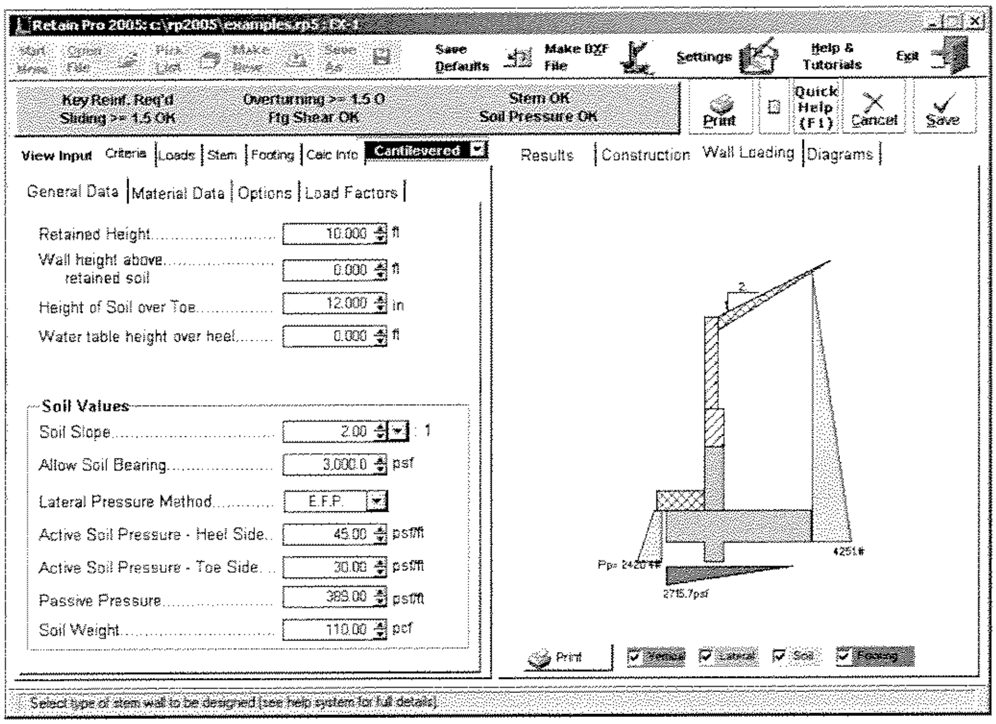
To print, use Print button at bottom left. Layers of information can be turned off/on by buttons at bottom.

THIS DRAWING WILL NOT DEPICT THE WALL UNTIL YOU HAVE ENTERED SUFFICIENT DATA. ONLY A DEFAULT GRAPHIC WILL APPEAR INITIALLY.

This graphics diagram shows loads you have entered, active pressure resultant, passive pressure resultant, and maximum soil pressure.

Loads are color-coded and may be turned off/on by clicking boxes at bottom.

To print, use button at lower left (not shown on above illustration.

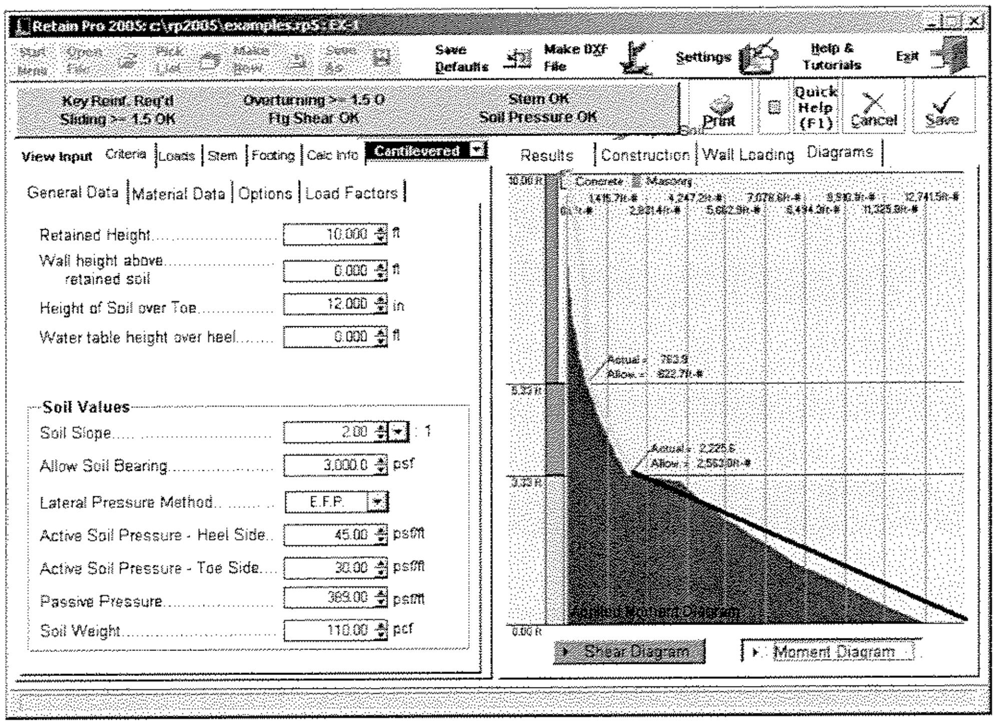


<u>Note that if seismic or adjacent footing loads are used, the pressure diagram curve does not graphically depict these loads, but they are included in the reaction shown at the bottom of the active pressure diagram.</u>

THIS DIAGRAM WILL NOT BE COMPLETE UNTIL YOU HAVE ENTERED SUFFICIENT DATA. ONLY A DEFAULT GRAPHIC WILL APPEAR INITIALLY.

Stem Diagram - Envelope Curves

These curves display applied and resisting moments plotted along the height of the stem. Each change in section (material, thickness, or reinforcing) is marked. For concrete stem sections, the applied moments are factored. Resisting moments are based upon strength design rather than working stress as for masonry sections.



The moment resisting line is usually sloped to reflect change in resisting capacity with reduced remaining development length.

These curves will be useful for visualizing and determining cutoff points for reinforcing, and general viewing of the stem adequacy.

AUTO MAINTENANCE UPDATES

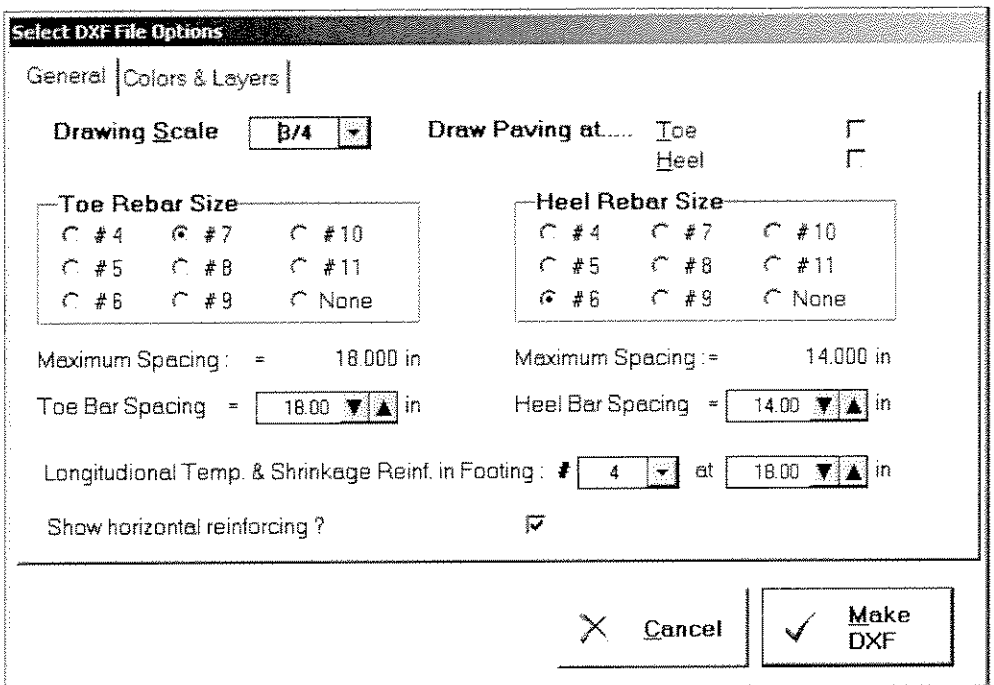
Retain Pro 2005 now has an automatic updating system to be sure you are always up to date on any maintenance and improvement updates we issue.

At timed intervals, after you start Retain Pro 2005, you will be asked whether you want to check for updates. Selecting "Yes" will shut down Retain Pro and launch the updating program (named RPUPDT.EXE).

This updating program will connect to www.retainpro.com (you need to have your Internet connection on) and compare the version you have installed with the latest version available, and then download the required update files as needed. (Note to your technical staff: we use strictly HTTP protocol over port 80 for all communications).

On the "Settings" screen you will see a last tab called "Updates". On this tab a prompt will ask you for: "Days between update checks", and an entry for you to put a number between 0 and 20, and a little note says "enter zero to disable checking".

By selecting Make DXF File from the Task Bar you can create a "DXF" format file to import your complete Retain Pro retaining wall construction drawing into any of a number of CAD and drawing programs.



If you choose to open the DXF file from within AutoCAD, follow these directions:

1) Choose File/Open from the pull-down menu bar.
2) Save the existing file you were working with so as not to lose your changes.
3) Change the file type from the pull-down menu located below the file name prompt in the Open screen to DXF.
4) Locate the folder (directory) where the Retain Pro DXF file occurs.

5) Click on the file name and exit the dialog box by clicking on OK to open the file.
6) You may proceed to step 4 in the Drag and Drop directions (below) to save the file as a drawing or as a block for later insertion.

NOTE: The DXF file is converted to the scale that you choose in Retain Pro. You may need to convert the scale of the drawing to match the drawing that you will insert the block into. Refer to your AutoCAD help menu for scaling instructions.

You can also use Windows drag and drop feature to create a DWG file from Retain Pro's DXF file. This can only be done upon opening a new drawing and will not allow insertion of the DXF file as a drawing.

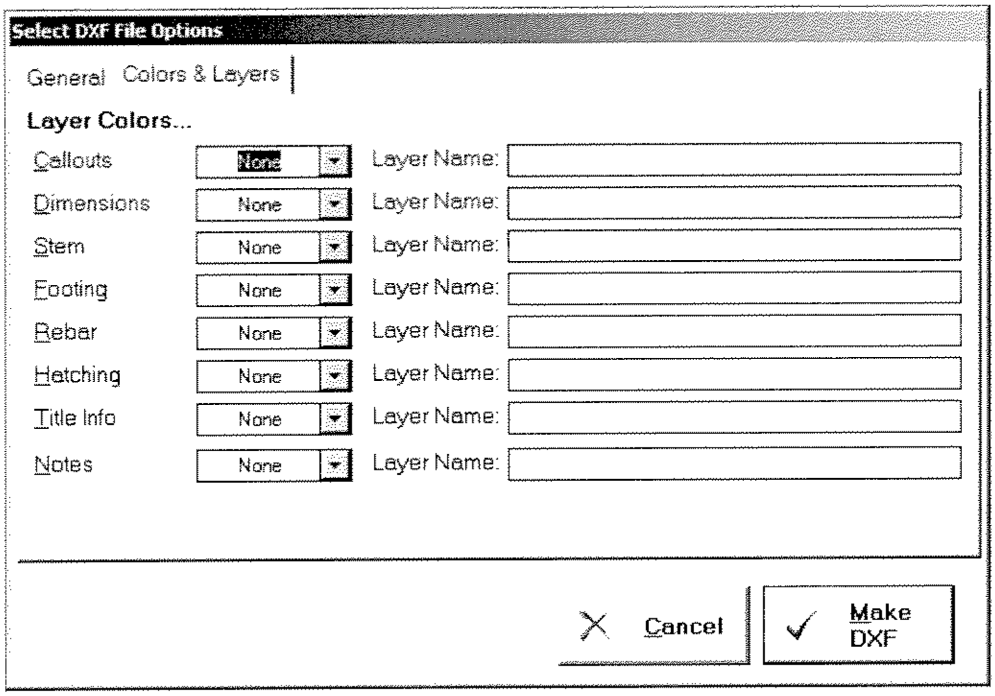
To use the Drag and Drop feature:

1) Start AutoCAD or AutoCAD LT (or other compatible) and choose to start a new drawing. You can not use an existing template drawing that contains any blocks or objects. Use the default acad.dwg that came with AutoCAD.
2) Open your file manager and proceed to the folder that contains the Retain Pro DXF file (HINT: Create your DXF file and save it to your Windows Desktop for easier manipulation).
3) Click on the DXF file and, holding down the right mouse button, drag the file into the AutoCAD window.
4) Save the file with any name you prefer. An AutoCAD DWG file will be created.
5) HINT - You may use long file names, however, if you choose to insert the file as a block you must use and underscore (_) character wherever a space occurs. The total length of the file name must be under 30 characters for AutoCAD to recognize it as an allowable block to be inserted.

NOTE: If the drawing is used as a block, there must be no spaces between the words in the name of the file. For example, if it is to be called Six Foot Wall.DWG, it must be written out as Six_Foot_Wall.DWG so that the spaces between words are filled with some other character than a space. This is a limitation of AutoCAD® that treats a block differently than it does a drawing.

Although this will create nearly all of the drawing, there still may be some touch-up and editing for your specific requirements.

Use this screen to establish up to eight layers for your CAD drawing.



Clicking **HELP** on the Tool Bar will give you seven choices:

Topic Index, where you can scroll to select a topic that you'd like explained.

Tutorial, where you can scroll through a list of get-started topics.

FAQs directs you to www.retainpro.com/support where common technical FAQs are accessible and are updated frequently.

Email Support will connect you to the Internet and give you a ready-to-use screen where you can ask a technical support question and email it to our staff.

FAX Support gives you a form ready for you to fill out, print, and FAX to our support staff.

This Version will give you information about the Retain Pro version you are currently using.

Access User's Manual allows you to download the complete User's Manual (in Adobe Acrobat .pdf format) for viewing and printing.

You can also click QuickHelp (on the Task Bar) to get entry explanations from every screen.

Also note that for every entry there is a brief description of its function at the bottom of the screen.

Methodology & Design / Analysis Assumptions

We recommend you red these notes to give you a greater understanding of Retain Pro 2005 and familiarize yourself with the programs capabilities, assumptions, and design methodology.

This program is for both **cantilevered and restrained retaining walls, including gravity walls**. For cantilevered walls the base of the stem is fixed to the footing, and the footing is free to rotate on the supporting soil, and no lateral restraint can exist at or near the top of the wall (otherwise it is not a cantilevered wall).

For restrained walls ("basement" and tie-back") the program assumes either 100% fixed at base, or pinned. Lateral support is near or at the top, and moment/shears are computed at the base, maximum positive, and at the upper support. The program does not check flexural stress reduction for axial loads (the unity interaction formula) since in most cases of basement walls the h/t ratio is below about 10 for masonry walls and somewhat higher for concrete, and axial stresses are low. If axial stresses are considered significant (say over 1000 lbs. per ft. length of wall), the interaction should be checked at the point of maximum positive moment. For tie-back walls, you must check the wall span horizontally between tie-backs.

References used for the development of this program are listed in Appendix E.

Stem design material is limited to concrete or concrete block masonry. Design strength of concrete and masonry may be specified.

Conventional "heel" and "toe" terminology is used, whereby the "heel" side of the wall supports the retained earth. In this program, the "heel" distance is measured from the front face of the stem.

Concrete design for stem and footing is based upon ultimate strength design (SD) using factored loads. Factors for various building codes will be displayed on the Criteria > Load Factors page, and may be edited. Since they are editable, be sure to check them before starting a design since you may have changed them.

Masonry design is based upon the Allowable Stress Method (ASD).

A geotechnical engineer will have determined design criteria (equivalent fluid pressure, soil bearing, sliding coefficient, etc.). If this is not the case, the designer should exercise special care in selecting these values appropriate to the site conditions. Optionally, you can enter the angle of internal friction for the soil, and the program will compute the corresponding active pressure, using the Rankine or Coulomb formulas based upon the soil density and backfill slope you have specified.

If either the **Rankine or Coulomb method** is chosen, passive pressure and toe active pressure will be based upon the Rankine Formula, assuming a level toe-side backfill.

The **factor of safety** against sliding and overturning should be at least 1.5:1, and the program displays warning messages when this condition is not satisfied.

Where **stem thickness varies**, it is assumed that the front face (toe side) of the stem is flush, and the change in thickness occurs on the heel side.

Weight of concrete block masonry can be lightweight, medium weight, or normal weight, per the table in this User's Manual. These weights can be modified using the Criteria > Materials screen. Refer to Appendix C.

Horizontal temperature/shrinkage reinforcing is at the discretion of the designer and is not computed by the program. Minimum for concrete is 0.0020 times the area of the wall, and 0.0007 for masonry. Some designers may add a layer of reinforcing on the front face of the wall. Two layers of reinforcing is required by code for walls over 10 inches thick; however, some codes exempt "basement walls", and presumably retaining walls since they too are in contact with earth. For horizontal temperature and shrinkage reinforcing for various stems see Appendix A. Some engineers consider a stem wall like a slab-on-grade and use a lesser percentage of horizontal reinforcing.

Toe and heel footing reinforcing may not be required if the footing extends only a short distance beyond the face of the stem. In these cases, shear and bending can be resisted by plain concrete (flexural tension and shear). The program calculates whether flexural tension is adequate by computing the section modulus of the footing (deducting 2" from the bottom of the footing per ACI recommendation) and allowable flexural tension. If this is the case the program indicates that no reinforcing is required, however, the designer may want to include it.

Axial loads may be applied to the top of the stem, and are considered in the overall capacity interaction formulas. Allowable axial load for masonry stems is calculated using the total wall height as an unsupported column with a "K" factor of 2.0. The ratio of fa/Fa is then added to fb/Fb for each stem design height to give the interaction ratio for each stem section on the Stem screen.

Only "positive" eccentricities from the centerline of the top stem are accepted (i.e. toward the toe), since negative eccentricity could lead to unconservative results.

Excessively high axial loads are not anticipated by the program and should not be applied if they would cause tension in the bottom of the footing heel – the program assumes typical retaining wall conditions where the heel moment causes tension at the top of the footing. If a design requires a very high axial load, say, over 3 kips/lf, suggest suing a footing design software or hand calculations.

A vertical component of active pressure, P_v can be assumed to act along a vertical plane at the back of the footing and the program (Options screen) allows choices of whether it is used to affect soil pressure, overturning resistance, or sliding resistance. Some engineers consider it non-conservative to apply it for soil pressure calculations, or for sliding resistance. Textbook examples vary on this issue, so we have provided a "Yes/No" check box on Criteria > Options screen to make your choice. It can make a large difference in soil pressures. When the Rankine method is chosen, the line of action of the resultant is assumed to be the angle of the backfill slope, β, therefore, P_v is $P_a \sin\beta$. If the Coulomb method is chosen, the line of action is δ, which is assumed to be $\phi/2$. Therefore, for the Coulomb method $P_v = P_a \sin(\phi/2)$. For the EFP method, ϕ is obtained by back-solving the Rankine formula, but using $P_v = P_h \tan(\phi/2)$. This allows you to use a vertical component for a level backfill by checking the appropriate box on the Criteria > Options screen.

Special inspection for masonry as defined in the Uniform Building Code limits F'_m to one-half its specified value if special inspection is not provided, but does not effect E_m used to calculate modular ratio. To provide for this requirement you may check or un-check the box on the Stem screen. The allowable bending, shear, and axial stresses will be multiplied by one-half when calculating overall allowable values.

Surcharge can be composed of either dead load, live load, or both. For the design of the footing and stem sections it is factored per the Load Factor criteria selected.

Concrete block thickness' of 6", 8", 10", 12", 14", and 16" are allowed in the program.

Stem reinforcing may be #4 through #10 bars. Soft Metric sizes are shown in parenthesis alongside.

Critical section for bending and shear in the footing is at the face of the stem for concrete and 1/4 nominal thickness within the wall for masonry stems, for bending. For shear, for both concrete and masonry stems, the critical section is a distance "d" from the face of the stem toward the toe, and at the face of the stem for the heel. The program does not calculate toe or heel bar development lengths inward from the face of the stem (where the moment is maximum). When selecting and detailing the arrangement of toe and heel bars this should be considered. Refer to Appendix B for development lengths in concrete, which can be adjusted for the stress level.

The program designs key reinforcing but flexural and shear stresses for plain concrete are generally adequate, particularly if the depth to width ratio of the key is less than about 1.5:1. The program calculates the bending in the key and determines whether reinforcing is required. For determining section modulus, 3" is deducted from the key width per ACI recommendation. If so, a message will appear. You can then change the key dimensions until the message disappears, or use the rebar suggestions displayed. The key moment and shear is produced by the passive resisting pressure acting against the key.

Bond stress for masonry stems. Flexural bond is a slipping (grip) stress between reinforcing and grout, resulting from the incremental change in moment from one point to another, and is a function of the total shear at the section. The program does not specifically check bond stress, but does use the formula $\mu = M / (j\ d\ \pi\ d_b)$, and compares this with the allowable development length. The formula for bond, relating to shear, is: $\mu = V / (\Sigma_o\ j\ d)$, where Σ_o is the perimeter of the bar(s) per linear foot. "j" and "d" are the familiar terms. This can be re-written to be approximately: $\mu = 0.35\ V\ s / d_b\ j\ d$, where "s" is the bar spacing in feet and d_b is the bar diameter, if the designer wishes to check to the bond.

Bond stress in masonry retaining walls is of questionable significance since the bars are customarily cast in grout which by code must be at least 2,000 psi, therefore comparable to embedment in concrete. Furthermore, Amrein (see bibliography) quotes a research study concluding the bond stress could be 400 psi based upon experimental studies showing minimum achieved stresses of 1,000 psi, thereby giving the former value a safety factor of 2.5.

This is probably a moot issue since rarely would bond stresses govern over shear stresses, particularly if the stress level in the reinforcing is factored in. Additionally, development lengths for reinforcing in masonry, and code required lap lengths, are considered quite conservative.

A lap length dilemma occurs when a masonry stem extends above a concrete stem. To illustrate, consider this: A #7 bar in concrete must be lapped 5'-2" (assuming class B splices, f_y = 60ksi, f'_c = 3,000 psi) whereas the same bar in masonry must only be lapped 3'-6" (assuming F_y = 24,000 psi). Nevertheless, that is the code, and furthermore no reduction is permitted for under-stressed reinforcing. The designers dilemma is deciding how far up a concrete stem must extend before continuing in masonry. Using the #7 bar example, one would extend the concrete portion up about 5'-6", then continue with masonry. In this case the bars in the masonry would need to lap below (into the concrete) 48 bar diameters (for F_y = 24,000 psi). Alternatively, and seemingly more logical, would be to extend the reinforcing in the concrete portion up into the masonry 48 bar diameters. But, in this case, how far up should the concrete portion extend? This is the designers' dilemma, and there appears to be no published guidelines. The program skirts the issue by only giving you the code required "lap lengths if above / below" the section considered.

Slab restraint at the base can be specified on the Criteria > Options screen. The program only allows this restraint to occur at the top of the footing – not higher.

Supplementary specifications or notes for the construction of the retaining wall should always be provided, including provisions for draining backfill and other site conditions affecting the design.

RESTRAINED WALLS:

A vertical component of active pressure is not activated, whether or not it is check on the Options screen, since the top of the wall is assumed not to deflect and thereby not activate such force. Overturning moment is not applicable, and therefore not displayed, since lateral stability is by restraint at or near the top of the wall and at the base either by slab restraint or a combination of friction and passive resistance.

When floor slab restraint is specified on the Options screen, the point of lateral support is assumed to be at the top of the footing. This may not be strictly true but is considered a reasonable design assumption.

When 100% base fixity is selected, and floor slab restraint is provided, soil pressures are computed as for cantilevered walls, using the fixed moment at the base of the stem as the overturning moment. Bending in toe of footing neglects any stiffening effect of floor slab. For this case, passive and frictional resistances are not displayed, nor is sliding ratio, but total lateral force at base is shown for checking floor slab.

When 100% base fixity is selected, and no floor slab restraint, soil pressures are computed as for cantilevered walls but using the fixed moment at the base of the stem as the overturning moment, and sliding resistance based upon lateral reaction at the base of the footing—this is somewhat conservative since if passive resistance is available the point of lateral support is slightly above the bottom of the footing.

When "Fix Stem @ Base" is unchecked, the footing will not be designed to provide base-of-stem fixity. In this case, the total lateral reactions assume all lateral restraint at bottom occurs at bottom of footing (pin-connection) even if floor slab is present. This may be slightly conservative or unconservative depending upon whether floor slab is present, or if not, if passive resistance is available. Reaction at top restraint assumes pin-connection at bottom of footing. Shear at base of stem is computed based upon lateral force above that point.

When base of stem is not "fixed" by footing, there will still be some moment at base of stem due to any eccentricity of resultant loads on the footing, and if slab restraint is not provided, an additional moment due to the lateral reaction at the bottom of the footing multiplied by the thickness of the footing. Since the bottom of the stem is assumed "pinned," for analysis purposes, the resulting soil pressure will be trapezoidal; however, in actuality there will be some fixity at the stem-footing interface. If the Stem Base moment capacity (shown on Stem Screen) is greater than the Moment used for Soil Pressure (shown on Stability screen), then the soil pressure will be uniform over the footing width.

U.S. DEPARTMENT OF ENERGY

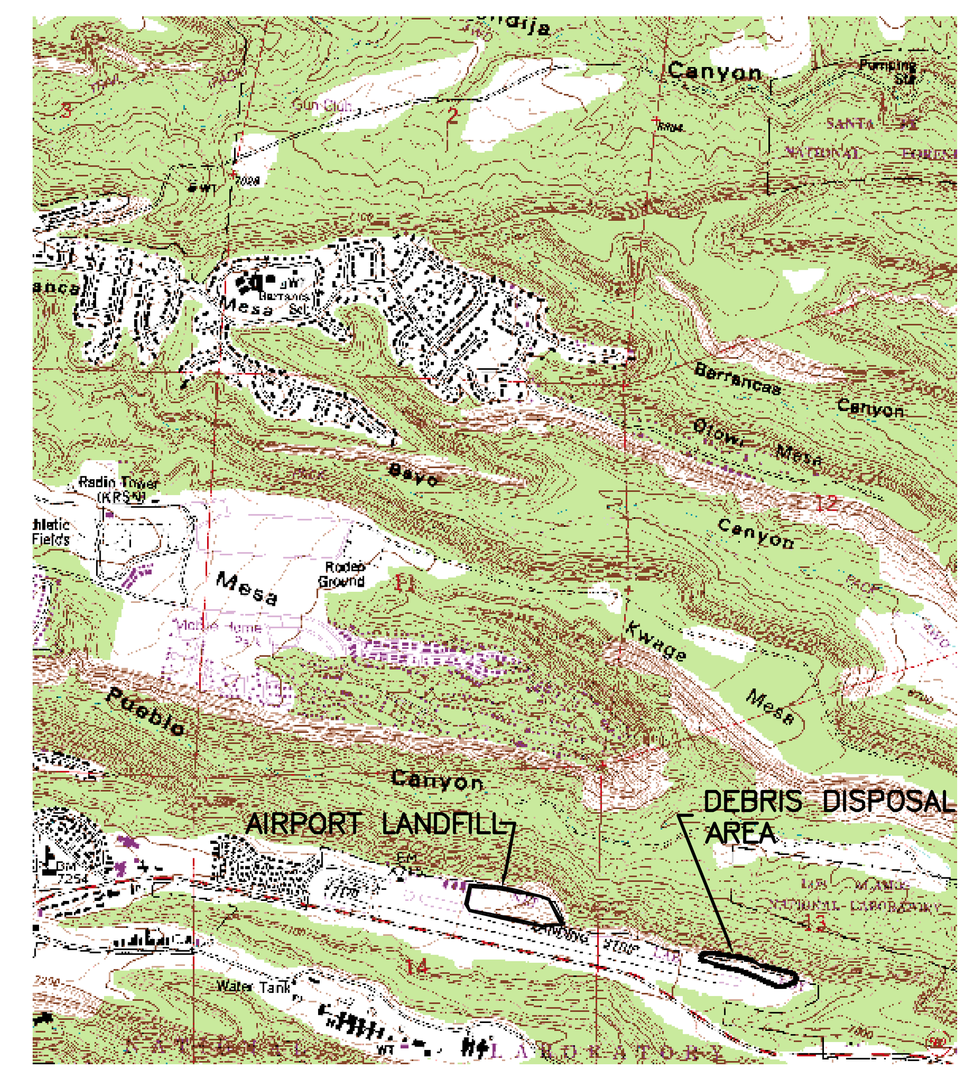
LOS ALAMOS SITE OFFICE

TA-73 AIRPORT LANDFILLS

FINAL CLOSURE DESIGN, REV. 1

LIST OF DRAWINGS:

LOS ALAMOS COUNTY, NM
W.O. NO. 13104.002.001.7000



LOCATION MAP
1"=2,000'

North Wind \ WESTON SOLUTIONS TEAM

BERG KESHIAN, JR.
NEW MEXICO
8590
LICENSED PROFESSIONAL ENGINEER

NOT FOR CONSTRUCTION

GENERAL NOTES

1. BASE MAP OBTAINED FROM:
   GISLAB
   MAP NO. M200001
   FEBRUARY 26, 2002

2. DEBRIS DISPOSAL AREA GROUND SURVEY BY:
   ALBUQUERQUE SURVEYING COMPANY INC.
   FEBRUARY 2004

3. HORIZONTAL DATUM: STATE PLANE COORDINATE SYSTEM NAD83
   (SOUTH ZONE) US SURVEY UNITS
   VERTICAL DATUM: NAVD88 US SURVEY FOOT UNITS

4. UNDERGROUND UTILITIES

   A. ALL APPROPRIATE UTILITIES WILL BE NOTIFIED OF THE WORK SCHEDULE PRIOR TO THE START OF CONSTRUCTION. EACH UTILITY OWNER SHALL VERIFY AND MARK THE LOCATION OF THEIR RESPECTIVE MAIN AND SERVICE LINES IN THE FIELD BEFORE THE START OF WORK.

   B. THE LOCATIONS OF EXISTING UTILITIES SHOWN ON THE PLANS ARE APPROXIMATE BASED ON THE BEST AVAILABLE INFORMATION AND DATA PROVIDED BY ALBUQUERQUE SURVEYING COMPANY INC. THE ACCURACY OF LOCATIONS FOR EXISTING SUBSURFACE UTILITY STRUCTURES SHOWN ON THE DRAWINGS IS NOT GUARANTEED. ALL EXISTING SURFACE OR SUBSURFACE UTILITIES MAY NOT BE SHOWN ON THE DRAWINGS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING THE PRESENCE AND LOCATION OF ALL UTILITIES PRIOR TO CONSTRUCTION.

   C. NECESSARY PRECAUTIONS WILL BE TAKEN TO MAINTAIN EXISTING UTILITIES SERVICE. ALL UTILITY MAINS, LATERALS AND SERVICE UTILITY LINES EXPOSED DURING CONSTRUCTION SHALL BE SECURED AND PROTECTED THROUGHOUT ALL OPERATIONS. IN THE EVENT THAT ANY EXISTING UTILITY LINE IS DAMAGED, THE CONTRACTOR WILL NOTIFY THE UTILITY OWNER IMMEDIATELY. ALL REPAIRS SHALL BE DIRECTED BY THE UTILITY OWNER.

5. FIELD MEASUREMENTS OF THE HORIZONTAL AND VERTICAL AS-BUILT LOCATIONS SHALL BE MAINTAINED AND SHALL BE RECORDED ON THE DRAWINGS FOR THE DEVELOPMENT OF FINAL RECORD PLANS.

6. ACCESS TO WORK AREAS WILL FOLLOW THE ROUTES SHOWN ON THE SITE DEVELOPMENT PLAN. THERE WILL BE NO DEVIATION FROM THE ROUTE, UNLESS APPROVED BY THE ENGINEER.

7. ALL CONSTRUCTION EQUIPMENT AND VEHICLES WILL ADHERE TO FAA CIRCULARS FOR SIGNAGE.

8. NORTHWIND\WESTON TEAM SHALL HEREAFTER BE REFERRED TO AS THE CONTRACTOR.

LIST OF UNDERGROUND USERS

ONE CALL SYSTEM TELEPHONE NO. 1–505–260–1990
nmonecall.org (REFERENCE COMPANY CODE 645)

USER'S NAME	TELEPHONE
LOS ALAMOS COUNTY	505–260–1990
LOS ALAMOS CABLE	800–826–1954
PNM GAS	800–464–7462
USWEST COMMUNICATIONS	800–573–1311
COMCAST	505–260–1990
QWEST COMMUNICATIONS	800–321–2537

IN CASE OF EMERGENCY CALL 1–866–DIG–NMOC (1–866–344–6662)
DURING REGULAR BUSINESS HOURS.

AIRPORT MONUMENTS

DESCRIPTION	SPC	GEODETIC	ELEVATION
R/W 27	1774918.731 1637374.111	35° 52' 41.413" N 106° 15' 36.974" W	7087.890
R/W 9	1776111.273 1631956.007	35° 52' 53.197" N 106° 16' 42.822" W	7170.640
MONUMENT A0001 "AIRPORT"	1775240.121 1634333.458	35° 52' 44.586" N 106° 16' 13.927" W	7136.000

NOTES:

1. RUNWAY END MONUMENTS ARE ALUMINUM CAPS MARKED LS 8670.
2. MONUMENT A0001 IS BRASS CAP MARKED LIMBAUGH "AIRPORT".
3. LAT/LONG, SPC, AND ELEVATION DATA SHOWN ABOVE IS FROM CONTROL SURVEY MAP PERFORMED BY JIM BOTSFORD, NMPS #5211, OCTOBER 2002.
4. ELEVATION IS MSL IN FEET.

LEGEND

Symbol	Description
— - - — - - —	PROPERTY LINE
—x — x — x — x —	FENCE
—s — s — s — s —	SEWER
—w — w — w — w —	WATER
—— 7200 ——	EXISTING CONTOUR
—— 7200 ——	PROPOSED CONTOUR
△	CONTROL POINT
⊠ 7145.55	SPOT ELEVATION

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/3/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA–73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind \ WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	AH	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

GENERAL NOTES, UTILITY LIST & LEGEND

DRAWN GDM | DATE 02/06/04 | DWG. NO. 1000 | REV. NO. 1
SCALE N.T.S. | W.O. NO. 13104.002.001 | SHT. ___ OF ___

G:\ACADPROJ\13104.002.001LANL\FINAL\1000.DWG

NOTES:

1. REFER TO DWG. 1000 FOR LEGEND AND NOTES.
2. REFER TO DWG. 2002 FOR LANDFILL FINAL GRADING PLAN AND DWG. 2010 FOR DEBRIS DISPOSAL AREA FINAL GRADING PLAN.
3. SURFACE FEATURES TAKEN FROM AIRPORT LAYOUT PLAN, LOS ALAMOS AIRPORT (LAM), REV. 03/19/03.
4. LIMIT OF WASTE AS IDENTIFIED IN THE VCM PLAN, DATED OCTOBER 2002.
5. PRIOR TO ANY CONSTRUCTION THE CONTRACTOR WILL COORDINATE ALL OF THE CONSTRUCTION ACTIVITIES WITH THE AIRPORT MANAGER.
6. CONTRACTOR ACCESS TO THE PROJECT SITE IS BY NMSR 503 THEN DIRECTLY NORTH ON EXISTING SPUR ROAD. CONTRACTOR IS RESPONSIBLE TO IMPROVE AND MAINTAIN THIS ACCESS WAY FOR THE PROPOSED OPERATIONS. AT THE COMPLETION OF CONSTRUCTION THE CONTRACTOR WILL RETURN THE AREA TO ITS' ORIGINAL CONDITION. THE CONTRACTOR SHALL REPAIR AND/OR REPLACE DAMAGED PAVED AREAS WITHIN THE AIRPORT PROPERTY CAUSED BY ITS OPERATIONS. WORK SHALL BE COORDINATED WITH THE AIRPORT MANAGER.
7. ALL EMPLOYEES OF THE CONTRACTOR WILL PARK ONLY IN AREAS DESIGNATED BY THE AIRPORT MANAGER.
8. NO PERSONALLY OWNED VEHICLES PERMITTED BEYOND AIRPORT SECURITY GATE. SITE ACCESS/SECURITY TO BE COORDINATED WITH AIRPORT MANAGER.
9. REMOVAL OF ANY FENCE FOR THE CONTRACTORS OPERATIONS SHALL BE COORDINATED WITH THE AIRPORT MANAGER.
10. RELOCATION OF EXISTING FENCE AND INSTALLATION OF NEW FENCE TO BE COORDINATED WITH THE AIRPORT MANAGER. REPLACE FENCE IN-KIND UNLESS DIRECTED OTHERWISE BY THE AIRPORT MANAGER.
11. THE CONTRACTOR SHALL COORDINATE THE DE-ENERGIZING AND REMOVAL OF THE EXISTING NDB AND ELECTRICAL BOX. RELOCATE ELECTRICAL BOX TO THE CONTRACTOR TRAILER AREA.
12. ELECTRIC SERVICE MAY BE FOUND AT THE BOX AND METER. THE CONTRACTOR IS RESPONSIBLE FOR CONNECTING TO THE EXISTING PANEL, RUN ALL WIRING, PAY FOR ALL ELECTRIC SERVICE ASSOCIATED HIS OPERATIONS, AND DISCONNECT THE SERVICE AT THE END OF CONSTRUCTION. ALL ELECTRICAL WORK WILL BE APPROVED AND SCHEDULE WITH THE AIRPORT MANAGER.
13. THE CONTRACTOR SHALL MAINTAIN THE PAVED AREAS OF THE ACCESS ROUTE IN A CLEAN CONDITION TO THE SATISFACTION OF THE AIRPORT MANAGER.
14. THE CONTRACTOR SHALL TEMPORARILY RELOCATE EXISTING AIRPORT SIGNS TO ALLOW COMPLETION OF THE WORK. THE RELOCATION AND REINSTALLATION OF THE SIGNS SHALL BE COORDINATED WITH THE AIRPORT MANAGER.
15. ACCESS TO THE SITE VIA PROPOSED ACCESS ROAD WILL BE COORDINATED WITH THE AIRPORT MANAGER.

LEGEND

⊙ AIRPORT MONUMENT

200 0 200 400
1"=200'

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/20/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/7/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	AH	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

SITE DEVELOPMENT PLAN

DRAWN	DATE	DWG. NO.	REV. NO.
GDM	02/06/04	2000	1
SCALE 1"=200'	W.O. NO. 13104.002.001	SHT. ___ OF ___	

G:\ACADPROJ\13104.002.001LANL\FINAL\2000.DWG

NOTES:

1. CONTRACTOR ACCESS TO THE PROJECT SITE IS FROM ROUTE NMSR 503.
2. THE NATURAL GRADES OF THE ORIGINAL HANGING VALLEY, PRIOR TO BEGINNING OF WASTE DISPOSAL, ARE NOT SHOWN ON THIS DRAWING. THE GRADING PLAN SHOWN FOR THE EAST SLOPE WILL BE REVISED AS NEEDED IF NATIVE GROUND IS ENCOUNTERED DURING EXCAVATION. SLOPES ON WASTE WILL BE CONSTRUCTED AS SHOWN, HOWEVER SLOPES ON NATIVE GROUND, IF ENCOUNTERED, WILL BE ASSESSED BY THE ENGINEER AND MAY BE STEEPER THAN SHOWN. NATIVE ROCK WILL NOT BE EXTENSIVELY EXCAVATED. ALL REVISED GRADES WILL BE REVIEWED BY THE ENGINEER.
3. THE CONTRACTOR SHALL FURNISH AN INTERIM SURVEY OF THE SURFACE OF NATIVE SOIL EXPOSED AS A RESULT OF WASTE EXCAVATION FROM THE EAST SLOPE FOR REVIEW BY THE ENGINEER. THE SURVEY SHALL INCLUDE THE EXPOSED NATIVE SOIL SURFACE, THE EXCAVATED WASTE SURFACE, AND THE UNDISTURBED NATIVE SOIL ACROSS THE EAST SLOPE OF THE LANDFILL.
4. THE CONTRACTOR SHALL NOT ORDER/PURCHASE INLETS 1 TO 10 AND MANHOLE 1 AND ASSOCIATED PIPE UNTIL WASTE HAS BEEN EXCAVATED FROM THE SOUTH EAST CORNER OF THE LANDFILL, AND THE ENGINEER HAS REVIEWED THE TOPOGRAPHIC SURVEY OF THE EXCAVATED SURFACE. THE CONTRACTOR MUST RECEIVE APPROVAL FROM THE ENGINEER PRIOR TO ORDERING/PURCHASING THIS MATERIAL.
5. CONTRACTOR TO FIELD VERIFY PRESENCE/LOCATION EXISTING WATERLINE AND COORDINATE RELOCATION WITH ENGINEER AND AIRPORT MANAGER.
6. TIC PLAN DEPICTS EXCAVATION OR FILL REQUIRED FROM EXISTING GRADES TO THE ELEVATIONS OF THE TOP OF CAP, REFER TO DWG 2002.
7. THE CONTRACTOR SHALL REMOVE ALL WASTE IN THE AREA WEST OF THE LANDFILL CAP BETWEEN THE EDGE OF CAP AND EDGE OF PAVEMENT. THIS AREA SHALL BE BACKFILLED WITH EXISTING/RELOCATED INTERIM FILL. THE CONTRACTOR SHALL PROTECT THE EXISTING PAVEMENT, TRENCH DRAIN AND STORM SEWER DURING THIS ACTIVITY.
8. THE CONTRACTOR SHALL ENSURE THAT ALL WASTE LOCATED ALONG THE SOUTH SIDE OF THE LANDFILL IS RELOCATED WITHIN THE CAP FOOTPRINT. ANY EXCAVATIONS BEYOND THE EDGE OF CAP SHALL BE BACKFILLED WITH EXISTING/RELOCATED INTERIM FILL.
9. THE CONTRACTOR SHALL DETERMINE THE EXTENT OF FENCE RELOCATION/REPLACEMENT REQUIRED. WORK SHALL BE COORDINATED WITH THE AIRPORT MANAGER.
10. THE CONTRACTOR SHALL CONTINUOUSLY MONITOR WASTE EXCAVATION AND WASTE PLACEMENT. WASTE PLACEMENT SHALL BE SEQUENCED IN A MANNER THAT WILL ASSURE THE MINIMUM REQUIRED SLOPES INDICATED ON THIS DRAWING ARE ACHIEVED. BECAUSE THE VOLUME OF WASTE TO BE RELOCATED CANNOT BE ACCURATELY QUANTIFIED AND BECAUSE SETTLEMENT IS ANTICIPATED TO OCCUR DURING CONSTRUCTION, THE ELEVATIONS SHOWN ON THIS DRAWING MAY HAVE TO BE ADJUSTED.
11. FOR STORM SEWER PLAN AND PROFILE, SEE DRAWING 2003.
12. FOR GAS COLLECTION SYSTEM PLAN, SEE DRAWING 2010.
13. FOR HANGER LAYOUT PLAN, SEE DRAWING 2024.

LEGEND

0.8	FILL (IN FEET)
0.4	CUT (IN FEET)
— — —	PROPERTY BOUNDARY
— — — —	LIMIT OF WASTE/GRADING FILL LAYER
—7130—	TOP OF PREPARATORY SURFACE
—7130—	EXISTING GROUND SURFACE
⊠7143.60	PROPOSED SPOT ELEVATION
	PROPOSED STORM SEWER
→	BENCH FLOW DIRECTION
— x — x —	EXISTING FENCE
— x — x —	NEW FENCE/RELOCATED EXISTING FENCE
— s — s —	EXISTING SEWER LINE
— w — w —	EXISTING WATER LINE

50 0 50 100

SCALE: 1"=50'-0"

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/20/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/3/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

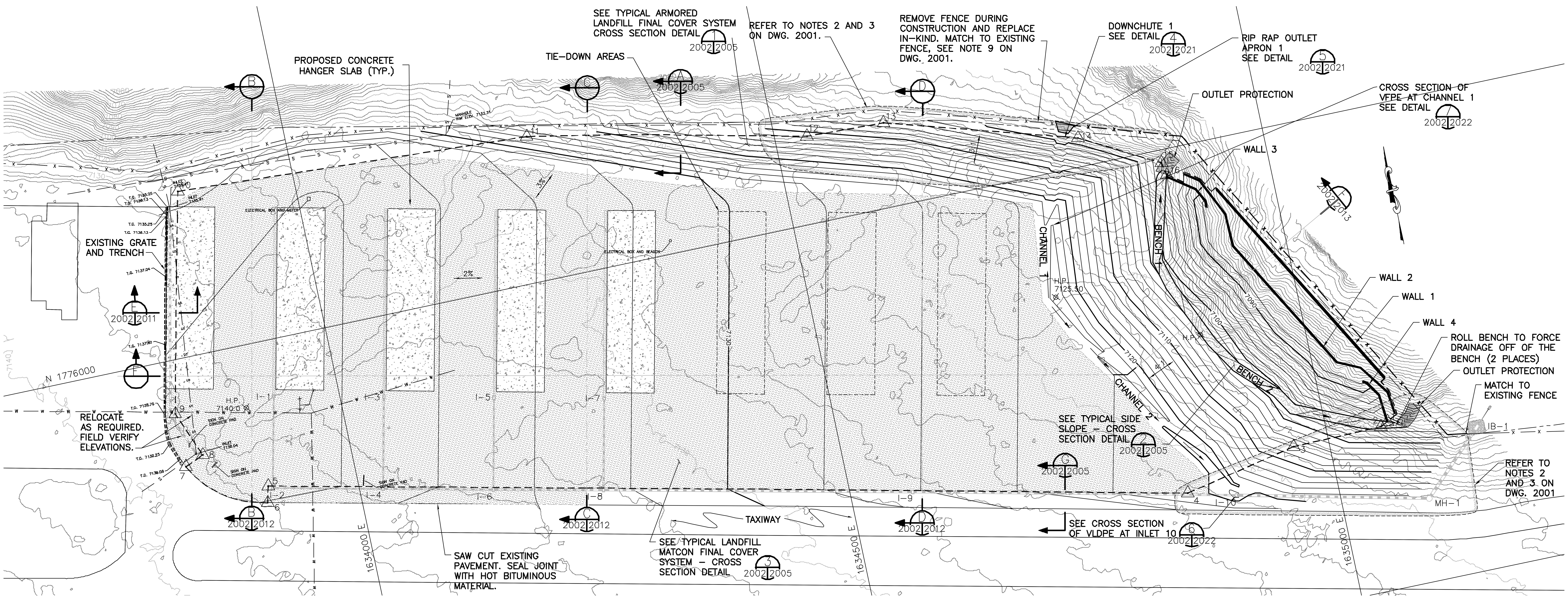
CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

LANDFILL
EXCAVATION TICK PLAN

DRAWN	DATE	DWG. NO.	REV. NO.
GDM	02/06/04	2001	1
SCALE	W.O. NO.	SHT. OF	
AS SHOWN	13104.002.001		

G:\ACADPROJ\13104.002.001LANL\FINAL\2001.DWG



PLAN
1"=50'

NOTES:

1. FOR STORM SEWER PLAN AND PROFILE, SEE DRAWING 2003.
2. FOR GAS COLLECTION SYSTEM PLAN, SEE DRAWING 2010.
3. FOR HANGER LAYOUT PLAN, SEE DRAWING 2024.

TOP OF CAP CONTROL POINTS

NO.	NORTHING	EASTING
1	1775673.657	1635063.617
2	1775669.858	1635056.092
3	1775668.462	1634962.619
4	1775644.003	1634844.563
5	1775850.718	1633907.199
6	1775833.912	1633902.975
7	1775888.377	1633827.472
8	1775896.792	1633847.191
9	1775944.609	1633827.924
10	1776170.955	1633878.790
11	1776151.145	1634246.793
12	1776090.652	1634533.180
13	1776087.664	1634614.125
14	1776030.101	1634809.330
15	1775986.716	1634888.951
16	1775973.170	1634892.218

LEGEND

- PROPERTY BOUNDARY
- LIMIT OF LANDFILL FINAL COVER SYSTEM/LIMIT OF WASTE
- 7130 TOP OF CAP
- 7130 EXISTING GROUND SURFACE
- ⊠7143.60 PROPOSED SPOT ELEVATION
- △1 CONTROL POINT
- BENCH FLOW DIRECTION
- EXISTING FENCE
- NEW FENCE/RELOCATED EXISTING FENCE
- EXISTING SEWER LINE
- EXISTING WATER LINE
- PAVED AREA
- CONCRETE HANGER PAD

50 0 50 100
SCALE: 1"=50'

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/2/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

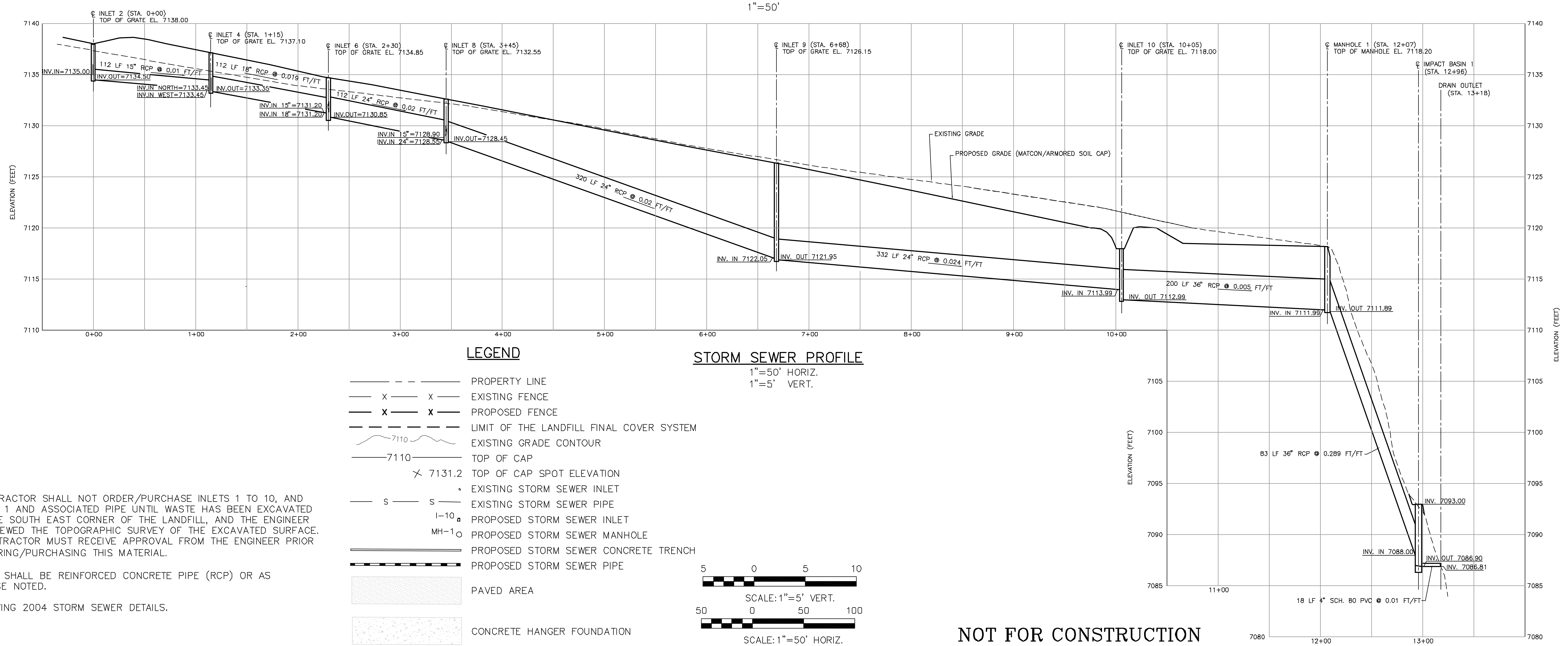
BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

LANDFILL
TOP OF CAP GRADING PLAN

DRAWN GPL DATE 02/06/04 DWG. NO. 2002 REV. NO. 1
SCALE 1"=50' W.O. NO. 13104.002.001 SHT. OF

G:\ACADPROJ\13104.002.001LANL\FINAL\2002.DWG

PLAN
1"=50'



STORM SEWER PROFILE
1"=50' HORIZ.
1"=5' VERT.

LEGEND

- PROPERTY LINE
- EXISTING FENCE
- PROPOSED FENCE
- LIMIT OF THE LANDFILL FINAL COVER SYSTEM
- EXISTING GRADE CONTOUR
- 7110 TOP OF CAP
- 7131.2 TOP OF CAP SPOT ELEVATION
- EXISTING STORM SEWER INLET
- EXISTING STORM SEWER PIPE
- I-10 PROPOSED STORM SEWER INLET
- MH-1 PROPOSED STORM SEWER MANHOLE
- PROPOSED STORM SEWER CONCRETE TRENCH
- PROPOSED STORM SEWER PIPE
- PAVED AREA
- CONCRETE HANGER FOUNDATION

SCALE: 1"=5' VERT. (5 0 5 10)

SCALE: 1"=50' HORIZ. (50 0 50 100)

NOTES:

1. THE CONTRACTOR SHALL NOT ORDER/PURCHASE INLETS 1 TO 10, AND MANHOLE 1 AND ASSOCIATED PIPE UNTIL WASTE HAS BEEN EXCAVATED FROM THE SOUTH EAST CORNER OF THE LANDFILL, AND THE ENGINEER HAS REVIEWED THE TOPOGRAPHIC SURVEY OF THE EXCAVATED SURFACE. THE CONTRACTOR MUST RECEIVE APPROVAL FROM THE ENGINEER PRIOR TO ORDERING/PURCHASING THIS MATERIAL.
2. ALL PIPE SHALL BE REINFORCED CONCRETE PIPE (RCP) OR AS OTHERWISE NOTED.
3. SEE DRAWING 2004 STORM SEWER DETAILS.

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/2/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS — NEW MEXICO

North Wind | WESTON SOLUTIONS | TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

LANDFILL
STORM SEWER PLAN AND PROFILE

DRAWN: GPL | DATE: 02/06/04 | DWG. NO. 2003 | REV. NO. 1
SCALE: 1"=50' | W.O. NO. 13104.002.001

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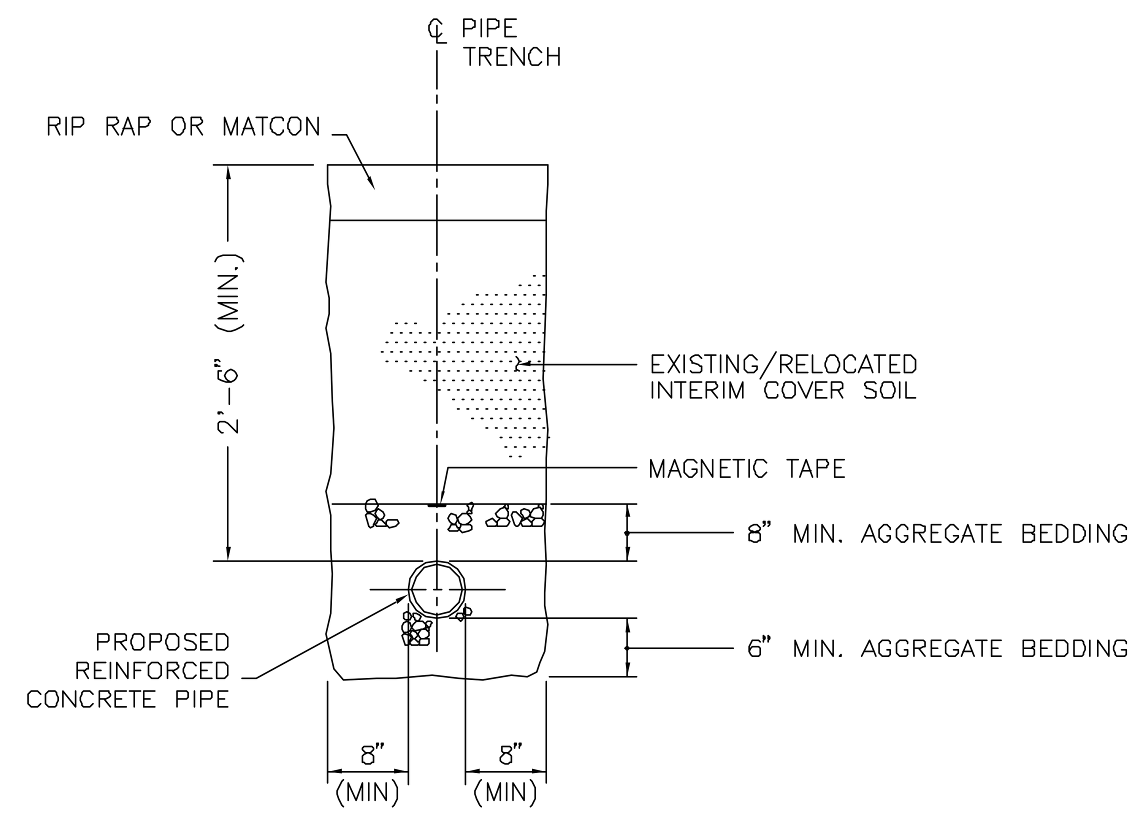
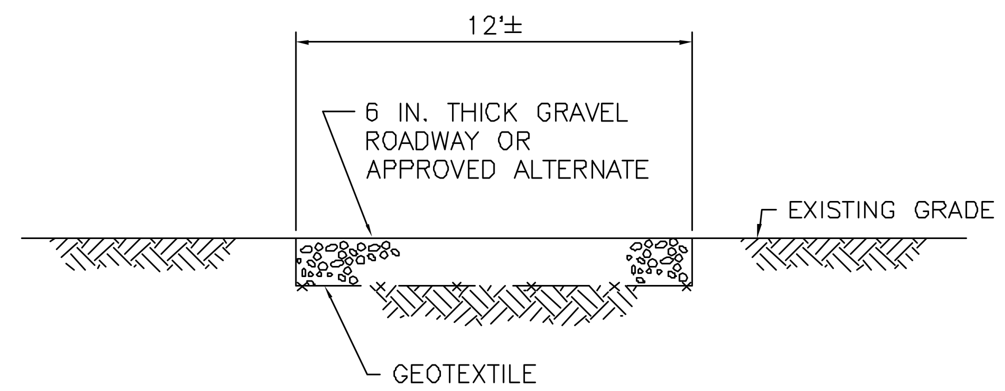


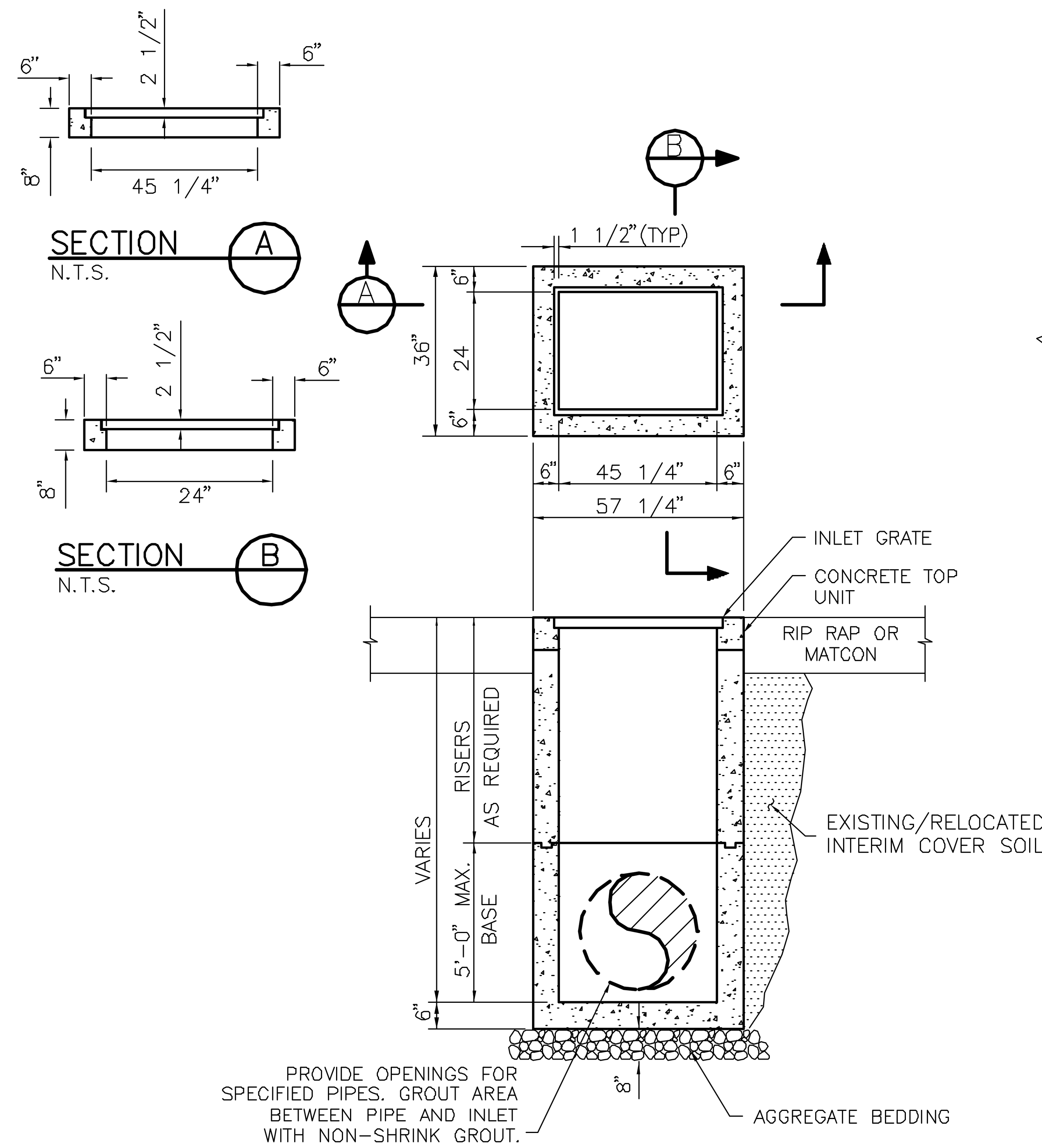
TYPICAL PIPE TRENCH

DETAIL 1
N.T.S. 2003|2004 2011



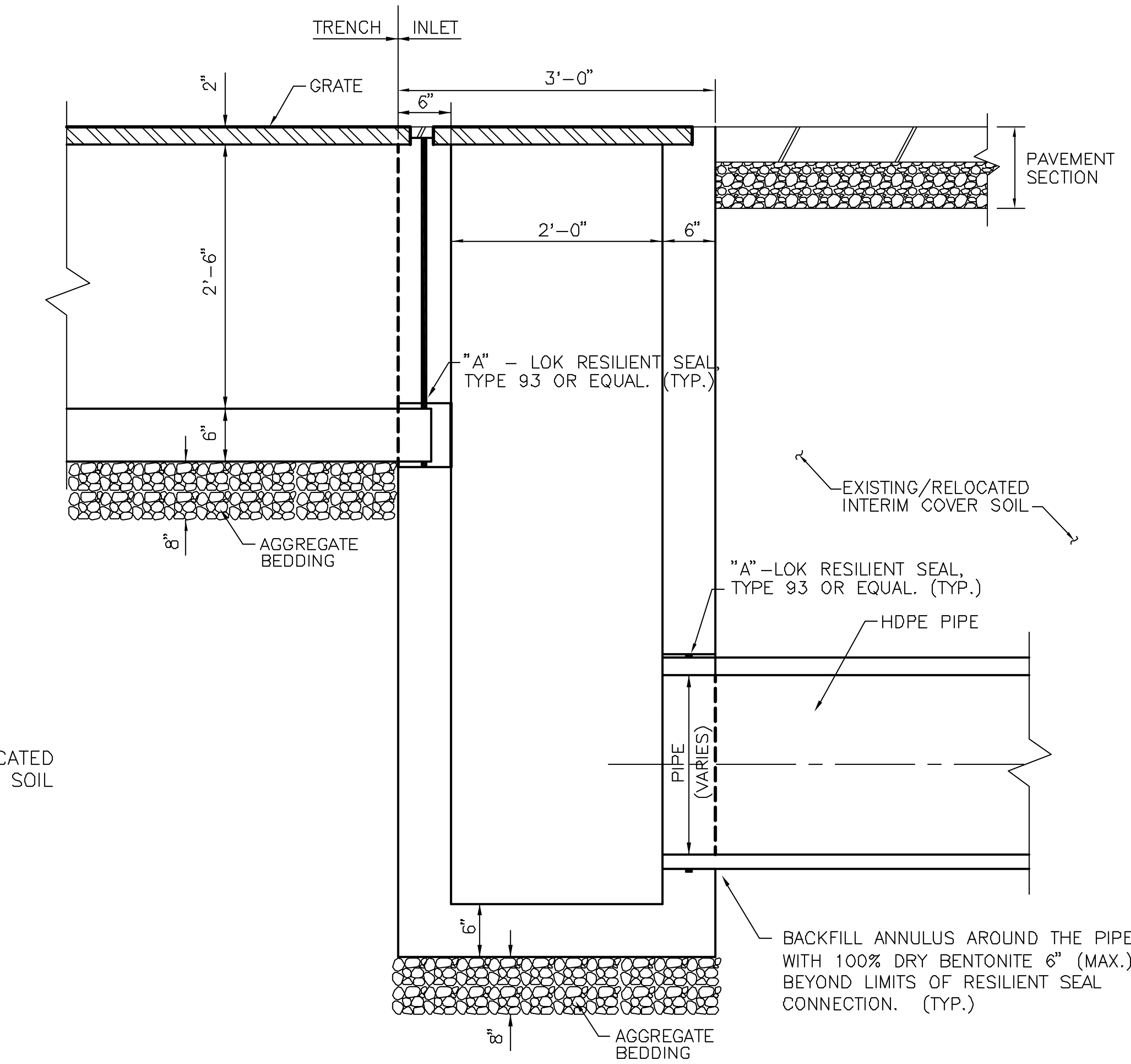
CONTRACTOR ACCESS ROAD CROSS-SECTION

DETAIL 3
N.T.S. 2000|2004



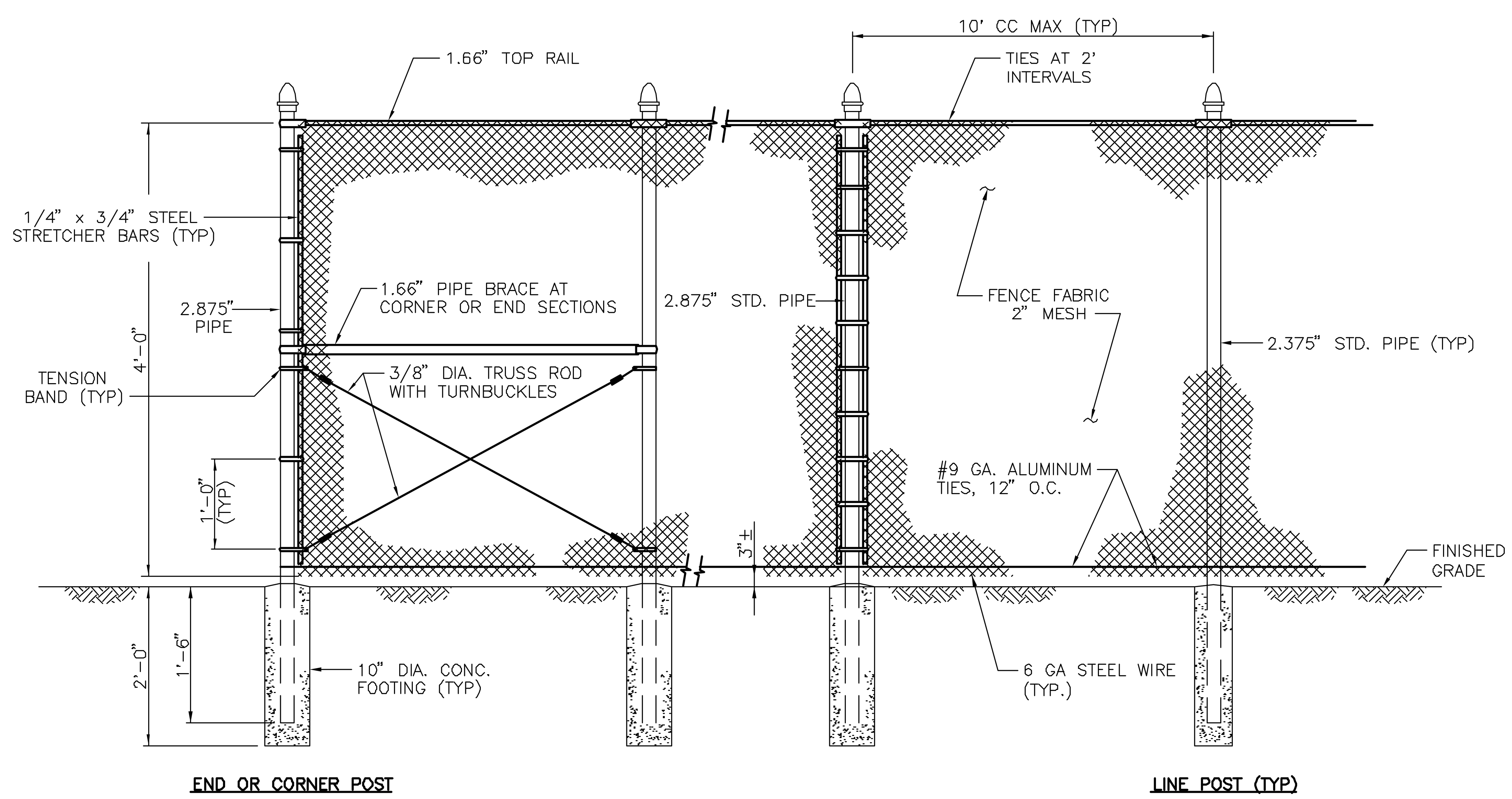
INLETS 1 TO 10
N.T.S.

NOTE:
1. STRUCTURES MUST MEET AASHTO HS-20 LOADING.
2. CONCRETE COMPRESSIVE STRENGTH SHALL BE 4,000 PSI.
3. REINFORCEMENT STEEL SHALL MEET ASTM A-185.



TYPICAL SECTION OF CONCRETE TRENCH & INLET

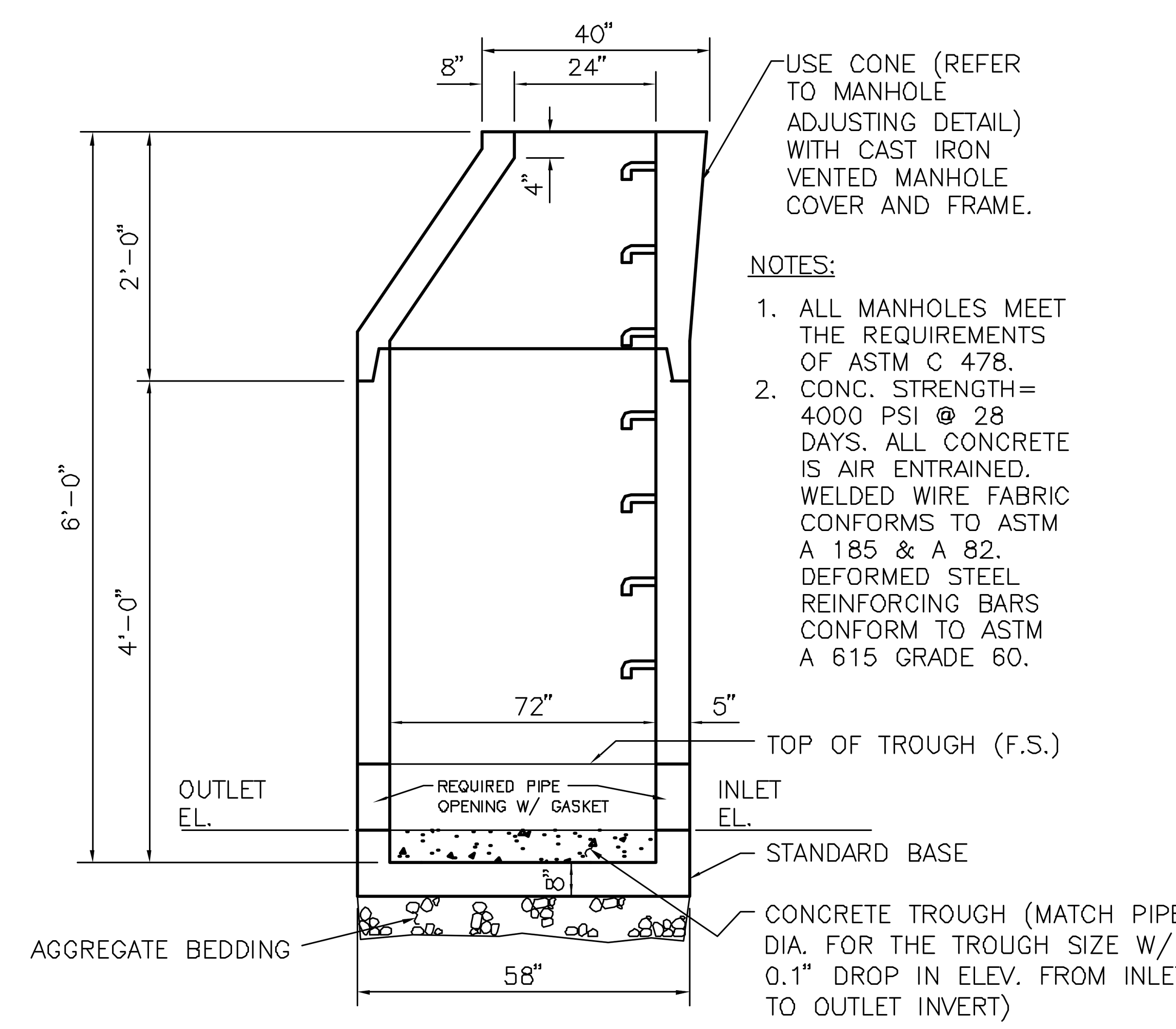
DETAIL 4
N.T.S. 2003|2004



CHAIN LINK FENCE

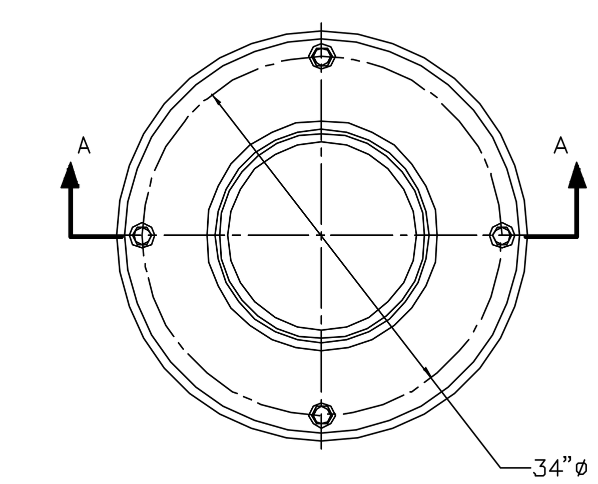
DETAIL 2
N.T.S. 2006|2004 2009

NOTES:
1. FENCE DETAIL APPLIES TO RETAINING WALLS ONLY.
2. BITUMASTIC PROTECTIVE COATING SHALL BE APPLIED TO BOTTOM 18' OF ALL POSTS PRIOR TO INSTALLING CONCRETE.
3. CONCRETE SHALL BE 2500 PSI. MIN., THE CONTRACTOR WILL BE PERMITTED TO REDUCE THE COARSE AGGREGATE SIZE WITH PRIOR WRITTEN APPROVAL OF THE MIX BY THE ENGINEER.
4. AT THE MSE WALL, FIELD DETERMINE TOP GRID AND CHECK CLEARANCE (6" MIN.) PRIOR TO INSTALLING FENCE POSTS.



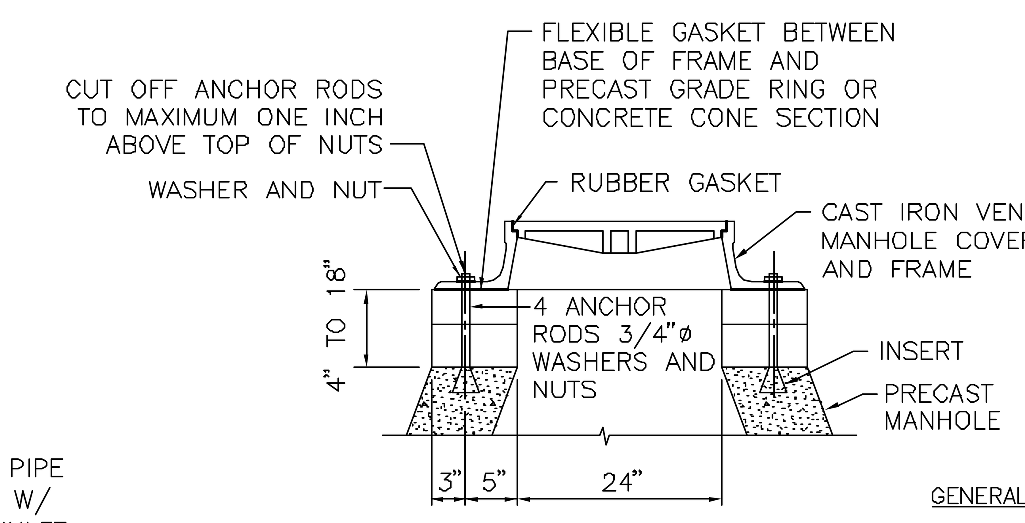
NOTES:
1. ALL MANHOLES MEET THE REQUIREMENTS OF ASTM C 478.
2. CONC. STRENGTH= 4000 PSI @ 28 DAYS. ALL CONCRETE IS AIR ENTRAINED. WELDED WIRE FABRIC CONFORMS TO ASTM A 185 & A 82. DEFORMED STEEL REINFORCING BARS CONFORM TO ASTM A 615 GRADE 60.

72" DIA. PRECAST MANHOLE 1
N.T.S.



PLAN

NOTES:
1. ADJUST MANHOLE FRAME AND COVER TO PROPER GRADE, CROSS SLOPE, AND ELEVATION IN SPACE DEDICATED TO PUBLIC USE, TRAVELED WAY, OR WHEN DESIGNATED TO MEET EXISTING GRADE. OTHERWISE PRECAST MANHOLE TO BE BUILT WITHOUT TRANSITION.
2. TO BRING AN INTERIM SETTING TO FINAL GRADE, REMOVE EXISTING ANCHOR RODS, WASHERS, NUTS, FRAME AND COVER, AND FLEXIBLE GASKET. INSTALL NEW ANCHOR RODS, GRADE RINGS AND REINSTALL EXISTING FRAME/COVER, AND NEW WASHERS/NUTS.



SECTION

MANHOLE ADJUSTING DETAIL
N.T.S.

GENERAL NOTE:
1. PRIOR TO ORDERING CONCRETE PRODUCTS, FIELD VERIFY DIMENSIONS AND OBTAIN WRITTEN APPROVAL FROM THE ENGINEER.

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/2/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

GENERAL SITE DETAILS

DRAWN: GDM | DATE: 02/06/04 | DWG. NO. 2004 | REV. NO. 1
SCALE: N.T.S. | W.O. NO. 13104.002.001 | SHT. OF

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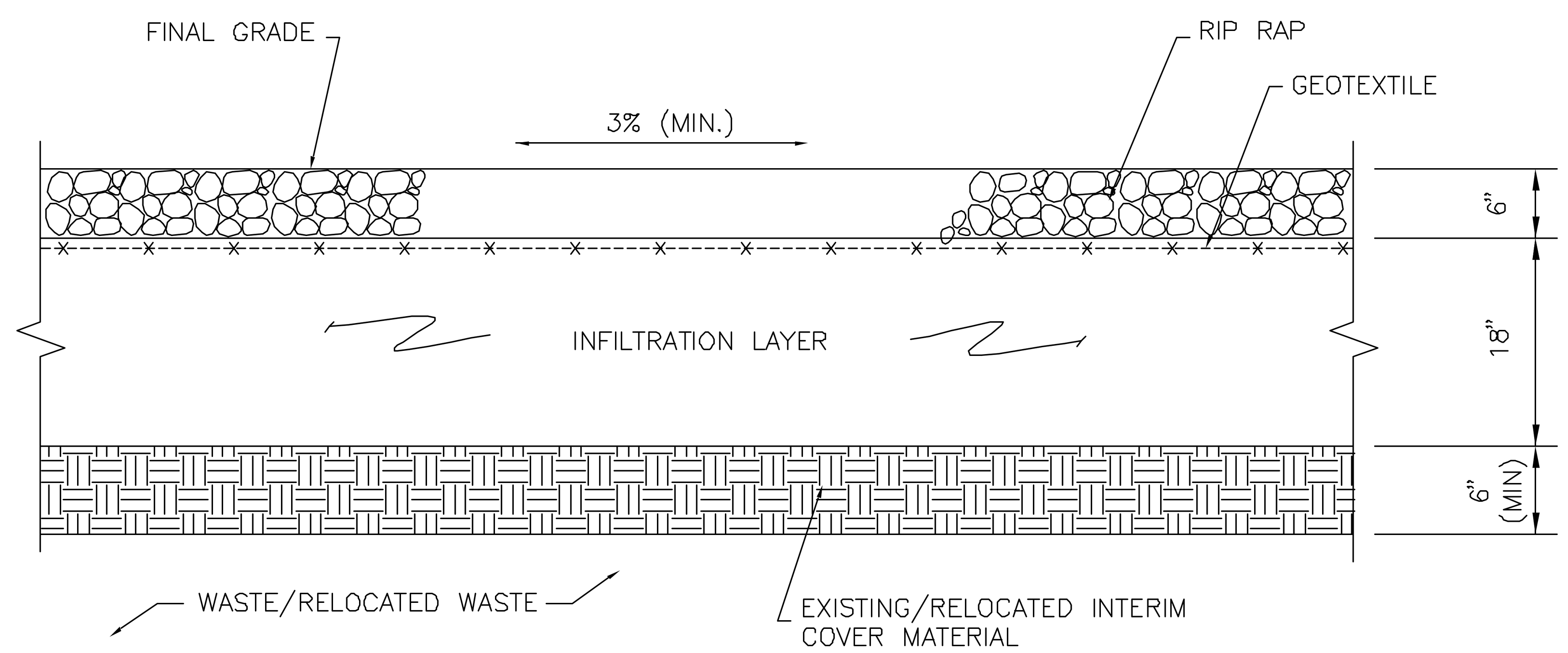
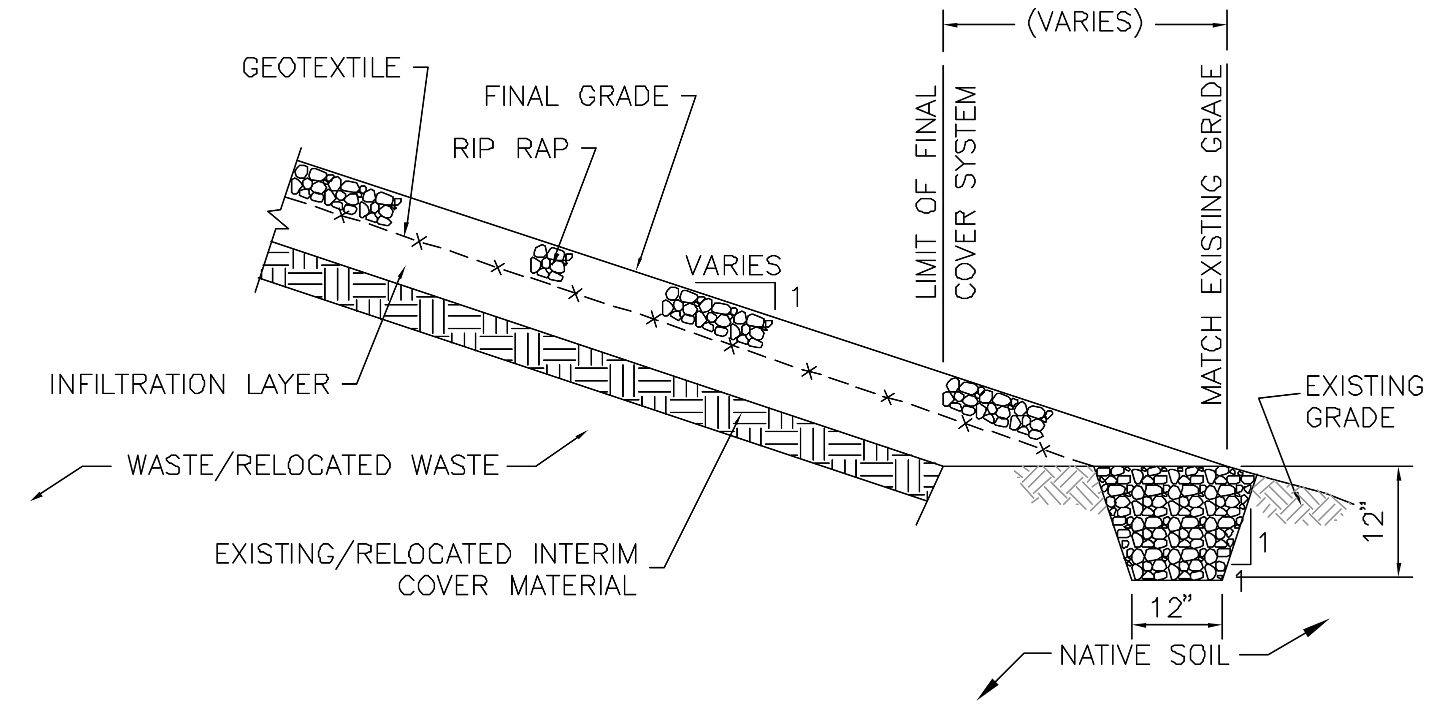


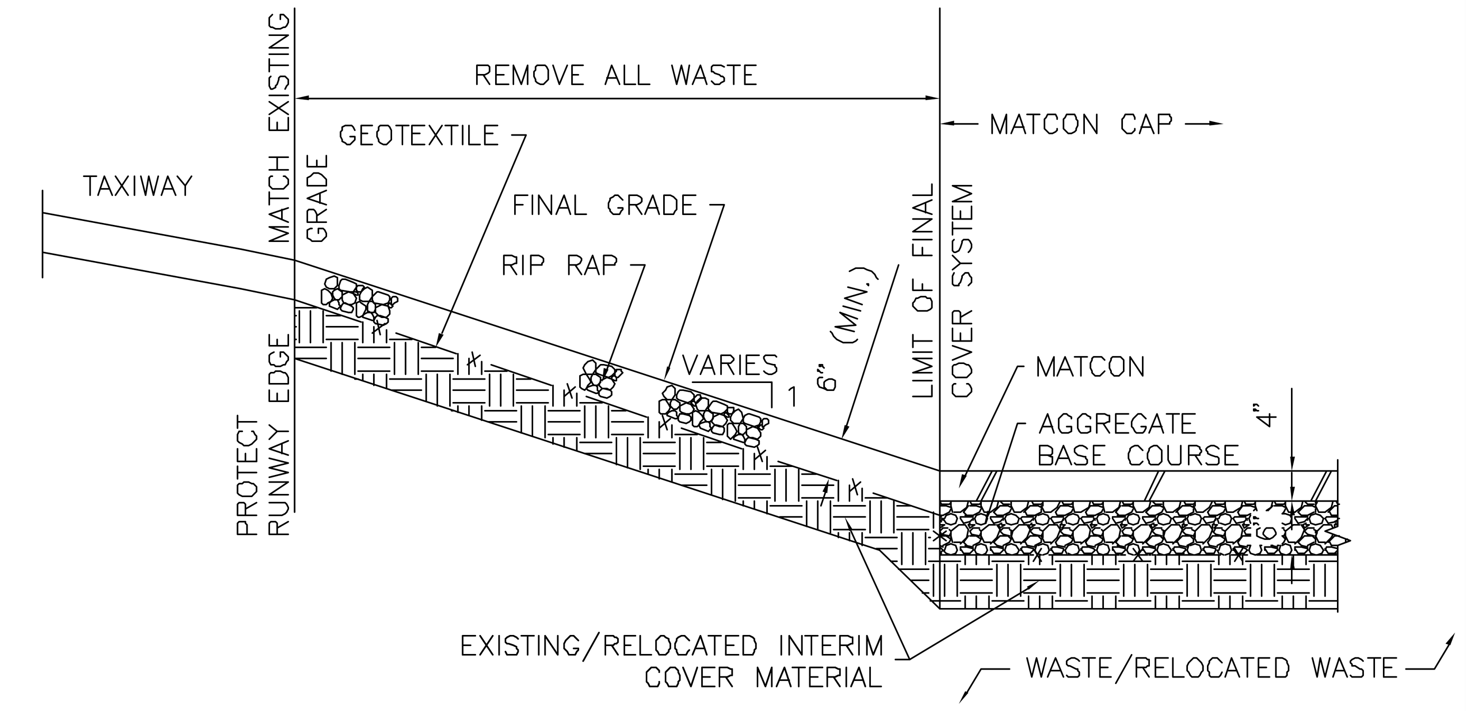
TYPICAL ARMORED LANDFILL FINAL COVER SYSTEM

DETAIL 1
N.T.S. 2002 | 2005



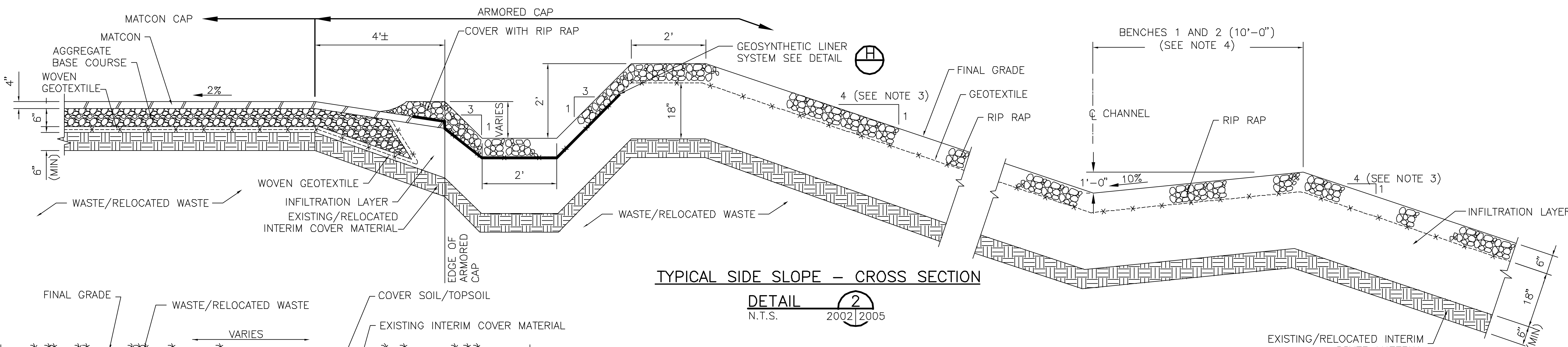
TYPICAL TOE OF SLOPE

SECTION A
N.T.S. 2002 | 2005



TYPICAL TAXIWAY SIDE SLOPE

SECTION G
N.T.S. 2002 | 2005

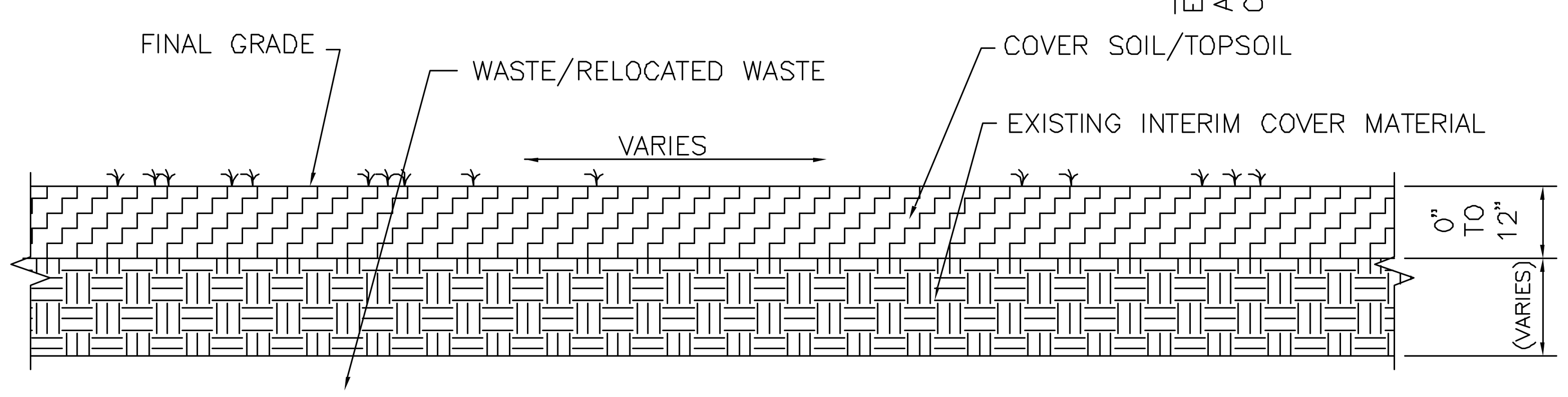


TYPICAL SIDE SLOPE – CROSS SECTION

DETAIL 2
N.T.S. 2002 | 2005

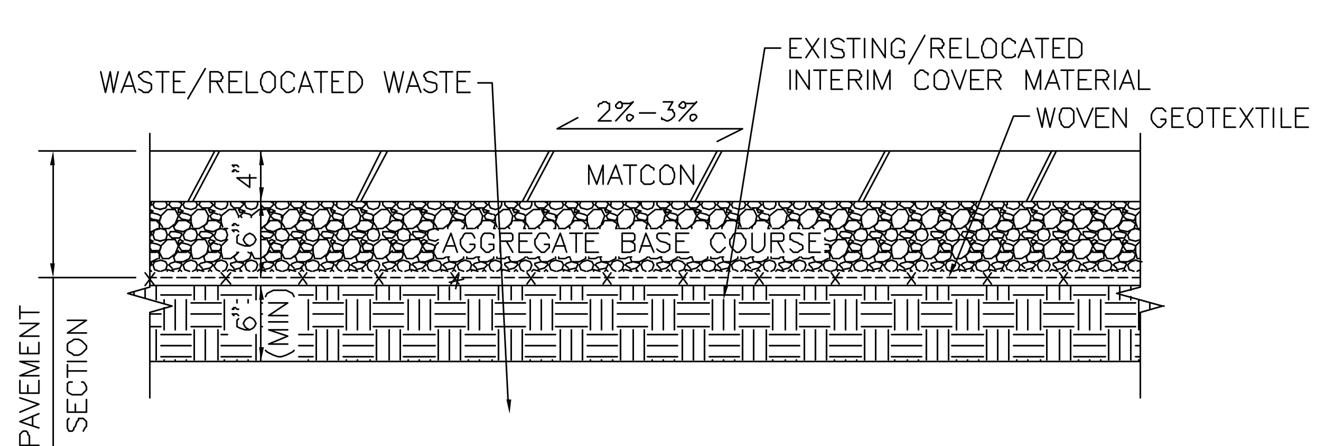
GENERAL NOTES:

1. FINAL GRADE DETAILS ARE SHOWN AT 4H:1V SLOPE FOR INFORMATIONAL PURPOSES ONLY. ACTUAL GRADES SHALL BE AS INDICATED ON DRAWING 2002 AND 2015.
2. REFER TO DRAWING 2021 FOR STORMWATER CONTROL DETAILS PERTAINING TO THE SWALE DETAILS.
3. PLACE R3 RIP RAP 6" THICK ON BENCHES 1 AND 2 AND ON ALL SIDESLOPES.
4. NORTH SLOPE IS A 3H:1V SLOPE.



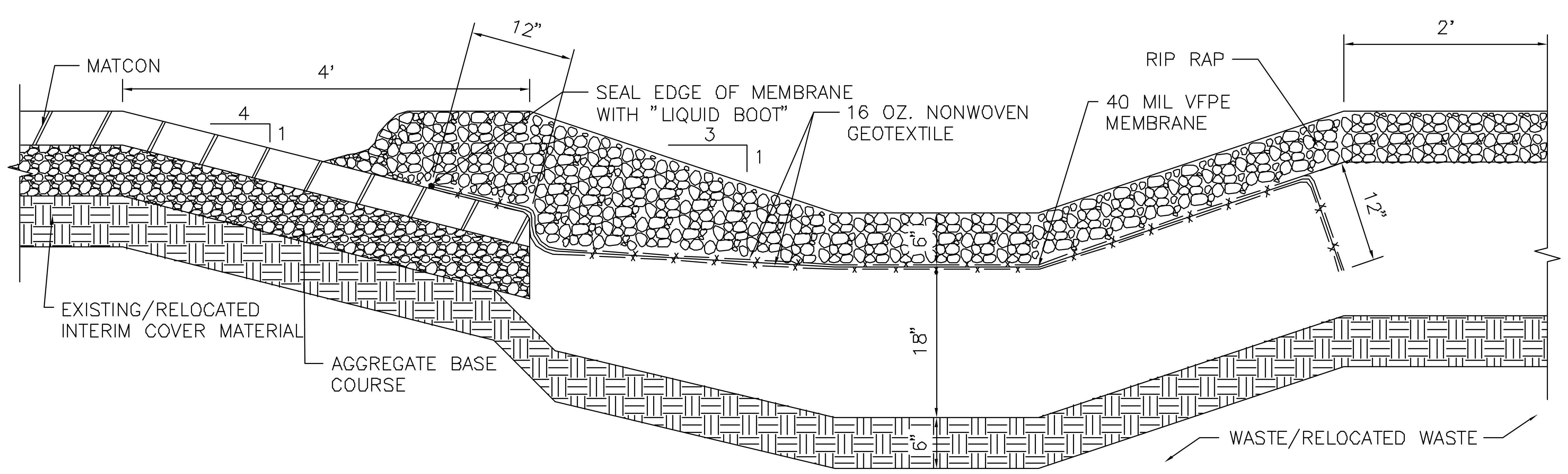
TYPICAL DDA FINAL COVER SYSTEM – CROSS SECTION

DETAIL 4
N.T.S. 2015 | 2005



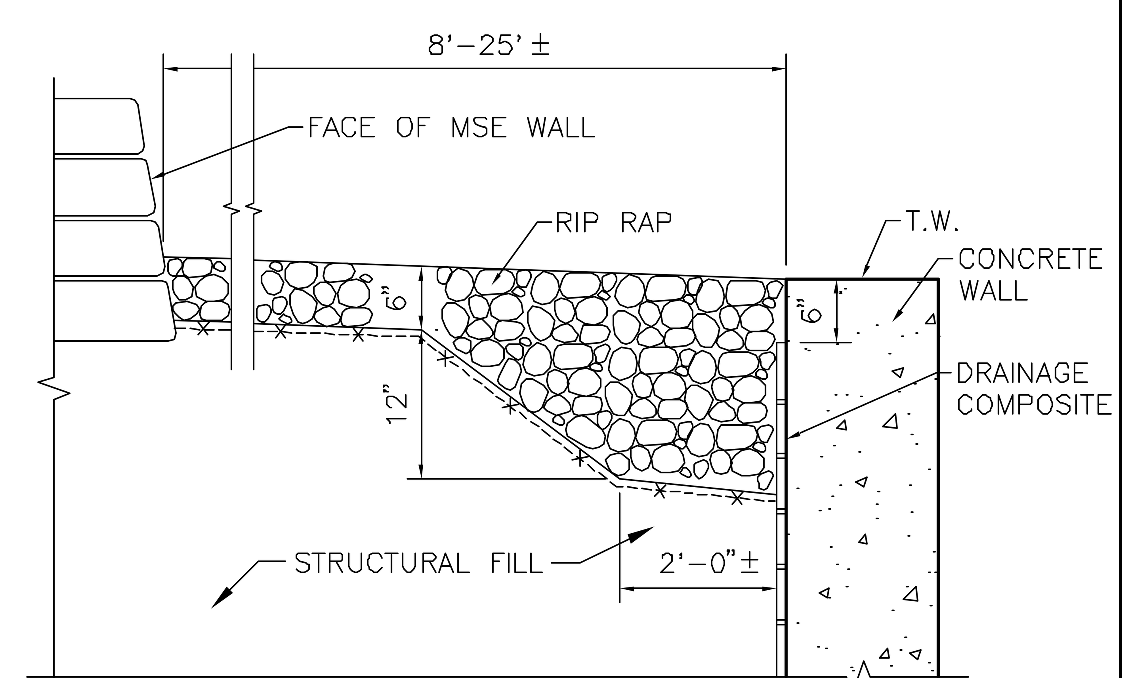
TYPICAL LANDFILL MATCON FINAL COVER SYSTEM
CROSS SECTION

DETAIL 3
N.T.S. 2002 | 2005



TYPICAL GEOSYNTHETIC LINER SYSTEM – CROSS SECTION

DETAIL H
N.T.S.



TYPICAL – ARMORED CAP AT CONCRETE WALL
CROSS SECTION

DETAIL 5
N.T.S. 2006 | 2005
2007

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NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
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LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	AH	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

CAPPING SYSTEM DETAILS

DRAWN	DATE	DWG. NO.	REV. NO.
EAD	02/06/04	2005	1
SCALE	W.O. NO.	SHT. ___ OF ___	
N.T.S.	13104.002.001		

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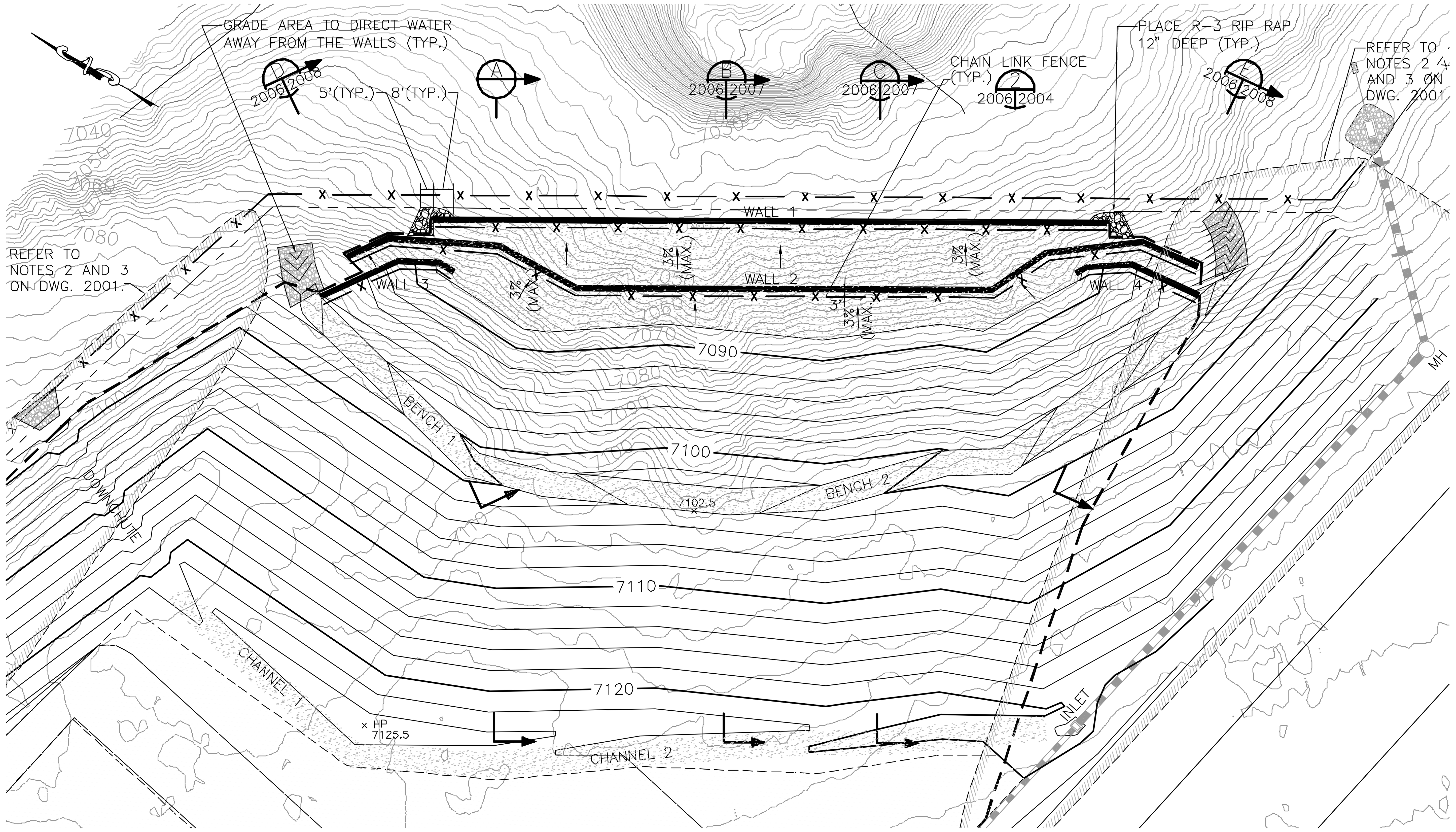


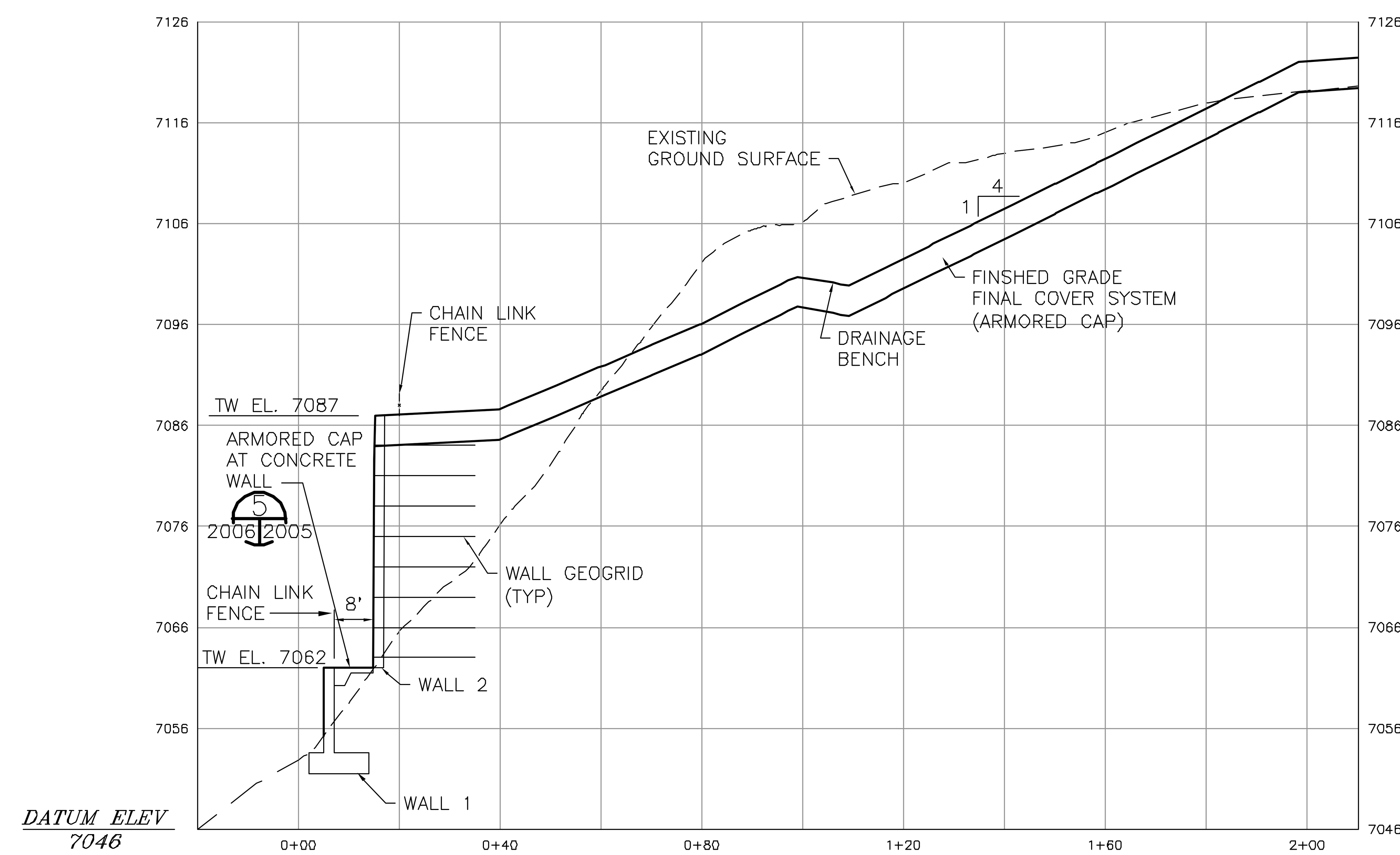
NOTE:

1. FOR WALL ELEVATION DRAWINGS, SEE DRAWING 2009.

PLAN

30 20 10 0 30 60

SCALE: 1"=30'-0"



SECTION A

10 0 10 20

VERT. SCALE: 1"=10'-0"

20 0 20 40

HORIZ. SCALE:1"=20'-0"

LEGEND

PROPERTY LINE
EXISTING FENCE
PROPOSED FENCE
LIMIT OF THE LANDFILL FINAL COVER SYSTEM
7110 EXISTING GRADE CONTOUR
7110 TOP OF CAP
× 7131.2 TOP OF CAP SPOT ELEVATION
PROPOSED STORM SEWER INLET
PROPOSED STORM SEWER MANHOLE
PROPOSED STORM SEWER CONCRETE TRENCH
PROPOSED STORM SEWER PIPE
PAVED AREA

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NO.	DATE	APPR.	REVISION
1	6/20/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
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LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind | WESTON SOLUTIONS | TEAM

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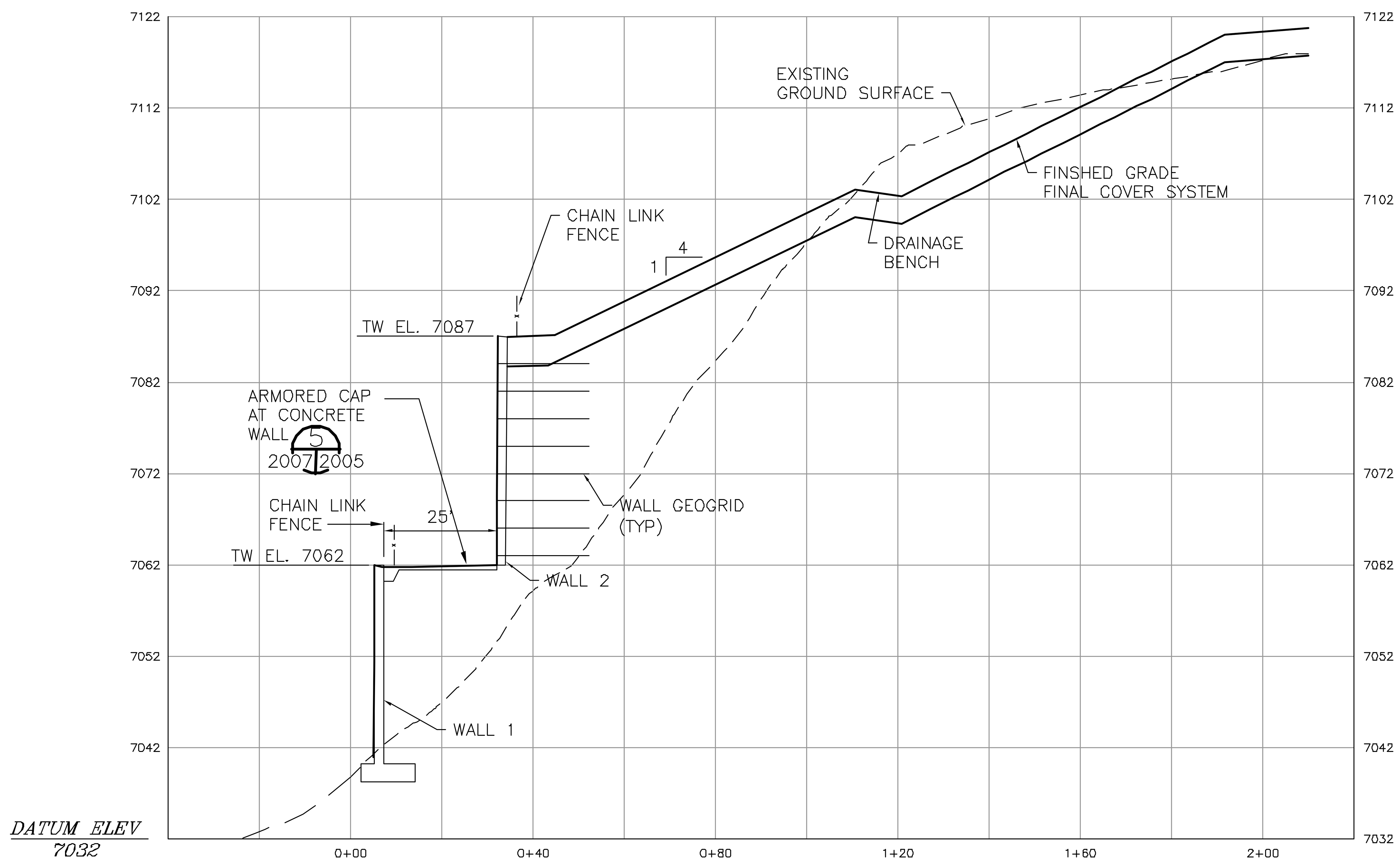
DES. ENG.	PSM	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

WALL PLAN AND WALL SECTIONS
SHEET 1 OF 3

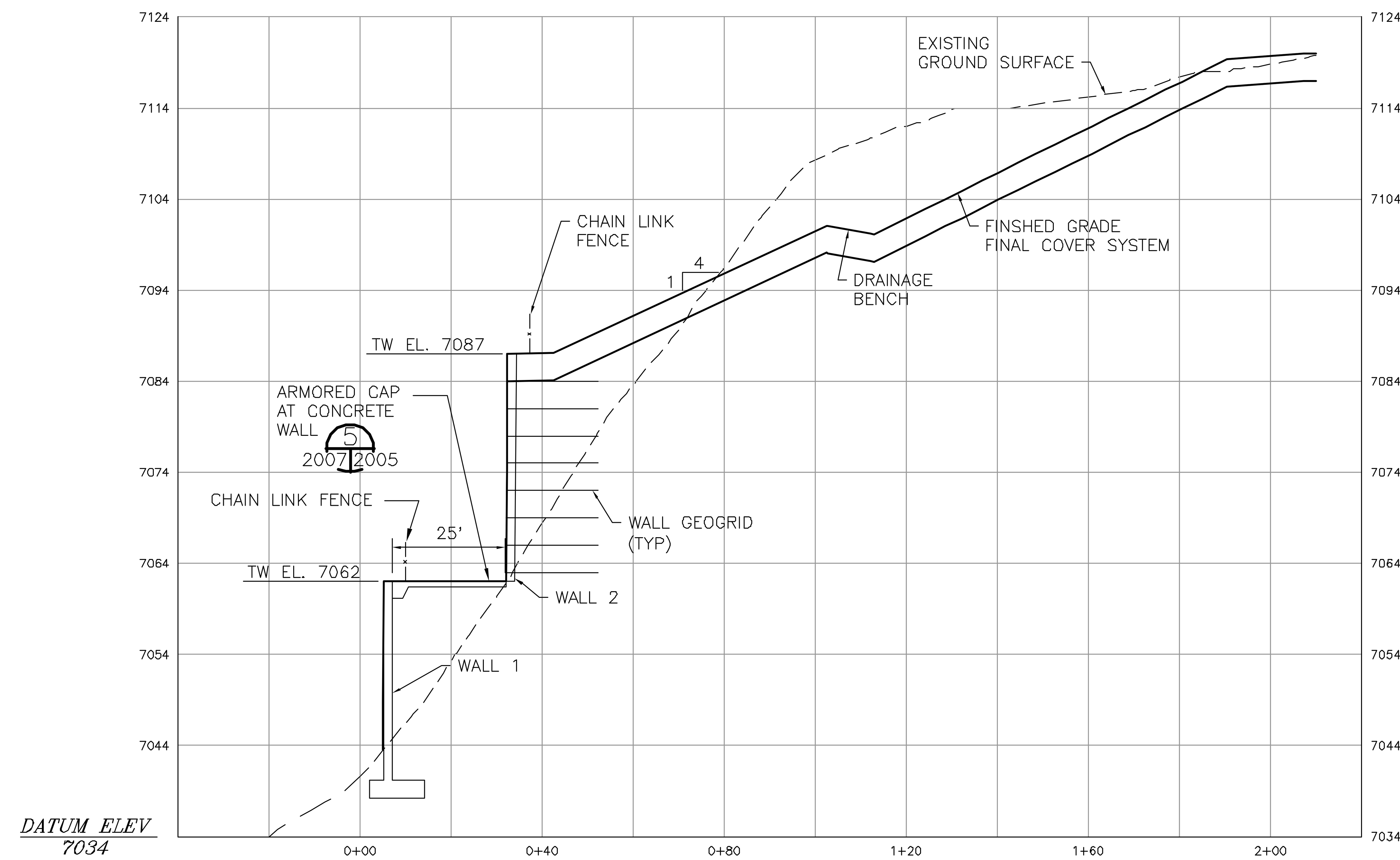
DRAWN	DATE	DWG. NO.	REV. NO.
EAD	02/06/04	2006	1
SCALE	W.O. NO.	SHT. OF	
AS SHOWN	13104.002.001		



SECTION B
2006 2007

VERT. SCALE: 1"=10'-0"

HORIZ. SCALE: 1"=20'-0"



SECTION C
2006 2007

VERT. SCALE: 1"=10'-0"

HORIZ. SCALE: 1"=20'-0"

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NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
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LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS — NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
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DES. ENG.	PSM	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

WALL SECTIONS
SHEET 2 OF 3

DRAWN: EAD — DATE: 02/06/04 — DWG. NO. 2007 — REV. NO. 1
SCALE: AS SHOWN — W.O. NO. 13104.002.001

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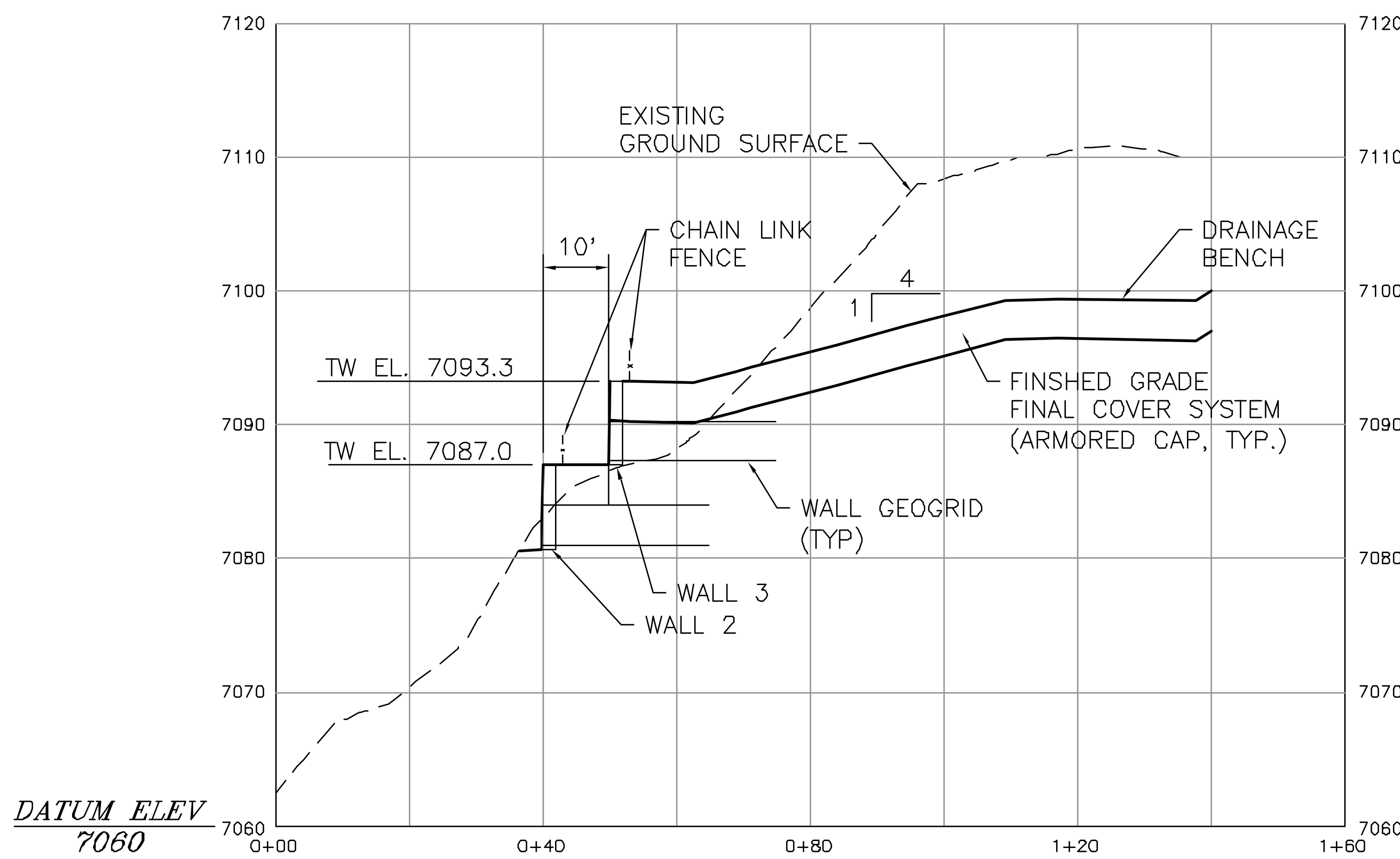
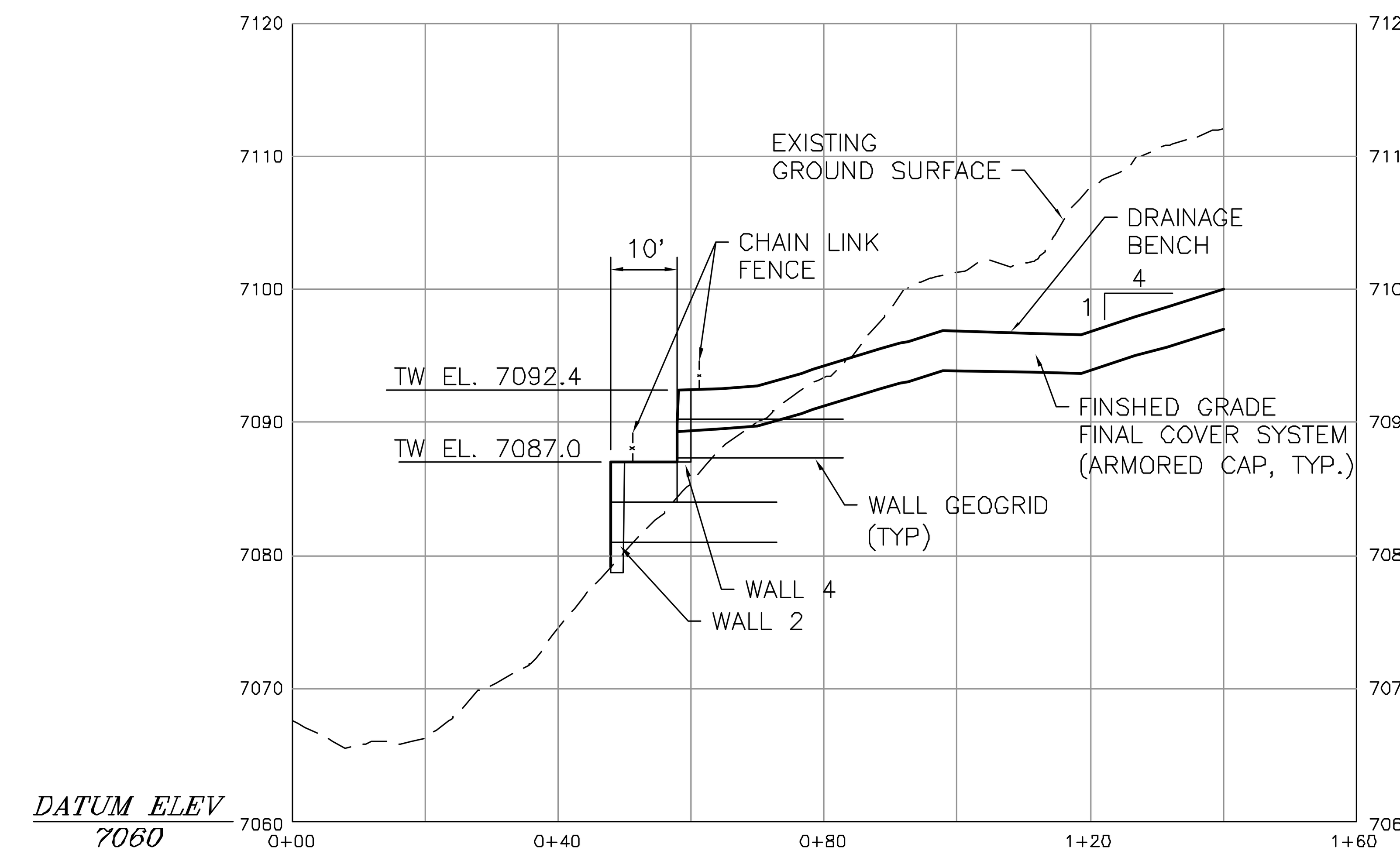


SECTION D 2006 2008

10 0 10 20
VERT. SCALE: 1"=10'-0"

20 0 20 40
HORIZ. SCALE: 1"=20'-0"



SECTION E 2006 2008

10 0 10 20
VERT. SCALE: 1"=10'-0"

20 0 20 40
HORIZ. SCALE: 1"=20'-0"

NOT FOR CONSTRUCTION

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NO.	DATE	APPR.	REVISION
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LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

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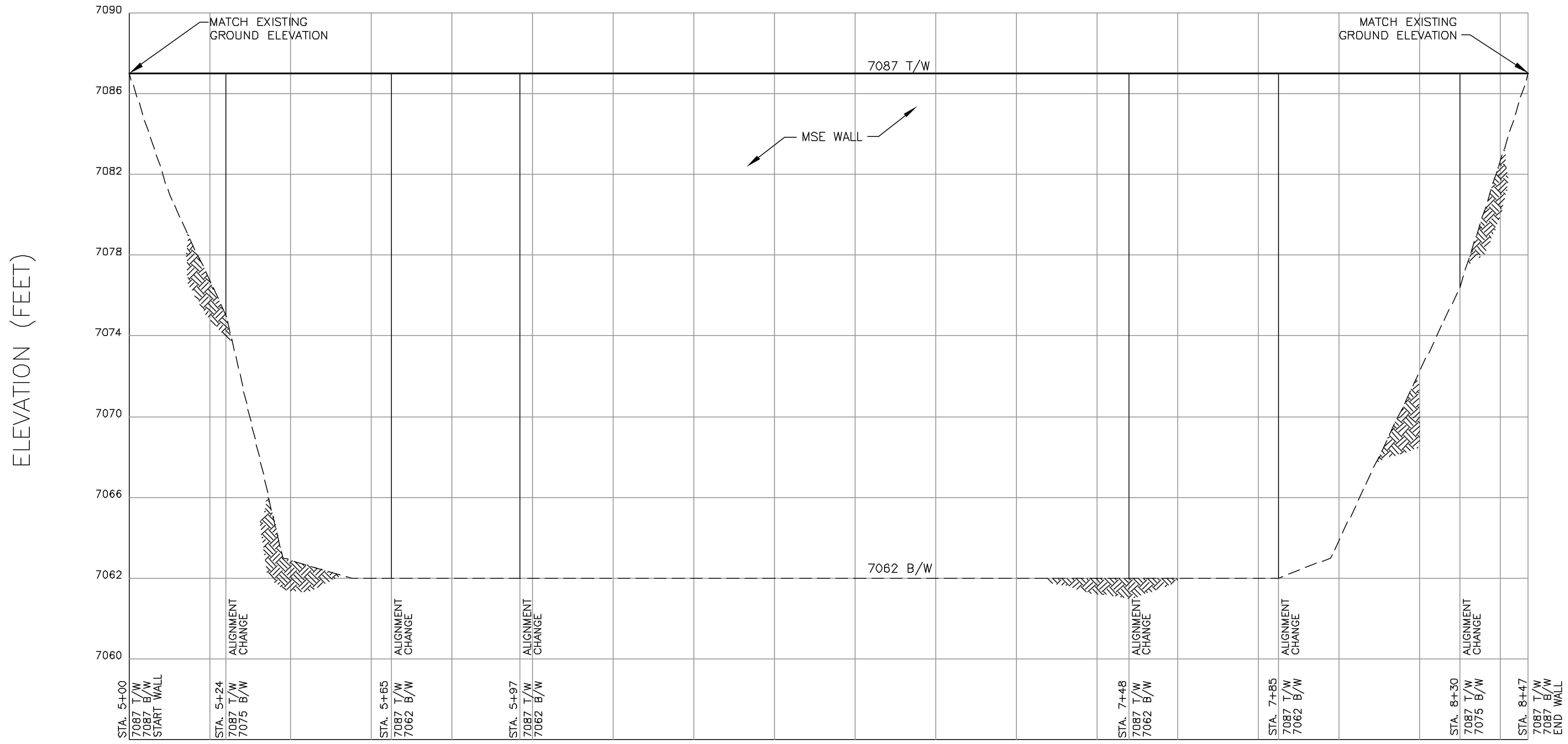
DES. ENG.	PSM	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

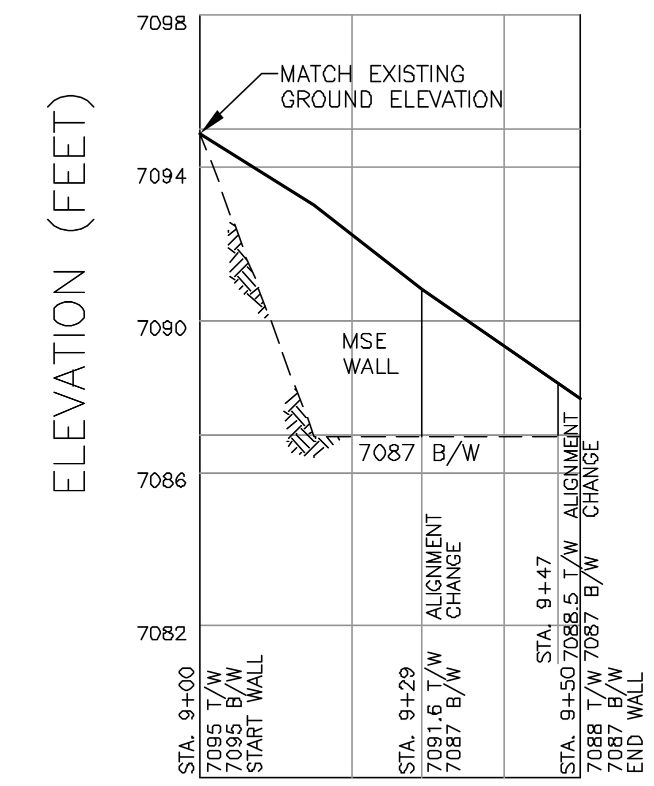
WALL SECTIONS
SHEET 3 OF 3

DRAWN	DATE	DWG. NO.	REV. NO.
EAD	02/06/04	2008	1
SCALE	W.O. NO.	SHT. OF	
AS SHOWN	13104.002.001		



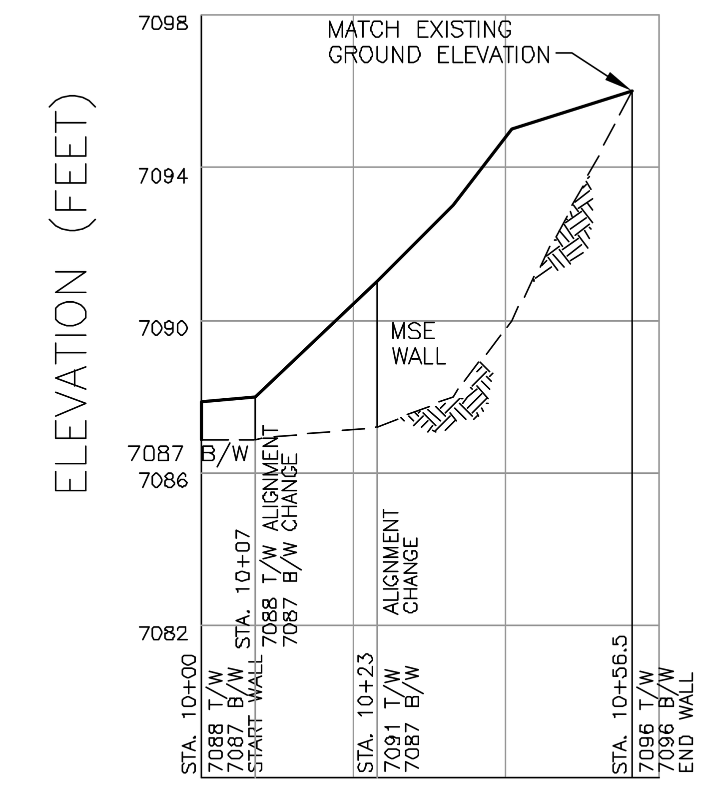
WALL 2 ELEVATION

VERT: 1"=4'
HORIZ: 1"=20'



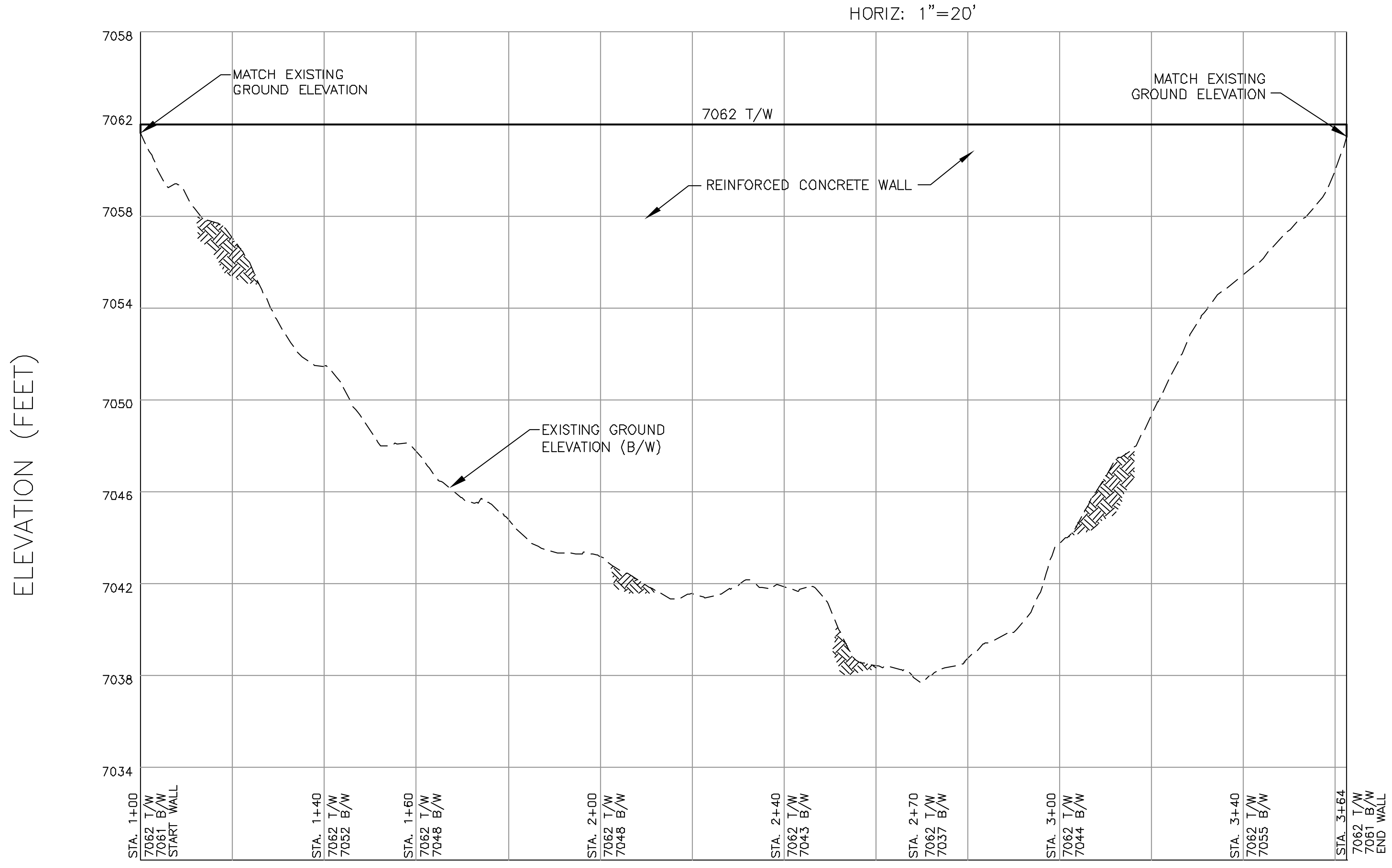
WALL 4 ELEVATION

VERT: 1"=4'
HORIZ: 1"=20'



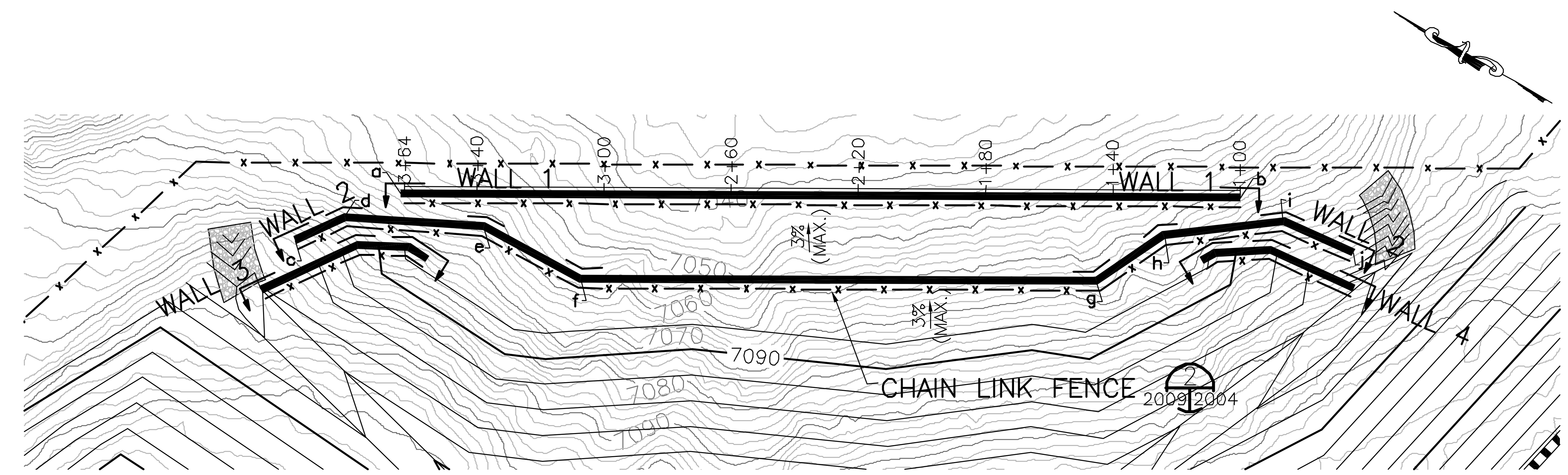
WALL 3 ELEVATION

VERT: 1"=4'
HORIZ: 1"=20'



WALL 1 ELEVATION

VERT: 1"=4'
HORIZ: 1"=20'



WALL ELEVATIONS LOCATION PLAN

SCALE: 1"=30'

NOTES:

1. SEE DRAWING 2006 FOR LEGEND.
2. WALL LOCATIONS SHALL BE FIELD VERIFIED PRIOR TO CONSTRUCTION.

WALL LOCATION CENTERLINE COORDINATES

PT	NORTHING	EASTING
a	1775948.5503	1634939.7400
b	1775719.2784	1635070.6231
c	1775970.1500	1634910.3633
d	1775960.0642	1634924.5297
e	1775920.6528	1634943.8292
f	1775886.3125	1634944.7675
g	1775745.2416	1635025.3356
h	1775734.2780	1635048.3005
i	1775703.5077	1635070.9805
j	1775679.7532	1635073.5780

VERT. SCALE: 1"=4'-0"

HORIZ. SCALE: 1"=20'-0"

NOT FOR CONSTRUCTION

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LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
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APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

WALL ELEVATIONS

DRAWN	DATE	DWG. NO.	REV. NO.
GDM	02/06/04	2009	1

SCALE	W.O. NO.	SHT.
AS SHOWN	13104.002.001	OF

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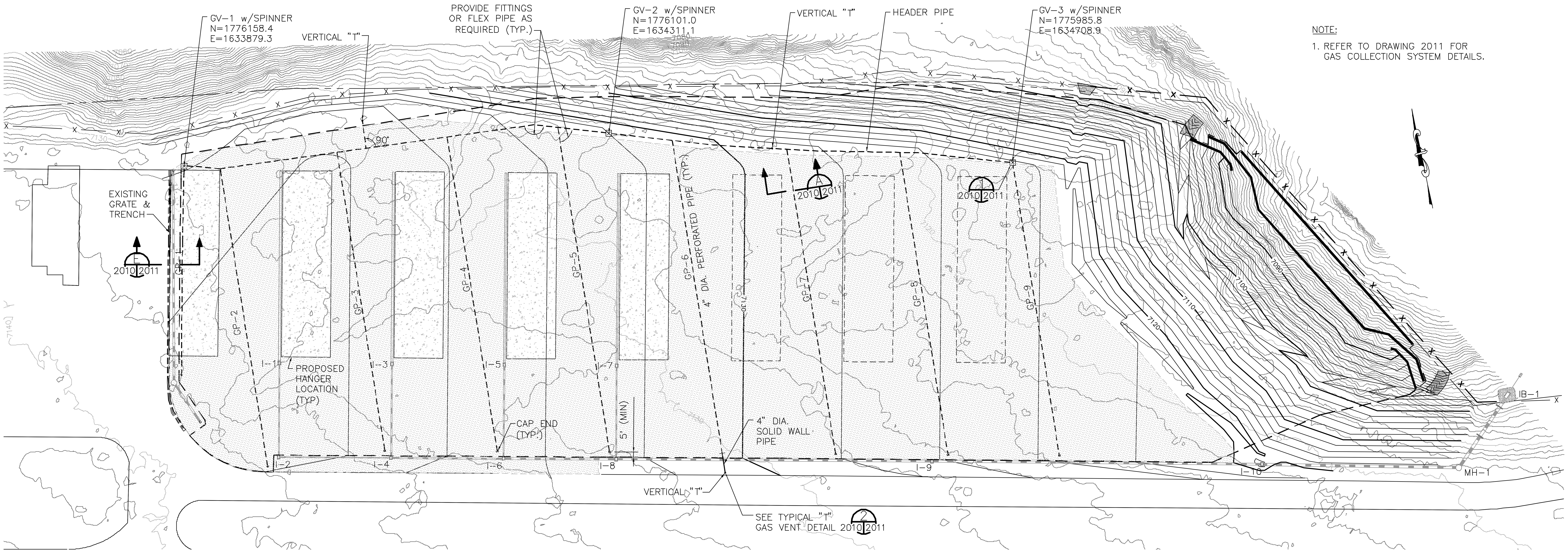
NOTE:

1. REFER TO DRAWING 2011 FOR GAS COLLECTION SYSTEM DETAILS.



PLAN

1"=50'

LEGEND

PROPERTY LINE

EXISTING FENCE

PROPOSED FENCE

LIMIT OF THE LANDFILL FINAL COVER SYSTEM

7110 EXISTING GRADE CONTOUR

7110 PROPOSED FINAL GRADE CONTOUR

PAVED AREA

EXISTING STORM SEWER INLET

S S EXISTING STORM SEWER PIPE

PROPOSED STORM SEWER INLET

PROPOSED STORM SEWER CONCRETE TRENCH

PROPOSED STORM SEWER PIPE

CONCRETE HANGER FOUNDATION

GV-1 GAS VENT LOCATION

GP-1 GAS COLLECTION PIPE

50 0 50 100

SCALE: 1"=50'

NOT FOR CONSTRUCTION

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0	6/7/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
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PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

LANDFILL
GAS COLLECTION SYSTEM PLAN

DRAWN	DATE	DWG. NO.	REV. NO.
GPL	02/06/04	2010	1
SCALE 1"=50'	W.O. NO. 13104.002.001	SHT. OF	

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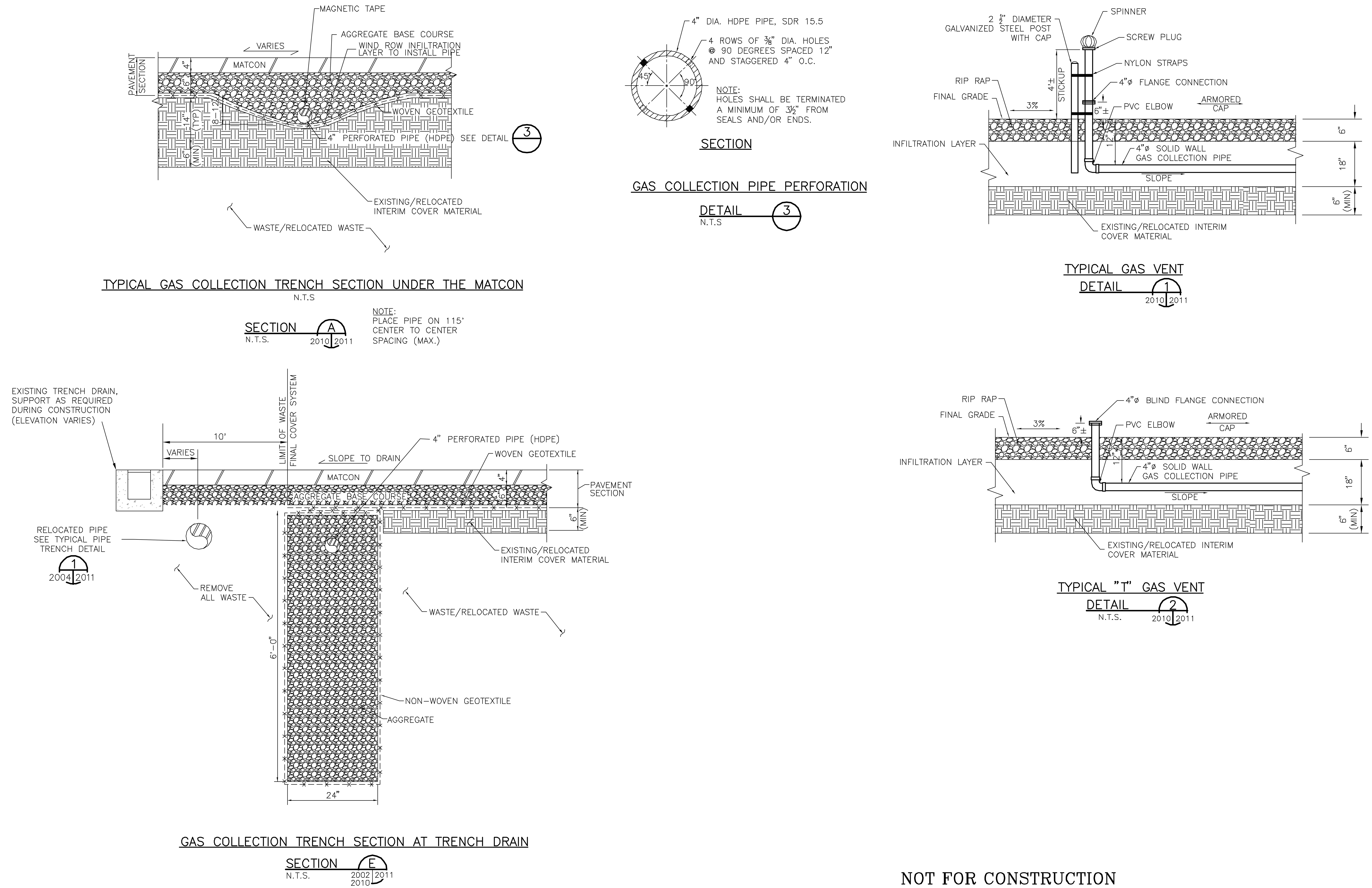

NOT FOR CONSTRUCTION

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NO.	DATE	APPR.	REVISION
1	6/20/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/2/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA–73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

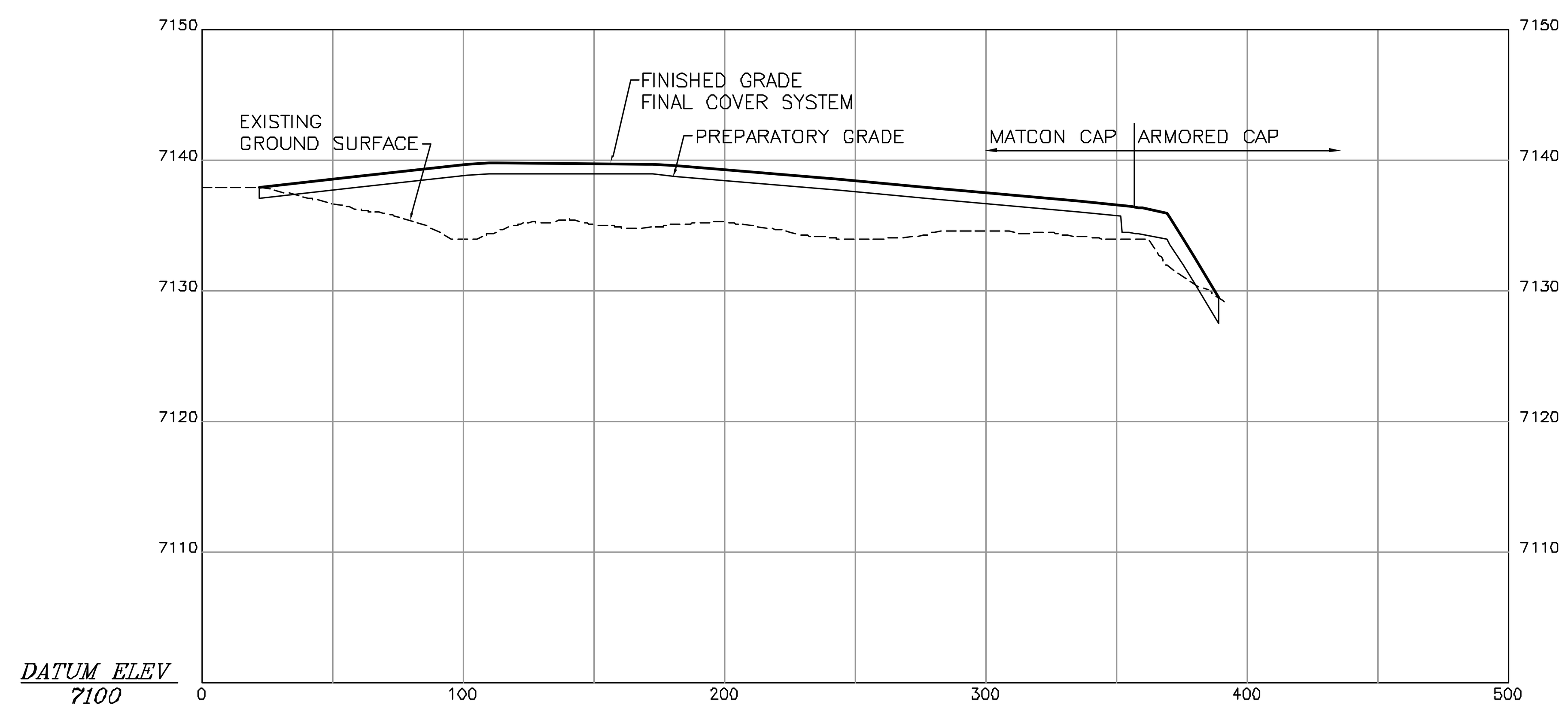
		DATE
CHECKED	RWM	6/22/05
DES. ENG.	AH	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

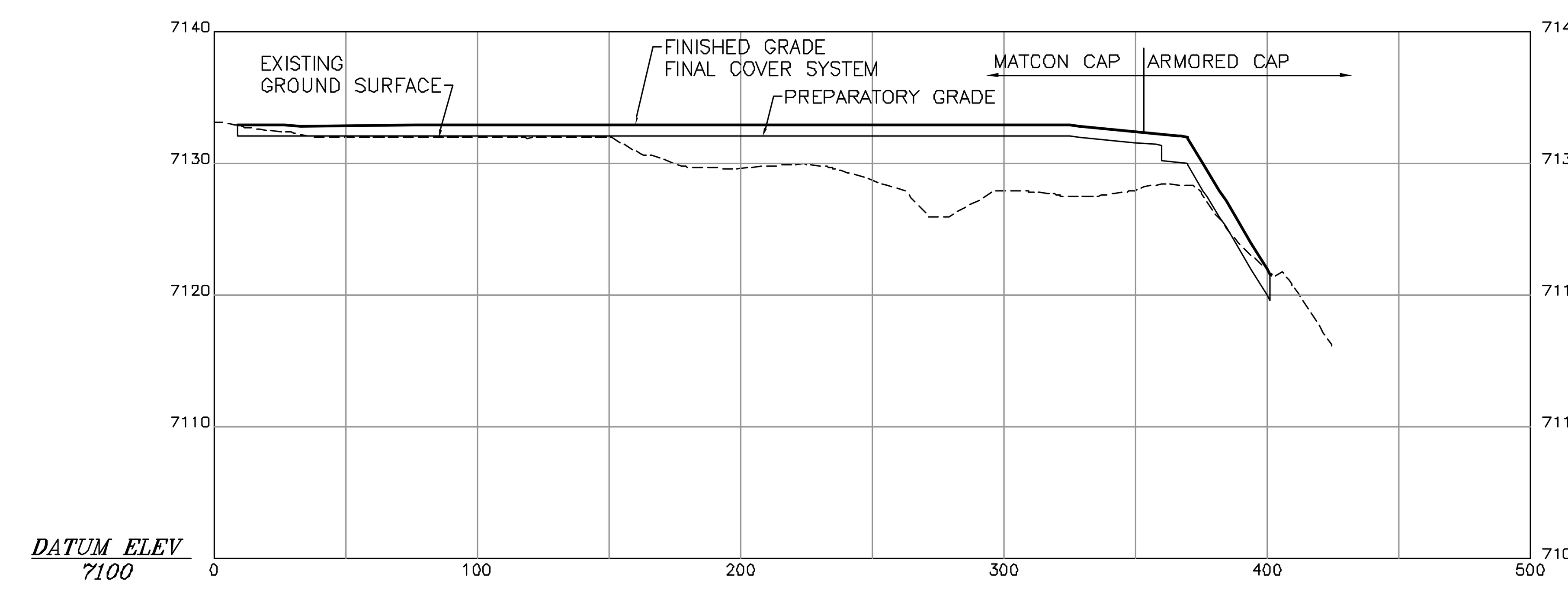
BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

LANDFILL
GAS COLLECTION SYSTEM DETAILS

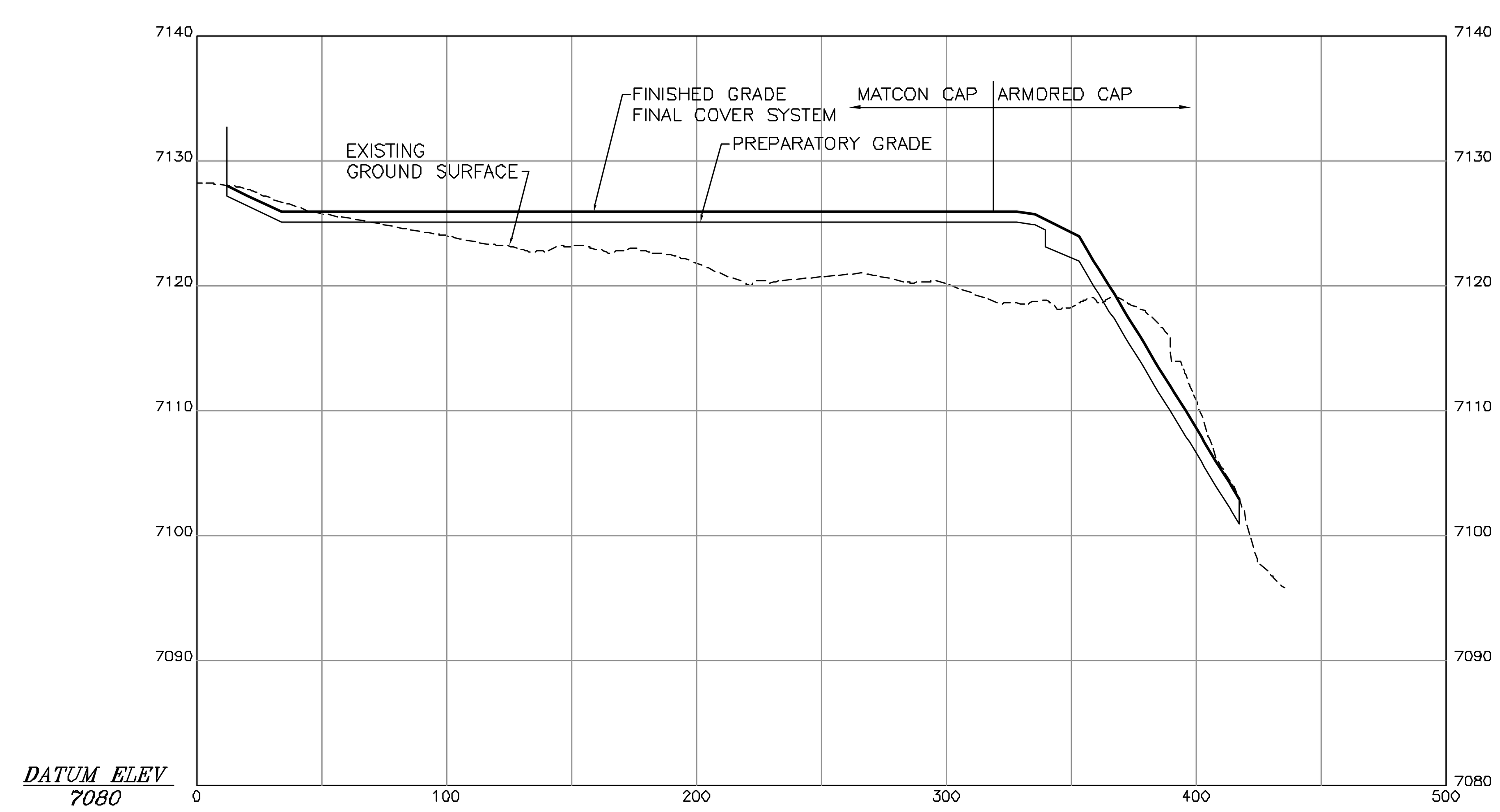
DRAWN	DATE	DWG. NO.	REV. NO.
G.LOELIGER	02/06/04	2011	1
SCALE	W.O. NO.	SHT. ___ OF ___	
AS SHOWN	13104.002.001		



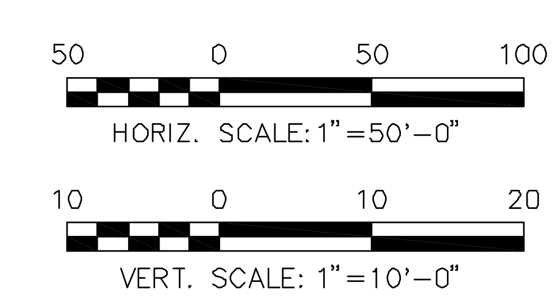
SECTION B 2002|2012



SECTION C 2002|2012



SECTION D 2002|2012



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NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/7/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

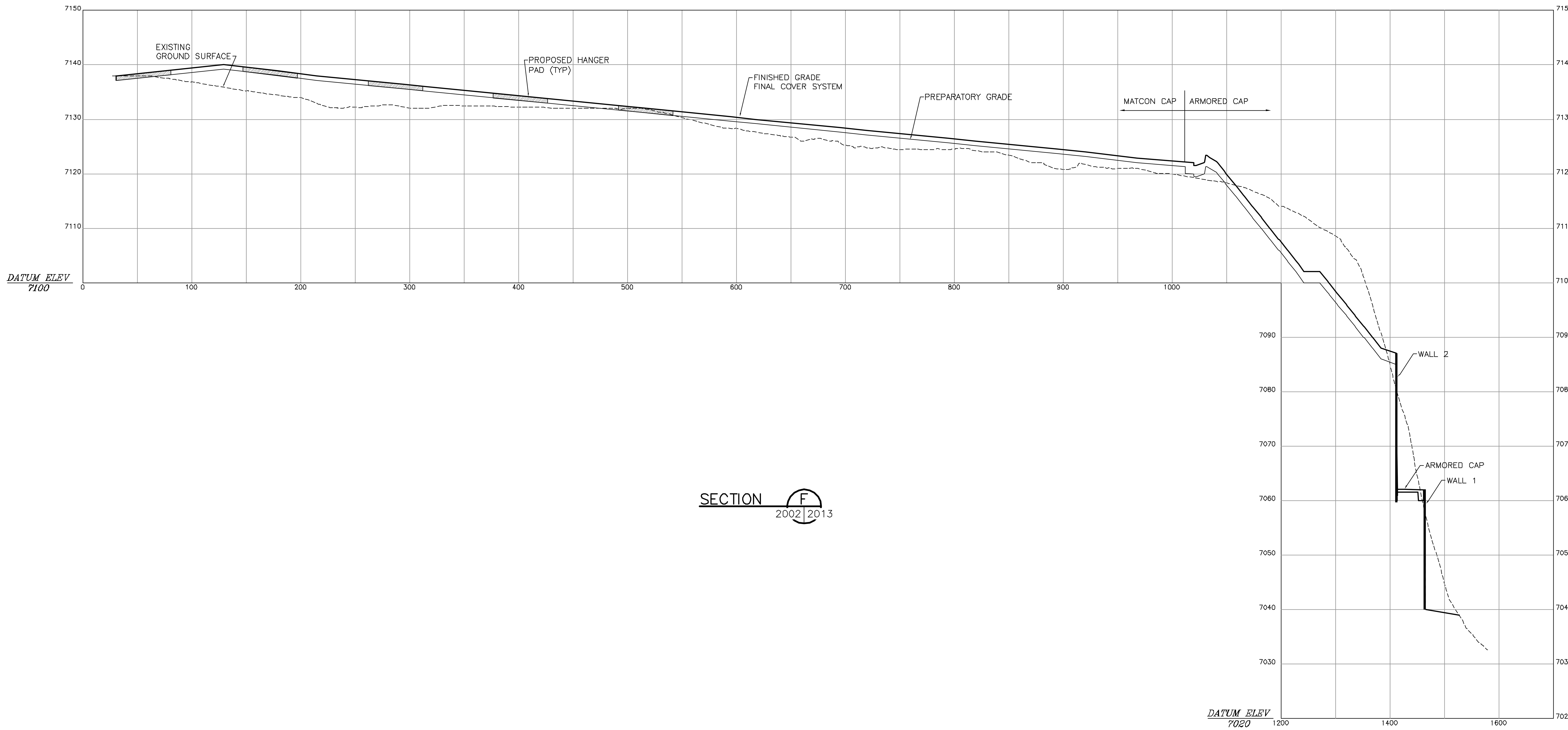
North Wind WESTON SOLUTIONS TEAM

		DATE	CLIENT APPROVALS	DATE
CHECKED	RWM	6/22/05		
DES. ENG.	SW	6/22/05		
PROJ. ENG.	AH	6/22/05		
PROJ. MGR.	BK	6/22/05		
APPROVED	BK	6/22/05		
APPROVED				

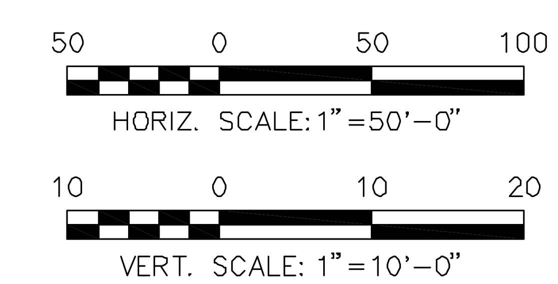
BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

LANDFILL CROSS-SECTIONS B, C, D
SHEET 1 OF 2

DRAWN	DATE	DWG. NO.	REV. NO.
DP	02/06/04	2012	1
SCALE	W.O. NO.	SHT. OF	
AS SHOWN	13104.002.001		



SECTION F
2002 | 2013



NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/3/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

LANDFILL CROSS-SECTION F
SHEET 2 OF 2

DRAWN	DATE	DWG. NO.	REV. NO.
DP	02/06/04	2013	1
SCALE	W.O. NO.	SHT. OF	
AS SHOWN	13104.002.001		

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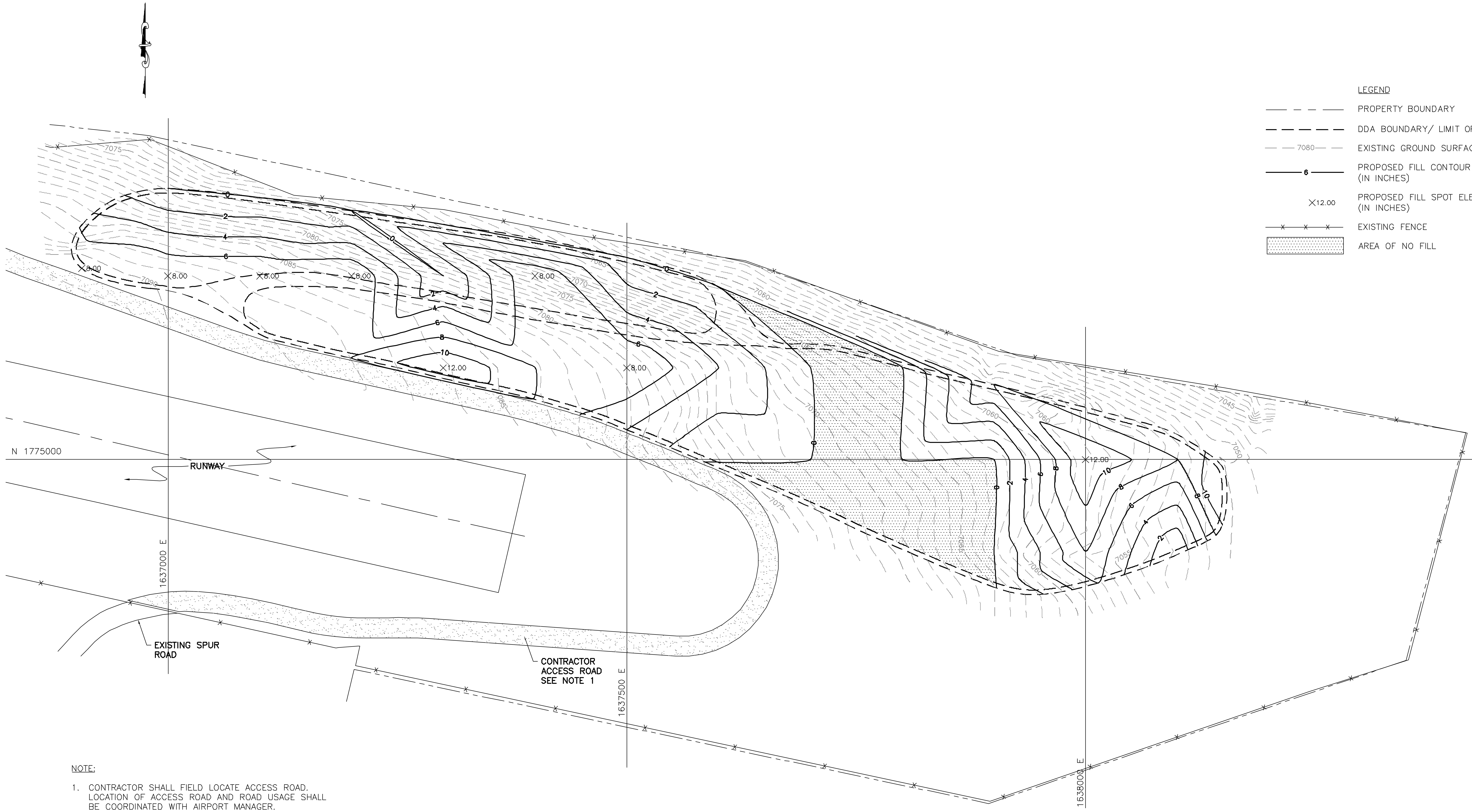

LEGEND

- PROPERTY BOUNDARY
- DDA BOUNDARY/ LIMIT OF WASTE
- 7080 EXISTING GROUND SURFACE
- 6 PROPOSED FILL CONTOUR (IN INCHES)
- ×12.00 PROPOSED FILL SPOT ELEVATION (IN INCHES)
- EXISTING FENCE
- AREA OF NO FILL

NOTE:

1. CONTRACTOR SHALL FIELD LOCATE ACCESS ROAD. LOCATION OF ACCESS ROAD AND ROAD USAGE SHALL BE COORDINATED WITH AIRPORT MANAGER.

50 0 50 100

SCALE: 1"=50'-0"

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/20/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/2/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

DEBRIS DISPOSAL AREA
FILL PLAN

DRAWN	DATE	DWG. NO.	REV. NO.
GDM	02/06/04	2014	1
SCALE AS SHOWN	W.O. NO. 13104.002.001	SHT. ___ OF ___	

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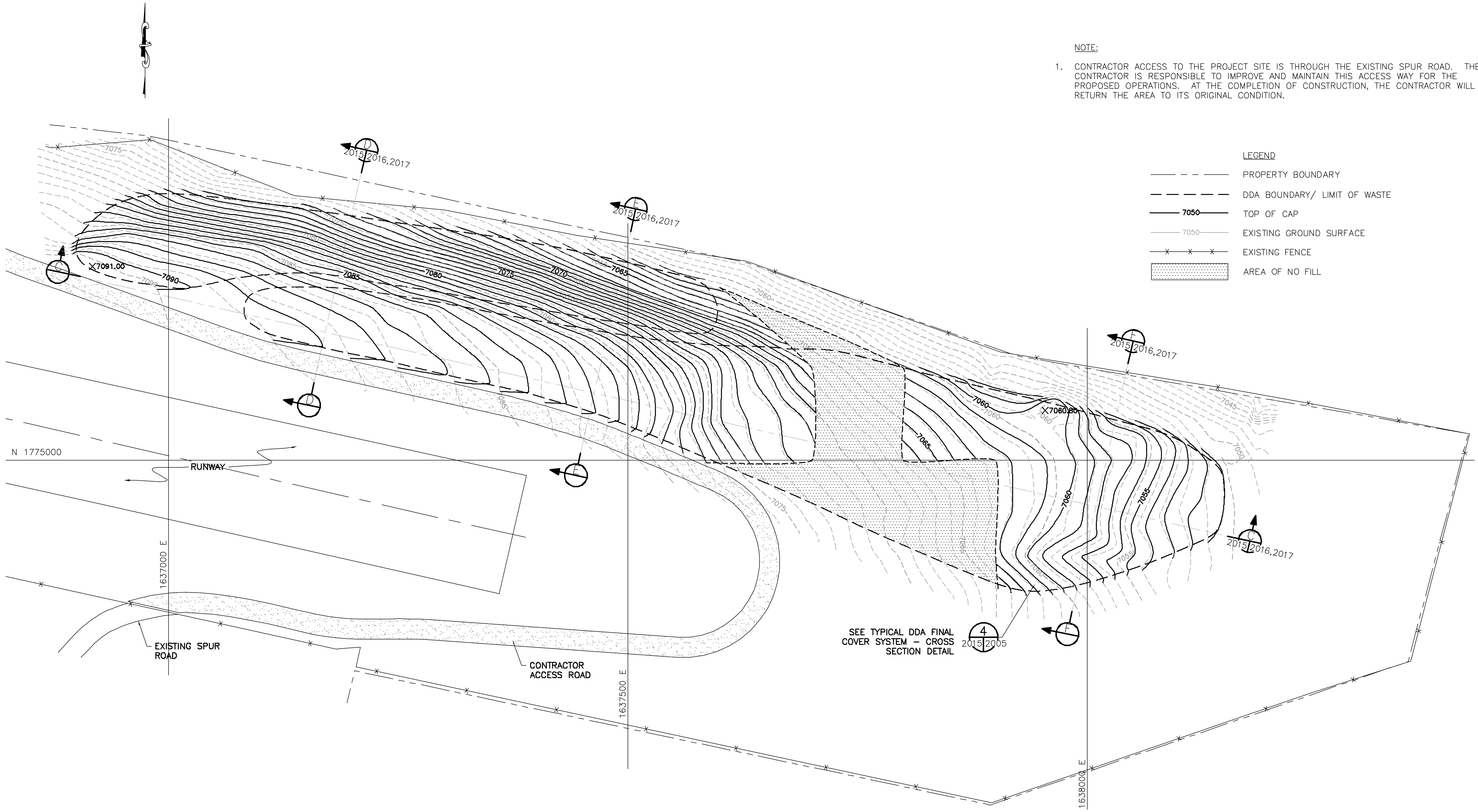
NOTE:

1. CONTRACTOR ACCESS TO THE PROJECT SITE IS THROUGH THE EXISTING SPUR ROAD. THE CONTRACTOR IS RESPONSIBLE TO IMPROVE AND MAINTAIN THIS ACCESS WAY FOR THE PROPOSED OPERATIONS. AT THE COMPLETION OF CONSTRUCTION, THE CONTRACTOR WILL RETURN THE AREA TO ITS ORIGINAL CONDITION.

LEGEND

— - —	PROPERTY BOUNDARY
— — —	DDA BOUNDARY/ LIMIT OF WASTE
—7050—	TOP OF CAP
—7050—	EXISTING GROUND SURFACE
—x—x—x—	EXISTING FENCE
(stippled)	AREA OF NO FILL



50 0 50 100

SCALE: 1"=50'–0"

NOT FOR CONSTRUCTION

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NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/7/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA–73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind | WESTON SOLUTIONS | TEAM

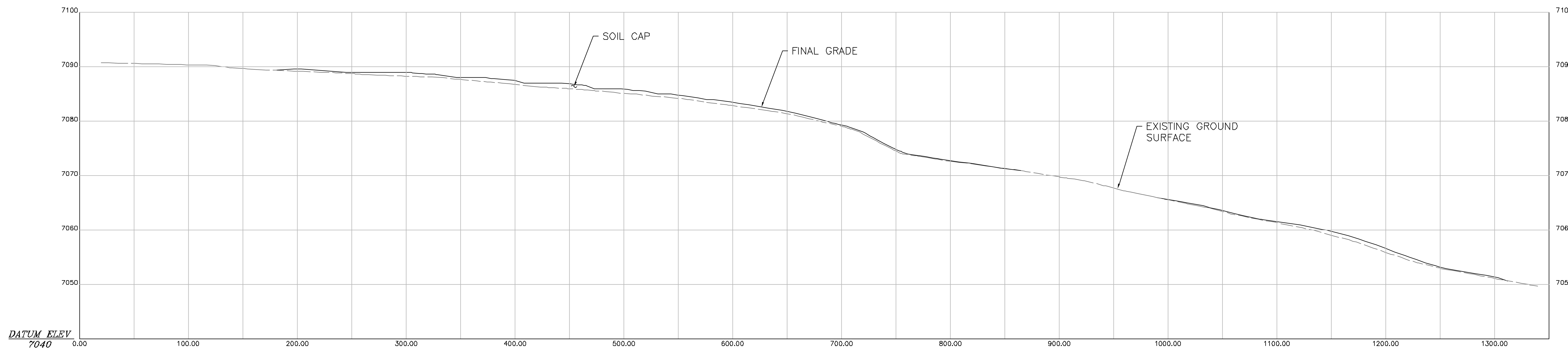
		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS | DATE

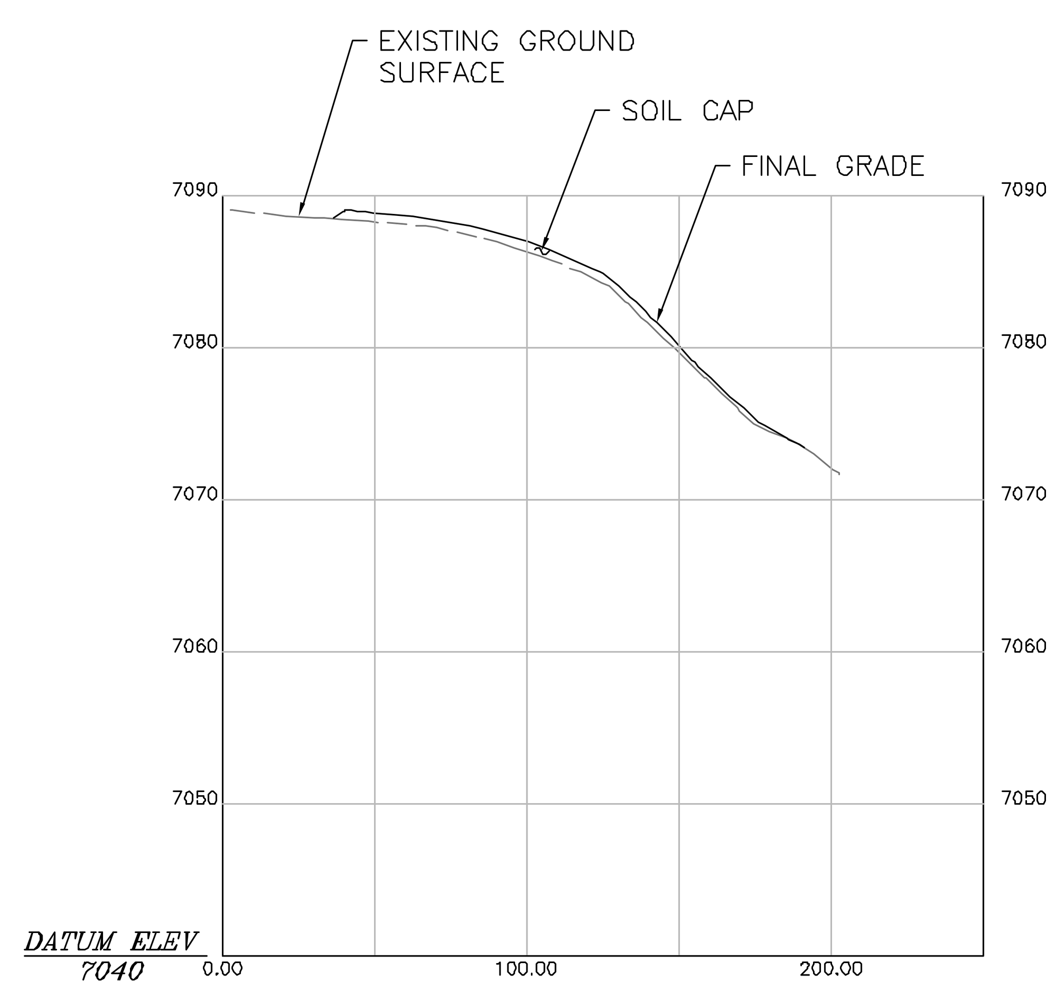
BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

DEBRIS DISPOSAL AREA
TOP OF CAP GRADING PLAN

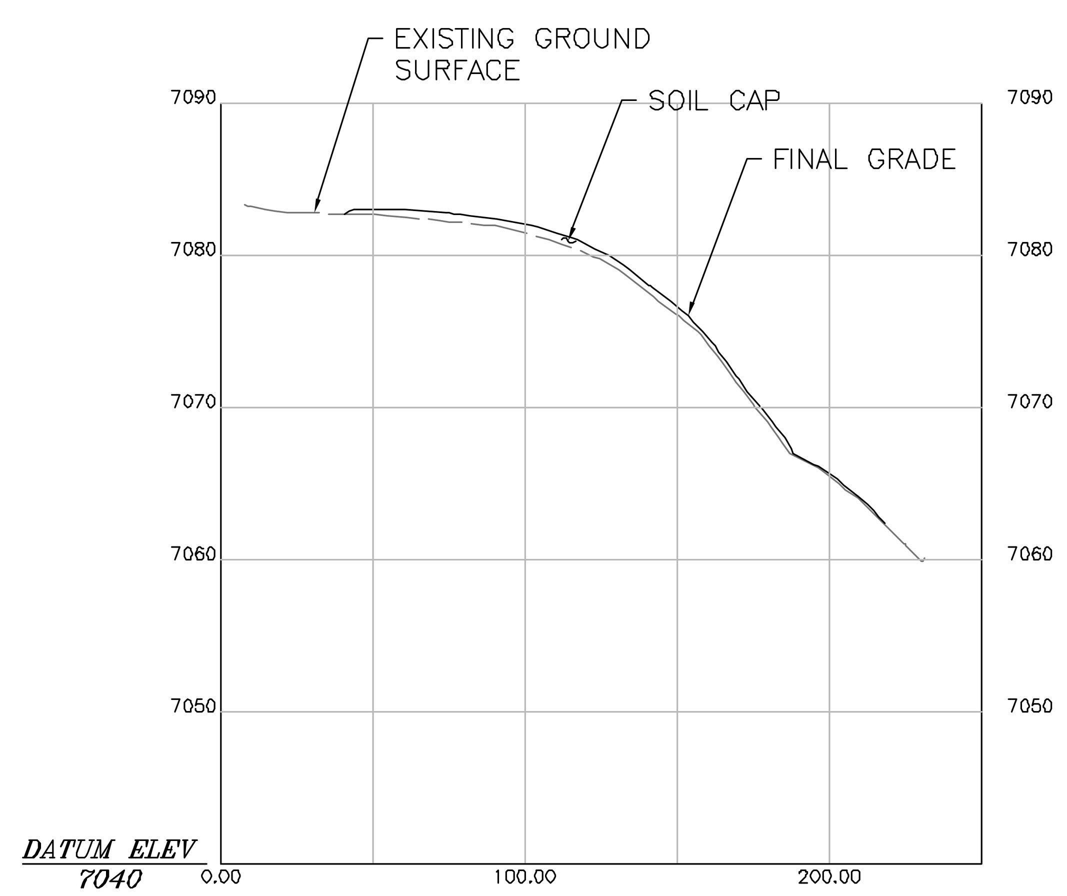
DRAWN	DATE	DWG. NO.	REV. NO.
GDM	02/06/04	2015	1
SCALE	W.O. NO.	SHT. ___ OF ___	
AS SHOWN	13104.002.001		



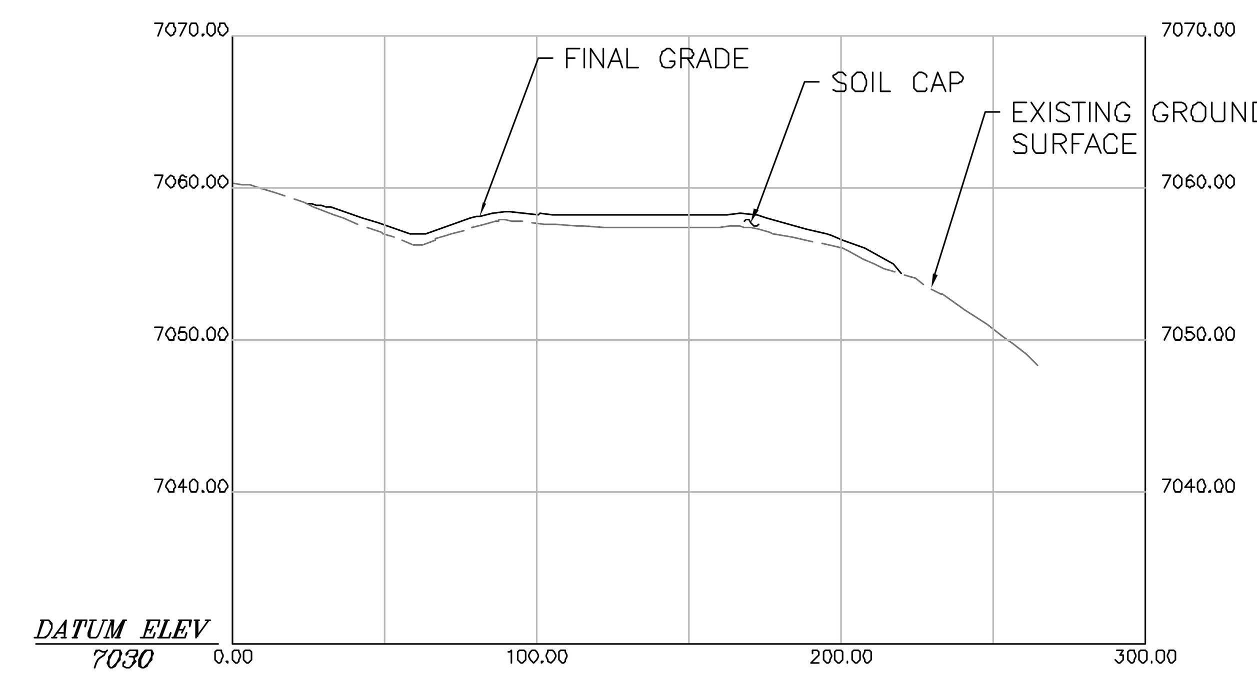
SECTION C
5H:1V 2015 | 2016



SECTION D
5H:1V 2015 | 2016



SECTION E
5H:1V 2015 | 2016



SECTION F
5H:1V 2015 | 2016

10 0 10 20
VERTICAL SCALE: 1"=10'-0"
50 0 50 100
HORIZONTAL SCALE: 1"=50'-0"

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/20/16	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/7/16	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind | WESTON SOLUTIONS | TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS | DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

DEBRIS AREA
CROSS-SECTIONS C, D, E AND F
SHEET 1 OF 2

DRAWN	DATE	DWG. NO.	REV. NO.
GDM	02/06/04	2016	1
SCALE: AS SHOWN	W.O. NO. 13104.002.001	SHT. ___ OF ___	

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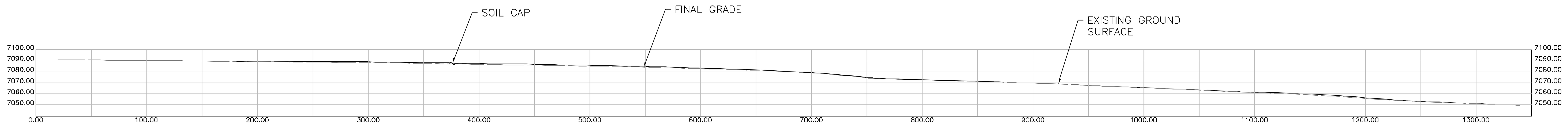
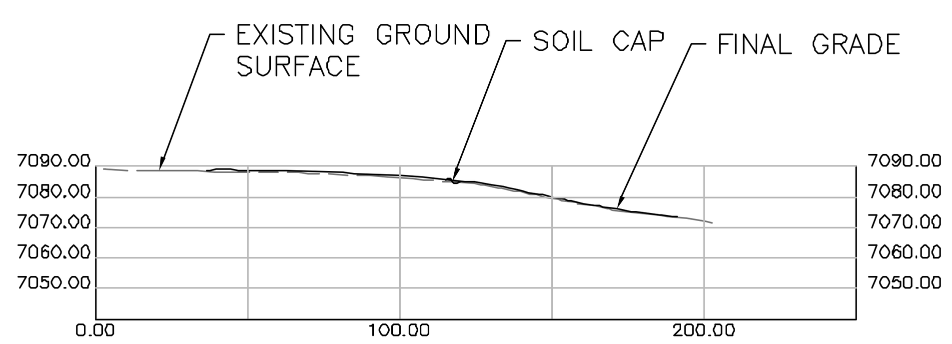
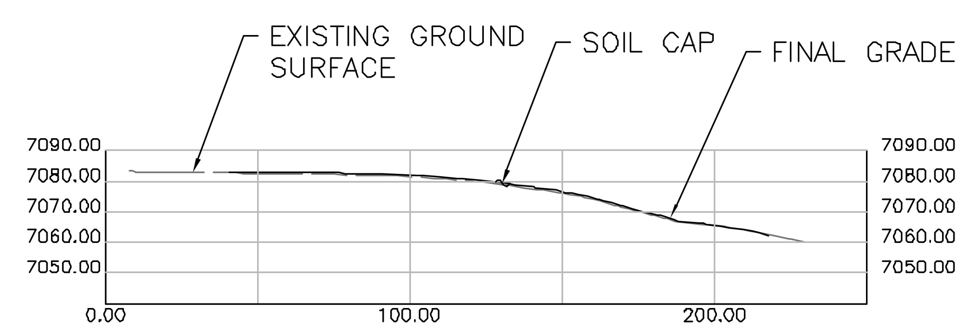


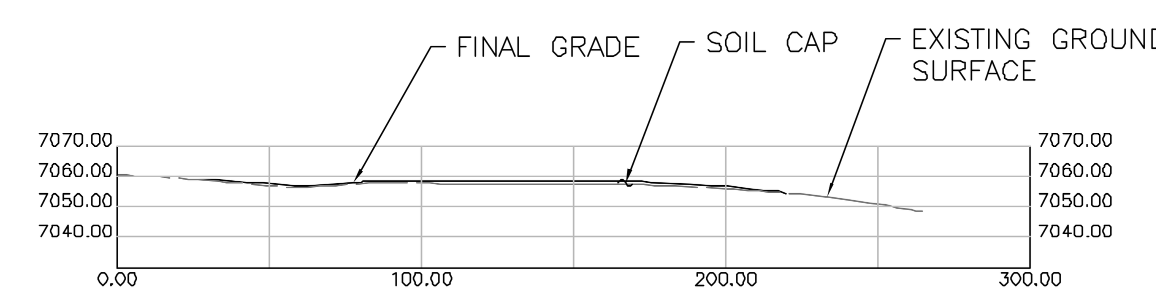
SECTION C
1H:1V 2015 | 2017



SECTION D
1H:1V 2015 | 2017



SECTION E
1H:1V 2015 | 2017



SECTION F
1H:1V 2015 | 2017

50 0 50 100
VERTICAL SCALE: 1"=50'-0"

50 0 50 100
HORIZONTAL SCALE: 1"=50'-0"

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/7/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

DEBRIS AREA
CROSS-SECTIONS C, D, E AND F
SHEET 2 OF 2

DRAWN GDM | DATE 02/06/04 | DWG. NO. 2017 | REV. NO. 1
SCALE AS SHOWN | W.O. NO. 13104.002.001 | SHT. OF

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NOTES:

1. REFER TO DRAWINGS 2020 AND 2022 FOR GENERAL EROSION AND SEDIMENTATION CONTROL PLAN NOTES AND DETAILS.
2. ALL SILT FENCE, DIVERSION BERMS AND CHECK DAMS TO BE REMOVED WHEN FINAL STABILIZATION HAS BEEN ACHIEVED.

LEGEND

- PROPERTY BOUNDARY
- LIMIT OF WASTE/GRADING FILL LAYER
- 7130 — TOP OF PREPARATORY GRADE
- 7130 — EXISTING GROUND SURFACE
- 7143.60 — PROPOSED SPOT ELEVATION
- BENCH FLOW DIRECTION
- X — EXISTING FENCE
- X — NEW FENCE/RELOCATED EXISTING FENCE
- S — EXISTING SEWER LINE
- W — EXISTING WATER LINE
- PROPOSED STORM SEWER
- DB — DIVERSION BERM
- SF — SILT FENCE
- CD — CHECK DAM
- SEDIMENT TRAP (EXCAVATED)
- INLET PROTECTION

50 0 50 100

SCALE: 1"=50'-0"

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
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0	6/7/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS
LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS / DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

EROSION AND SEDIMENTATION CONTROL PLAN LANDFILL AREA

DRAWN	DATE	DWG. NO.	REV. NO.
PAH	02/06/04	2018	1
SCALE: AS SHOWN	W.O. NO.: 13104.002.001	SHT. OF	

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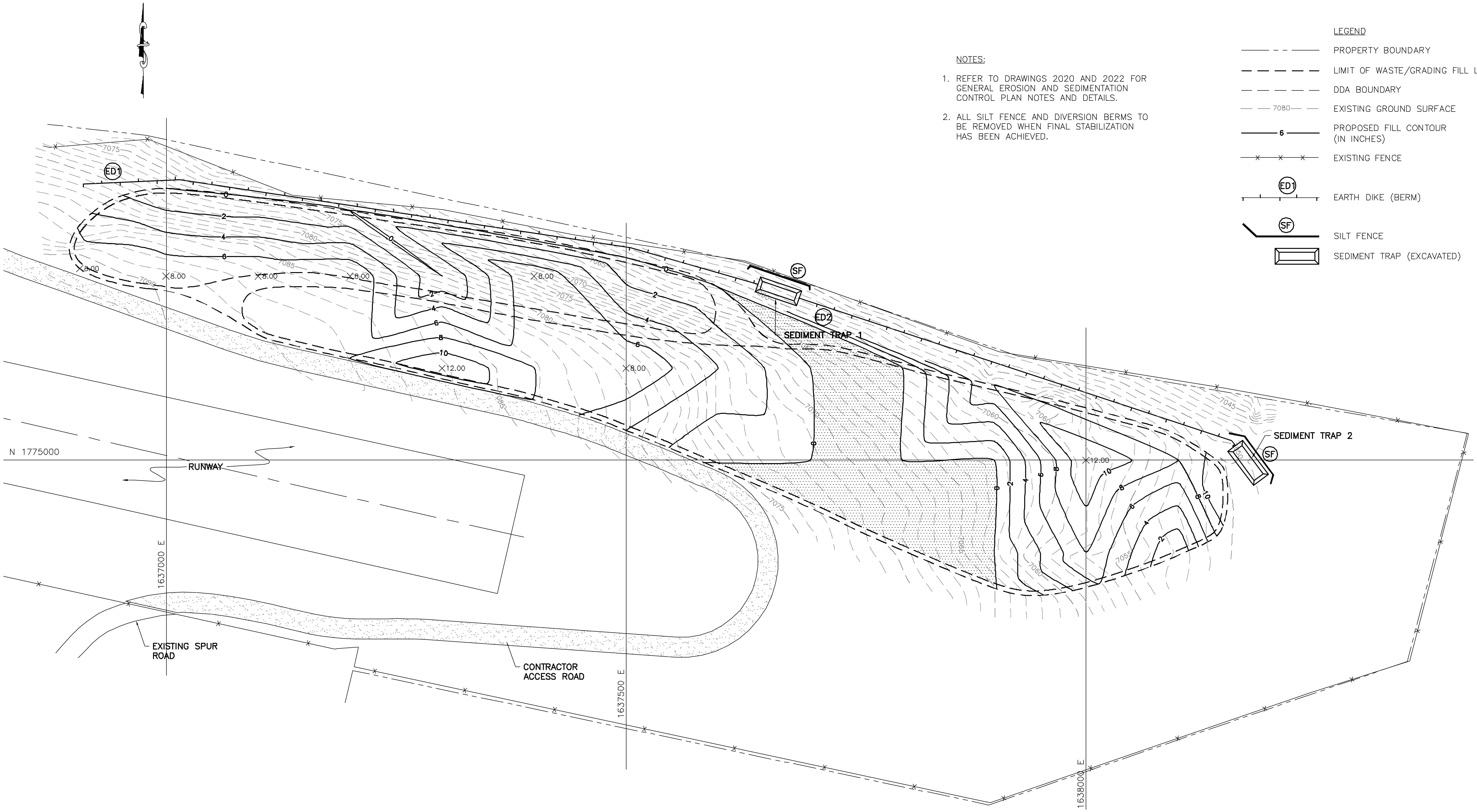
NOTES:

1. REFER TO DRAWINGS 2020 AND 2022 FOR GENERAL EROSION AND SEDIMENTATION CONTROL PLAN NOTES AND DETAILS.
2. ALL SILT FENCE AND DIVERSION BERMS TO BE REMOVED WHEN FINAL STABILIZATION HAS BEEN ACHIEVED.

LEGEND

- PROPERTY BOUNDARY
- LIMIT OF WASTE/GRADING FILL LAYER
- DDA BOUNDARY
- 7080 EXISTING GROUND SURFACE
- 6 PROPOSED FILL CONTOUR (IN INCHES)
- EXISTING FENCE
- (ED1) EARTH DIKE (BERM)
- (SF) SILT FENCE
- SEDIMENT TRAP (EXCAVATED)



50 0 50 100

SCALE: 1"=50'-0"

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/7/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
TA-73 AIRPORT LANDFILLS

LOS ALAMOS NEW MEXICO

North Wind WESTON SOLUTIONS TEAM

		DATE
CHECKED	RWM	6/22/05
DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

EROSION AND SEDIMENTATION CONTROL PLAN
DEBRIS DISPOSAL AREA

DRAWN	DATE	DWG. NO.	REV. NO.
GDM	02/06/04	2019	1
SCALE	W.O. NO.	SHT. OF	
AS SHOWN	13104.002.001		

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SOIL EROSION AND SEDIMENTATION CONTROL PLAN

THE CONTRACTOR WILL FULLY COMPLY WITH ALL THE APPLICABLE FEDERAL AND STATE OF NEW MEXICO REGULATIONS AND STANDARDS.

EROSION CONTROL MEASURES

TEMPORARY

TEMPORARY CONTROL MEASURES INCLUDE CONSTRUCTION ENTRANCES, SILT FENCES, CHECK DAMS, INLET FILTERS AND MAINTENANCE OF EROSION AND SEDIMENT CONTROLS. THE CONSTRUCTION ENTRANCE IS A STONE APRON OVER WHICH ALL VEHICLES WILL PASS. SILT FENCE WILL BE USED TO INTERCEPT SHEET RUNOFF. CHECK DAMS WILL REDUCE FLOW VELOCITY IN DIVERSION CHANNELS. MAINTENANCE IS THE REGULAR AND ROUTINE INSPECTION OF THE SEDIMENT AND EROSION CONTROLS, AND THE REPAIR OF THOSE CONTROLS TO PREVENT SEDIMENT FROM LEAVING THE SITE.

PERMANENT

ALL AREAS OF EARTH DISTURBED BY CONSTRUCTION WILL BE SEEDED AND MULCHED IMMEDIATELY AFTER COMPLETION OF CONSTRUCTION. IN THE EVENT THAT SEEDING CANNOT TAKE PLACE IMMEDIATELY DUE TO WEATHER CONDITIONS, MULCH OR HEAVY JUTE MATS WILL BE SPREAD OVER THE DISTURBED AREAS UNTIL SEEDING MAY BE PROPERLY COMPLETED.

MAINTENANCE PROGRAM FOR SEDIMENT AND EROSION CONTROLS

THE CONTRACTOR IS RESPONSIBLE FOR MAINTAINING ALL EROSION CONTROL FACILITIES INCLUDING SEDIMENT REMOVAL DURING CONSTRUCTION, AND DURING THE SURCHARGE AND EMBANKMENT CONSOLIDATION PERIOD. ALL DAMAGED FACILITIES WILL BE REPAIRED WITHIN 24 HOURS. WHEN SILT HAS ACCUMULATED TO A DEPTH OF SIX INCHES AGAINST OR AROUND ANY CONTROL FACILITY THE SILT WILL BE REMOVED IMMEDIATELY AND RETURNED TO THE SITE.

THE CONTRACTOR WILL NOT REMOVE ANY CONTROL FACILITY UNTIL DIRECTED BY THE ENGINEER. MATERIALS USED FOR EROSION CONTROL WILL BE DISPOSED OF OFF–SITE WHEN REMOVED. SUCH MATERIALS ARE CONSIDERED PROPERTY OF THE CONTRACTOR.

CONSTRUCTION ENTRANCE

THE STRUCTURE'S THICKNESS WILL BE CONSTANTLY MAINTAINED TO THE SPECIFIED DIMENSIONS BY ADDING ROCK. A STOCKPILE OF ROCK MATERIAL WILL BE MAINTAINED ON THE SITE FOR THIS PURPOSE.

AT THE END OF EACH CONSTRUCTION DAY, ALL SEDIMENT DEPOSITED ON PUBLIC ROADWAYS WILL BE REMOVED BY USE OF A ROAD SWEEPER, WATER, VACUUM OR BROOM AND RETURNED TO THE CONSTRUCTION SITE.

SILT FENCE

THE FENCE INSTALLATION SHALL BE INSPECTED AFTER EVERY PRECIPITATION EVENT. ANY NECESSARY REPAIRS WILL BE MADE IMMEDIATELY.

ACCUMULATED SEDIMENTS WILL BE REMOVED AS REQUIRED TO KEEP THE FENCE FUNCTIONAL. IN ALL CASES REMOVE DEPOSITS WHERE ACCUMULATIONS REACH 1/3 OF THE ABOVE GROUND HEIGHT OF THE FENCE.

ALL UNDERCUTTING OR EROSION OF THE TOE ANCHOR WILL BE REPAIRED IMMEDIATELY WITH COMPACTED BACKFILL MATERIALS.

ADHERE TO ANY MANUFACTURER'S RECOMMENDATION FOR REPLACING SILT FENCE DUE TO WEATHERING.

VEGETATIVE SURFACE STABILIZATION AND SEEDING

ALL SEEDING AND FERTILIZER AND MULCH APPLICATION SHALL BE PER THE TECHNICAL SPECIFICATION, SECTION 02932.

ALL AREAS OF THE LANDFILL NOT COVERED BY THE ARMORED SOIL CAP WILL BE COVERED WITH AN EROSION CONTROL BLANKET, OR MULCH.

FOLLOWING INITIAL SOIL DISTURBANCE OR REDISTURBANCE, PERMANENT OR TEMPORARY STABILIZATION SHALL BE COMPLETED IN ACCORDING WITH:

A. 7 CALENDAR DAYS AS TO THE SURFACE OF ALL PERIMETER CONTROLS, DIKES, SWALES, DITCHES, PERIMETER SLOPES, STOCKPILES, AND ALL SLOPES GREATER THAN 2 HORIZONTAL TO 1 VERTICAL (2:1)
B. 14 DAYS AS TO ALL OTHER DISTURBED OR GRADED AREAS ON THE PROJECT SITE. THE IN–PLACE SEDIMENT CONTROL MEASURES WILL BE MAINTAINED ON A CONTINUING BASIS UNTIL THE SITE IS PERMANENTLY STABILIZED AND ALL PERMIT REQUIREMENTS ARE MET.

SEDIMENT TRAPS, DIVERSION CHANNELS OR BERMS, AND STOCKPILES MUST BE SEEDED AND MULCHED IMMEDIATELY.

COMPLIANCE WITH STATE AND LOCAL REQUIREMENTS

THE EROSION & SEDIMENT POLLUTION CONTROL REPORT, APPLICATION DOCUMENTS, NARRATIVE(S), CONTRACT PLANS AND SPECIFICATIONS ARE ALL INCLUDED HEREWITH BY REFERENCE AS AN INTEGRAL PART OF THIS CONTRACT. ANY QUESTIONS, COMMENTS, APPROVAL CONDITIONS OR PERMIT REQUIREMENTS CONTAINED WITHIN A REGULATORY REVIEW LETTER FOR THIS PROJECT ARE HEREBY INCLUDED AS AN INTEGRAL PART OF THIS CONTRACT, AND THE CONTRACTOR SHALL FULLY COMPLY WITH ANY APPROVAL CONDITIONS OR PERMIT REQUIREMENTS AS IF THEY WERE INCLUDED HEREWITH IN THEIR FULL TEXT. COPIES OF ALL STATE AND LOCAL REGULATORY AGENCY REVIEWS, COMMENTS, APPROVAL CONDITIONS OR PERMIT REQUIREMENTS MAY BE OBTAINED THROUGH THE LOCAL CONSERVATION DISTRICT OFFICE.

DUST CONTROL

THE CONTRACTOR WILL EMPLOY CONSTRUCTION METHODS AND MEANS THAT WILL KEEP DUST TO THE MINIMUM. THE CONTRACTOR WILL PROVIDE FOR THE SPRAYING OF WATER ON THE PROJECT AREA (INCLUDING STOCKPILES), AND ON ROADS, STREETS AND OTHER AREAS IMMEDIATELY ADJACENT TO THE PROJECT LIMITS, WHEREVER TRAFFIC, OR BUILDINGS THAT ARE OCCUPIED OR IN USE, ARE AFFECTED BY SUCH DUST CAUSED BY HAULING OR OTHER OPERATIONS. THE MATERIALS AND METHODS USED FOR WATER SPRAYING SHALL BE SUBJECT TO THE APPROVAL OF THE OWNER. THE CONTRACTOR SHALL PROVIDE FOR PROMPT REMOVAL FROM EXISTING PAVING ALL DIRT AND OTHER MATERIAL THAT HAVE BEEN SPILLED, WASHED UPON, TRACKED UPON OR OTHERWISE DEPOSITED THEREON BY HIS HAULING AND OTHER OPERATIONS WHENEVER THE ACCUMULATION IS SUFFICIENT TO CAUSE THE FORMATION OF DUST, MUD, INTERFERE WITH DRAINAGE, DAMAGE PAVEMENTS OR CREATE A TRAFFIC HAZARD.

STANDARD EROSION AND SEDIMENTATION CONTROL PLAN NOTES

ONLY LIMITED DISTURBANCE WILL BE PERMITTED TO PROVIDE ACCESS TO SEDIMENT BASINS (IF REQUIRED), INTERCEPTOR CHANNELS, SILT FENCE AND ROCK FILTERS AS INDICATED ON THE PLANS, FOR GRADING AND ACQUIRING BORROW TO CONSTRUCT THESE CONTROLS.

EROSION AND SEDIMENTATION CONTROLS MUST BE CONSTRUCTED, STABILIZED, AND FUNCTIONAL BEFORE GENERAL SITE DISTURBANCE WITHIN THE TRIBUTARY AREAS OF THOSE CONTROLS.

AFTER FINAL SITE STABILIZATION HAS BEEN ACHIEVED, TEMPORARY EROSION AND SEDIMENTATION CONTROL MUST BE REMOVED. AREAS DISTURBED DURING REMOVAL OF THE CONTROLS MUST BE STABILIZED.

STOCKPILE HEIGHTS MUST NOT EXCEED 35 FEET OR VIOLATE AIRPORT CONICAL SURFACES. STOCKPILE MUST BE 2:1 OR FLATTER.

UNTIL FINAL STABILIZATION HAS BEEN ACHIEVED, ALL EROSION AND SEDIMENTATION CONTROLS MUST BE MAINTAINED PROPERLY. MAINTENANCE MUST INCLUDE INSPECTION OF ALL EROSION AND SEDIMENTATION CONTROLS AT LEAST ONCE EVERY 14 CALENDAR DAYS AND WITHIN 24 HOURS OF THE END OF A STORM EVENT OF 0.5 INCHES PRECIPITATION OR GREATER. THE INSPECTION FREQUENCY MAY BE REDUCED TO AT LEAST ONCE EVERY MONTH AFTER ALL EARTH DISTURBING ACTIVITIES HAVE BEEN COMPLETED AND CERTAIN CRITERIA, AS DEFINED IN SECTION 8.1 OF THE SWPPP, ARE MET. ALL PREVENTIVE AND REMEDIAL MAINTENANCE WORK, INCLUDING CLEAN OUT, REPAIR, REPLACEMENT, REGRADING, RESEEDING, REMULCHING, AND RENETTING, MUST BE PERFORMED AS SOON AS POSSIBLE AND BEFORE THE NEXT STORM EVENT. IF MAINTENANCE BEFORE THE NEXT STORM EVENT IS IMPRACTICABLE, MAINTENANCE MUST BE COMPLETED AS SOON AS POSSIBLE.

FINAL STABILIZATION HAS BEEN ACHIEVED WHEN ALL SOIL–DISTURBING ACTIVITIES HAVE BEEN COMPLETED AND A UNIFORM VEGETATIVE COVER WITH A DENSITY OF 70 PERCENT OF THE NATIVE BACKGROUND VEGETATIVE COVER FOR THE AREA HAS BEEN ESTABLISHED ON ALL UNPAVED AREAS AND AREAS NOT COVERED BY PERMANENT STRUCTURES. FINAL STABILIZATION OF AREAS WHERE A ROCK ARMOR HAS BEEN INSTALLED WILL BE ACHIEVED IMMEDIATELY UPON PLACEMENT OF THE ROCK ARMOR.

ALL ROADS AND UTILITIES WILL BE CONSTRUCTED AND STABILIZED BEFORE BEGINNING CONSTRUCTION OF ANY ONSITE STRUCTURES.

THE CONTRACTOR WILL BE RESPONSIBLE FOR THE PROPER CONSTRUCTION, STABILIZATION, AND MAINTENANCE OF ALL EROSION AND SEDIMENTATION CONTROLS AND RELATED ITEMS INCLUDED WITHIN THESE PLANS.

SHOULD ANY MEASURES CONTAINED WITHIN THIS PLAN PROVE INCAPABLE OF ADEQUATELY REMOVING SEDIMENT FROM ONSITE FLOWS PRIOR TO DISCHARGE OR OF STABILIZING THE SURFACES INVOLVED, ADDITIONAL MEASURES MUST BE IMMEDIATELY IMPLEMENTED BY THE CONTRACTOR TO ELIMINATE ALL SUCH PROBLEMS.

PROTECTION (I.E., RIP RAP) FOR DIVERSION CHANNELS, SWALES, OUTLET APRONS AND DESIGNATED SLOPES, SHALL BE IMMEDIATELY INSTALLED UPON CONSTRUCTION OF THE SAME.

SHOULD CONDITIONS ARISE IN THE FIELD WHICH RENDER THE E & S CONTROLS FOR THIS PROJECT INAPPROPRIATE OR INADEQUATE, THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE OWNER. ADDITIONAL DRAWINGS OF MODIFICATIONS TO EXISTING DRAWINGS REQUIRED WILL BE FURNISHED BY THE CONTRACTOR. THESE REVISIONS SHALL BECOME A PART OF AND A CONDITION OF THE E & S CONTROL PLAN.

NOT FOR CONSTRUCTION

NO.	DATE	APPR.	REVISION
1	6/30/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
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LOS ALAMOS SITE OFFICE
TA–73 AIRPORT LANDFILLS
LOS ALAMOS, NEW MEXICO

North Wind | WESTON SOLUTIONS | TEAM

		DATE
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DES. ENG.	SW	6/22/05
PROJ. ENG.	AH	6/22/05
PROJ. MGR.	BK	6/22/05
APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS — DATE

BERG KESHIAN, JR. — NEW MEXICO — 8590 — LICENSED PROFESSIONAL ENGINEER

EROSION AND SEDIMENTATION CONTROL NOTES

DRAWN: GDM | DATE: 02/06/04 | DWG. NO.: 2020 | REV. NO.: 1
SCALE: N.T.S. | W.O. NO.: 13104.002.001 | SHT. ___ OF ___

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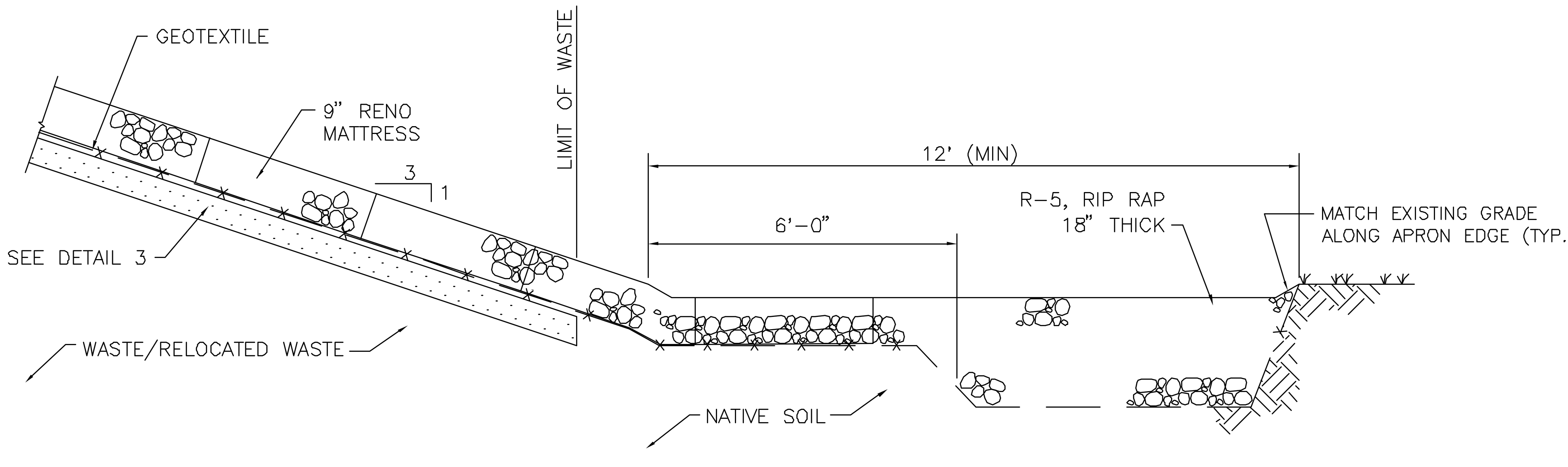
TABLE 1 : CHANNEL CHARACTERISTICS

CHANNEL	DESIGN FLOW (CFS)	CHANNEL DIMENSIONS BED SLOPE (%)	T (FT)	D (FT)	B (FT)	z1	z2	FLOW CHARACTERISTICS d (FT)	F (FT)	VELOCITY (FPS)	CHANNEL BED PROTECTION
CHANNEL 1	5.87	2.00	VARIES	VARIES	2	3	3	0.54	VARIES	3.03	R-3 RIP RAP
CHANNEL 2	11.73	2.00	VARIES	VARIES	2	3	3	0.75	VARIES	3.65	R-3 RIP RAP
BENCH 1	2.93	4.00	14	1	N/A	4	10	0.39	0.61	2.81	R-3 RIP RAP
BENCH 2	3.91	4.00	14	1	N/A	4	10	0.43	0.57	3.02	R-3 RIP RAP
DOWNCHUTE	5.87	33.33	12	1	6	3	3	0.12	0.88	7.62	RENO MATTRESS

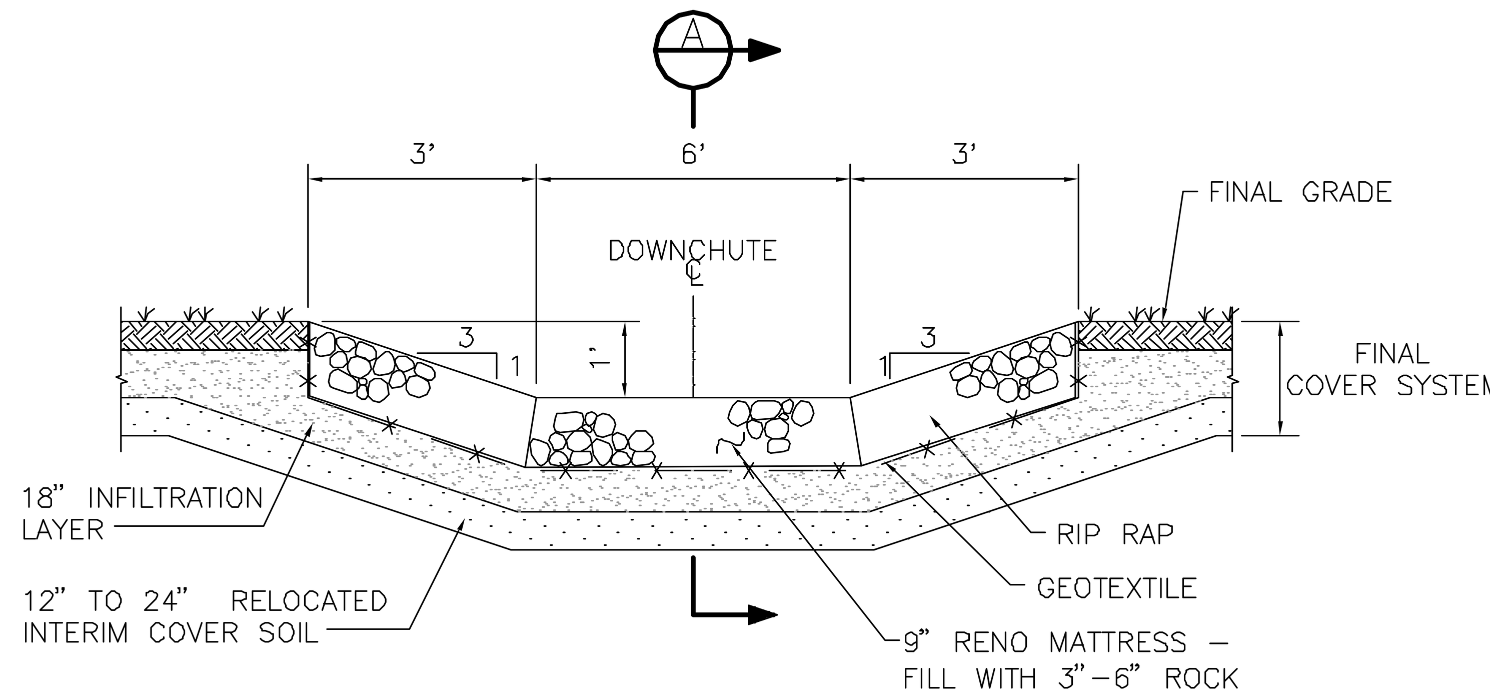
TABLE 2: SEDIMENT TRAPS SIZING

RUNOFF AREA	REQUIRED STORAGE	STORAGE DEPTH	TOTAL DEPTH (INCL. 1' FREEBOARD)	APPROXIMATE BOTTOM DIMENSIONS WIDTH	LENGTH	SEDIMENT STORAGE
Ac	CF	FT	FT	FT	FT	CF
1	2000	2	3	19.2	38.4	700
2	4000	2	3	28.5	57.0	1400
3	6000	2	3	35.6	71.3	2100
4	8000	2	3	41.6	83.3	2800
5	10000	2	3	46.9	93.9	3500



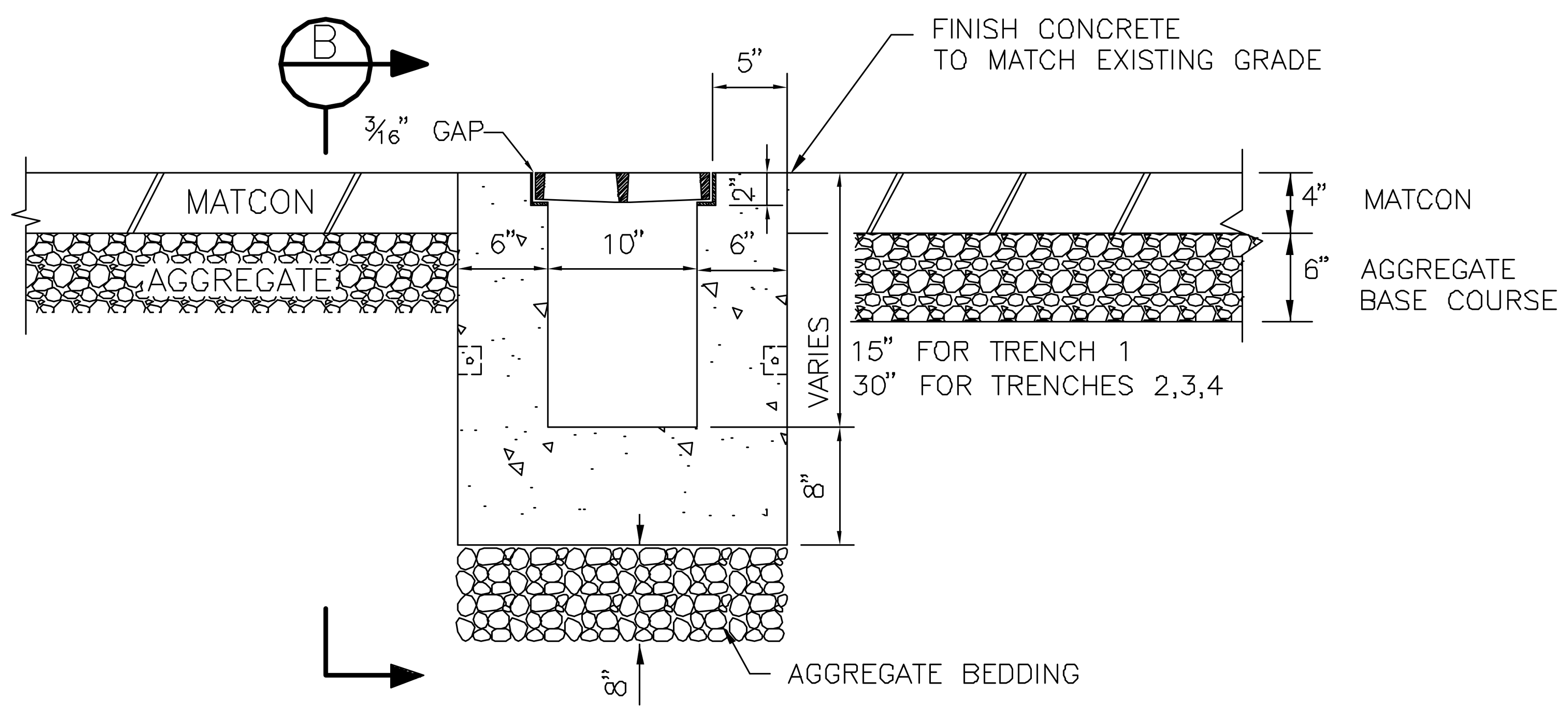
RIP RAP OUTLET APRON 1

SECTION A
N.T.S.



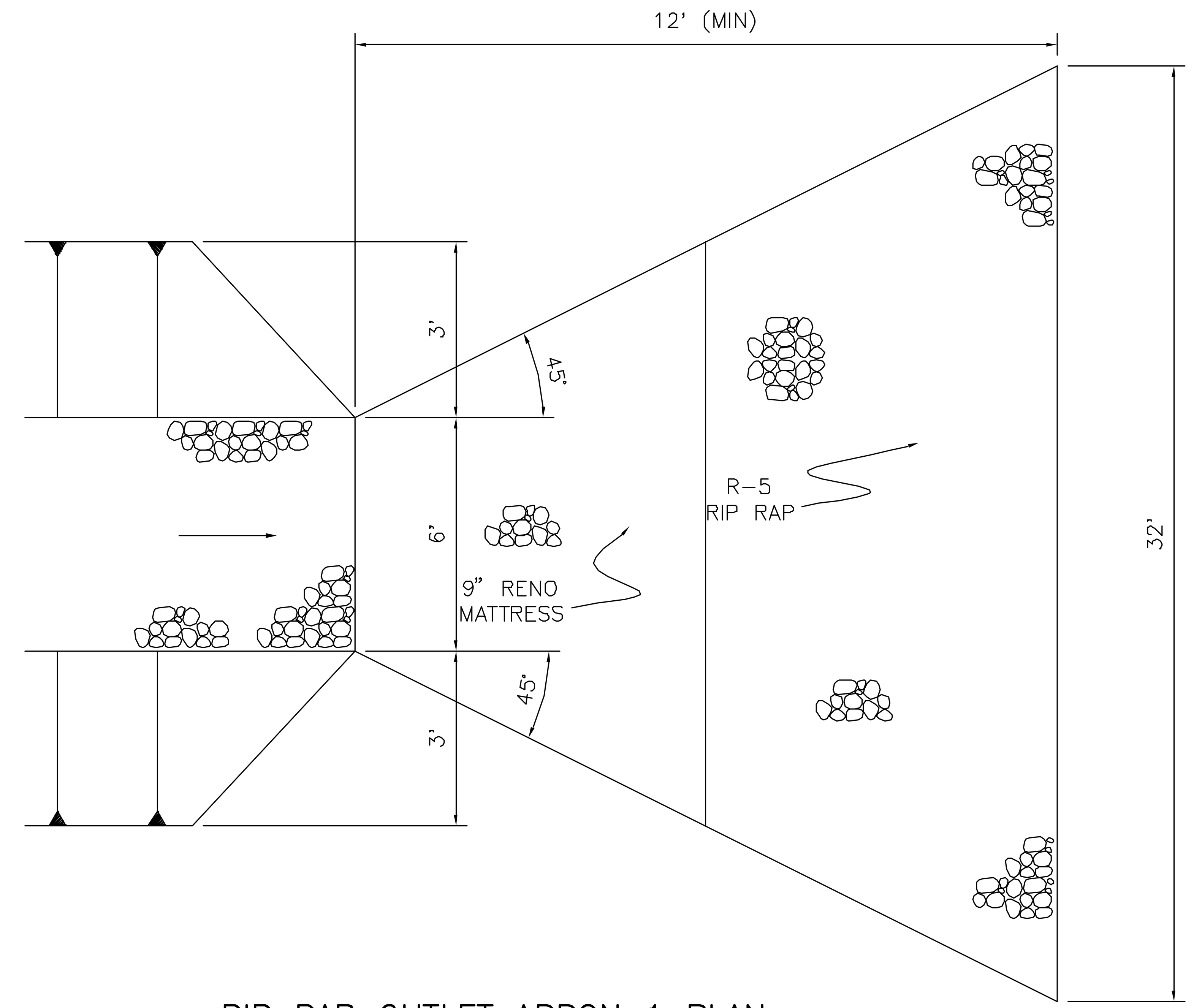
DOWNCHUTE - SECTION

DETAIL 4
N.T.S. 2002 | 2021



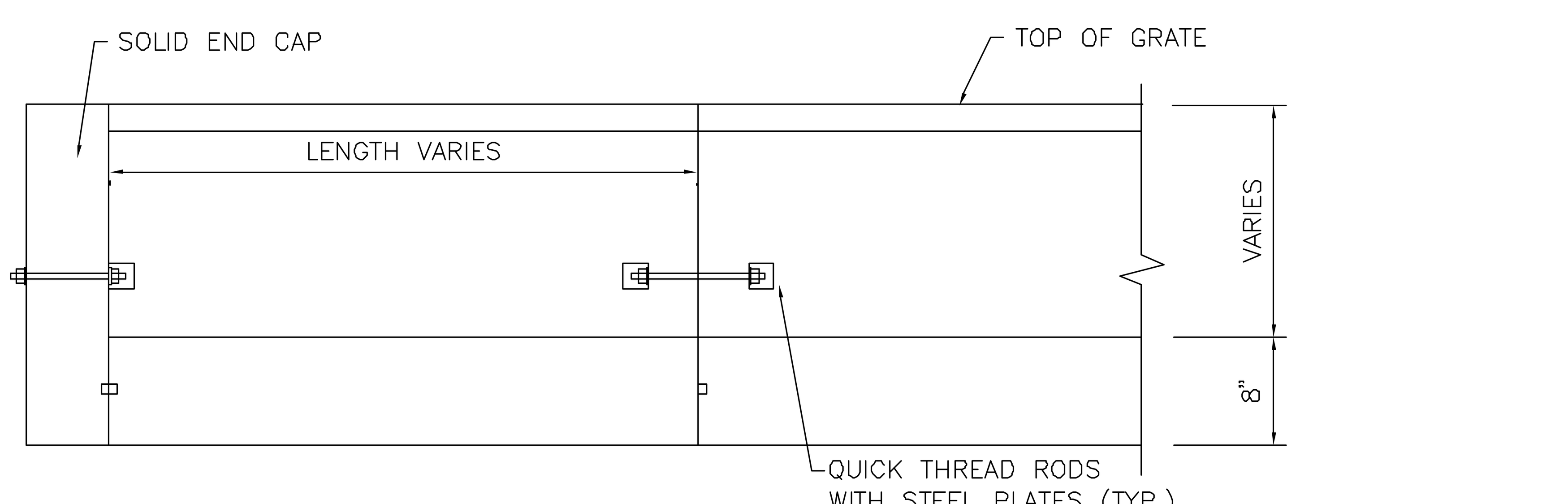
CONCRETE TRENCH TYPICAL
N.T.S.

DETAIL 3
N.T.S. 2003 | 2021



RIP RAP OUTLET APRON 1 PLAN

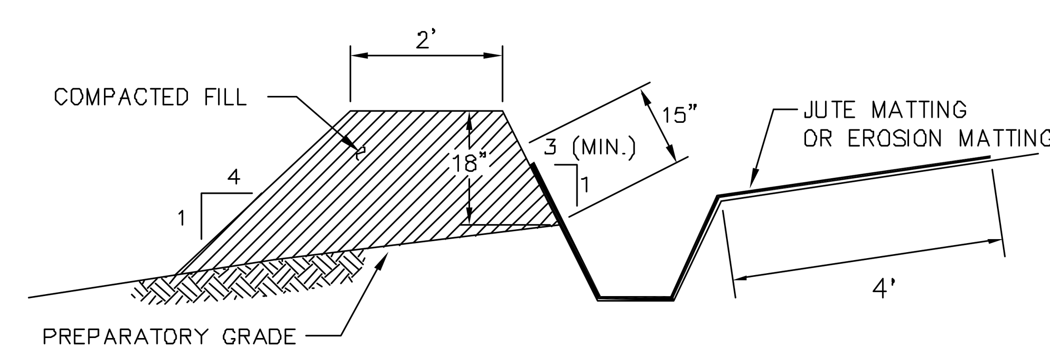
DETAIL 5
N.T.S. 2002 | 2021



SECTION B
N.T.S.

NOTES:

1. REFER TO MANUFACTURER'S INSTRUCTIONS FOR DETAILS AND INSTALLATION INSTRUCTIONS.
2. GRATES SHALL BE BOLTED TO FRAMES.
3. USE TYPE A GRATE OPENING.
4. SECTIONS CONNECTED TOGETHER WITH 3/4" QUICK THREAD RODS AND STEEL PLATES.



TEMPORARY DIVERSION BERM

DETAIL 4
N.T.S. 2018 | 2021

NOTES:

1. REFER TO DRAWING 2002 FOR DOWNCHUTE SECTION LOCATIONS.
2. FINAL GRADE DETAILS ARE SHOWN AT 3H:1V SLOPE FOR INFORMATIONAL PURPOSES ONLY. ACTUAL GRADES SHALL BE AS INDICATED ON DRAWING 2002 AND 2010.

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TA-73 AIRPORT LANDFILLS
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North Wind WESTON SOLUTIONS TEAM

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CLIENT APPROVALS

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

STORMWATER CONTROL DETAILS
SHEET 1 OF 2

DRAWN GDM | DATE 02/06/04 | DWG. NO. 2021 | REV. NO. 1
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CLIENT APPROVALS

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

STORMWATER CONTROL DETAILS
SHEET 2 OF 2

DRAWN	DATE	DWG. NO.	REV. NO.
GPL	02/06/04	2022	1
SCALE: AS SHOWN	W.O. NO.: 13104.002.001	SHT. ___ OF ___	

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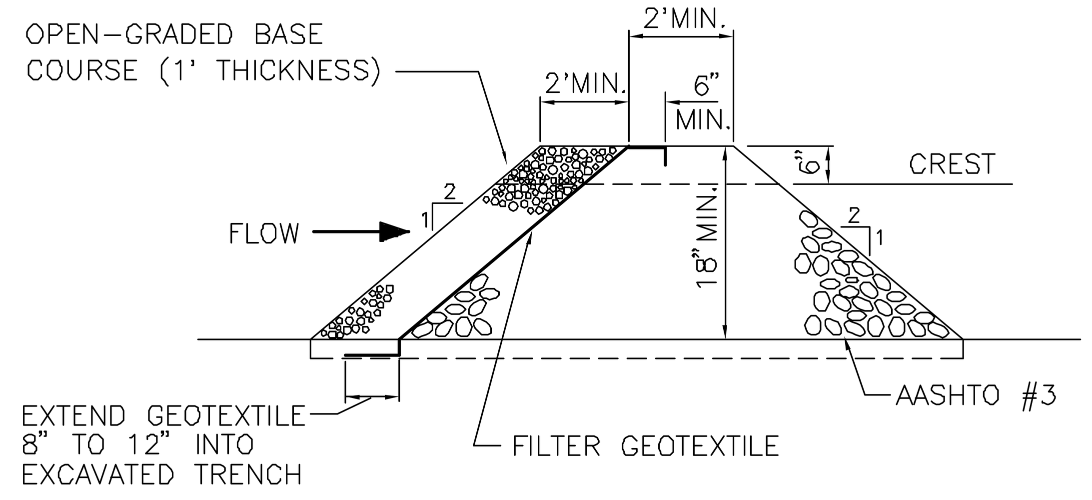
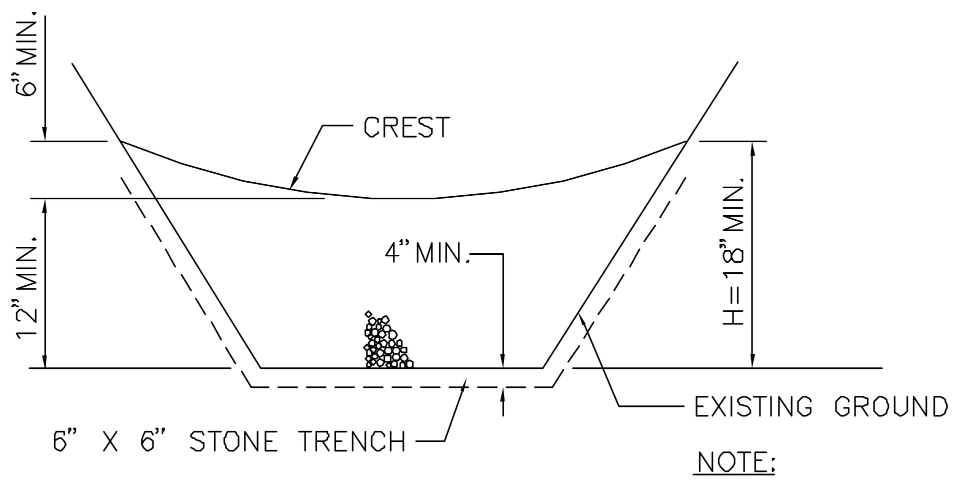


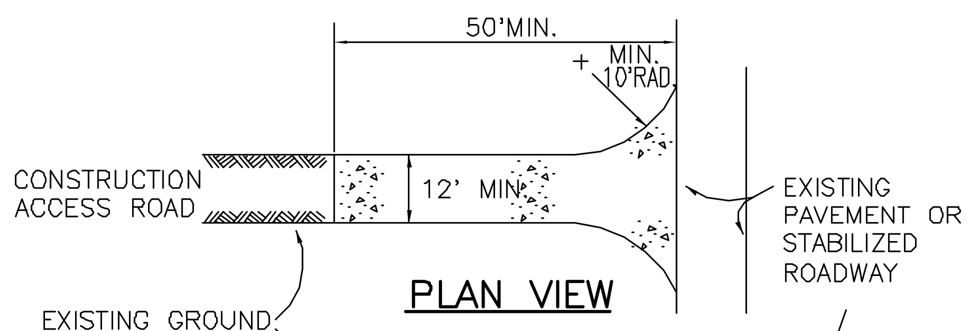
CROSS SECTION



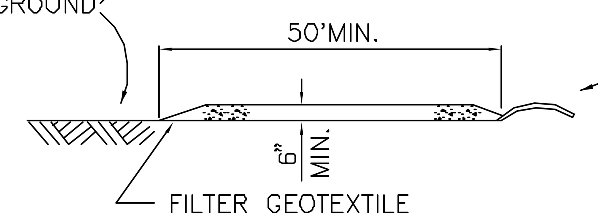
PROFILE

CHECK DAM DETAIL

NOTE:
EXTEND ROCK DAM FOR FULL WIDTH OF SWALE OR CHANNEL



PLAN VIEW

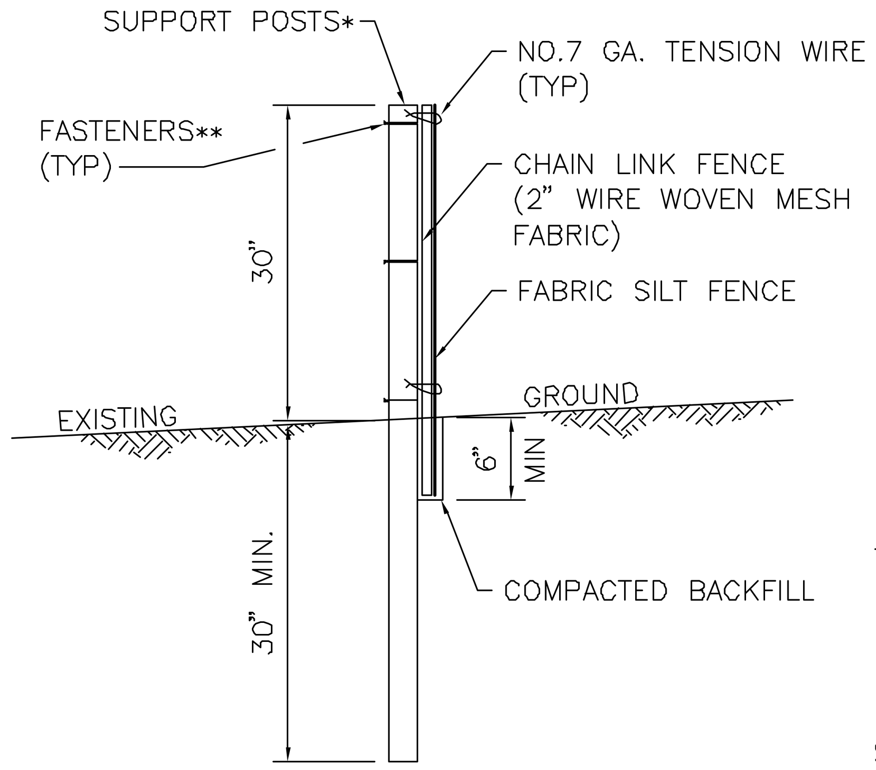


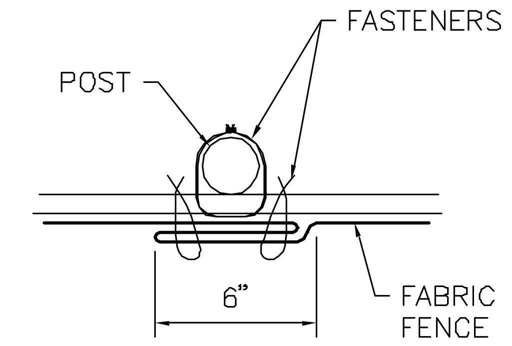
PROFILE

CONSTRUCTION ENTRANCE

CONSTRUCTION SPECIFICATIONS

1. STONE SIZE – AASHTO #3 OR RECYCLED CONCRETE EQUIVALENT
2. LENGTH – NOT LESS THAN 50 FT.
3. THICKNESS – NOT LESS THAN SIX (6) INCHES.
4. WIDTH – TWELVE (12)FT. MIN., BUT NOT LESS THAN THE FULL WIDTH AT POINTS WHERE INGRESS OR EGRESS OCCURS.
5. FILTER GEOTEXTILE – WILL BE PLACED OVER THE ENTIRE AREA PRIOR TO PLACING OF STONE.
6. MAINTENANCE – THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHTS–OF–WAY. THIS MAY REQUIRE PERIODIC TOP DRESSING WITH ADDITIONAL STONE AS CONDITIONS DEMAND AND REPAIR AND/OR CLEANOUT OF ANY MEASURES USED TO TRAP SEDIMENT. ALL SEDIMENT SPILLED, DROPPED, WASHED OR TRACKED ONTO PUBLIC RIGHTS–OF–WAY MUST BE REMOVED IMMEDIATELY AND INCORPORATED WITHIN THE FILL OPERATIONS.
7. WASHING – WHEELS SHALL BE CLEANED TO REMOVE SEDIMENT PRIOR TO ENTRANCE ONTO PUBLIC RIGHTS–OF–WAY.
8. PERIODIC INSPECTION AND NEEDED MAINTENANCE SHALL BE PROVIDED AFTER EACH RAIN.





JOINING FENCE SECTION

SILT FENCE
(SUPER SILT FENCE)
N.T.S.

* POSTS SPACED @ 10' MAX. USE 2"x2" WOOD POSTS OR 2½" DIA. GALVANIZED OR ALUMINUM POSTS.

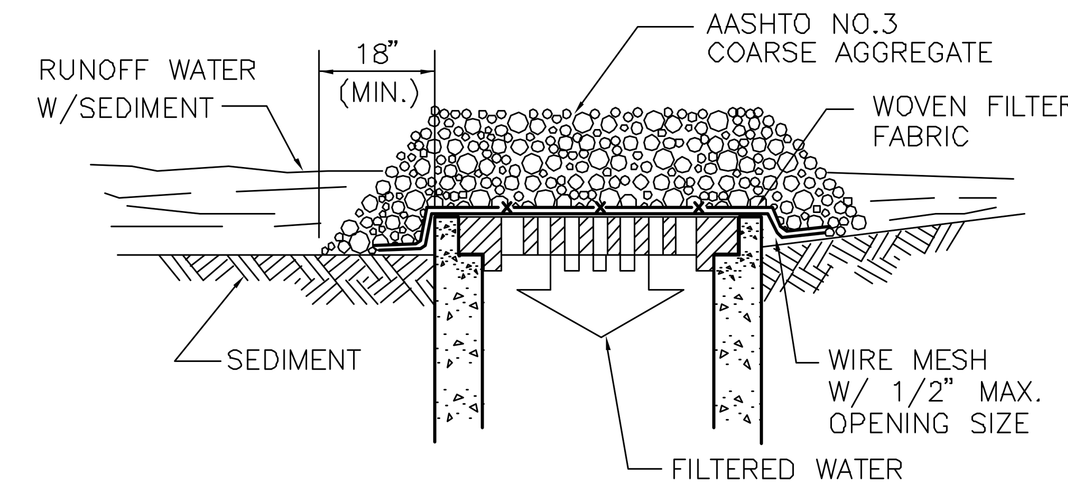
** CHAIN LINK TO POST FASTENERS SPACED @ 14" MAX. USE NO. 6 GA. ALUMINUM WIRE OR NO. 9 GALVANIZED STEEL PRE–FORMED CLIPS. CHAIN LINK TO TENSION WIRE FASTENERS SPACED @ 60" MAX. USE NO. 10 GA. GALVANIZED STEEL WIRE. FABRIC TO CHAIN FASTENERS SPACED @ 24" MAX C TO C.

NO. 7 GA. TENSION WIRE INSTALLED HORIZONTALLY AT TOP AND BOTTOM OF CHAIN–LINK FENCE.

FILTER FABRIC FENCE MUST BE PLACED AT EXISTING LEVEL GRADE. BOTH ENDS OF THE BARRIER MUST BE EXTENDED AT LEAST 8 FEET UPSLOPE AT 45° TO MAIN BARRIER ALIGNMENT.

SEDIMENT MUST BE REMOVED WHEN ACCUMULATIONS REACH ½ THE ABOVE GROUND HEIGHT OF THE FENCE.

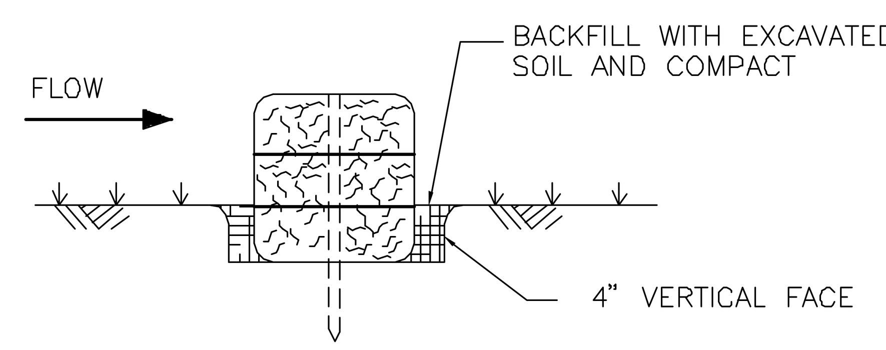
SILT FENCE MAY BE ATTACHED TO THE EXISTING OR RELOCATED/NEW CHAIN LINK FENCE PROVIDING THE REQUIRED EMBEDMENT DEPTH IS ACHIEVED.



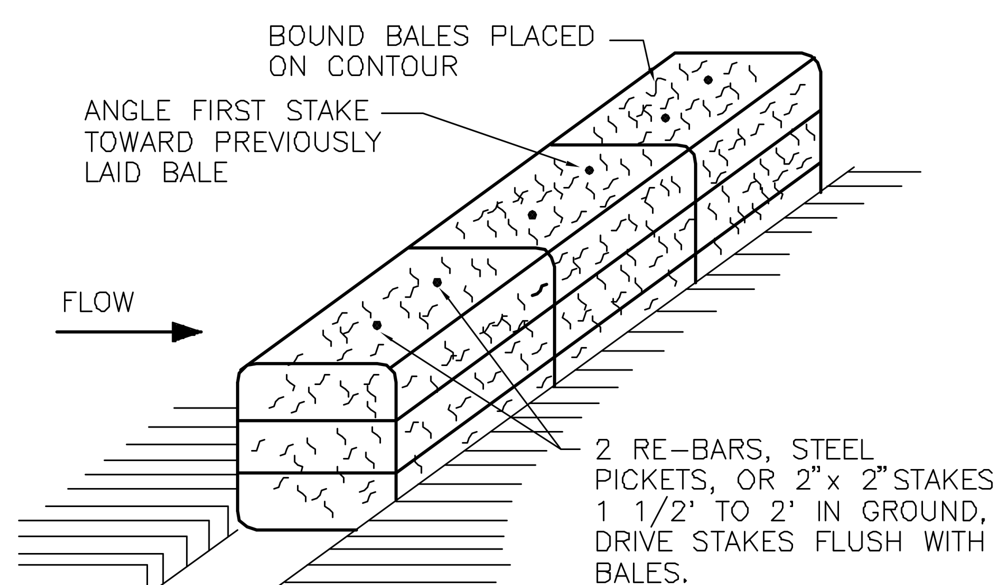
INLET PROTECTION
N.T.S.

NOTES:

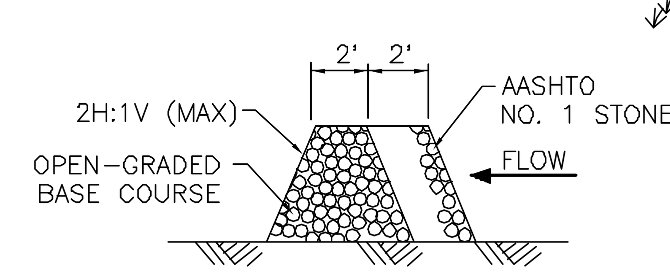
1. WIRE MESH SHALL BE LAID OVER THE INLET SO THAT THE WIRE EXTENDS TO A MINIMUM OF 1 FOOT BEYOND EACH SIDE OF THE INLET STRUCTURE. HARDWARE CLOTH OR COMPARABLE WIRE MESH WITH MAXIMUM 1/2" OPENINGS SHALL BE USED. IF MORE THAN ONE STRIP OF MESH IS NECESSARY, THE STRIPS SHALL BE OVERLAPPED 3 INCHES (MIN.).
2. AASHTO NO.3 COARSE AGGREGATE SHALL BE PLACED OVER THE WIRE MESH AS SHOWN. THE DEPTH OF STONE SHALL BE AT LEAST 12" OVER THE ENTIRE INLET OPENING. THE STONE SHALL EXTEND BEYOND THE INLET OPENING AT LEAST 18" ON ALL SIDES.
3. IF THE STONE FILTER BECOMES CLOGGED WITH SEDIMENT SO THAT IT NO LONGER ADEQUATELY PERFORMS ITS FUNCTION, THE STONES MUST BE PULLED AWAY FROM THE INLET, CLEANED AND REPLACED.
4. WOVEN FILTER FABRIC SHALL MEET THE REQUIREMENTS OF FILTER CLOTH FOR SILT FENCE.
5. IN UNPAVED AREAS, SILT FENCE OR STRAW BALES MAY BE INSTALLED AROUND THE INLET PER THE DETAILS IN LIEU OF THE GRAVEL AND WIRE MESH SEDIMENT FILTER.



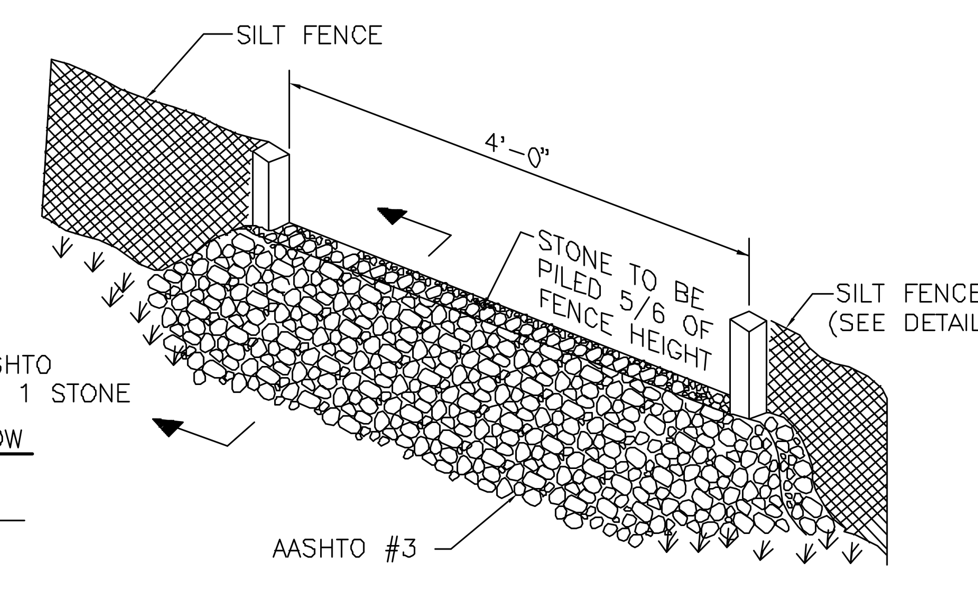
BEDDING DETAIL



ANCHORING DETAIL
STRAW BALE BARRIER



SECTION



GRAVEL OUTLET DETAIL
N.T.S.

NOTES:

1. GRAVEL OUTLETS TO BE PROVIDED AT ALL EXISTING OR GRADED LOW POINTS, EVERY 250 FEET, (UNLESS OTHERWISE NOTED) AND ALL AREAS OF POTENTIAL CONCENTRATED FLOWS.
2. IF INSPECTION OF SILT FENCE REVEALS UNDERMINING OR OVERTOPPING OF THE FENCE, REMOVE PORTION OF SILT FENCE AND REPLACE WITH A GRAVEL OUTLET.
3. ACCUMULATED SEDIMENTS WILL BE REMOVED WHEN ACCUMULATION REACH 1/3 THE ABOVE GROUND HEIGHT OF THE FENCE.

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LOS ALAMOS SITE OFFICE
TA–73 AIRPORT LANDFILLS
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North Wind WESTON SOLUTIONS TEAM

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APPROVED	BK	6/22/05
APPROVED		

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BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

EROSION AND SEDIMENTATION CONTROL DETAILS

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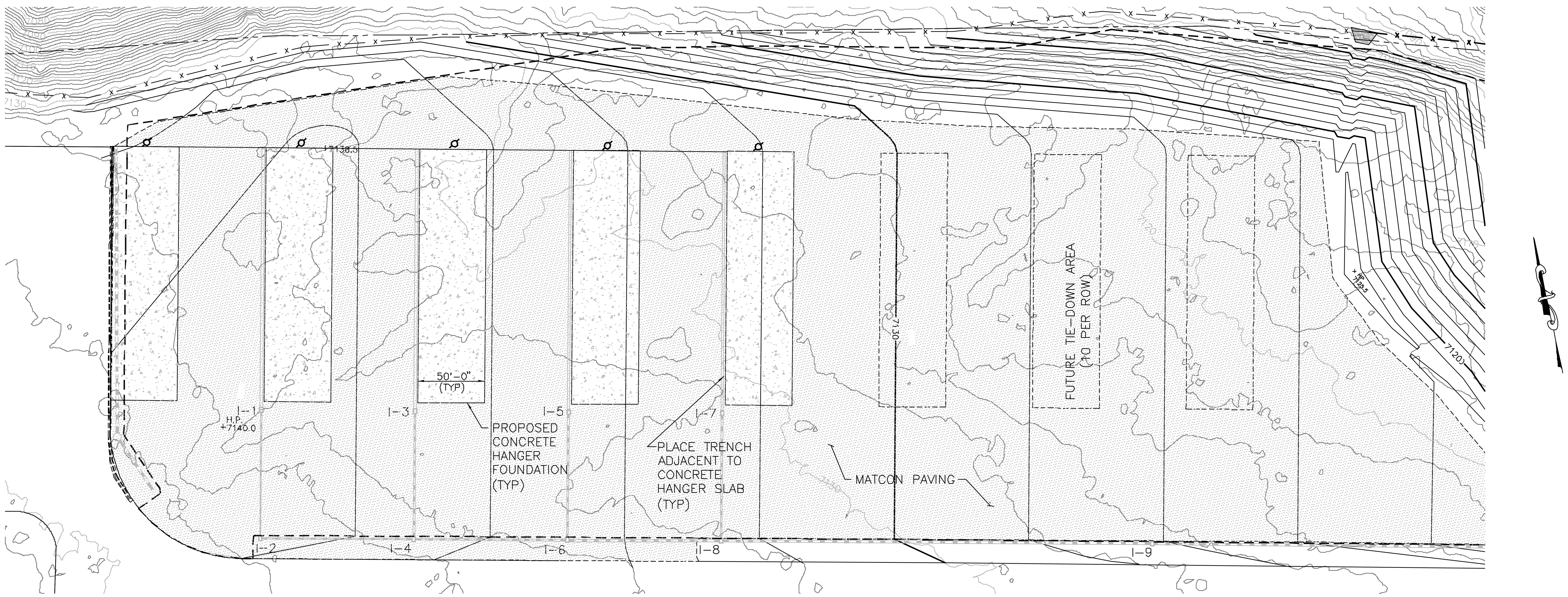
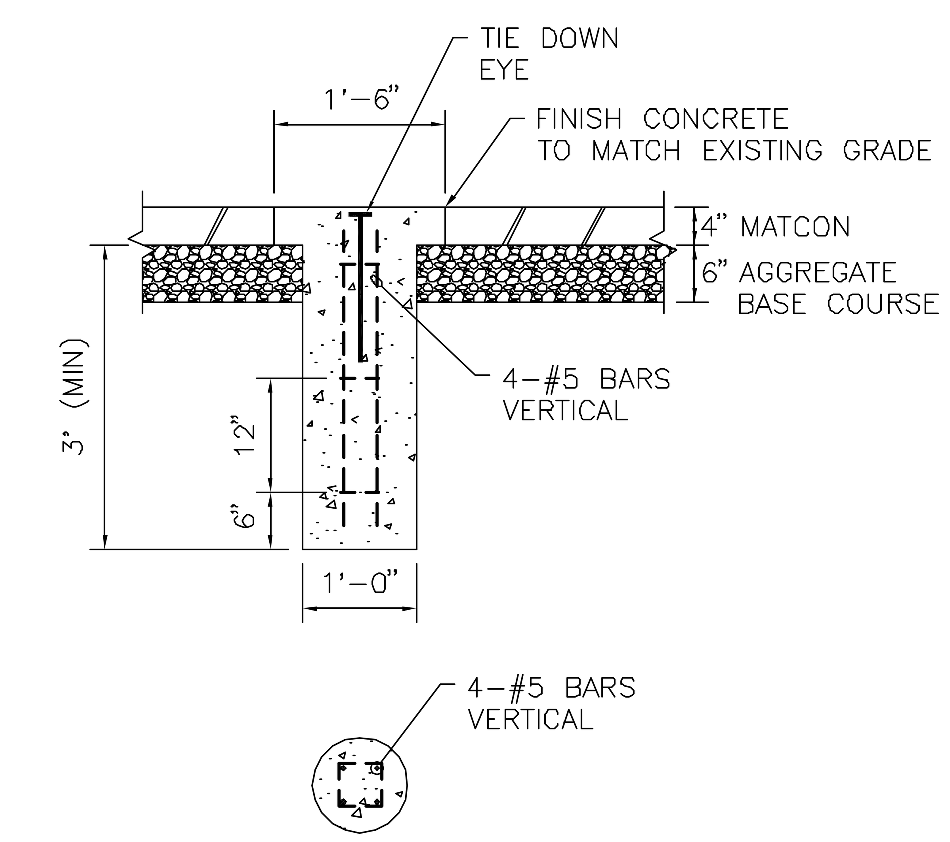


PLAN

1"=50'



TYPICAL TIE-DOWN DETAIL

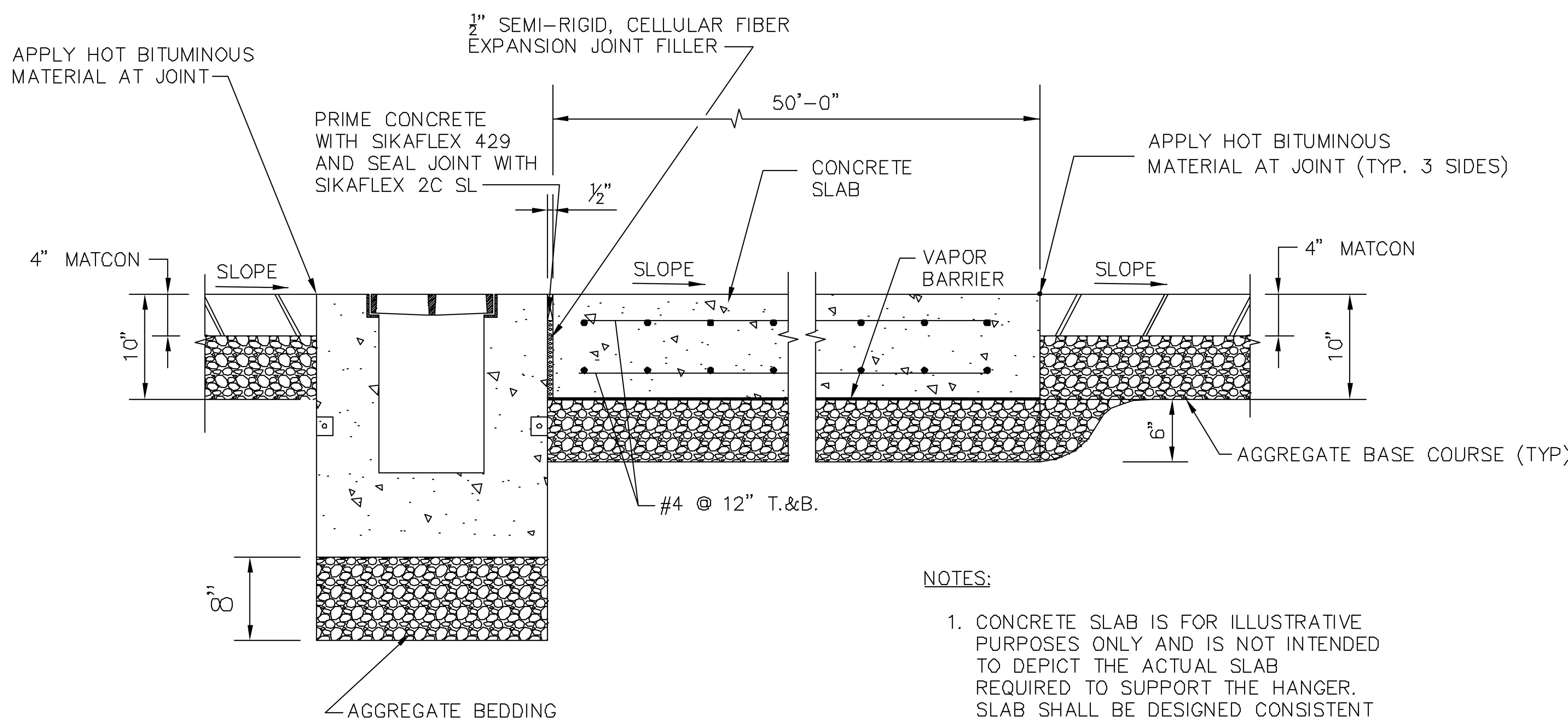
N.T.S.

NOTES:

1. CORE DRILL AN 18" DIAMETER HOLE IN THE MATCON TO FULL DEPTH OF PAVEMENT.
2. DRILL A 12" DIAMETER HOLE TO THE BOTTOM OF THE CONCRETE PIER.
3. PLACE REINFORCEMENT AND TIE-DOWN EYE IN THE HOLE AND BACKFILL WITH 3,000 PSI CONCRETE.

GENERAL NOTES:

1. INSTALL UTILITY POLES AT NORTH END OF HANGERS FOR FUTURE USE.
2. GUTTERS AND DOWNSPOUTS SHALL BE PROVIDED ON ALL HANGERS. DOWNSPOUTS ON THE WEST SIDE SHALL DISCHARGE INTO THE TRENCH DRAINS. LEADERS SHALL BE INSTALLED ON THE EAST SIDE AND SHALL DISCHARGE BEYOND THE CONCRETE/MATCON INTERFACE.
3. APPROXIMATELY 165 TIE-DOWN ANCHORS WILL BE INSTALLED. LOCATIONS WILL BE DETERMINED IN THE FIELD.

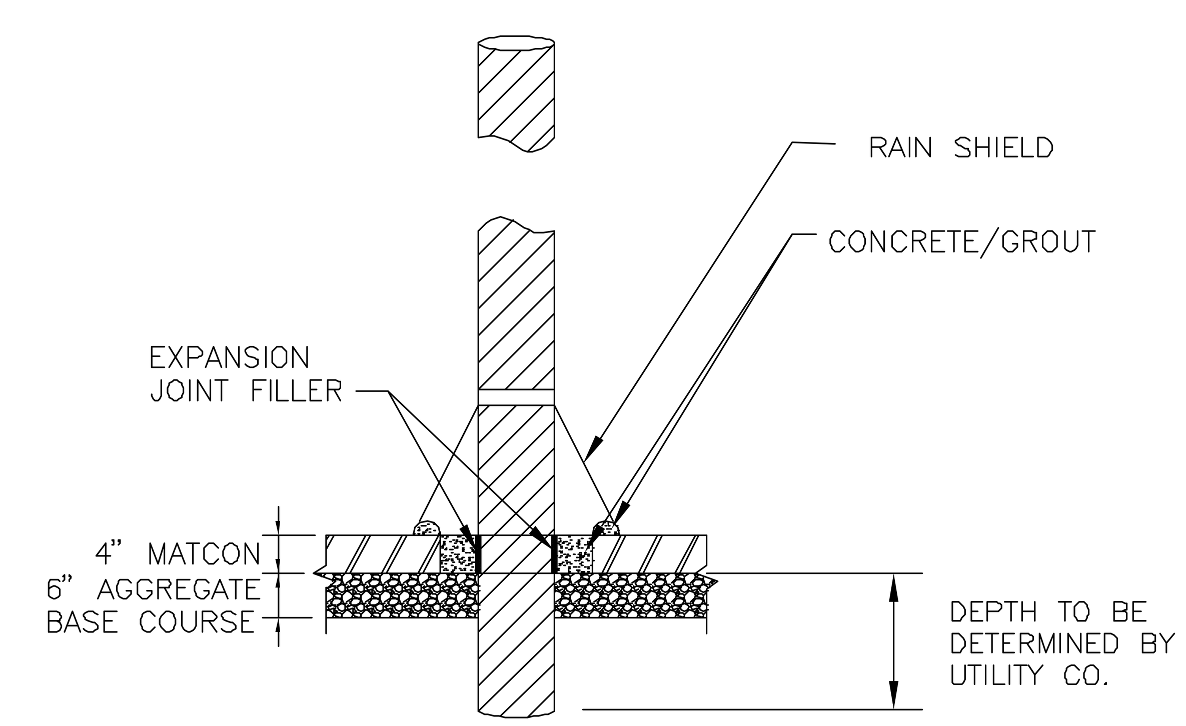


NOTES:

1. CONCRETE SLAB IS FOR ILLUSTRATIVE PURPOSES ONLY AND IS NOT INTENDED TO DEPICT THE ACTUAL SLAB REQUIRED TO SUPPORT THE HANGER. SLAB SHALL BE DESIGNED CONSISTENT WITH LOADINGS PROVIDED BY SELECTED HANGER MANUFACTURER.

TYPICAL HANGER SLAB

N.T.S.



UTILITY POLE PENETRATION DETAIL

N.T.S.

LEGEND

- PROPERTY LINE
- EXISTING FENCE
- PROPOSED FENCE
- LIMIT OF THE LANDFILL FINAL COVER SYSTEM
- 7110 EXISTING GRADE CONTOUR
- 7130 PROPOSED FINAL GRADE CONTOUR
- I-10 PROPOSED STORM SEWER INLET
- MH-1 PROPOSED STORM SEWER MANHOLE
- PROPOSED STORM SEWER CONCRETE TRENCH
- PROPOSED STORM SEWER PIPE
- PAVED AREA
- CONCRETE HANGER FOUNDATION
- UTILITY POLE

50 0 50 100

SCALE: 1"=50'

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BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

HANGER PLAN

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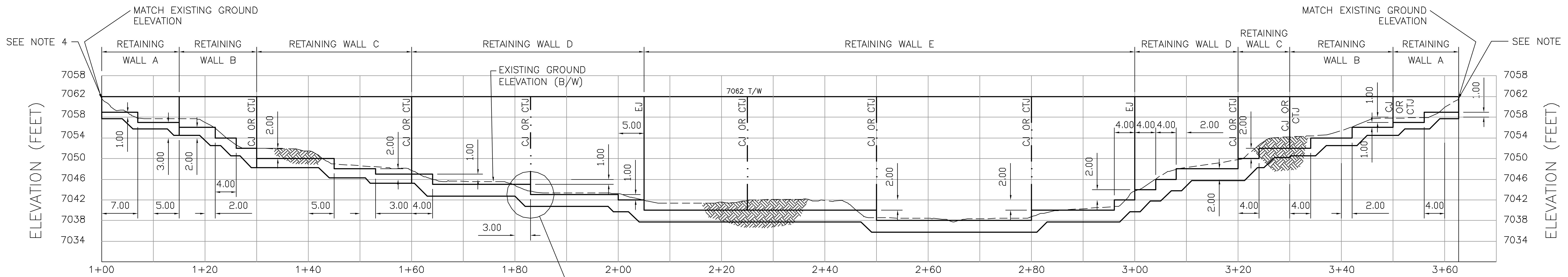
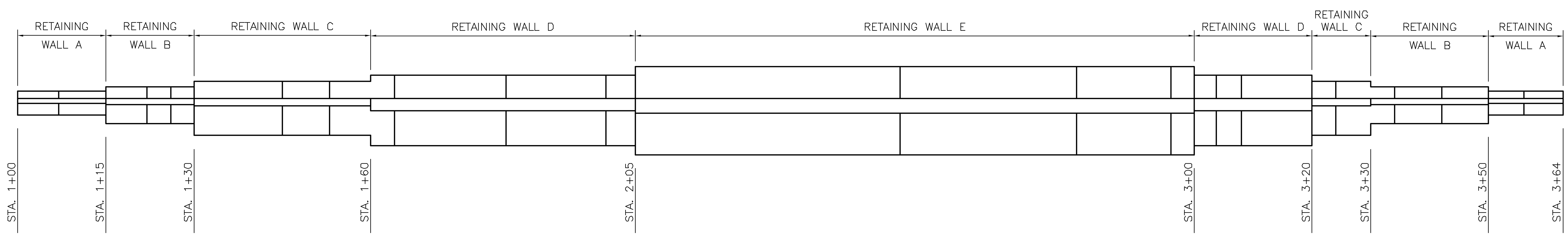


A
3000 3002

WALL 1 ELEVATION

(LOOKING WEST)
SCALE: 1"=10'



WALL 1 PLAN

SCALE: 1"=10'

NOTE:
FOR DETAILS OF RETAINING WALLS SEE DWG. 3001 & 3002

NOTES:

1. SEE DRAWING 2002 FOR SITE GRADES.
2. SEE DRAWING 2007 AND 2008 FOR GENERAL WALL ELEVATIONS AND SECTIONS.
3. SEE DRAWING 3002 FOR JOINT SYMBOLS AND DETAILS.
4. ADJUST WALL HEIGHT AND KEY INTO NATIVE GROUND/BEDROCK.
5. THE BOTTOM OF FOUNDATIONS SHALL BE CARRIED A MINIMUM OF 2 FEET INTO COMPETENT BEDROCK. IF OVER–EXCAVATION IS REQUIRED TO ACHIEVE 2 FEET EMBEDMENT INTO COMPETENT BEDROCK A LEAN CONCRETE MIX MAY BE PLACED BELOW THE DESIGN FOUNDATION BEARING LEVEL. REINFORCING BARS SHALL BE INSTALLED TO TIE THE LEAN MIX TO THE FOUNDATION AS DIRECTED BY THE ENGINEER.

   ALTERNATIVELY, IF OVER–EXCAVATION IS REQUIRED TO ACHIEVE 2 FEET EMBEDMENT INTO COMPETENT BEDROCK THE WALL HEIGHT MAY BE INCREASED AND THE APPROPRIATE WALL SECTION CONSTRUCTED AT THAT LOCATION. THE MAXIMUM WALL HEIGHT SHALL NOT EXCEED 24"–0".

10 0 10 20
HORIZ. SCALE: 1"=10'

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APPROVED		

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BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

STRUCTURAL WALL 1 PLAN AND ELEVATIONS

DRAWN	DATE	DWG. NO.	REV. NO.
JAS	02/06/04	3000	1
SCALE: AS NOTED	W.O. NO. 13104.002.001	SHT. ___ OF ___	

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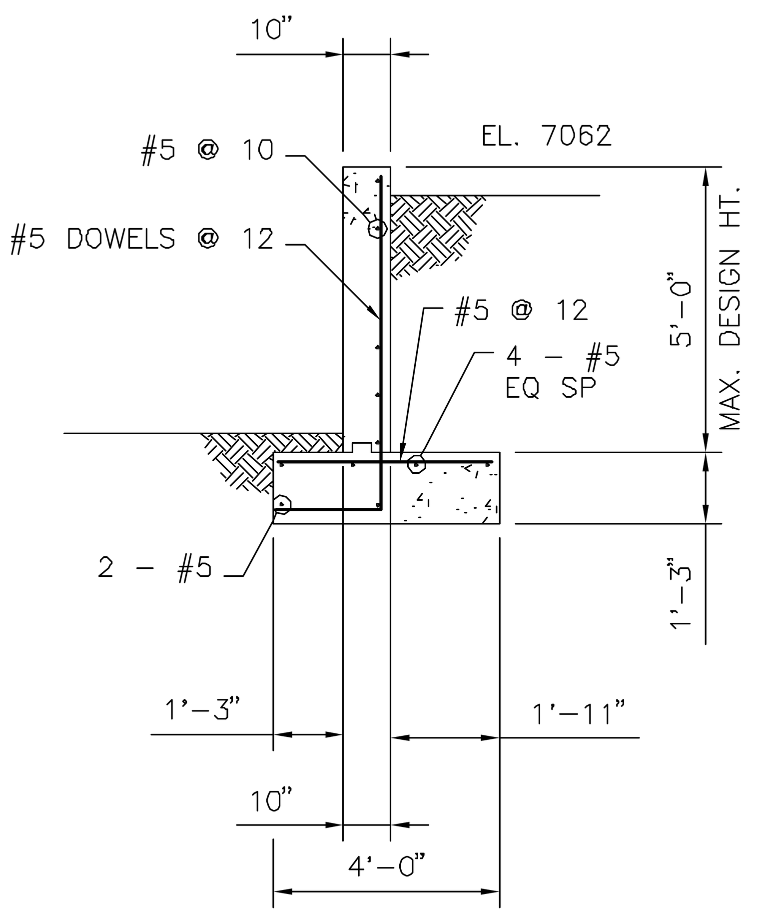
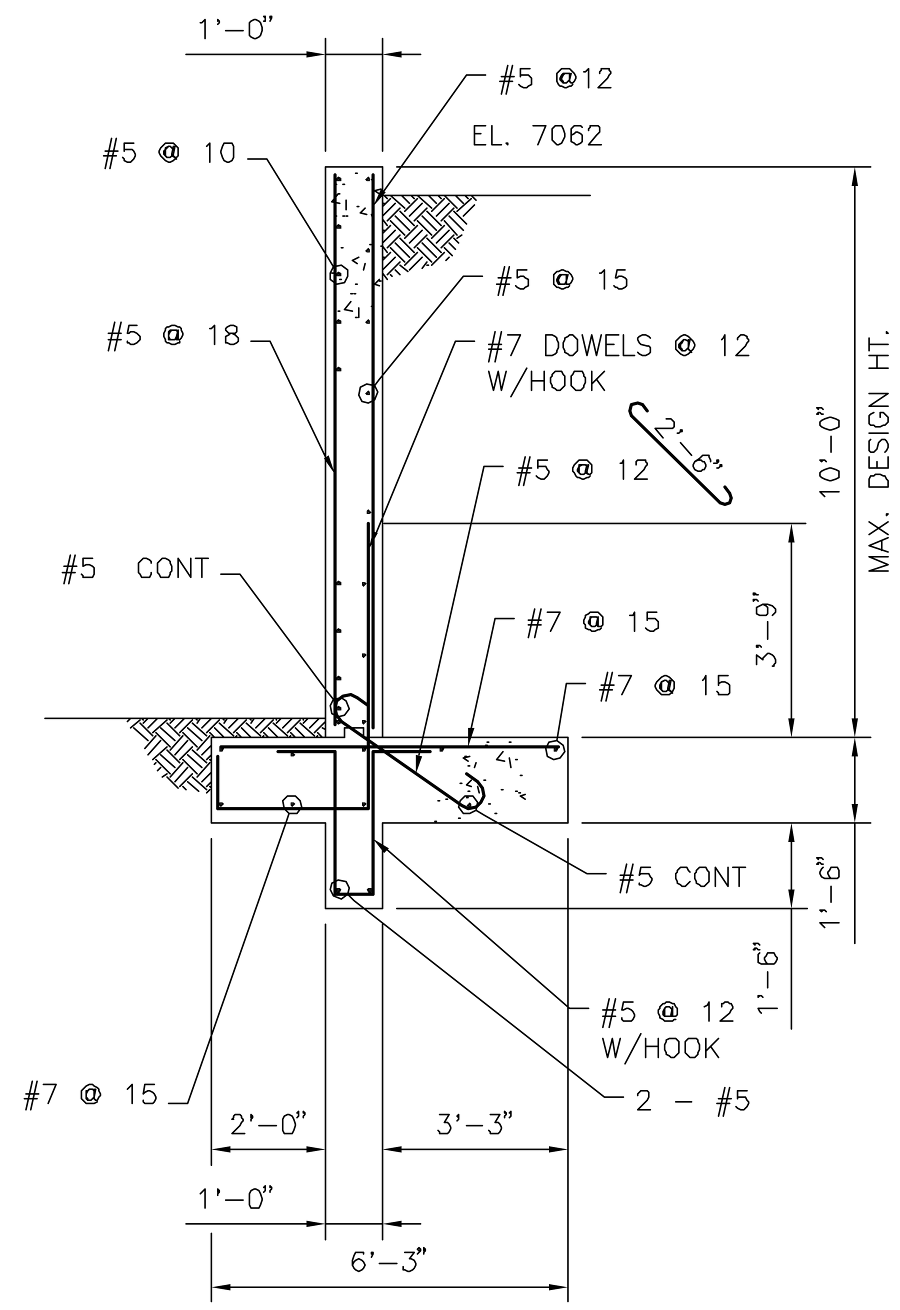


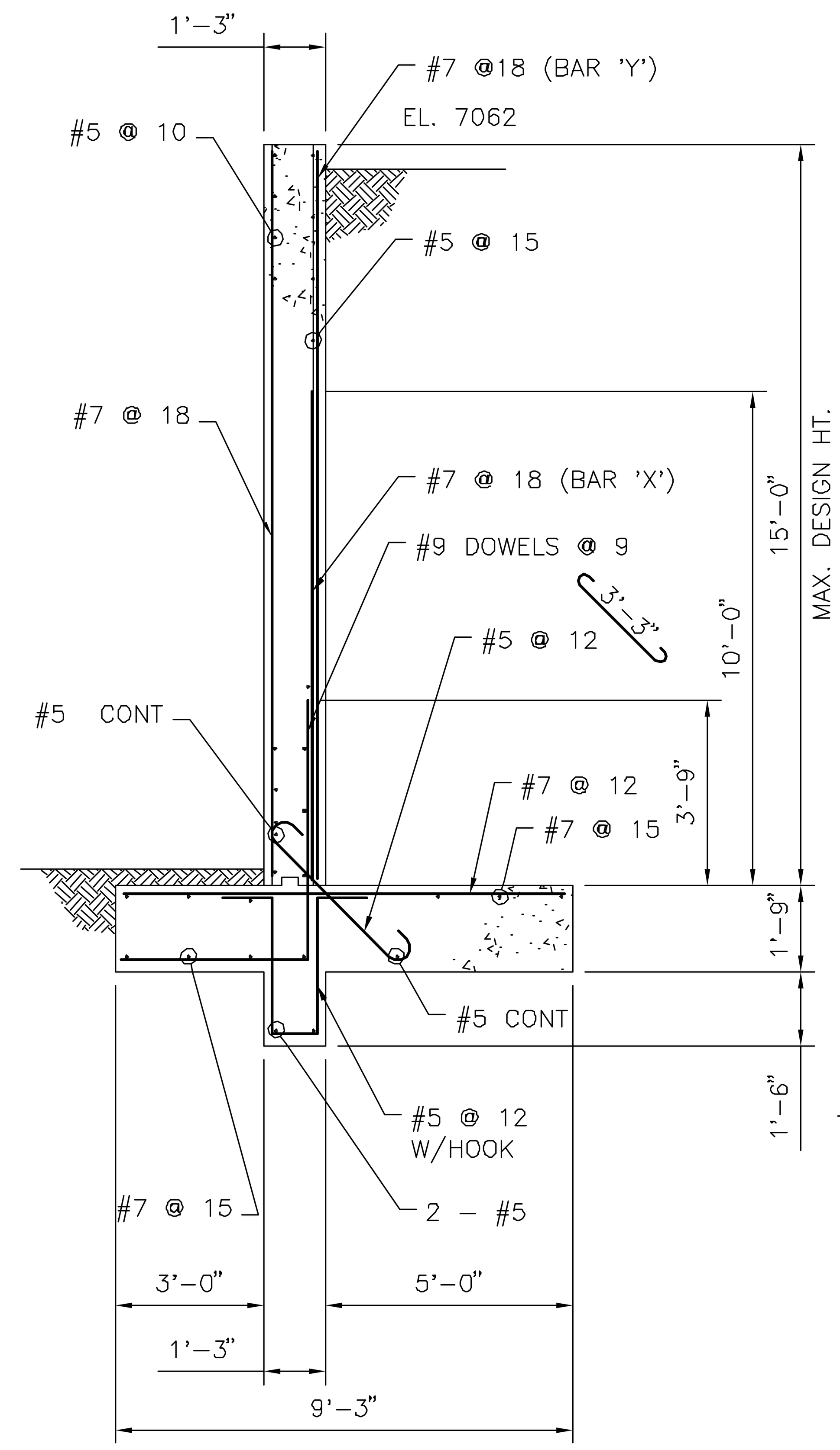
RETAINING WALL A

SCALE: 3/8"=1'–0"
SEE DWG. 3002 FOR KEY AND JOINT DETAILS



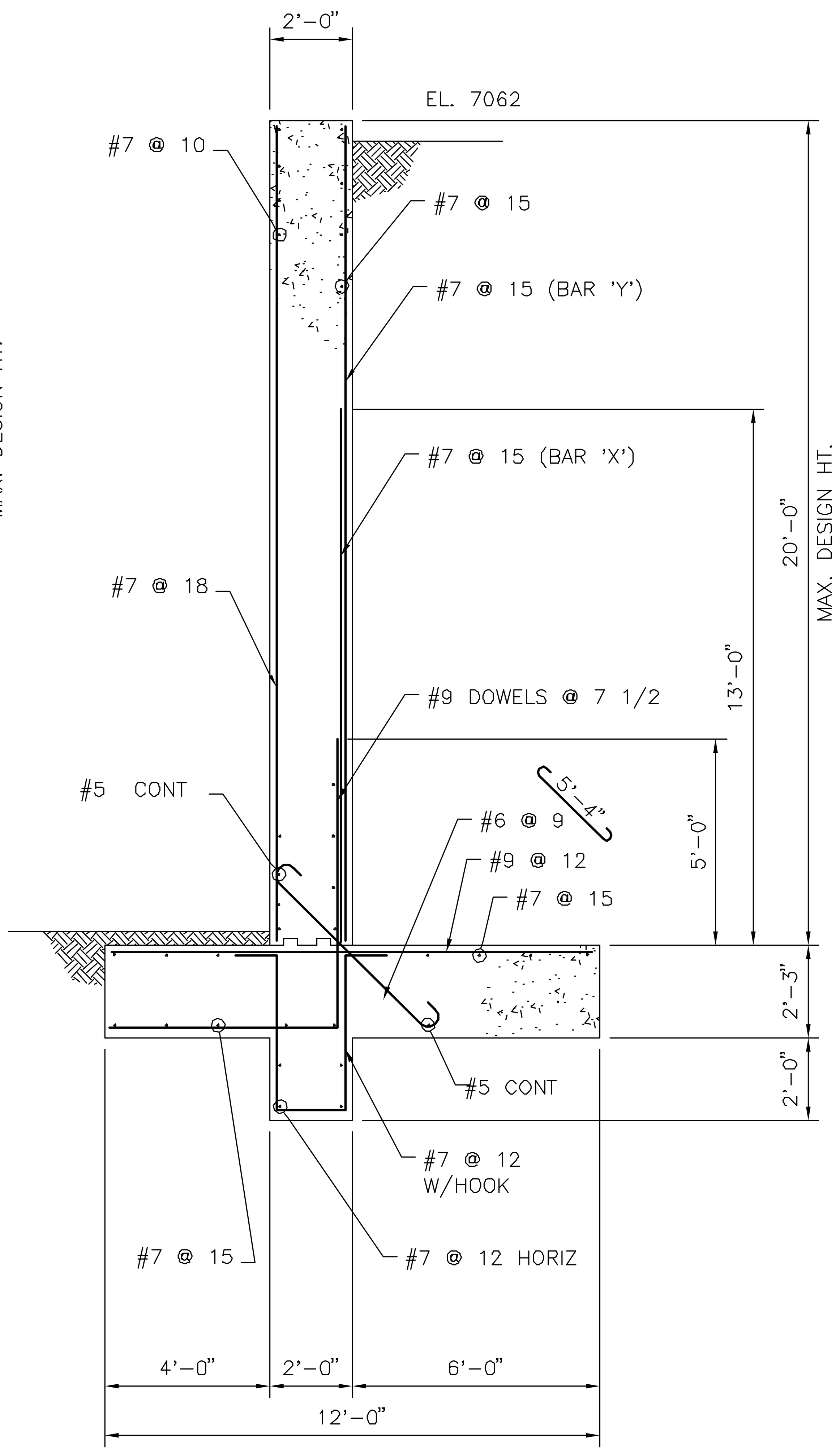
RETAINING WALL B

SCALE: 3/8"=1'–0"
SEE DWG. 3002 FOR KEY AND JOINT DETAILS



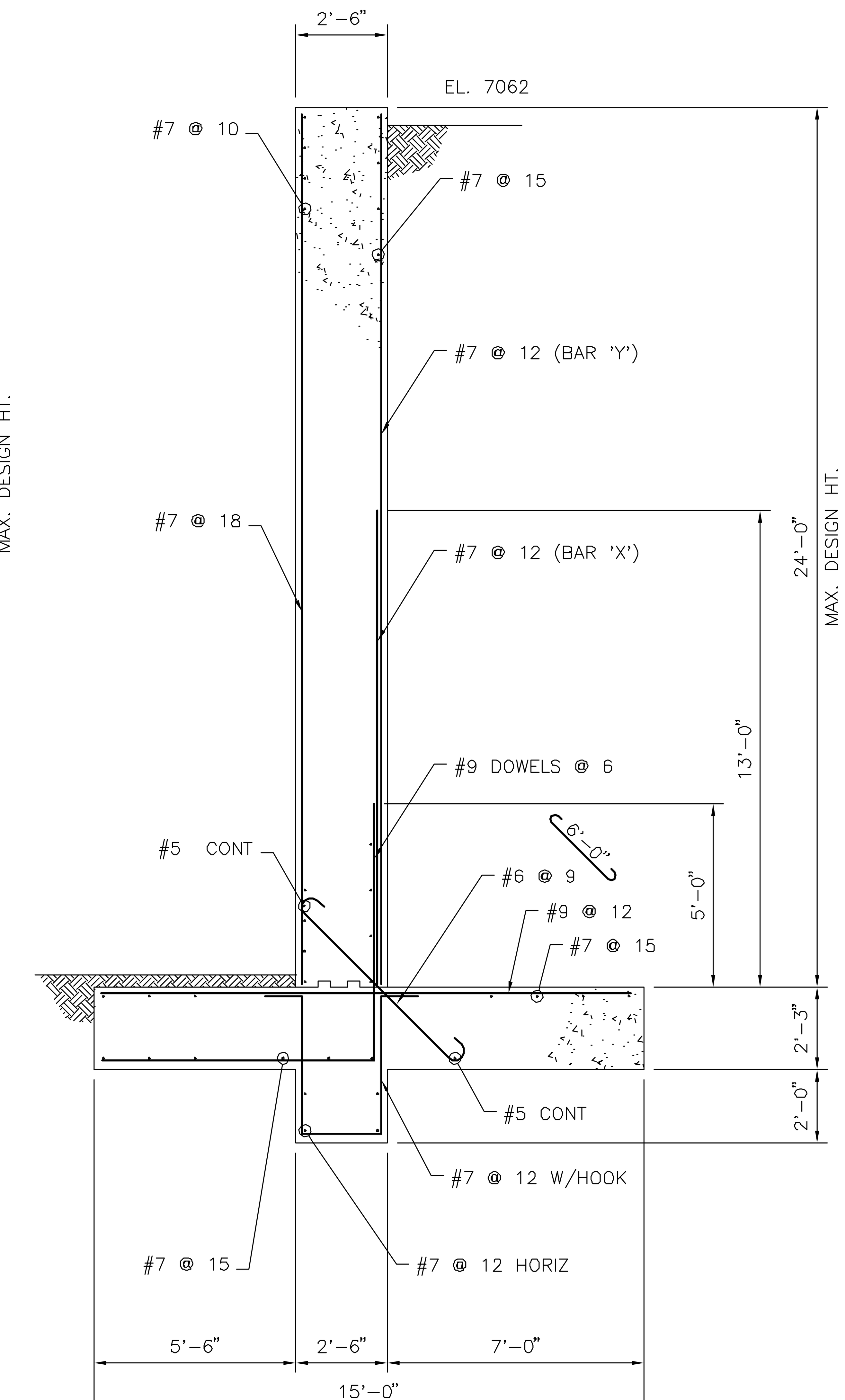
RETAINING WALL C

SCALE: 3/8"=1'–0"
SEE DWG. 3002 FOR KEY AND JOINT DETAILS



RETAINING WALL D

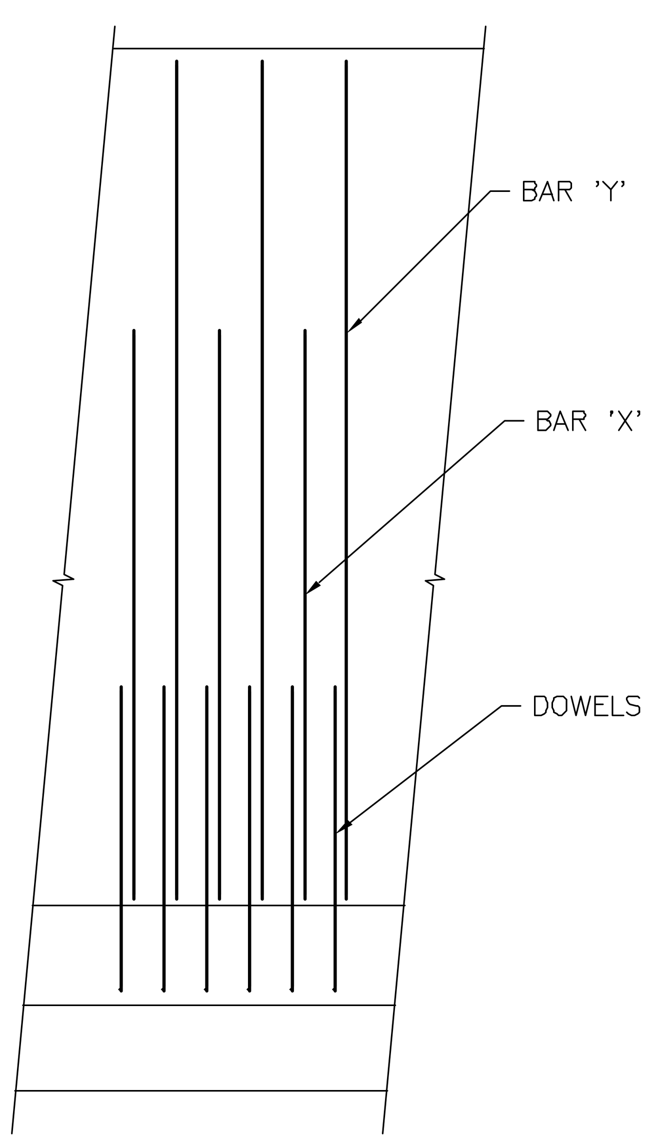
SCALE: 3/8"=1'–0"
SEE DWG. 3002 FOR KEY AND JOINT DETAILS



RETAINING WALL E

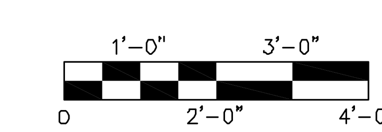
SCALE: 3/8"=1'–0"
SEE DWG. 3002 FOR KEY AND JOINT DETAILS

NOTE:
FOR ADDITIONAL RETAINING WALL DETAILS, SEE TYPICAL RETAINING WALL DETAIL, DWG. 3002.



ELEVATION BACK FACE RETAINING WALL
VERTICAL REBAR ARRANGEMENT

SCALE: NONE



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NO.	DATE	APPR.	REVISION
1	6/20/05	BK	FINAL ISSUED TO NMED FOR PERMIT REVIEW
0	6/2/05	AH	90% ISSUED TO DOE FOR REVIEW

LOS ALAMOS SITE OFFICE
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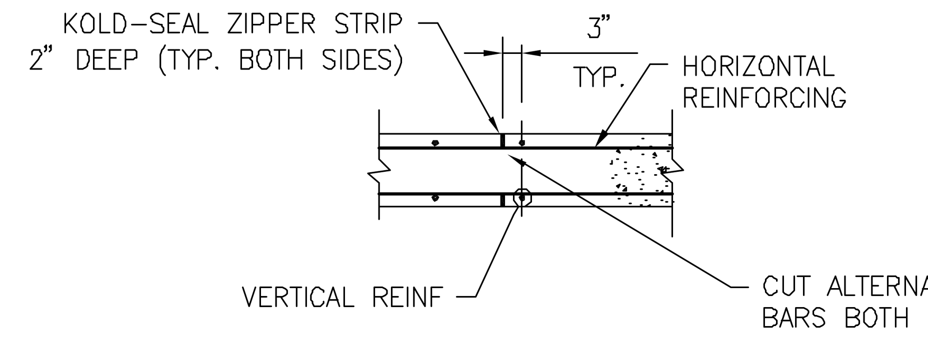
		DATE	CLIENT APPROVALS	DATE
CHECKED	JJF	6/22/05		
DES. ENG.	JJF	6/22/05		
PROJ. ENG.	AH	6/22/05		
PROJ. MGR.	BK	6/22/05		
APPROVED	BK	6/22/05		
APPROVED				

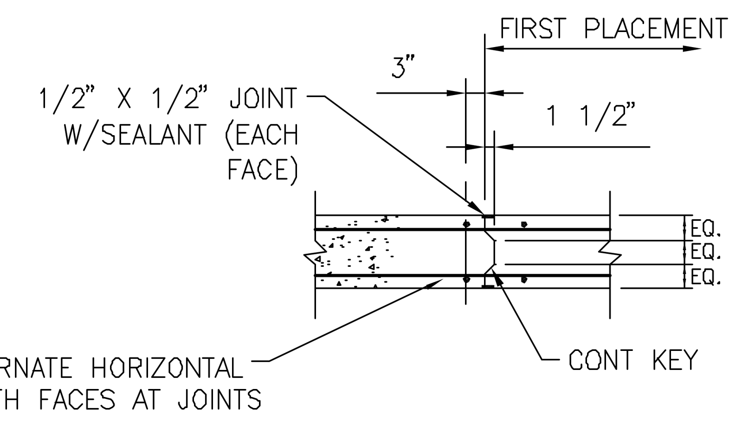
BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

STRUCTURAL WALL 1
SECTIONS

DRAWN	DATE	DWG. NO.	REV. NO.
JAS	02/06/04	3001	1
SCALE	W.O. NO.	SHT. OF	
AS NOTED	13104.002.001		



CONTRACTION JOINT (CTJ)

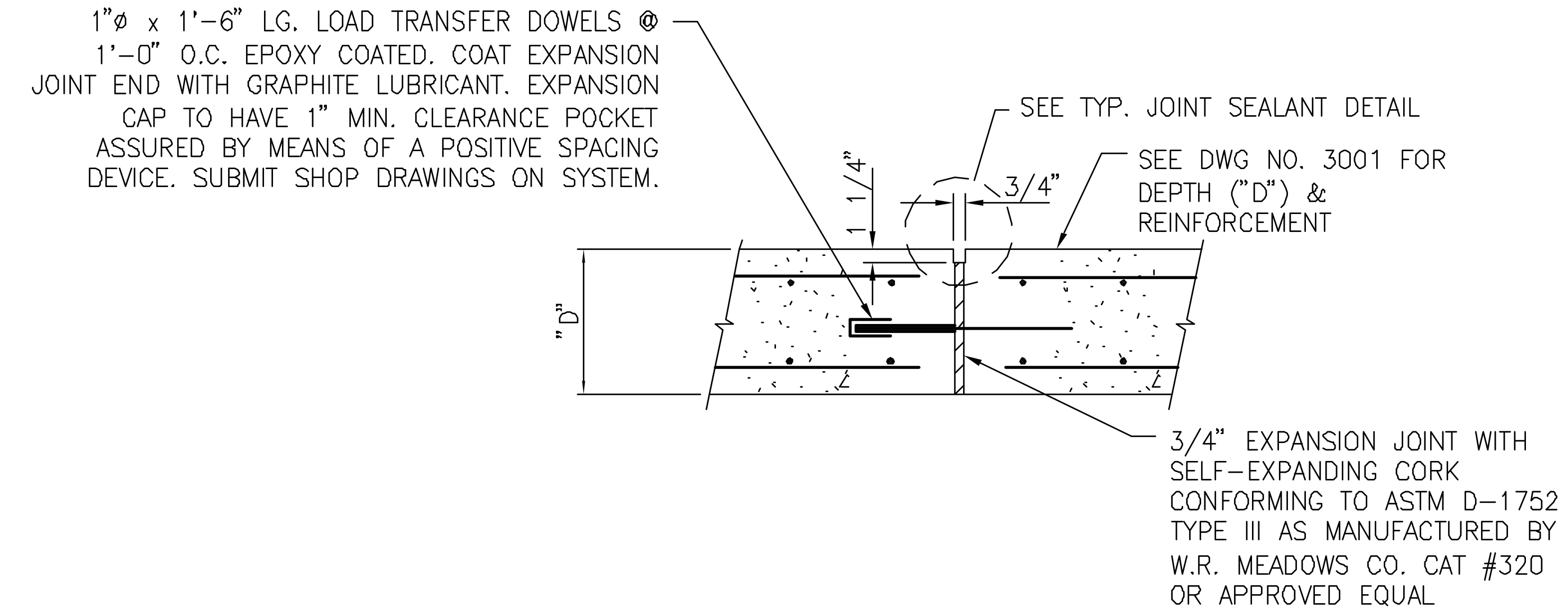


CONSTRUCTION JOINT (CJ)

VERTICAL JOINT DETAIL – CONCRETE WALL

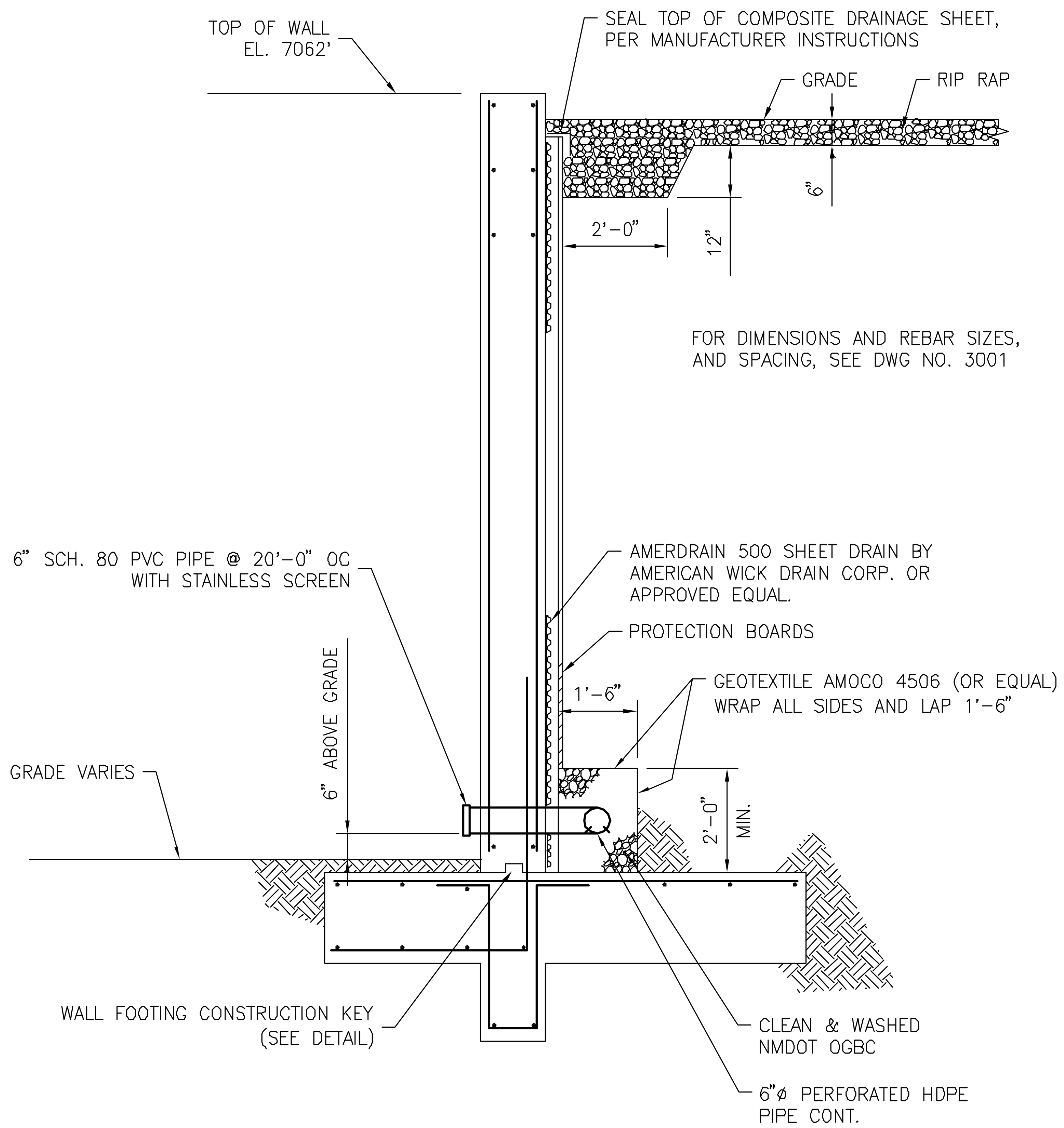
SCALE: NONE

NOTES:
1. PRIOR TO SECOND PLACEMENT OF WALL AT CONSTRUCTION JOINTS, ABRASIVE BLAST OR CHIP FIRST PLACEMENT FACE JOINT TO REMOVE LAITANCE, HONEY COMBING, ETC. CLEAN WITH WATER AND STIFF BRUSH WITH "WELD CRETE" OR EPOXY BONDING AGENT.



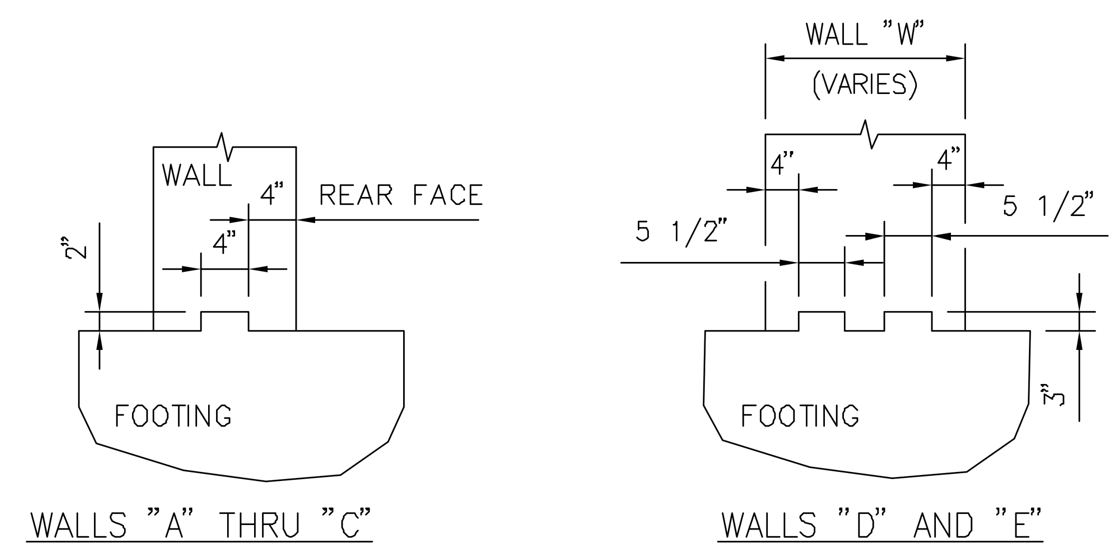
WALL CONTROL EXPANSION JOINT DETAIL (EJ)

SCALE: NONE



TYPICAL RETAINING WALL DETAIL

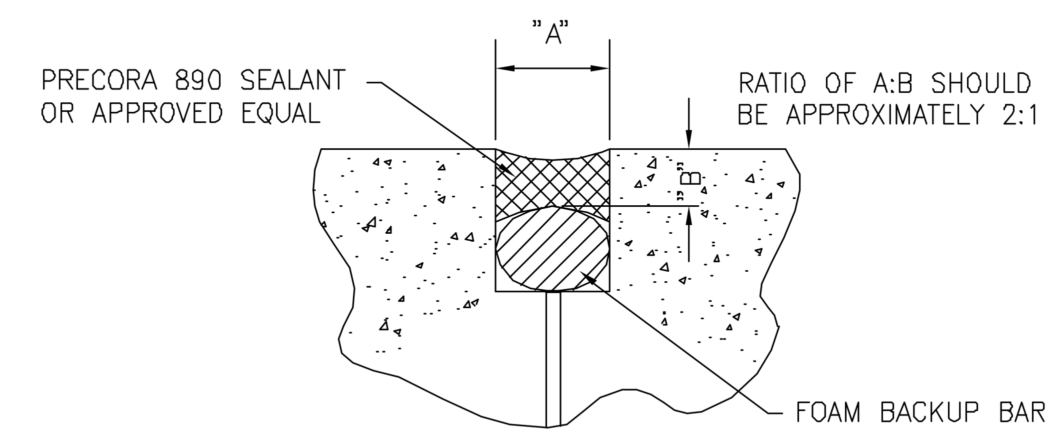
SCALE: NONE



TYPICAL WALL – FOOTING CONSTRUCTION KEYS

SCALE: NONE

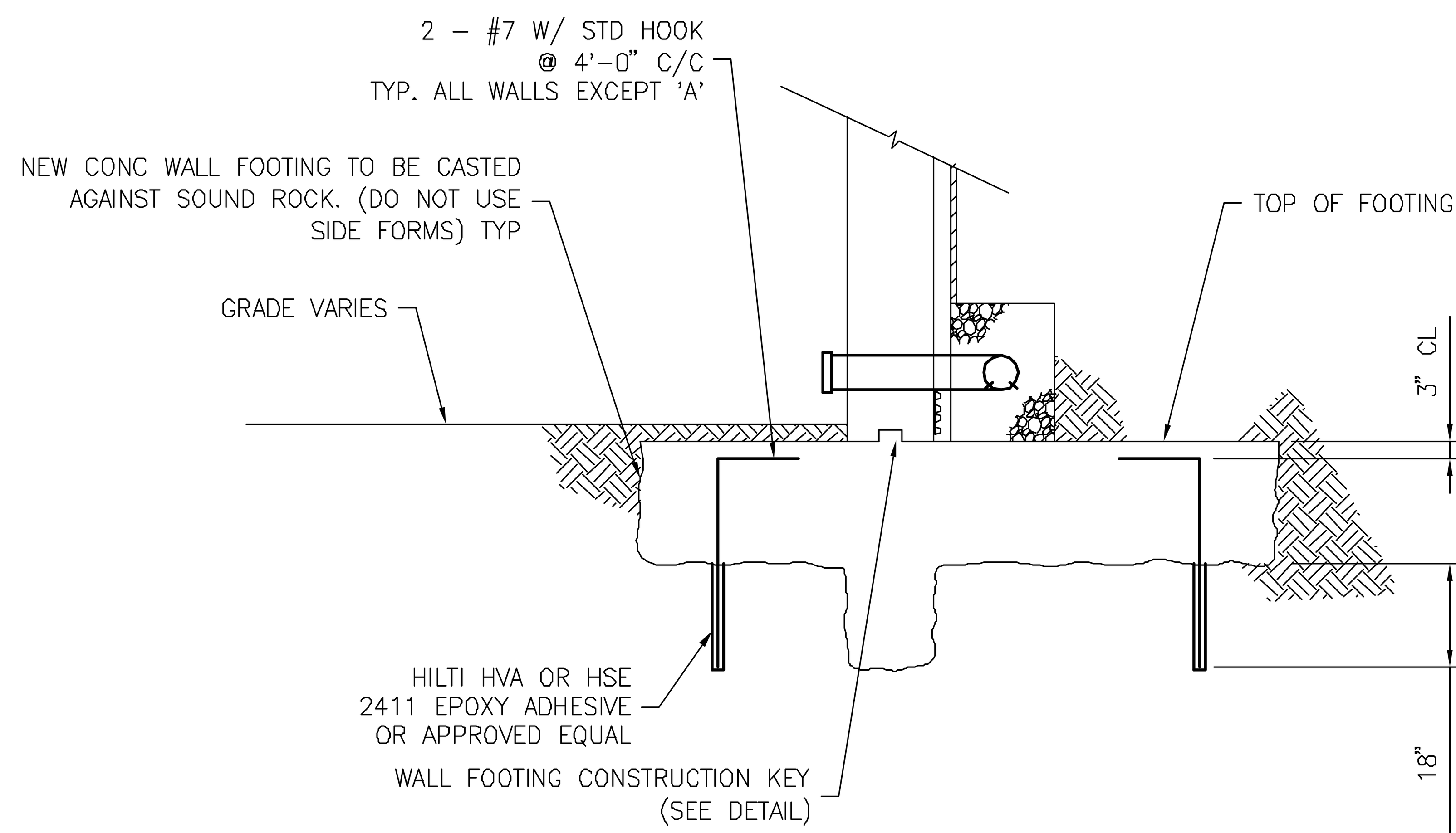
NOTES:
1. PRIOR TO SECOND PLACEMENT OF WALL AT CONSTRUCTION JOINTS, ABRASIVE BLAST OR CHIP FIRST PLACEMENT FACE JOINT TO REMOVE LAITANCE, HONEY COMBING, ETC. CLEAN WITH WATER AND STIFF BRUSH WITH "WELD CRETE" OR EPOXY BONDING AGENT.



JOINT SEALANT DETAIL

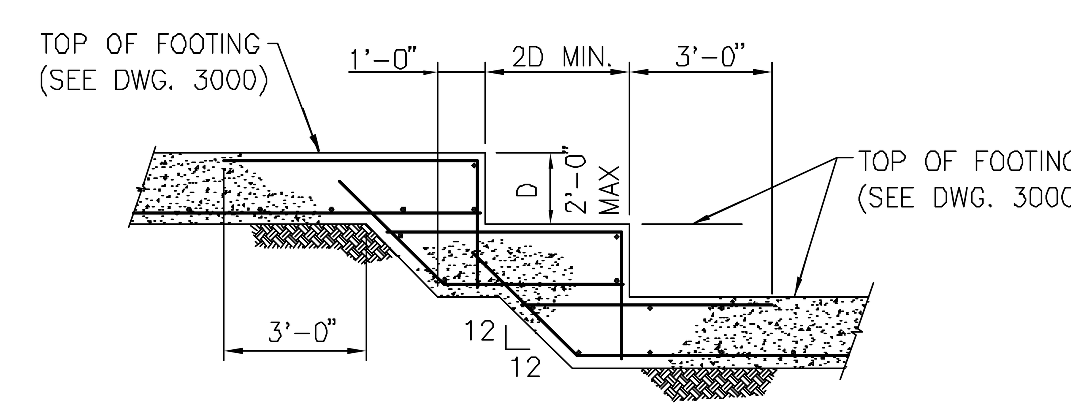
SCALE: NONE

REBAR LAP LENGTHS		
BAR SIZE	LAP LENGTH (HORIZONTAL)	LAP LENGTH (VERTICAL)
#5	3'-3"	3'-0"
#7	4'-3"	3'-9"
#9	5'-6"	4'-9"



TYPICAL FOOTING ROCK EMBEDMENT AND ANCHOR DETAIL

SCALE: NONE



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3000 3002

VERTICAL JOINT DETAIL CONCRETE WALL

SCALE: NONE

NOTES:

DESIGN CRITERIA:

1.0 THE RETAINING WALL WAS DESIGN IN ACCORDANCE WITH IBC 2003, ASCE 7-02, AND ACI 318-02.

2.0 SECISMIC DESIGN CRITERIA:

2.1 SEISMIC USE GROUP: I
2.2 SEISMIC DESIGN CATEGORY: C
2.3 SDS = 0.40 (SHORT PERIOD)
2.4 SD1 = 0.12 (1 SEC. PERIOD)
2.5 SOIL SITE CLASS: B

CONCRETE NOTES:

1.0 CONCRETE & REINFORCEMENT STEEL

1.1 CONSTRUCTION SHALL CONFORM TO AMERICAN CONCRETE INSTITUTE (ACI) CODE 318-02.
1.2 CONCRETE STRENGTH SHALL BE A MINIMUM OF 3,000 P.S.I. (28 DAY COMPRESSIVE STRENGTH).
1.2.1 MAXIMUM WATER CEMENT RATIO 0.46 (lbs/lbs)
1.2.2 CEMENT FACTOR (BAGS/C.Y.) MIN. 7.00
1.2.3 SLUMP RANGE (INCHES) 1-3
1.2.4 ALL CONCRETE SHALL BE AIR ENTRAINED, AND SHALL HAVE AN AIR CONTENT OF 6% +/- 1%.
1.3 ALL EXPOSED CONCRETE SHALL HAVE AN "EARTH TONE" COLOR. SUBMIT SAMPLES FOR APPROVAL.

2.0 REINFORCEMENT SHALL BE NEW DEFORMED STEEL BARS HAVING A MINIMUM YIELD STRESS OF 60,000 P.S.I., IN ACCORDANCE WITH LATEST ASTM SPECIFICATION A615, GRADE 60, AND SUPPLEMENT S-1.

3.0 CONCRETE PROTECTION (COVER) FOR REINFORCEMENT SHALL BE AS FOLLOWS:

3.1.1 CAST AGAINST EARTH : 3 INCHES
3.1.2 FORMED SURFACE TO BE EXPOSED TO FLUID OR IN CONTACT WITH EARTH: 2 INCHES

4.0 AT SPLICES, BARS ARE TO BE LAPPED IN ACCORDANCE WITH ACI 318-02 AND THE TABLE SHOWN ON THIS DRAWING.

5.0 CONCRETE SHALL BE WET CURED FOR A MINIMUM OF SEVEN (7) DAYS. (THE USE OF AN APPROVED LIQUID MEMBANE-FORMING CURING COMPOUND IS PERMITTED).

6.0 THE PROTECTION OF CONCRETE DURING PLACEMENT IN EITHER COOL AND COLD WEATHER, OR HOT WEATHER SHALL MEET THE MINIMUM REQUIREMENTS OF ACI 318-02.

7.0 DO NOT BACKFILL UNTIL CONCRETE HAS CURED A MINIMUM OF SEVEN (7) DAYS. CONFIRM CONCRETE STRENGTH BY BREAK TEST.

GEOTECHNICAL NOTES:

1.0 ALL EXCAVATIONS SHALL BE COMPLETED IN COMPLIANCE WITH OSHA REQUIREMENTS FOR EXCAVATION (29 CFR PART 1926 SUBPART B).

2.0 THE BOTTOM OF FOUNDATIONS SHALL BE CARRIED A MINIMUM OF 2'-0" INTO COMPETENT ROCK.

3.0 BACKFILL SHALL BE PLACED AND COMPACTED IN ACCORDANCE WITH THE REQUIREMENTS OF SPECIFICATION SECTION 02200.

TOPOGRAPHICAL NOTES:

1.0 ALL DIMENSIONS AND GRADES SHOWN ON THE DRAWINGS SHALL BE FIELD VERIFIED PRIOR TO START OF CONSTRUCTION.

NOT FOR CONSTRUCTION

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APPROVED	BK	6/22/05
APPROVED		

CLIENT APPROVALS DATE

BERG KESHIAN, JR. NEW MEXICO 8590 LICENSED PROFESSIONAL ENGINEER

STRUCTURAL WALL I DETAILS

DRAWN JAS DATE 02/06/04 DWG. NO. 3002 REV. NO. 1
SCALE AS NOTED W.O. NO. 13104.002.001 SHT. OF

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