AECOM Environment

Submitted to:
Colorado Springs Utilities
Colorado Springs, CO

Submitted by:
AECOM
Fort Collins, Colorado
60729498
November 8, 2024

Coal Combustion Residuals (CCR) Landfill Closure Plan
Clear Spring Ranch
El Paso County, Colorado

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Clear Spring Ranch
El Paso County, Colorado

Prepared By
Olivia Helinski, Environmental Engineer

Reviewed By
Amber Cooper, Project Engineer

Approved By
Patrick Clem, Project Manager

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List of Acronyms

CCR	coal combustion residuals
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
cm/sec	centimeters per second
CQA	Construction Quality Assurance
CQAP	Construction Quality Assurance Plan
CSR	Clear Spring Ranch
CSU	Colorado Springs Utilities
CYs	cubic yards
EDOP	Engineering Design and Operations Plan
GP1 Monofill	Gravel Pit #1 Water Treatment Plant Residuals Monofill
HDPE	high-density polyethylene
H:V	horizontal to vertical
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
SWDA	Grit Solid Waste Disposal Area
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
Utilities	Colorado Springs Utilities

1.0 Introduction

This Closure Plan has been prepared on behalf of Colorado Springs Utilities (Utilities) to meet the Coal Combustion Residuals (CCR) Regulations (CCR Rule) as detailed in 40 Code of Federal Regulations (CFR) 257.102. The CCR Landfill (or "the site") currently operates under the Closure Plan dated October 2016 (AECOM, 2016). Historically, the site has received CCR from the Martin Drake and Ray Nixon Power Plants; however, the Martin Drake Power Plant was decommissioned in 2021 and the Ray Nixon Power Plant is projected to close in approximately 2029. To account for these closures and the change in expected CCR volume, Utilities prepared a Final 30% Design Package for the redesign of the CCR Landfill in December 2023 (**Appendix A**). This Closure Plan will account for the change in expected CCR volume and reflect the details of the redesign. Closure of the CCR Landfill will be completed by leaving the CCR in place and installing a final cover system as required by the regulations. This section discusses site background, regulatory drivers, and purpose.

1.1 Background

Clear Spring Ranch (CSR) is a 4,759-acre property located at the intersection of Interstate 25 and Ray Nixon Road, approximately 17 miles south of Colorado Springs (**Figure 1**). It was acquired in 1972 by the City of Colorado Springs on behalf of its enterprise Colorado Springs Utilities. The primary land uses on the CSR property are those related to utility services: electric generation & transmission, water / wastewater treatment & delivery, and waste management. Power generation at Utilities' Ray Nixon Power Plant produces CCR. Utilities places these residuals in the CCR Landfill (or "the site") located in the southern part of CSR. Utilities' materials currently authorized by the Colorado Department of Public Health and Environment (CDPHE) and El Paso County for placement in the CCR Landfill are listed in the facility's Engineering Design and Operations Plan (EDOP) (CSU, 2019). The location of the CCR Landfill is shown on **Figure 1**.

1.2 Regulations

The CCR Landfill is regulated by the CCR Rule promulgated by the United States Environmental Protection Agency (USEPA, 202) under 40 CFR Part 257, Subtitle D of the Resource Conservation and Recovery Act (RCRA). The CCR Landfill is also regulated by the CDPHE Hazardous Materials and Waste Management Division under the Regulations Pertaining to Solid Waste Sites and Facilities (6 Code of Colorado Regulations 1007-2, Part 1) (Solid Waste Regulations) (CDPHE, 2024) and by the Local Governing Authority (i.e., El Paso County). The disposal area, as shown on **Figure 1**, is located within the boundaries established by the Clear Spring Ranch Certificate of Designation (CD-04-001) and Use Subject to Special Review (AL-05-006), which were approved by the Board of County Commissioners. This Closure Plan was developed to meet the requirements of the CCR Rule, as detailed in 40 CFR 257.102.

1.3 Owner/Operator Information

The owner and operator of the CCR Landfill (and the contact throughout closure and during the post-closure period) is:

Colorado Spring Utilities – Operations Division
Attn: Power Plant Manager
P.O. Box 1103, Mail Code 40
Colorado Springs, CO 80947
Phone: 719-668-4800
Email: askus@csu.org

1.4 Purpose

The purpose of this Closure Plan is as follows.

1. Account for the change in expected CCR volume due to the shutdown of the Martin Drake Power Plant (2021) and the expected closure of the Ray Nixon Power Plant (~2029) by incorporating the details of the Final 30% CCR Landfill Redesign Package (**Attachment A**).
2. Describe the steps necessary to close the CCR Landfill at any point during the active life of the CCR Landfill consistent with recognized and generally accepted good engineering practices.
3. Provide a narrative description of how the CCR Landfill will be closed in accordance with 40 CFR 257.102.
4. Describe the final cover system and the methods and procedures to be used to install the final cover.
5. Provide a schedule for completing all activities necessary to satisfy the closure criteria in 40 CFR 257.102.

2.0 Site Characterization

This section characterizes the site and includes a discussion of the site hydrology, hydrogeology, soil, and current conditions at the CCR Landfill.

2.1 Site Hydrology and Hydrogeology

The CCR Landfill is located in the area referred to as Sand Canyon, which is a small, west-east trending topographic depression that is bounded to the north and south by outcroppings of Pierre Shale. Approximately 50 feet of Quaternary sediments have been deposited in the canyon. These sediments, referred to as the Piney Creek Alluvium, consist of horizontal layers of clay, silty clay, sand, and gravel. Most of the alluvium is poorly-sorted and fine-grained with silt-sized materials predominating. Bedding is poorly defined except for a thin layer of gravel near the base of the deposit. The Piney Creek Alluvium is saturated beneath the CCR Landfill and forms the uppermost water-bearing zone in Sand Canyon. It is underlain by approximately 3,500 to 4,000 feet of Pierre Shale that forms a hydraulic barrier between the alluvium and deeper water-bearing formations, if present. Groundwater within the Piney Creek Alluvium flows to the east-southeast along the top of the alluvium-Pierre Shale contact. Water level measurements indicate that the saturated thickness of the alluvial water-bearing zone is approximately zero to 25 feet.

Approximately one mile east of the CCR Landfill, Sand Canyon intersects the north-south alluvial channel of Fountain Creek. The upgradient portion of Sand Canyon occupied by the CCR Landfill is cut off from Fountain Creek by the Retention Dam installed by Utilities in 1978. The Retention Dam, located approximately 3,000 feet downgradient (east) of the landfill (**Figure 1**), has a bentonite core and is keyed into the Pierre Shale bedrock. It captures surface water run-off from the CCR Landfill and also restricts groundwater flow. To enhance the dam's performance, Utilities installed a bentonite barrier wall through the upgradient toe of the dam in October 1994. The Retention Dam is intended to prevent any releases that may occur from migrating downgradient to Fountain Creek.

2.2 Site Surficial Soil

According to the United States Department of Agriculture (USDA) Web Soil Survey (USDA, 2016), the CCR Landfill was constructed in an area consisting primarily of two soil types: Razor-Midway complex and Limon clay. The Razor-Midway complex is well-drained, and the surface layer consists of stony/cobbly clay loam and clay to a depth of approximately 15 to 30 inches. Permeability of the soil is estimated to be moderately low to moderately high and the available water storage capacity is low to very low. The Limon clay is well-drained, and the surface layer consists of clay, silty clay, and silty clay loam to a depth of at least 60 inches. Permeability of the soil is estimated to be moderately low to moderately high and the available water storage capacity is high. A printout showing the locations of each soil type from the Web Soil Survey is provided in **Appendix B**.

2.3 Current Conditions

The current CCR Landfill extent is shown on **Figure 2** and includes topography from 2018, supplemented with LiDAR within the landfill boundary performed in December 2022. The majority of the CCR Landfill is currently filled to an elevation of approximately 5505 feet with CCR stacked to an elevation of approximately 5526 feet in the southeast corner (30 to 80 feet above the surrounding ground surface) with a maximum future elevation of 5531 feet, including the thickness of the final cover. Existing side slopes are permitted to remain at 3:1 (H:V) based on the stability analyses presented in the 2009 Ash Landfill Slope Stability Investigation (Kleinfelder, 2009). The current top of the CCR Landfill is relatively flat.

Bottom ash is currently being mined out from the west side of the CCR Landfill for off-site beneficial use purposes. Fly ash is currently being placed by pushing up the slope in lifts of about 4 inches and compacted within the east expansion area of the CCR Landfill.

Utilities maintains a Coal Combustion Residuals Fugitive Dust Control Plan (CSU, 2023) to aid in ensuring that operations at the CCR Landfill are performed in accordance with the applicable air quality provisions of the CCR Rule, specifically those within 40 CFR Part 257.80 (a) through (d).

The working pad is the area on the landfill on which the trucks delivering ash to the working face travel and maneuver to dump their loads as the landfill is built up to its final waste grade. The working pad on the east portion of the landfill is typically covered with approximately six inches of bottom ash overlain by roughly three inches of gravel. The gravel provides stability, dust control, and assists in minimizing the tracking of ash outside of the landfill.

All areas other than the active west side and east side have been covered with a minimum one-foot thick temporary soil cap in accordance with the definition of adequate intermediate cover contained in the CDPHE Regulations (6 Code of Colorado Regulations 1007-2, Part 1, Section 1). These areas have also been vegetated in general accordance with the EDOP (CSU, 2019).

As of December 8, 2022, the landfill area was approximately 75 acres (including the west mining area and the east expansion area) and held approximately 3,824,000 cubic yards (CYs). The west portion of the landfill contained approximately 555,000 CYs of bottom ash and the east portion contained approximately 3,269,000 CYs of fly ash.

As required by 40 CFR 257.102(b), the maximum inventory of CCR ever on-site over the active life of the CCR unit is estimated to be approximately 5,220,600 CYs (CSU, 2019). The landfill was originally designed as a 75-acre unit capable of holding this volume; however, the maximum area requiring the final cover is currently estimated to be approximately 58-acres due to the reduction of CCR. Bottom ash is currently disposed of in the western portion of the landfill and mined out of the area (through top down cutting of slopes) for off-site beneficial use purposes. Fly ash is currently placed in the eastern portion of the landfill by pushing up the slope in lifts and compacting it, before it is also removed from the site for beneficial reuse. Currently volumes of bottom ash beneficial reuse exceed volumes of bottom ash disposal and mining of bottom ash for beneficial reuse is expected to continue. There is an estimated 555,000 CY of bottom ash to be beneficially reused, and a maximum volume of approximately 3,269,000 CY of CCR waste remaining at the landfill. It is anticipated that approximately 500,000 CY of material will be generated for disposal by the time the Ray Nixon Plant closes and will need to be placed within the footprint of the landfill. The total anticipated maximum volume of waste being disposed of for closure-in-place is 3,769,000 CY.

3.0 Final Cover System Design

Closure of the CCR Landfill will be completed by leaving the CCR in place and installing an engineered turf final cover system, known as ClosureTurf® (AGRU, 2023). In accordance with 40 CFR 257.102(d), ClosureTurf® will ensure that the CCR Landfill is closed in a manner that will:

- Control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere;
- Preclude the probability of future impoundment of water, sediment, or slurry;
- Include measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period;
- Minimize the need for further maintenance of the CCR unit; and
- Be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices.

These performance standards will be met through construction of ClosureTurf® (see Section 3.1), proper sloping to preclude impoundment of water and provide stability (see Section 3.3), settlement monitoring (see Section 3.4), quality control during installation (see Section 4.3), and scheduling (see Section 5.0).

3.1 ClosureTurf® Components

ClosureTurf® is comprised of three components: a structured geomembrane, an engineered turf, and a specified infill material. The design of the ClosureTurf® (from bottom to top) are described below. A conceptual cross-section of the ClosureTurf® cover is shown within **Figure 3**.

3.1.1 Intermediate Cover

Earthen material will be placed directly upon the CCR waste to serve as a barrier between the waste and geomembrane layer. The CCR Landfill does not have a bottom liner as Utilities requested a waiver from this requirement, which was approved in a letter from CDPHE in November of 2008 (CDPHE, 2008).

3.1.2 Geomembrane Liner

The infiltration of liquids through the closed CCR Landfill will be prevented through the use of a 40-mil AGRU MicroSpike® high-density polyethylene (HDPE) or linear low density polyethylene (LLDPE) geomembrane liner. The geomembrane is designed to be impermeable and have high tensile and shear strength values to ensure flexibility and stability during placement. AGRU MicroDrain Liner® will be placed on slopes that measure greater than 4:1 in place of the MicroSpike®, to facilitate the flow of stormwater runoff without compromising the sand in the engineered turf. Approximately 2.58 million square feet of liner is expected to be used.

3.1.3 Engineered Synthetic Turf

One to two inches of engineered synthetic turf will be laid on top of the geomembrane layer. The turf will provide further stability to the geomembrane and protect it from weathering. In addition, the turf will provide a natural look to the site. Approximately 2.58 million square feet of turf is expected to be used. A half an inch of sand infill will be placed within the synthetic turf to provide stability, further protect the system from weather events, and reduce heat absorption.

3.2 Borrow Soil

According to the Web Soil Survey (USDA, 2024), the soil within the Crooked Canyon borrow area consists of Limon clay. The Limon clay is well-drained, and the surface layer consists of clay, silty clay, and silty clay loam to a depth of at least 60 inches. Permeability of the soil is estimated to be moderately low to moderately high and the available water storage capacity is high. A printout from the Web Soil Survey showing the Limon clay in the Crooked Canyon area is Soil Survey is provided in **Appendix B**. A volume of approximately 100,000 CY would be needed for an intermediate cover thickness of 12 inches. There is adequate soil available for the final cover in the proposed 120 acres of Crooked Canyon.

In 2022 and 2023, in support of continuing planning and design activities related to the Grit Solid Waste Disposal Area (SWDA) and Gravel Pit #1 Water Treatment Plant Residuals Monofill (GP1 Monofill) at CSR, a Pre-Design Investigation was completed that included a supplemental borrow source evaluation. The borrow source evaluation was completed to determine if existing on-site soils from newly identified borrow source areas (identified as Northwest Borrow and South Borrow) would be adequate, in quality and quantity, to use as either final cover material at the Grit SWDA, GP1 Monofill, or for use at other on-site solid waste disposal units such as the CCR Landfill. The results are detailed in the Clear Spring Ranch Water Balance Cover Construction Quality Assurance Plan (HDR 2023) (excerpts provided in **Appendix C**). Generally, the investigation confirms that soils present in the two borrow areas would be suitable for use in an intermediate cover application.

3.3 Final Contours / Stability

The estimated final contours at closure are shown on **Figure 3**. The final grades on the side slopes of the CCR Landfill will be no greater than 3:1 (horizontal to vertical [H:V]) and the final grades on the top of the CCR Landfill will be crowned with a slope of no less than 20:1 (H:V). These grades will promote surface water run-off and preclude the future impoundment of water. The final contours, including the ClosureTurf®, will reach an elevation no greater than 5,531 feet at the highest grade. The overall height of the landfill will be approximately 70-80 feet above the surrounding native ground surface.

The western portion of the landfill, currently designated as the Bottom Ash Mining Area is anticipated to be either fully destacked for beneficial reuse or placed in the remaining portion of the landfill. All material will be excavated to base grades, as shown on the Design Plans, and the area will be seeded.

According to Utilities, the 3:1 (H:V) grade was approved as part of the approval of the 2004 Certificate of Designation for Clear Spring Ranch (CDPHE, 2004). In 2009, Utilities hired a third-party geotechnical engineering firm (Kleinfelder) to assess the global stability of the landfill's then-current configuration and its anticipated configuration with various cover thicknesses at closure. Kleinfelder's slope stability analysis concluded that there was a low risk of slope instability under any of the analyzed closure configurations (Kleinfelder, 2009).

3.4 Settling / Subsidence

The disruption of the integrity of the final cover system will be minimized through a design that accommodates settling and subsidence. As the landfill contains relatively homogenous soil-like waste, and does not contain putrescible materials, settling and subsidence is anticipated to be minimal. A baseline survey of the landfill's contours will be conducted upon completion of the final cover. If merited at any time following placement of the final cover, a new survey of the landfill will be conducted and compared to the initial survey to evaluate if subsidence is of concern.

3.5 Revegetation

Revegetation of the landfill final cover system will not be necessary due to the use of engineered synthetic turf.

The Bottom Ash Mining Area will be seeded according to the Soil Conservation Service guidelines. The specific seed mix will consist of grasses native to Colorado, or otherwise considered appropriate by overseeing regulatory agencies, and will be chosen based on prior experience with the seed mix at the facility. The goal will be to obtain a good stand of grass with a dense root structure.

If necessary to support vegetative growth, commercial fertilizer (or other soil amendments) can be incorporated into the seedbed prior to seeding of permanent species. The permanent perennial seeding may consist of both cool- and warm-season native grasses that are tolerant to drought and adaptable to fine-textured clay soils.

Straw mulch may be applied and anchored with a straw crimper to promote plant germination and growth by decreasing soil surface temperature, conserving soil moisture, and controlling erosion from wind and water run-off.

4.0 Final Cover System Installation Methods/Procedures

The Final 30% Design Package includes the technical specifications, design drawings, and associated calculations of the proposed final cover configuration (**Appendix A**). A complete design plan will be developed prior to closure. This section discusses some of the methods and procedures that will be implemented during installation of the ClosureTurf®.

4.1 Temporary Erosion / Sediment Control

Soil erosion is not expected to occur as a result of capping the site using the ClosureTurf® system with the impermeable geomembrane layer. Minimal movement of the sand infill down the side slopes of the landfill is expected to occur over time. To account for this potential movement, the distribution of the sand infill will be monitored in inspections and redistributed if determined necessary. The turf will extend through the perimeter channel surrounding the site and be anchored approximately two feet beyond the outer edge of the channel.

4.2 Permanent Run-on / Run-off Control

The ClosureTurf® system is expected to produce a considerable amount of runoff in a short period of time due to its impermeable geomembrane layer. To account for this runoff, permanent run-on/run-off controls will be installed during closure to manage flows in post-closure. These controls include stormwater letdowns, benching, tack-on berms, and culverts. The design details of these controls and the overall stormwater management plan can be viewed on Figures 10A, 10B, and 11 within the Final 30% Design Package (**Appendix A**). The runoff will be conveyed to the surrounding perimeter ditch and ultimately into the Clear Spring Ranch stormwater retention pond which is located to the east of the landfill (**Figure 1**). In December of 2023, a Proposed Landfill Drainage and Perimeter Ditch Evaluation was conducted to evaluate the volume and peak flows of the stormwater runoff using the proposed design from the Final 30% Design Package (**Appendix A**). The evaluation determined that the perimeter channels and culverts are appropriately sized and meet the CDPHE and USEPA regulations.

4.3 Dust Control

To minimize fugitive dust due to vehicle travel or winds, a water truck is used at the facility to wet down the disposal area, unpaved roads, stockpiles, and traveled areas. Dust control measures shall comply with the Nixon Title V Operating Permit (permit #95OPEP106) as stated in the EDOP (CSU, 2019) and the Coal Combustion Residuals Fugitive Dust Control Plan (CSU, 2023).

4.4 Quality Control

Construction Quality Assurance (CQA) is the process by which the engineer and owner ensure construction conforms with project drawings and specifications. As part of the CQA program, a Construction Quality Assurance Plan (CQAP) will be prepared (prior to start of construction) to outline the quality assurance/quality control (QA/QC) process. The CQAP will include:

- Roles and responsibilities of the project team and contractors during project construction
- Description of the detail required for project documentation
- A discussion of the QA/QC methods for soils and all imported materials

Inspections and testing will be performed throughout the construction process to ensure compliance with the CQAP. An initial survey of the top of grade of the landfill will be performed prior to placing geomembrane. A final survey will be performed after all construction is complete.

5.0 Closure Schedule

As required by 40 CFR 257.102(b), the following is an estimated/draft schedule for completion of all activities related to design and construction of a final cover at the CCR Landfill. The schedule will be refined and details added prior to closure.

Closure Task	Approximate Month/Year/Schedule
Prepare initial written closure plan	November 4, 2024
Perform additional modeling (if needed), and prepare detailed closure plan (with revised schedule)	Between 270 and 180 days prior to beginning closure activities
Prepare notification of intent to close	Prior to beginning closure activities
Coordinate with agencies and obtain necessary approvals and permits	Prior to beginning closure activities
Installation of the final cover system	Approximately 2029, following closure of the Ray Nixon Power Plant and cessation of the removal of CCR for beneficial use. Expected to take approximately 6 months.
Prepare a notification of closure	Within 60 days of completing closure activities

Closure of the CCR Landfill is expected to occur in approximately 2029, when the landfill is no longer receiving waste materials from the Ray Nixon Power Plant. In accordance with 40 CFR 257.102(e), closure of the CCR Landfill will commence within 2 years of the last receipt of CCR (or last removal of CCR for beneficial use) or no later than 30 days after the date on which the CCR Landfill receives the known final receipt of CCR (or removes the known final volume of CCR for beneficial use). Utilities may obtain two-year extensions provided that they continue to be able to demonstrate that there is reasonable likelihood that the CCR Landfill will accept wastes in the foreseeable future or will remove CCR from the Landfill for the purpose of beneficial use.

In accordance with 40 CFR 257.102(f), Utilities will complete closure of the CCR Landfill within six months of commencing closure activities. This timeframe may be extended if Utilities can demonstrate that it is not feasible to complete closure of the CCR Landfill within the required timeframe due to factors beyond the facility's control. If Utilities seeks a time extension, a demonstration, including a narrative discussion providing the basis for additional time, will be completed.

6.0 Post-Closure Care

The post-closure period begins when closure of the CCR Landfill has been completed in accordance with this plan and closure has been deemed adequate. During post-closure, the CCR Landfill will be inspected and maintained to ensure that the ClosureTurf® system is properly intact and any potential erosion or settlement does not compromise the final cover system. As-needed maintenance may include potential removal of the sand infill from the stormwater channels and redistribution of the sand in areas of ClosureTurf® where it has shifted. This is expected to occur every three to five years and require minimal equipment. Post-closure activities may also include long-term groundwater monitoring to verify groundwater quality has not been impacted. Post-closure care will be as described in the CCR Landfill Post-Closure Plan to be submitted under separate cover.

7.0 Amendment, Recordkeeping, and Notification

7.1 Amendment of the Plan

As required by 40 CFR 257.102(b)(3), Utilities may amend this Closure Plan at any time provided the revised plan is placed in the facility's Operating Record. Utilities will amend this plan whenever there is a change in operation of the CCR Landfill that would substantially affect the plan and if unanticipated events necessitate a revision of this plan (either before or after closure activities have commenced). Utilities will amend this plan at least 60 days prior to a planned change in the operation of the CCR Landfill, or no later than 60 days after an unanticipated event requires revising the existing plan. If this plan is revised after closure activities have commenced for the CCR Landfill, Utilities will amend the plan no later than 30 days following the triggering event. Any amendment of this plan will be certified by a qualified Professional Engineer.

7.2 Recordkeeping

Utilities will maintain their files with this Closure Plan, any subsequent revisions/amendments of this Closure Plan, inspection reports, documentation of maintenance, and other pertinent documents within the facility's Operating Record for a period of at least five years in accordance with 40 CFR 257.105.

7.3 Notification

Utilities will notify CDPHE whenever the Closure Plan (along with any subsequent updates) has been placed in the operating record in accordance with the notification requirements specified in 40 CFR 257.106. Prior to initiation of closure, Utilities will prepare a notification of intent to close the CCR Landfill. The notification must include a written certification from a qualified Professional Engineer stating that the design of the final cover system meets the requirements of this plan. Within 30 days of completion of closure of the CCR Landfill, Utilities will prepare a notification of closure for the CCR Landfill. The notification must include a written certification from a qualified Professional Engineer verifying that closure has been completed in accordance with this closure plan.

7.3.1 Deed Notations

Following closure of the CCR Landfill and in accordance with 40 CFR 257.102(i), Utilities will record a notation on the deed to the property, or some other instrument that is normally examined during title search. The notation on the deed must in perpetuity notify any potential purchaser of the property that the land has been used as a CCR Landfill and its use is restricted. Within 30 days of recording a notation on the deed to the property, Utilities will prepare a notification stating that the notation has been recorded.

8.0 Certification

Certification Statement 40 CFR § 257.102(d)(3)(iii) – Design of the Final Cover System for Closure of the Coal Combustion Residuals (CCR) Landfill, Clear Spring Ranch, El Paso County, Colorado

CCR Unit – Colorado Springs Utilities, Clear Spring Ranch, CCR Landfill

I, Patrick Clem, being a Registered Professional Engineer in good standing in the State of Colorado, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the design of the final cover system as included in the CCR Landfill Closure Plan dated November 8, 2024, meets the requirements of 40 CFR § 257.102.

Patrick Clem
Printed Name

November 8, 2024
Date

9.0 References

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Figures

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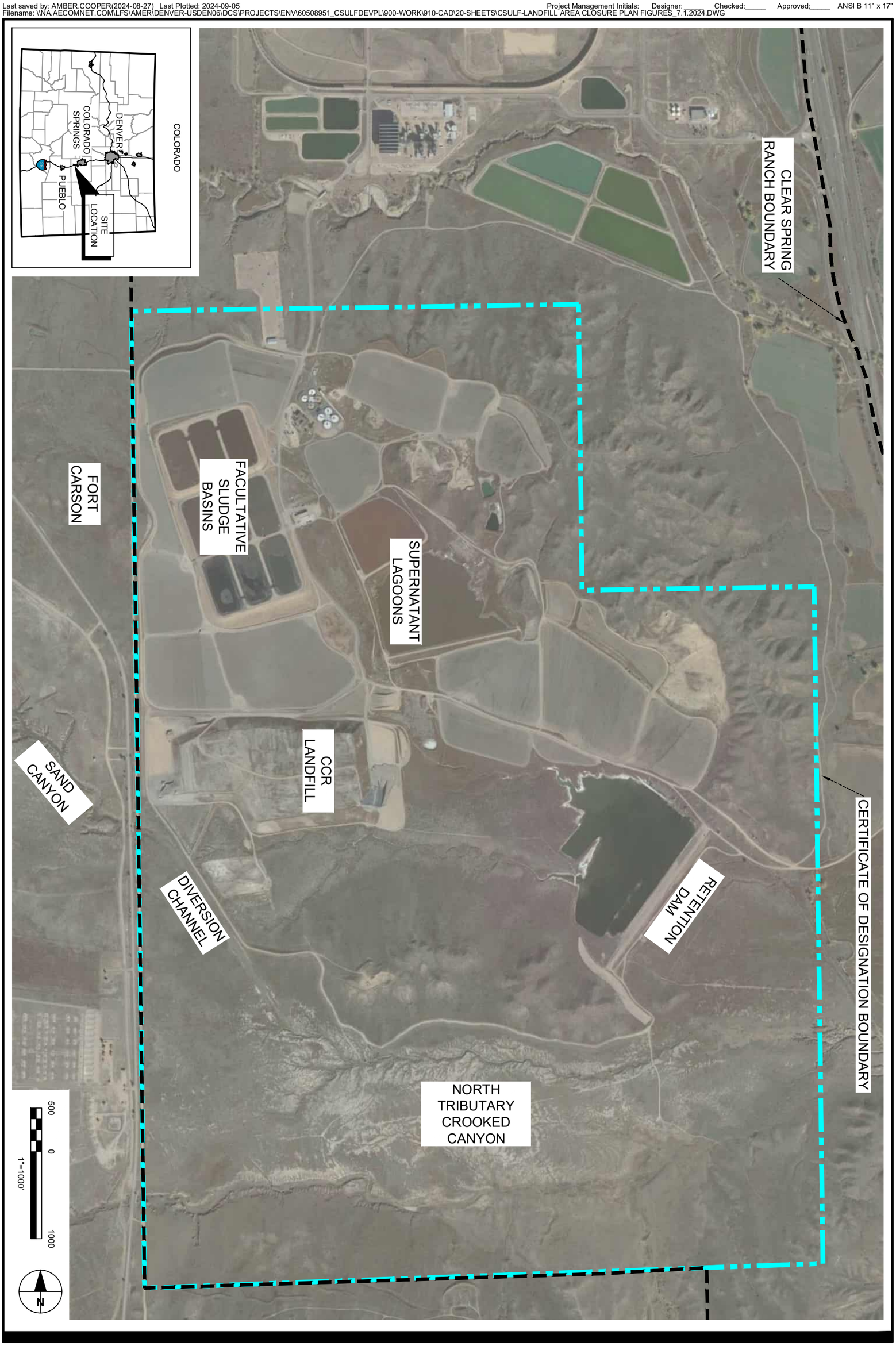

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60729498 Date: 9/5/2024

CCR LANDFILL CLOSURE
SITE LOCATION MAP

AECOM

Figure: 1

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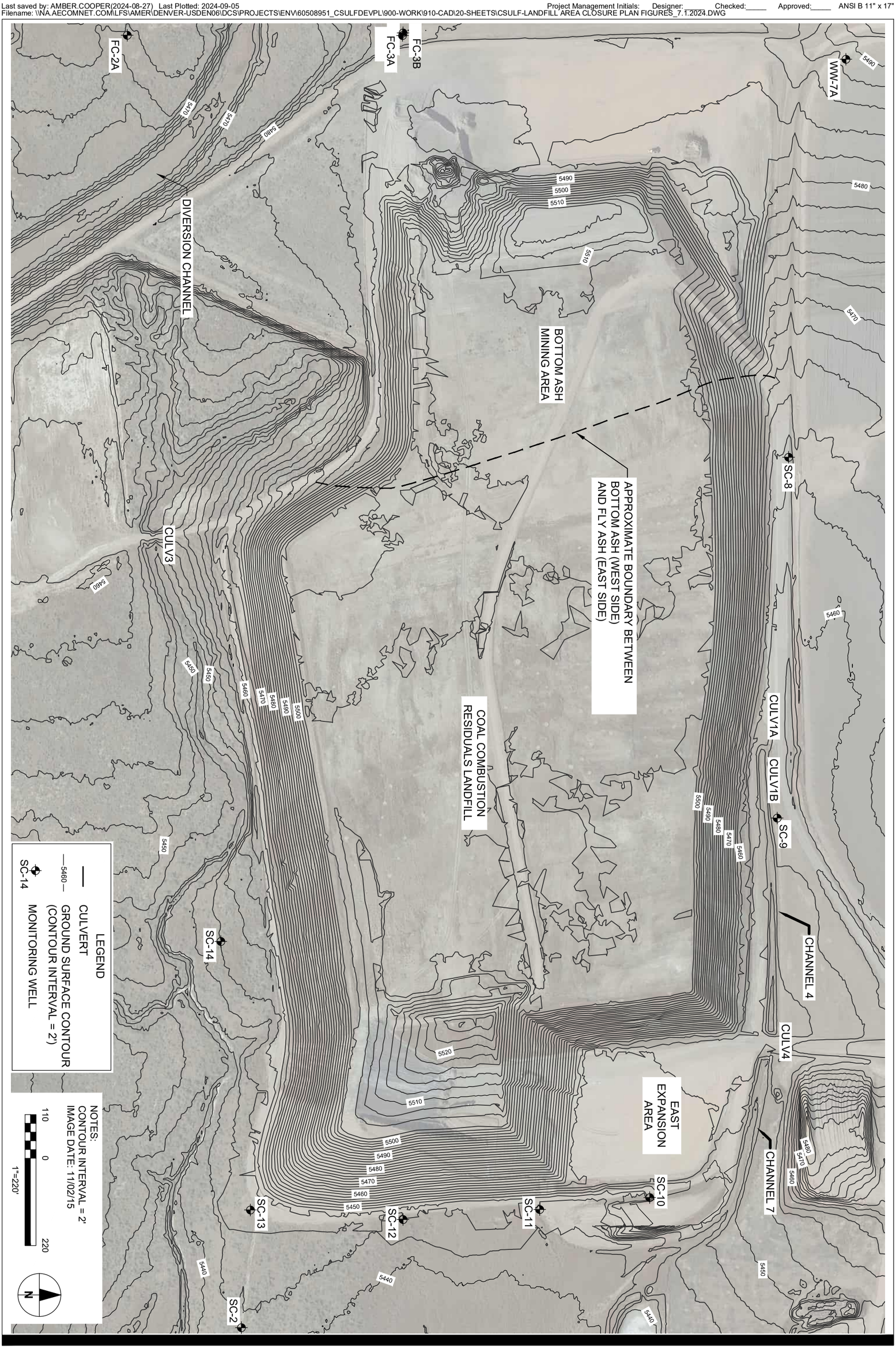
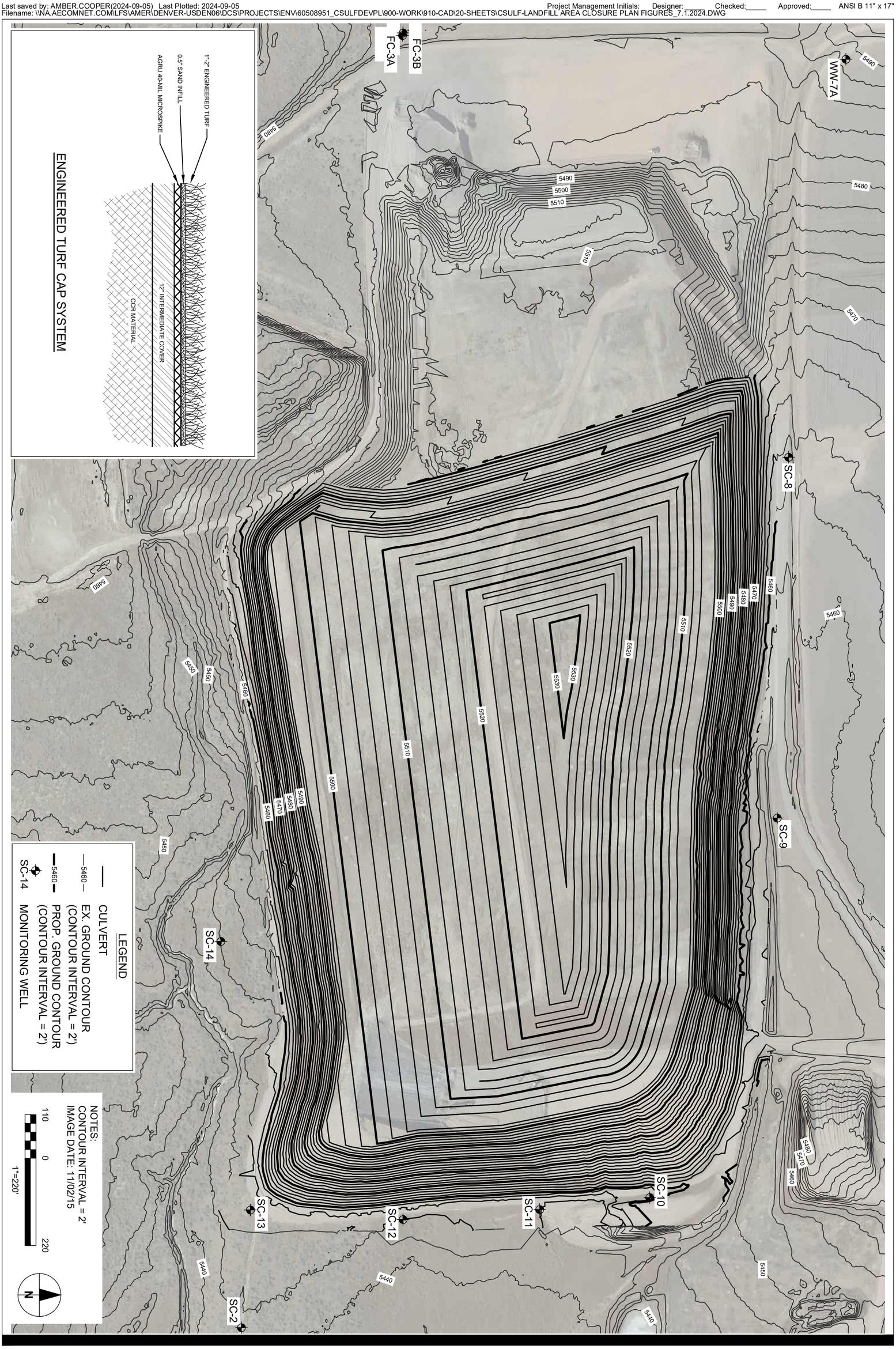


CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60729498 Date: 9/5/2024

CCR LANDFILL PLAN - CURRENT CONDITIONS

AECOM

Figure: 2



CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60729498 Date: 9/5/2024

CCR LANDFILL CLOSURE GRADING PLAN

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Figure: 3

Appendix A
30% CCR Landfill Redesign

AECOM
1601Prospect Park Way
Fort Collins, Colorado 80525

December 20, 2023

Ms. Heather Barbare
Colorado Springs Utilities
121 S. Tejon Street, 4th Floor
Colorado Springs, CO 80947

Subject: CCR Landfill Redesign
Clear Spring Ranch
Colorado Springs, Colorado
Final 30% Design Package

Dear Ms. Barbare:

AECOM Technical Services, Inc. (AECOM) prepared the attached Final 30% Design Package for the redesign of the CCR Landfill at Clear Spring Ranch. The 30% Design Package has been prepared in accordance with Task 3 of Task Order #2023.000799 between AECOM and Colorado Springs Utilities and represents the culmination of the design process to date including the Alternative Analysis conducted as part of Task 2. AECOM addressed and incorporated comments provided by Utilities on the draft version of the document prior to finalization.

Please see the attached technical specifications, design drawings and associated calculations. Calculations include the landfill drainage and perimeter ditch evaluation in the form of a technical memorandum and the slope stability assessment.

Sincerely,

Patrick Clem, PE
Project Manager
patrick.clem@aecom.com

Steve Walker, PE
Project Engineer
steve.walker@aecom.com

Enclosure:

Final 30% Design Drawings
Final 30% Design Technical Specifications
Landfill Drainage and Perimeter Ditch Evaluation Technical Memorandum
Slope Stability Assessment

CC: Heather Barbare
Brock Foster

COLORADO SPRINGS UTILITIES
CLEAR SPRING RANCH

EL PASO COUNTY, COLORADO

LATITUDE: 38°36'28.83"N ; LONGITUDE: 104°42'45.66"W

CCR LANDFILL REDESIGN
30% DESIGN SUBMITTAL

PREPARED FOR:
COLORADO SPRINGS UTILITIES
111 S. CASCADE AVE
COLORADO SPRINGS, CO, 80903

PREPARED BY:
AECOM TECHNICAL SERVICES
1601 PROSPECT PKWY
FORT COLLINS, CO, 80525

NO.	DWG DESCRIPTION
01	TITLE SHEET
02	GENERAL NOTES
03	OVERALL SITE PLAN
04	EXISTING CONDITIONS
04B	EXISTING CONDITIONS - CCR DISPOSAL AREAS
05	BOTTOM ASH AREA REGRADE
06	PROPOSED TOP OF WASTE
07	PROPOSED TOP OF INTERMEDIATE COVER
08	PROFILES - BOTTOM ASH AREA
09	PROFILES - LANDFILL
10A	DETAILS I
10B	DETAILS II
11	STORMWATER MANAGEMENT PLAN

SITE OVERVIEW MAP - 1" = 1000'

REV	DATE	JOB NO.	PROJECT TYPE	DES	DFTR	CHKD	ENG	APPD	DESCRIPTION
0	10-27-2023	60702594	LANDFILL CLOSURE	AMC	AMC	SCW	SCW	SCW	30% DRAFT SUBMITTAL
1	12-13-2023	60702594	LANDFILL CLOSURE	AMC	AMC	SCW	SCW	SCW	30% DESIGN SUBMITTAL

AECOM

SHEET 01

CCR LANDFILL CLOSURE
TITLE SHEET

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 12-18-2023

1. PURPOSE

THE PURPOSE OF THE WORK IS TO CLOSE THE PERMITTED SOLID WASTE LANDFILL LOCATED AT CLEAR SPRING RANCH LOCATED IN EL PASO COUNTY, COLORADO.

1.1. THESE PLANS CONSIST OF THE MODIFICATION AND CLOSURE OF THE LANDFILL. THESE ACTIVITIES WILL CONSIST OF:

1.1.1. MINIMIZE THE FOOTPRINT OF THE CURRENT PERMITTED LANDFILL TO ACCOMMODATE THE ANTICIPATED AIRSPACE REQUIRED DUE TO THE CLOSURE OF THE POWER PLANTS THAT CONTRIBUTE COAL COMBUSTION RESIDUALS (CCR) TO THE LANDFILL AND THE BENEFICIAL REUSE OF THE EXISTING PLACED ASH;

1.1.2. ANALYZE THE UPDATED AIRSPACE REQUIRED AND THE FOOTPRINT THAT WILL BE AVAILABLE PRIOR TO BENEFICIAL USE MINING OF THE WESTERN PORTION OF THE LANDFILL;

1.1.3. PROVIDE GRADING PLAN FOR NEW LANDFILL FOOTPRINT THAT FULFILLS THE AIRSPACE DEMAND AND STORMWATER MANAGEMENT ELEMENTS NEEDED FOR EROSION CONTROL;

1.1.4. EVALUATE SITE STORMWATER REQUIREMENTS;

1.1.5. SELECTION OF FINAL CLOSURE TREATMENT THAT BEST FITS THE NEEDS OF THE SITE;

1.1.6. PREPARE DESIGN DOCUMENTS FOR THE FINAL CLOSURE OF THE CLEAR SPRING RANCH LANDFILL;

2. DEFINITIONS

2.1. THE FACILITY AND ITS ANCILLARY FUNCTIONS ARE OWNED AND OPERATED BY COLORADO SPRINGS UTILITIES (OWNER). THE OWNER WILL BE RESPONSIBLE FOR OVERALL MANAGEMENT OF CONSTRUCTION ACTIVITIES INCLUDING CONTRACTING AND ADMINISTRATION. THE OWNER WILL DESIGNATE AN ON-SITE REPRESENTATIVE TO SERVE AS CONSTRUCTION SUPERVISOR (CS). THE OWNER CS WILL SERVE AS THE OWNER REPRESENTATIVE AND OVERSEE ALL ASPECTS OF THE PROJECT.

2.2. THE ENGINEER IS RESPONSIBLE FOR THE ENGINEERING DESIGN AND THESE PLANS. THE ENGINEER IS AN OFFICIAL REPRESENTATIVE OF THE OWNER. THE ENGINEER WILL BE RESPONSIBLE FOR PROVIDING CONSTRUCTION QUALITY ASSURANCE FOR THE PROJECT AND WORKING WITH THE OWNER ON PROPER RESOLUTION OF QUALITY ISSUES THAT ARISE DURING CONSTRUCTION. THE ENGINEER IS AECOM. AECOM HAS PREPARED THE PLANS AND NOTES HEREIN, AND IS TO ASSIST THE OWNER IN MONITORING THE PERFORMANCE OF THE WORK.

2.3. THE CONTRACTOR FOR THE WORK WILL BE SELECTED BY THE OWNER. THE CONTRACTOR IS RESPONSIBLE FOR COMPLETING THE WORK OUTLINED IN THESE PLANS. ANY SUB-CONTRACTORS PROPOSED BY THE CONTRACTOR MUST BE APPROVED BY THE OWNER. THE CONTRACTOR SHALL BE RESPONSIBLE FOR CONSTRUCTION ACTIVITIES AND CONSTRUCTION QUALITY CONTROL (CQC) ASSOCIATED WITH THIS PROJECT INCLUDING MEETING ALL OF THE REQUIREMENTS FOR PROJECT QUALITY AS DEFINED BY THESE PLANS FOR ITS WORK AS WELL AS THAT OF ITS SUB-CONTRACTORS.

3. SURVEY CONTROL AND EXISTING TOPOGRAPHIC/SITE INFORMATION

3.1. CONTRACTOR SHALL MAKE THEIR OWN INVESTIGATIONS AS TO THE LOCATION OF UTILITIES PRIOR TO COMMENCEMENT OF ANY WORK. EXISTING UTILITIES AND STRUCTURES (SUBSURFACE, SURFACE, AND OVERHEAD) ARE INDICATED ONLY TO THE EXTENT THAT SUCH INFORMATION WAS KNOWN, MADE AVAILABLE, OR DISCOVERED BY THE ENGINEER IN PREPARING THE PLANS. THE LOCATIONS, CONFIGURATIONS, AND ELEVATIONS OR SUBSURFACE FACILITIES AND UTILITIES ARE APPROXIMATE, AND NOT ALL UTILITIES AND FACILITIES MAY BE INDICATED. THE EXISTING CONDITIONS SHOWN ON THESE DRAWINGS ARE BELIEVED TO REPRESENT THE BEST KNOWN DATA AVAILABLE FROM HISTORIC DRAWINGS PROVIDED BY UTILITIES. ALTHOUGH THIS INFORMATION HAS BEEN INCLUDED IN THE CONSTRUCTION PLANS BY AECOM, THEY ARE NOT NECESSARILY THE WORK PRODUCT OF AECOM AND HAVE BEEN INCORPORATED IN RESPONSE TO CERTAIN ASSIGNED CONDITIONS. AECOM HAS NOT SURVEYED OR FIELD VERIFIED ANY OF THE EXISTING CONDITIONS INFORMATION AND CANNOT BE RESPONSIBLE FOR THE ACCURACY OR COMPLETENESS OF THIS DATA.

4. GENERAL REQUIREMENTS

4.1. THE PROCEDURES SPECIFIED IN THESE PLANS SHALL BE FOLLOWED, PROVIDED THEY ARE CONSISTENT WITH LOCAL PRACTICE IN THE REGION. IF PROCEDURES ARE NOT CONSISTENT WITH LOCAL PRACTICE, ALTERNATE PROCEDURES SHALL BE SUBMITTED TO THE ENGINEER FOR APPROVAL PRIOR TO THE START OF WORK.

4.2. THE ENGINEER SHALL HAVE THE RIGHT TO REVIEW FOR ACCEPTANCE WORK BEING PERFORMED BY THE CONTRACTOR. THIS REVIEW BY THE ENGINEER DOES NOT ALLEVIATE ANY RESPONSIBILITY OF THE CONTRACTOR TO PROVIDE COMPLETE, ACCURATE, AND CORRECT DATA.

4.3. ACCESS INTO THE WORK AREA ("SITE") FOR DELIVERY OF EQUIPMENT, MATERIALS AND WORKFORCE MUST BE REVIEWED DAILY BY THE CONTRACTOR, AND CONTROLLED AS NEEDED TO PREVENT ANY DAMAGE TO OWNER'S FACILITY INFRASTRUCTURE, EQUIPMENT, OR MATERIALS. IF EQUIPMENT OR MATERIAL HAULING CAUSES DAMAGE, THE DAMAGE MUST BE IMMEDIATELY REPAIRED BY THE CONTRACTOR, AND THE METHODS FOR HAULING MUST BE ALTERED TO PREVENT FURTHER DAMAGE. THE CONTRACTOR SHALL NOT MAKE ANY UNPLANNED EXCAVATIONS WITHOUT THE APPROVAL OF THE OWNER AND THE ENGINEER. DURING CONSTRUCTION, THE CONTRACTOR IS RESPONSIBLE FOR PRECAUTIONS REQUIRED TO PROTECT THE INTEGRITY OF EXISTING PAVEMENT, UTILITIES, OR OTHER SITE FEATURES.

4.4. THE CONTRACTOR SHALL TAKE EVERY PRECAUTION TO AVOID OIL OR FUEL SPILLS DURING CONSTRUCTION. THE CONTRACTOR SHALL HAVE OIL/FUEL CONTROL EQUIPMENT (ABSORBENT BOOMS, ETC.) ON SITE AT ALL TIMES. IF OIL OR FUEL IS RELEASED OR OBSERVED DURING CONSTRUCTION, THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE OWNER AND DEPLOY OIL/FUEL CONTROL EQUIPMENT. THE CONTRACTOR SHALL COORDINATE WITH THE ENGINEER AND THE OWNER ON OIL/FUEL CLEANUP, AS NECESSARY.

4.5. THE CONTRACTOR SHALL COORDINATE WITH THE OWNER TO DETERMINE THE LOCATION OF STAGING OR PARKING AREAS FOR REQUIRED EQUIPMENT OR MATERIAL STORAGE AND FOR OTHER CONSTRUCTION LAY DOWN ACTIVITY, INCLUDING STOCKPILING. STAGING AND STOCKPILING AREAS SHALL BE PROVIDED WITH EROSION AND SEDIMENT PERIMETER CONTROLS. CONTRACTOR TO CONSULT WITH ENGINEER BEFORE SETTING UP STAGING AND STOCKPILING AREAS.

4.6. WHENEVER REFERENCE IS MADE TO COLORADO DEPARTMENT OF TRANSPORTATION (CDOT) STANDARD SPECIFICATIONS, COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT (CDPHE), AMERICAN CONCRETE INSTITUTE (ACI), AMERICAN WATER WORKS ASSOCIATION (AWWA), AMERICAN SOCIETY OF TESTING AND MATERIALS (ASTM) AND OTHER PUBLISHED STANDARDS OR SPECIFICATIONS, IT SHALL MEAN THE LATEST VERSION IN ITS ENTIRETY.

4.7. THE CONTRACTOR SHALL MAKE NO DEVIATIONS FROM THE PLANS, ASSOCIATED SPECIFICATIONS, OR SHOP DRAWINGS WITHOUT PRIOR APPROVAL FROM THE OWNER AND THE ENGINEER. THE CONTRACTOR SHALL KEEP A RECORD PLAN SET NOTING ALL DEVIATIONS IN LOCATION OR ELEVATION OF ANY INSTALLATION FROM THAT SHOWN ON THE PLANS (INCLUDING TEMPORARY EROSION AND SEDIMENTATION CONTROL PLANS). AT COMPLETION OF THE PROJECT, A SET OF RED-LINED DRAWINGS SHALL BE PROVIDED TO THE ENGINEER.

4.8. ALL EXISTING MONITORING WELLS AND ASSOCIATED INSTRUMENTATION SHALL BE PROTECTED BY THE CONTRACTOR DURING CONSTRUCTION ACTIVITIES.

4.9. THE CONTRACTOR IS RESPONSIBLE FOR CONTROL OF FUGITIVE DUST GENERATED DURING CONSTRUCTION AND SHALL COORDINATE WITH UTILITIES FOR SITE SPECIFIC REQUIREMENTS.

4.10. ALL MATERIALS, LABOR, AND EQUIPMENT ARE TO BE PROVIDED BY THE CONTRACTOR UNLESS STATED OTHERWISE HEREIN.

5. ENVIRONMENTAL PROTECTION

5.1. THE CONTROL OF ENVIRONMENTAL POLLUTION, WHICH COULD RESULT FROM CONSTRUCTION OPERATIONS UNDER THIS CONTRACT, REQUIRES CONSIDERATION OF LAND, WATER, AND AIR QUALITY AT THE SITE.

5.2. THE CONTRACTOR SHALL COMPLY WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL LAWS AND REGULATIONS CONCERNING ENVIRONMENTAL POLLUTION CONTROL OR ABATEMENT. THE CONTRACTOR SHALL MAKE SURE THAT NECESSARY PERMITS HAVE BEEN OBTAINED AND THAT THIS WORK IS IN COMPLIANCE WITH SUCH PERMITS CONCERNING ENVIRONMENTAL PROTECTION.

5.3. THE OWNER WILL NOTIFY THE CONTRACTOR IN WRITING OF ANY NONCOMPLIANCE WITH THESE PLANS AND THE ACTION TO BE TAKEN. THE CONTRACTOR SHALL IMMEDIATELY TAKE CORRECTIVE ACTION.

5.4. PROTECTION OF LAND RESOURCES

5.4.1. LAND RESOURCES ADJACENT TO THE PROJECT BOUNDARIES SHALL BE PRESERVED IN THEIR PRESENT CONDITION OR RESTORED TO A NATURAL APPEARANCE.

5.4.2. THE CONTRACTOR SHALL EXERCISE CARE IN CONDUCTING ALL OPERATIONS ON PRIVATE PROPERTY TO MINIMIZE THE AMOUNT OF DISTURBANCE AND DAMAGE RELATED TO GAINING ACCESS TO, AND WORKING AT THE PLANNED LOCATION(S). THE CONTRACTOR SHALL NOT INJURE OR DESTROY TREES OR SHRUBS ADJACENT TO THE PROJECT SITE THAT ARE NOT SHOWN ON THESE PLANS TO BE REMOVED. AREAS DISTURBED BY CONSTRUCTION ACTIVITIES SHALL BE CONFINED TO THE MAXIMUM EXTENT POSSIBLE.

5.4.3. THE CONTRACTOR SHALL MAINTAIN A STABLE, CLEAN, WORKABLE SURFACE IN THE CONSTRUCTION AREA. THE CONTRACTOR WILL BE RESPONSIBLE FOR PURCHASING, HAULING, AND PLACEMENT OF STONE, IF NEEDED. AREAS DISTURBED BY CONSTRUCTION ACTIVITIES SHALL BE MINIMIZED TO THE EXTENT POSSIBLE.

5.4.4. THE CONTRACTOR SHALL PERFORM THE FINAL RESTORATION OF THE CONSTRUCTION AREA (E.G. PLANT GRASS). REPAIRS WHICH ARE, IN THE OPINION OF THE OWNER, REQUIRED TO RESTORE ANY LAND, STRUCTURES, OR APPURTENANCES DAMAGED THROUGH CARELESSNESS, NEGLIGENCE, OR IRRESPONSIBLE ACTS ON THE PART OF THE CONTRACTOR, OR ANY OF THEIR EMPLOYEES, SHALL BE THE SOLE RESPONSIBILITY OF THE CONTRACTOR AND WILL NOT BE PAID FOR BY THE OWNER. SUCH REPAIRS SHALL BE CARRIED OUT IN A TIMELY MANNER AT THE DIRECTION OF, AND TO THE SATISFACTION OF THE OWNER.

5.5. PROTECTION OF WATER RESOURCES

5.5.1. THE CONTRACTOR SHALL NOT ADVERSELY AFFECT THE EXISTING WATER QUALITY WITHIN OR ADJACENT TO THE PROJECT SITE. NO CONSTRUCTION WASTES OR OTHER HARMFUL MATERIALS SHALL BE PERMITTED TO ENTER THESE WATER RESOURCES.

5.5.2. SURFACE DRAINAGE FROM WORK ACTIVITIES SHALL BE MANAGED USING EFFECTIVE EROSION AND SEDIMENT CONTROL BMPS OR THE WORK AREAS SHALL BE GRADED TO CONTROL EROSION WITHIN ACCEPTABLE LIMITS IN ACCORDANCE WITH THE SITE STORMWATER MANAGEMENT PLAN (SWMP). THESE MEASURES SHALL BE MAINTAINED UNTIL ALL WORK HAS BEEN COMPLETED. REFER TO THE EROSION AND SEDIMENT CONTROL DETAILS FOR MORE INFORMATION.

6. EARTHWORK AND AGGREGATES

6.1. REFER TO SPECIFICATION SECTION 312300 FOR EXCAVATION SPECIFICATIONS AND SECTION 031200 FOR EARTHWORK AND AGGREGATE SPECIFICATIONS.

7. SURVEYING

6.1. REFER TO SPECIFICATION SECTION 022100 FOR SURVEY SPECIFICATIONS.

7. SEQUENCE OF CONSTRUCTION

7.1. TRAFFIC THROUGH/AROUND THE CONSTRUCTION SITE MUST BE MAINTAINED.

7.2. THE CONTRACTOR IS RESPONSIBLE FOR DETERMINING A DETAILED SEQUENCE OF CONSTRUCTION FOR SUCCESSFUL PROJECT COMPLETION. A RECOMMENDED SEQUENCE OF KEY ITEMS CRITICAL TO PROJECT SUCCESS INCLUDE, BUT ARE NOT LIMITED TO THE FOLLOWING:

7.2.1. INSTALL EROSION CONTROL DEVICES AS SHOWN ON THE PLANS.

7.2.2. IMPLEMENT CONSTRUCTION CLOSURE DETAILS AS INDICATED ON THE PLANS.

7.2.3. STABILIZE ALL AREAS UPON COMPLETION OF CONSTRUCTION OF FINAL GRADES. IMPLEMENT PERMANENT STABILIZATION MEASURES AS SPECIFIED ON THE PLANS.

7.2.4. EROSION AND SEDIMENT CONTROL MEASURES SHALL BE MAINTAINED UNTIL FINAL STABILIZATION IS ACHIEVED FOR ALL DISTURBED AREAS. DO NOT REMOVE ANY EROSION AND SEDIMENT CONTROL MEASURES WITHOUT PRIOR APPROVAL FROM ENGINEER.

8. VOLUME SUMMARY

8.1. THE VOLUME SUMMARY IS PROVIDED FOR INFORMATION ONLY. THE CONTRACTOR IS RESPONSIBLE FOR DETERMINING BID QUANTITIES.

8.2. THE TOP OF WASTE GRADES SHOWN IN THIS PLAN SET ARE APPROXIMATE AND ARE BASED ON THE ESTIMATED CCR VOLUMES EXPECTED TO BE PRESENT AT THE TIME OF CLOSURE. THE ACTUAL FINAL VOLUME OF WASTE TO BE DISPOSED MAY VARY AND THE FINAL TOP OF WASTE GRADES AND FINAL CLOSURE COVER GRADES MAY REQUIRE ASSOCIATED ADJUSTMENTS.

8.2.1. EXISTING TOP OF WASTE GRADES ARE H3::V1. ANY NEW CONSTRUCTION TO THE TOP OF WASTE GRADES SHALL HAVE A MINIMUM SLOPE OF H4:V1 (or 25%) , AND BENCHES ARE TO BE USED AT INTERVALS OF APPROXIMATELY 15 TO 20-FT VERTICAL WITH A MINIMUM CROSS SLOPE OF 1% BETWEEN DOWNDRAINS.

8.3. IF NECESSARY, AS DETERMINED BY THE ENGINEER OR OWNER, THE ENGINEER WILL ISSUE REVISED DRAWINGS OR BULLETINS TO THE DRAWINGS TO UPDATE THE FINAL GRADES BASED ON VARIANCES BETWEEN ESTIMATED AND ACTUAL WASTE FILL VOLUMES.

9. DATUM AND TOPOGRAPHIC INFORMATION

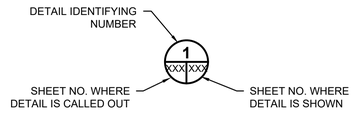
9.1. THE EXISTING CONDITIONS, TOPOGRAPHIC AND SURVEY INFORMATION SHOWN ON THESE DRAWINGS WERE PROVIDED BY UTILITIES. THE EXISTING CONDITIONS SHOWN ON THESE DRAWINGS ARE BELIEVED TO REPRESENT THE BEST KNOWN DATA AVAILABLE.

9.2. TOPOGRAPHIC MAPPING IS BASED UPON THE FOLLOWING DATUM:

HORIZONTAL DATUM: COLORADO STATE PLANE, CENTRAL ZONE, NAD 1983

VERTICAL DATUM: NGVD 1929

UNITS: US SURVEY FEET



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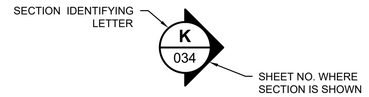

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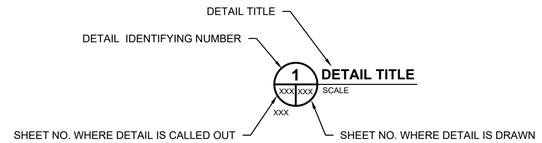

DETAIL, NUMBER, & TITLE ON SHEET WHERE DETAIL IS SHOWN

AECOM

SHEET 02

CCR LANDFILL CLOSURE
GENERAL NOTES

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 12-18-2023

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Project Management Initials: Designer: AMC Checked:SCW Approved:____ ANSI D 22" x 34"

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 10-27-2023

CCR LANDFILL CLOSURE
OVERALL SITE PLAN

AECOM

SHEET 03

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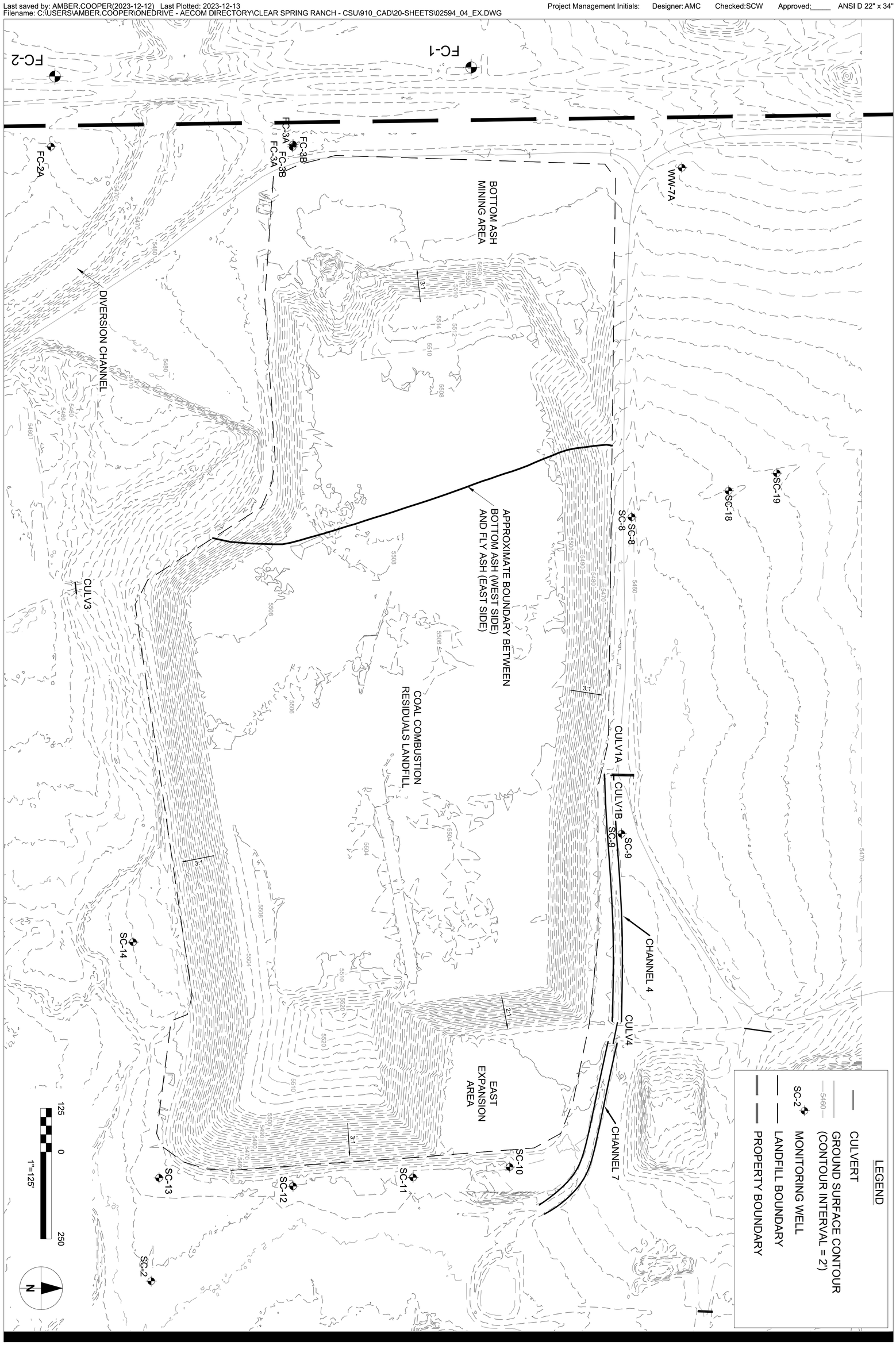

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 10-27-2023

CCR LANDFILL PLAN - EXISTING CONDITIONS

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Figure: 04

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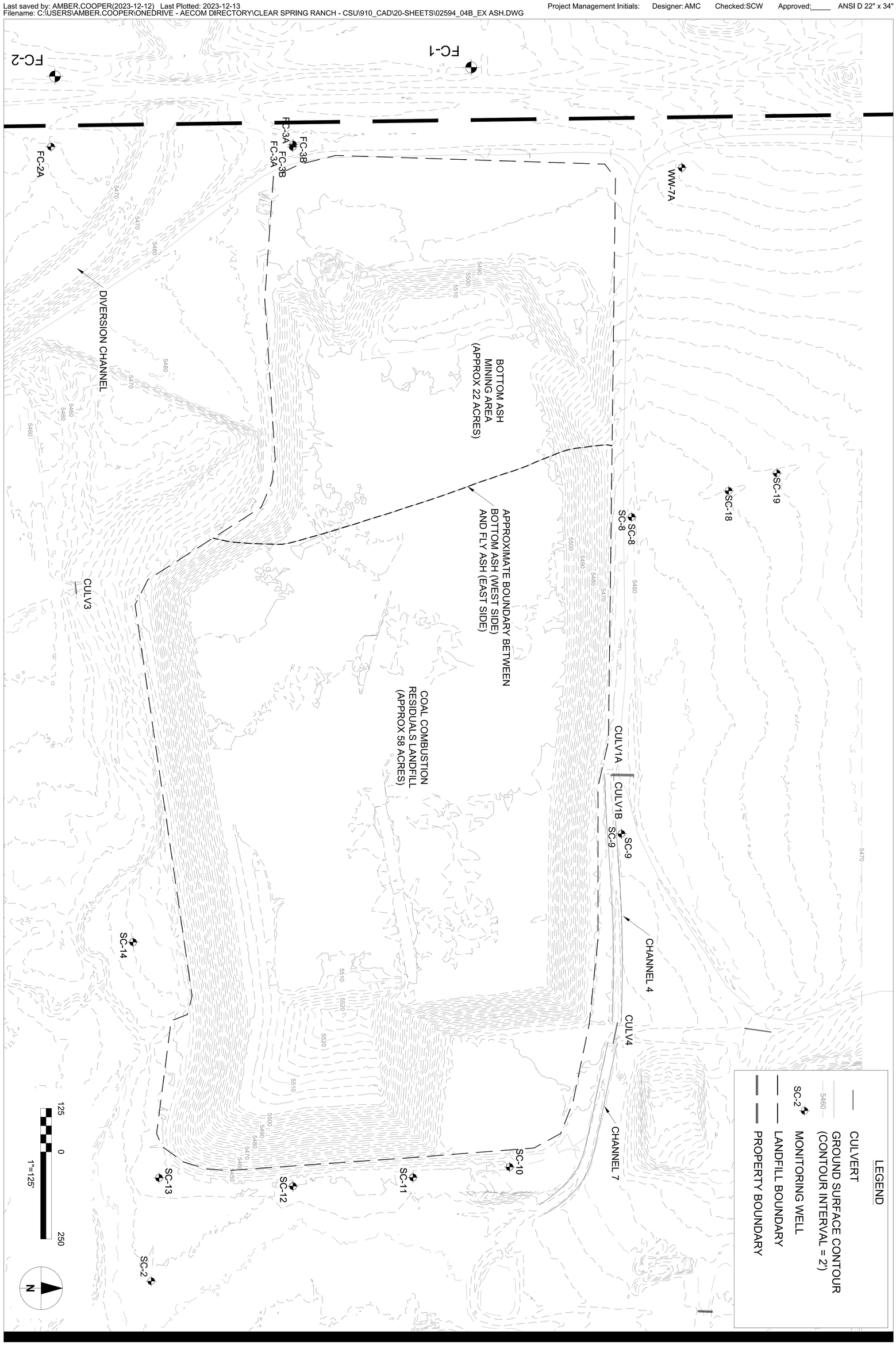

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 10-27-2023

CCR LANDFILL PLAN -
EXISTING CONDITIONS - CCR DISPOSAL AREAS

AECOM

Figure: 04B

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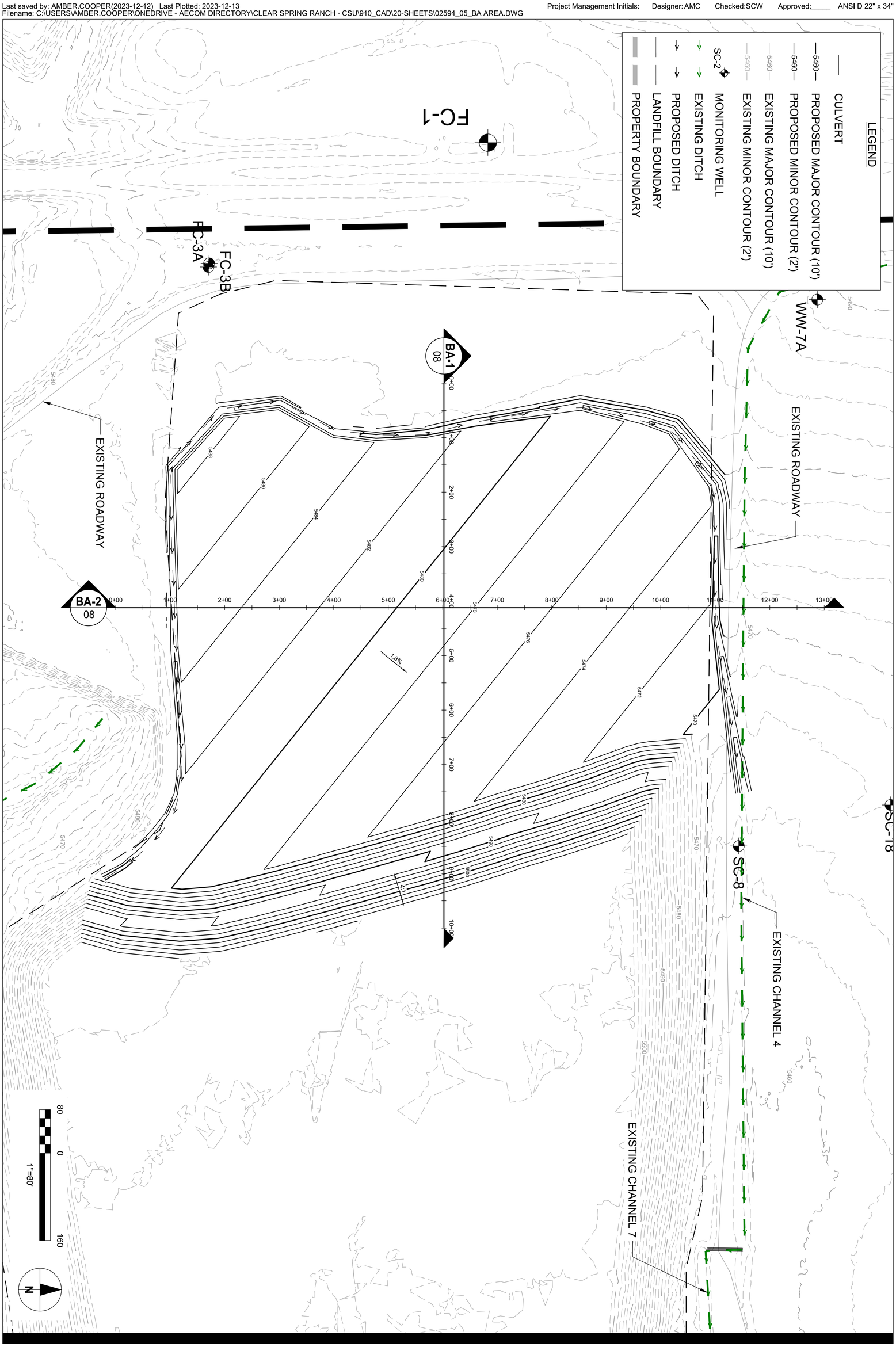
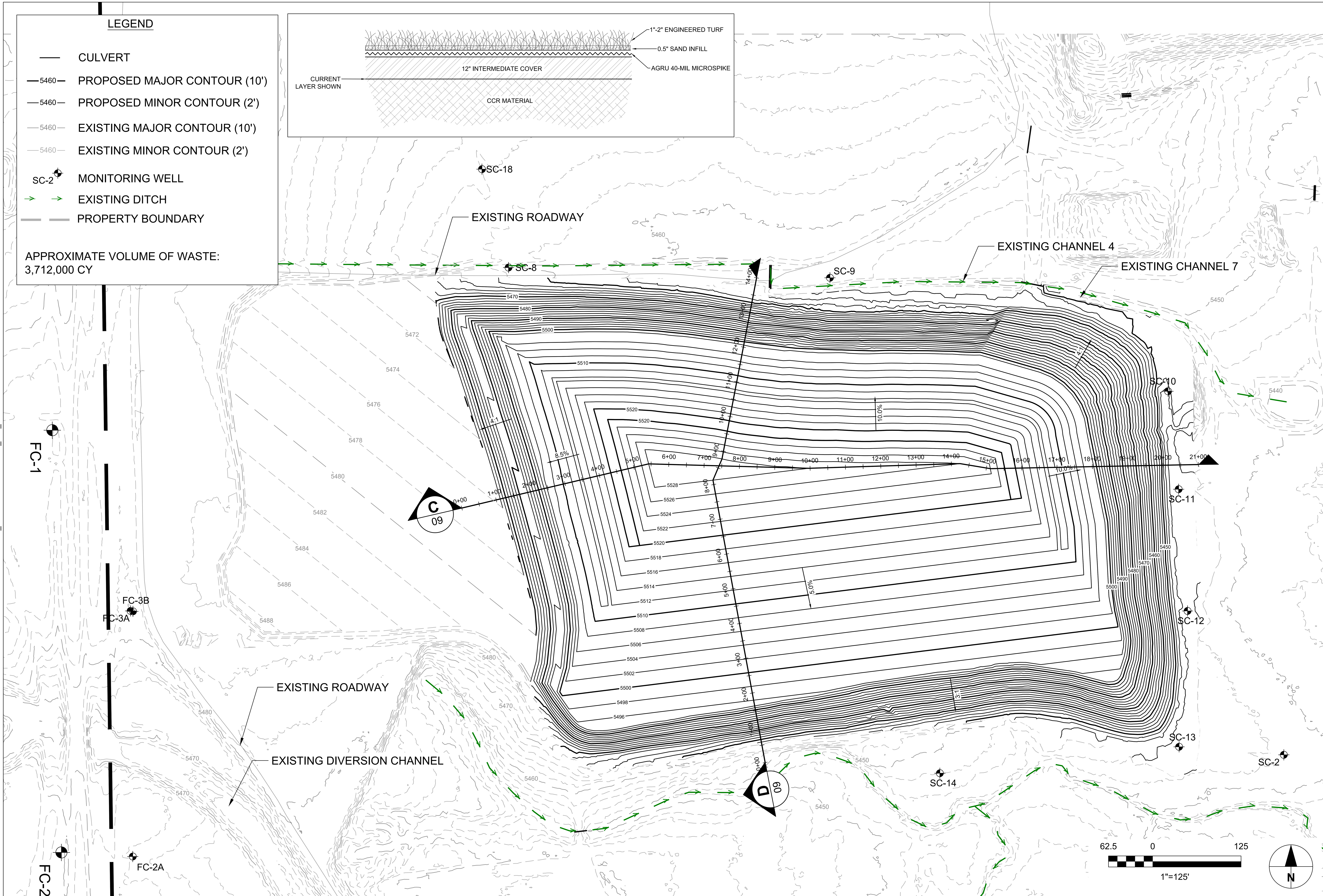


CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 10-27-2023

CCR LANDFILL CLOSURE GRADING PLAN
BOTTOM ASH AREA REGRADE

AECOM

Figure: 05



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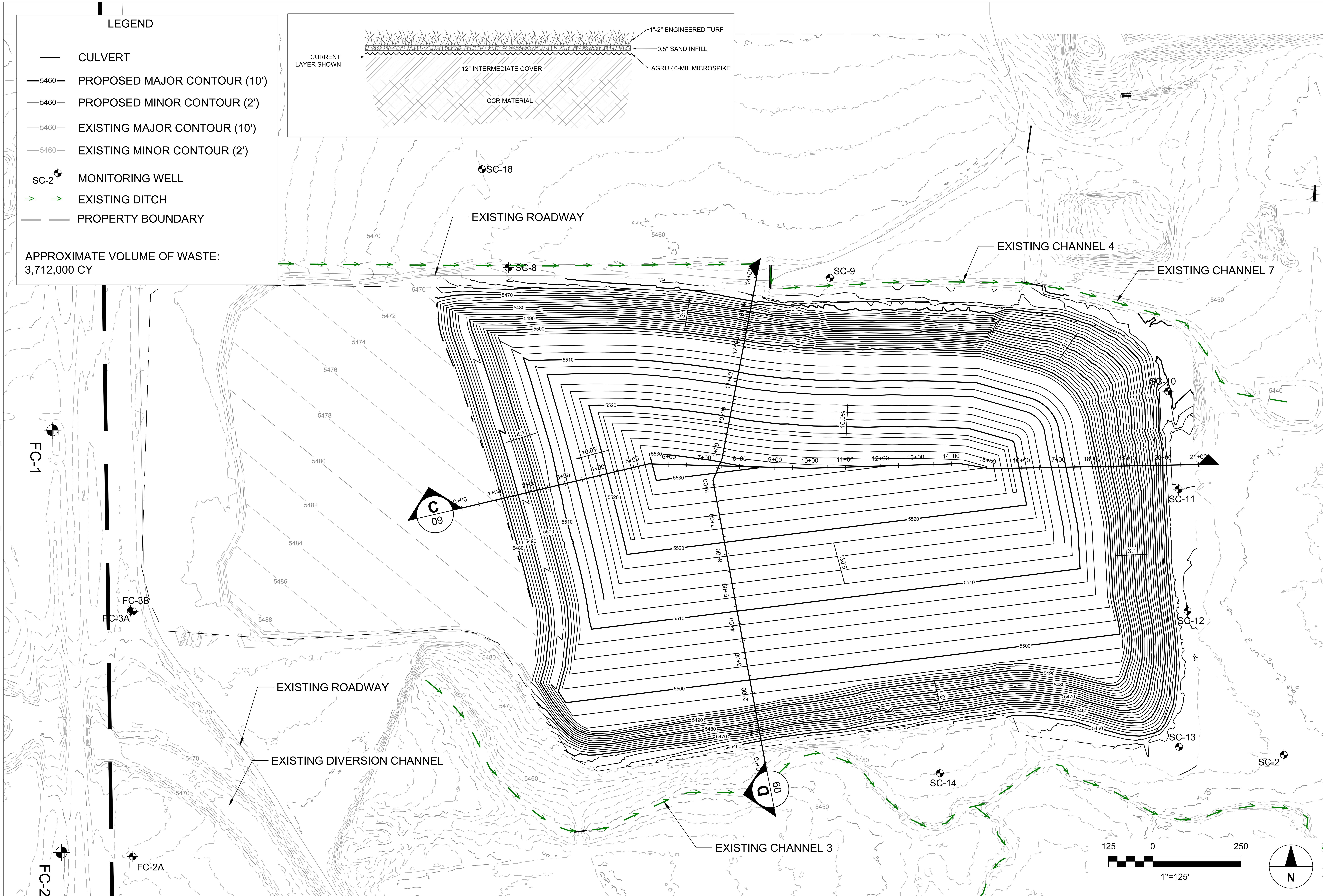
Project Management Initials: Designer: AMC Checked: SCW Approved: ANSI D 22" x 34"

AECOM

Figure: 06

CCR LANDFILL CLOSURE GRADING PLAN
PROPOSED TOP OF WASTE

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 10-27-2023



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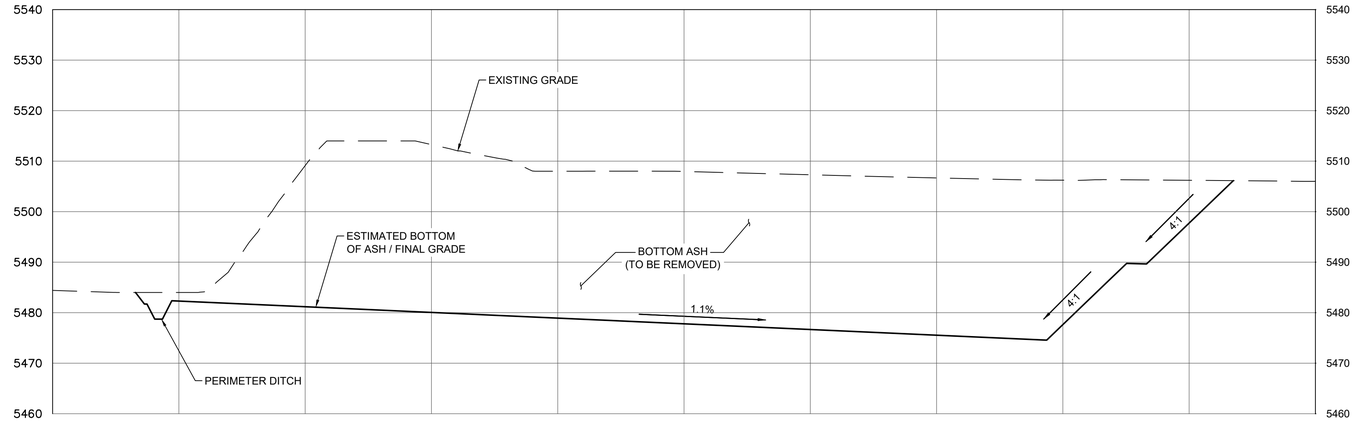
Project Management Initials: Designer: AMC Checked: SCW Approved: ____ ANSI D 22" x 34"

AECOM

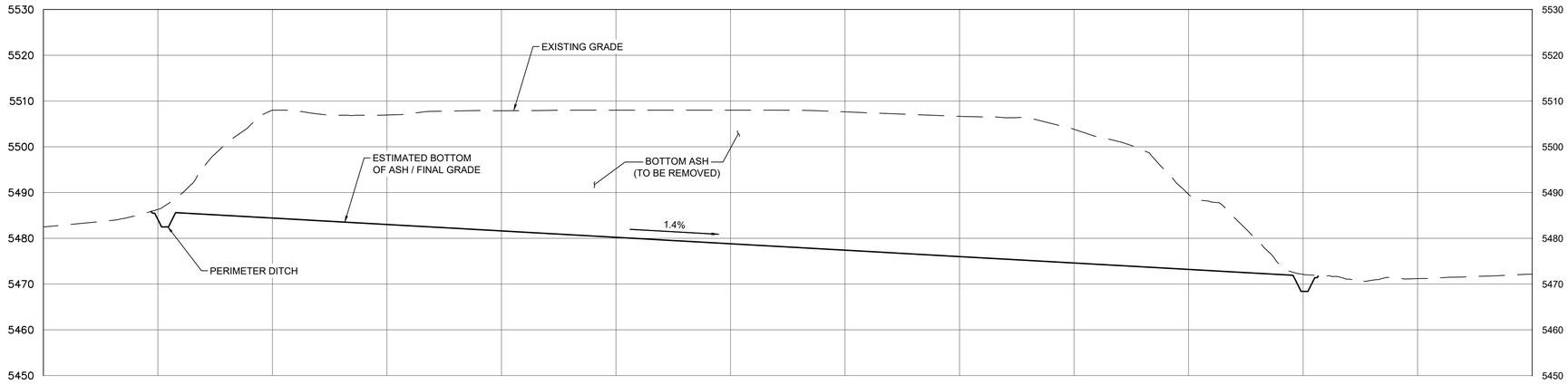
Figure: 07

CCR LANDFILL CLOSURE GRADING PLAN
PROPOSED TOP OF INTERMEDIATE COVER

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 10-27-2023



BA-1 PROFILE STA. 0+00 TO STA 10+00



BA-2 PROFILE STA. 0+00 TO STA 13+00

LEGEND

EXISTING GRADE PROFILE

PROPOSED GRADE PROFILE

60 0 120

1"=60'

VERTICAL EXAGGERATION: 10

N

AECOM

Figure: 08

CCR LANDFILL CLOSURE GRADING PLAN
PROFILES - BOTTOM ASH AREA

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 10-27-2023

Project Management Initials: Designer:AMC Checked:SCW Approved:_____ ANSI D 22" x 34"

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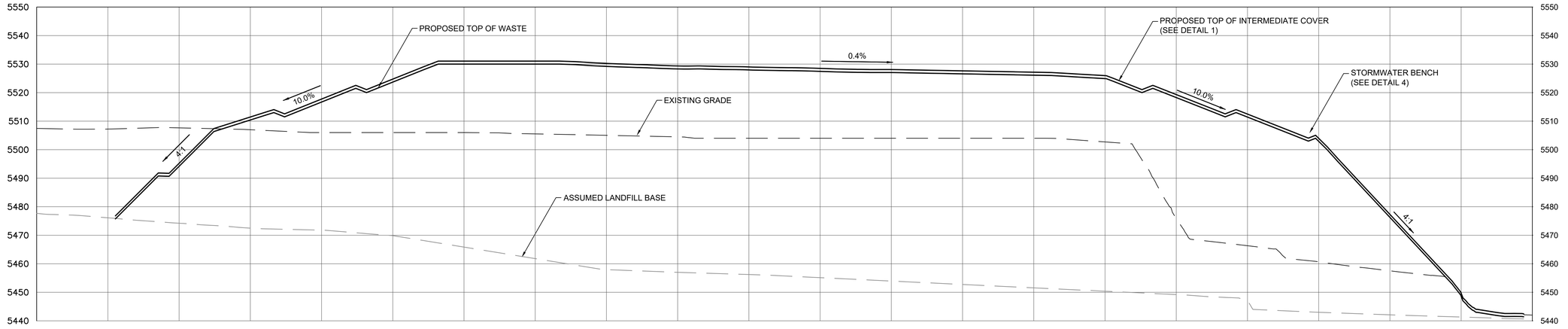
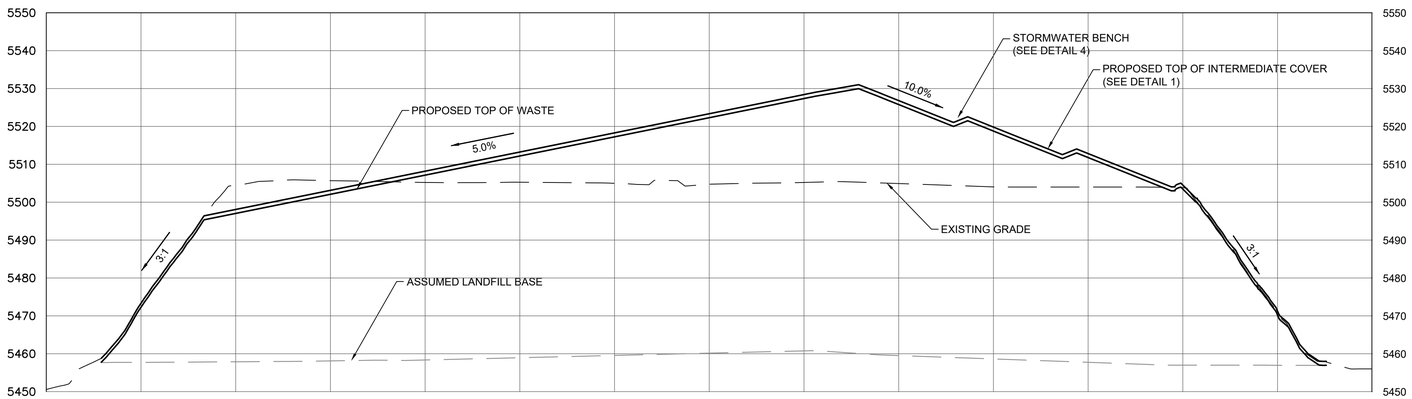


C-C PROFILE STA. 0+00 TO STA 21+00



D-D PROFILE STA. 0+00 TO STA 14+00

LEGEND

- EXISTING GRADE PROFILE
- PROPOSED GRADE PROFILE
- LANDFILL BASE GRADE PROFILE

80 0 160

1"=80'

VERTICAL EXAGGERATION: 10

N

AECOM

Figure: 09

CCR LANDFILL CLOSURE GRADING PLAN
PROFILES - LANDFILL

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 12-18-2023

Last saved by: AMBER.COOPER(2023-12-13) Last Plotted: 2023-12-13
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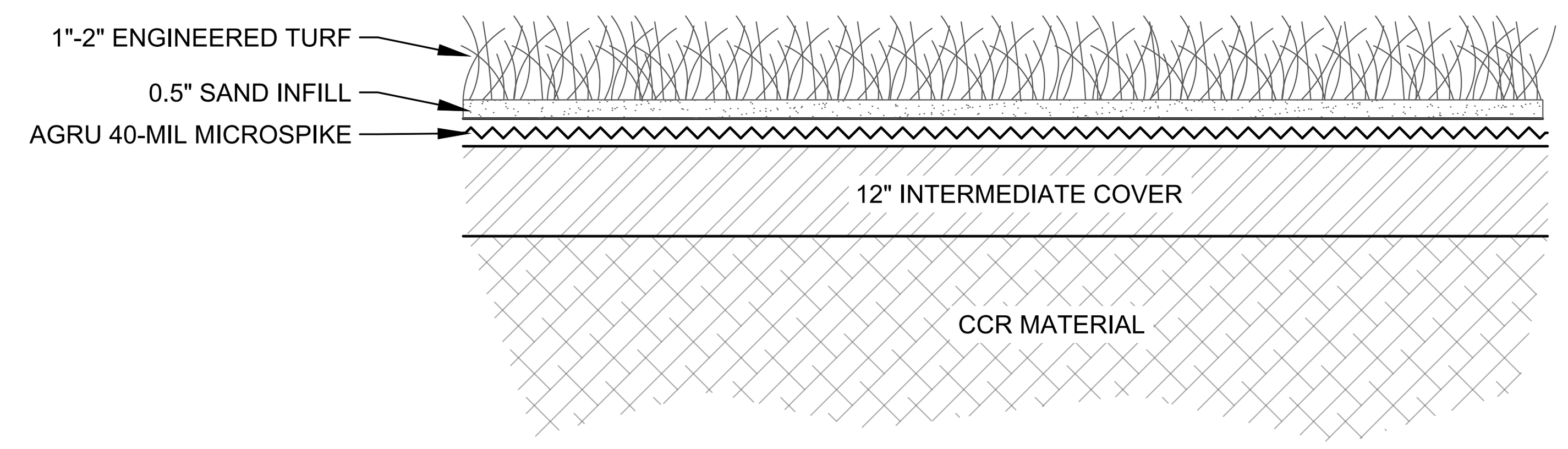
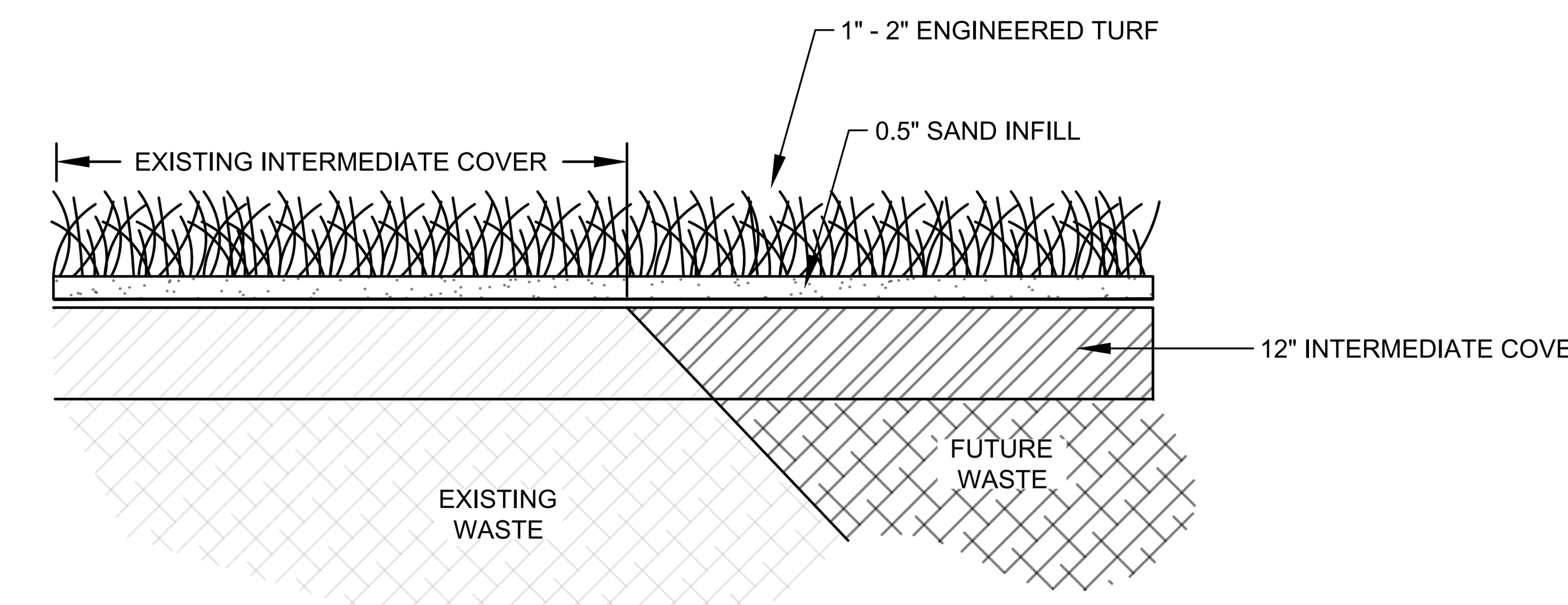
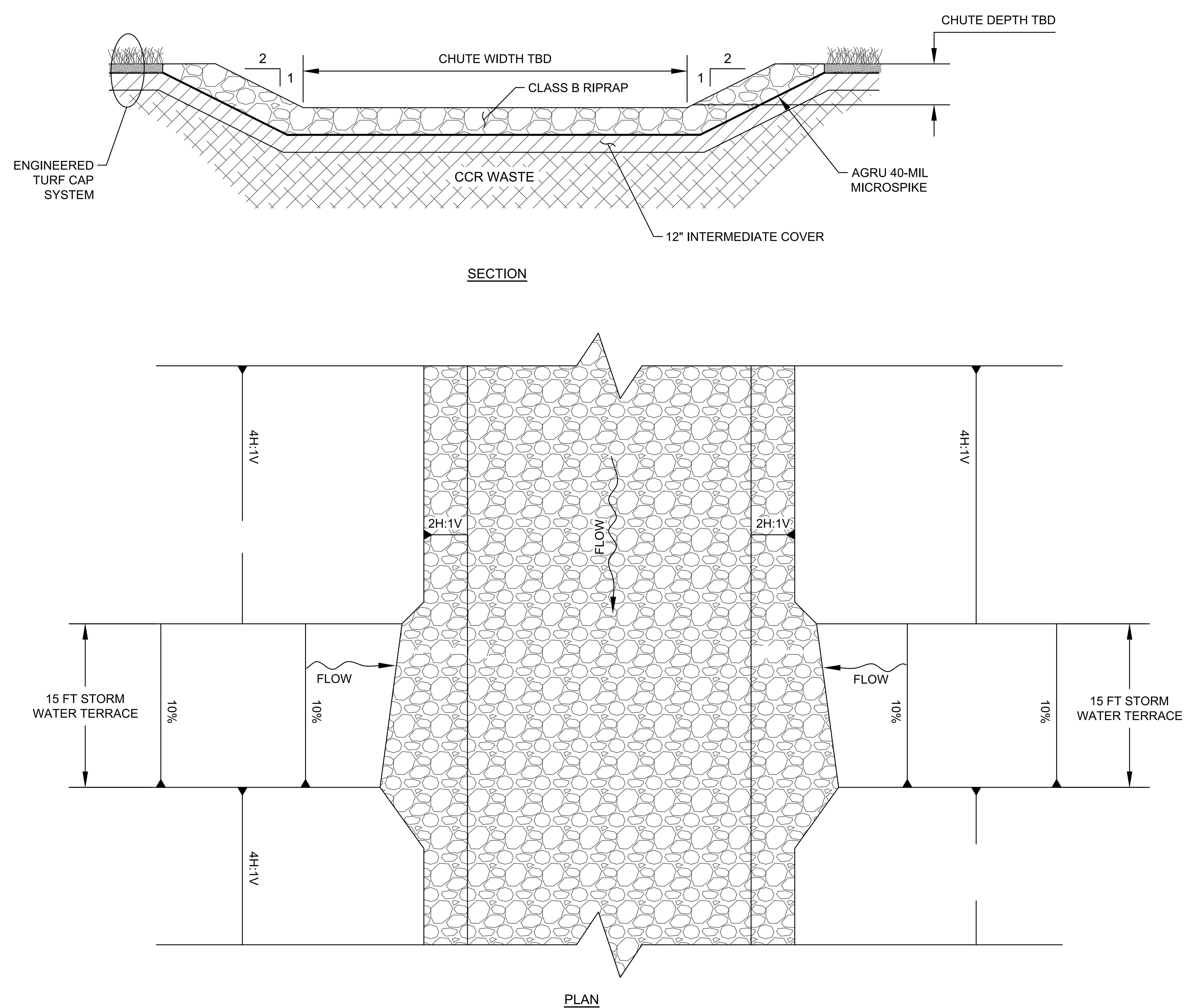
Project Management Initials: Designer:AMC Checked:SCW Approved:_____ ANSI D 22" x 34"



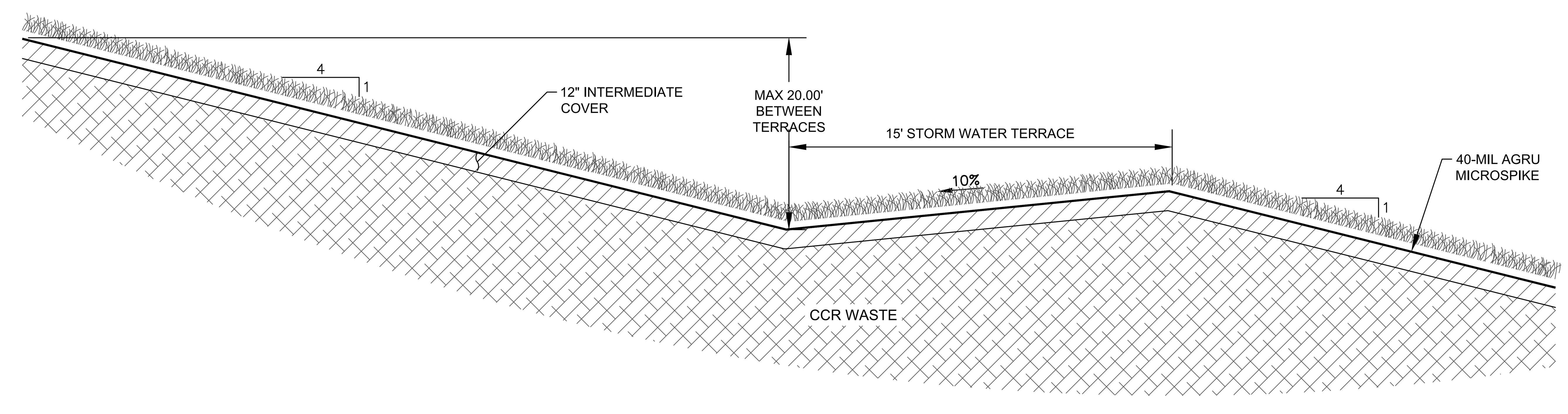
1 ENGINEERED TURF CAP SYSTEM
07 | 10A
NOT TO SCALE
09
10A
10B



2 CONNECTION TO EXISTING COVER
07 | 10A
NOT TO SCALE



3 STORMWATER LETDOWN
11 | 10A
NOT TO SCALE



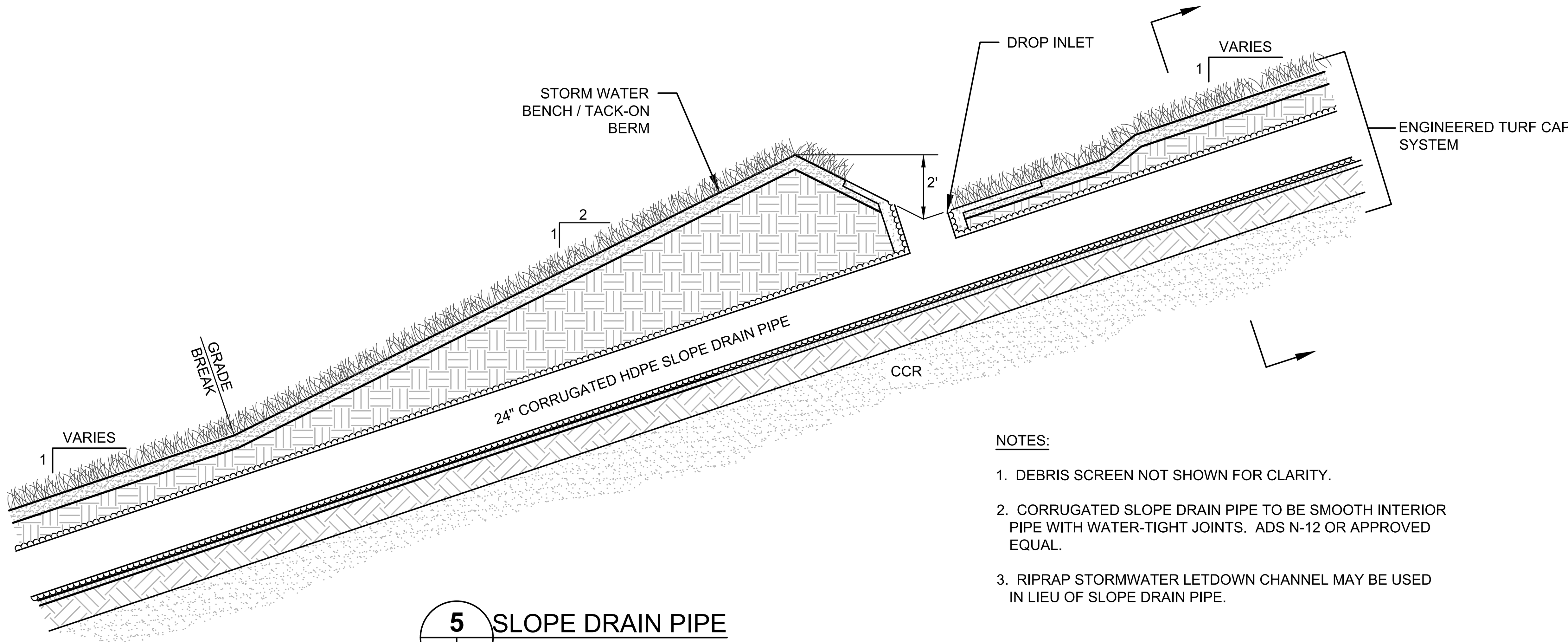
4 STORMWATER BENCH
11 | 10A
NOT TO SCALE

AECOM

10A

CCR LANDFILL CLOSURE GRADING PLAN
DETAILS I

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 10-27-2023

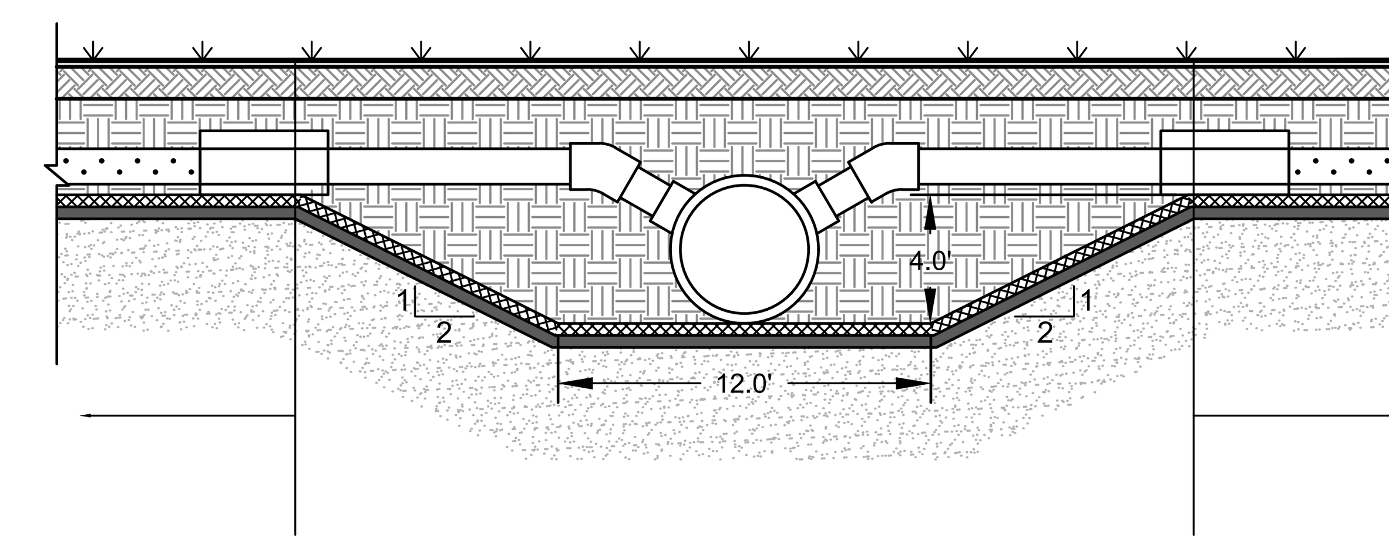


NOTES:

1. DEBRIS SCREEN NOT SHOWN FOR CLARITY.
2. CORRUGATED SLOPE DRAIN PIPE TO BE SMOOTH INTERIOR PIPE WITH WATER-TIGHT JOINTS. ADS N-12 OR APPROVED EQUAL.
3. RIPRAP STORMWATER LETDOWN CHANNEL MAY BE USED IN LIEU OF SLOPE DRAIN PIPE.

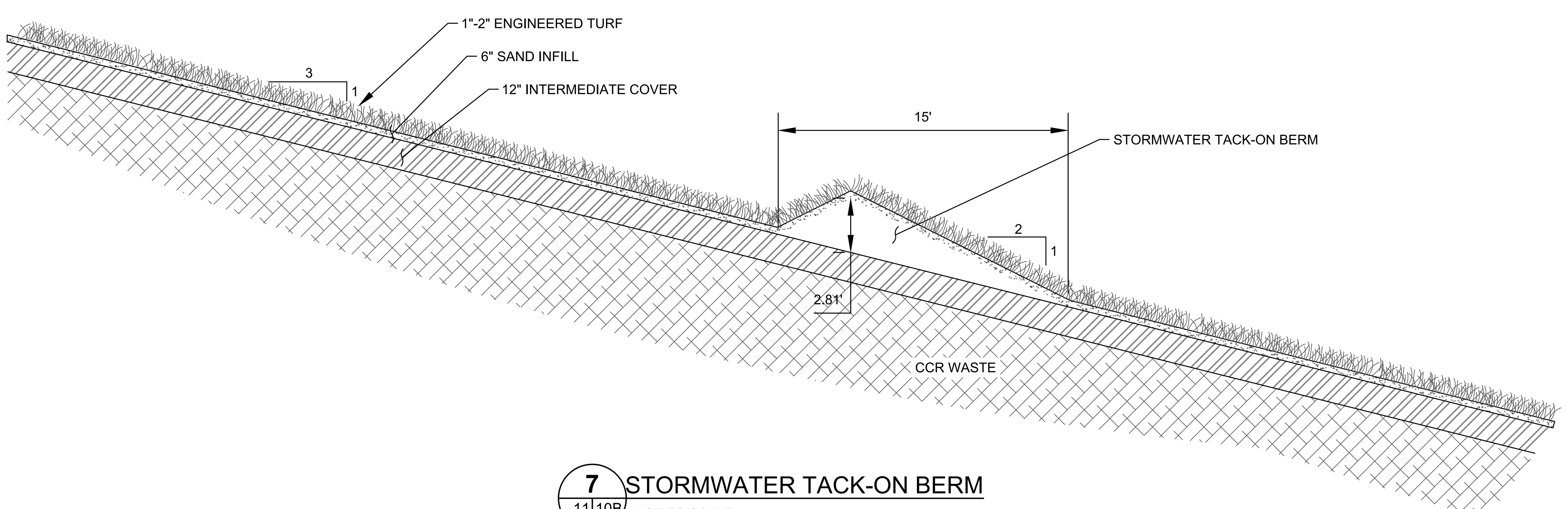
5 (10B | 10B) SLOPE DRAIN PIPE

NOT TO SCALE



6 (10B | 10B) TYPICAL SLOPE DRAIN CROSS SECTION

NOT TO SCALE



7 (11 | 10B) STORMWATER TACK-ON BERM

NOT TO SCALE

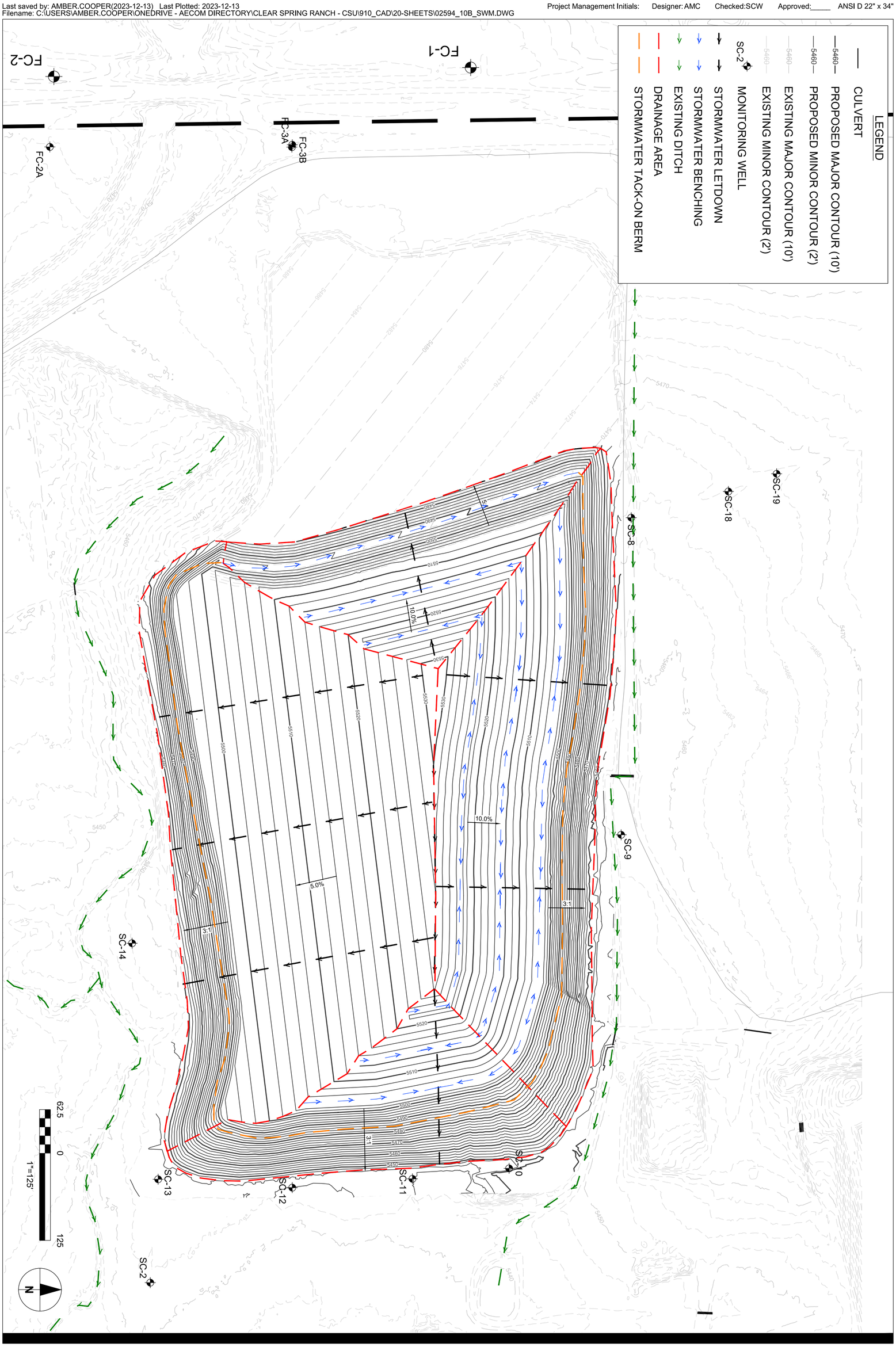
Project Management Initials: Designer: AMC Checked: SCW Approved: ____ ANSI D 22" x 34"

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 10-27-2023

CCR LANDFILL CLOSURE GRADING PLAN
DETAILS II

AECOM

10B



CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 10-27-2023

CCR LANDFILL CLOSURE GRADING PLAN
STORMWATER MANAGEMENT PLAN

AECOM

Figure: 11

Clear Spring Ranch Landfill Redesign

Technical Specifications

Colorado Springs Utilities
111 S. Cascade Ave.
Colorado Springs, CO 80903

December 19, 2023

30% Design

TABLE OF CONTENTS

SECTION 01 33 00 – SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Related Sections

B. Submittal Procedures

C. Construction Progress Schedules

D. Waste Management Plan

E. Health and Safety Plan

F. Close-Out Submittals

1.2 RELATED SECTIONS

A. Section 01 35 23 – Health, Safety and Emergency Procedures (to be submitted at a later date)

B. Section 01 78 00 – Closeout Procedures

1.3 SUBMITTAL PROCEDURES

A. Transmit each submittal with Owner's Engineer accepted form.

B. Sequentially number the transmittal form. Revise submittals with original number and a sequential alphabetic suffix.

C. Identify Project, Contractor, Subcontractor and Specification Section number as appropriate.

D. Apply Contractor's stamp, signed or initials certifying the review, verification of projects/equipment/materials required, field dimensions, adjacent construction work and coordination of information is in accordance with the requirements of the Work and Contract Documents.

E. Schedule submittals to expedite the Work and deliver to the Owner's Engineer. Coordinate submission of related items.

F. For each submittal for review, allow 5 days excluding delivery time to and from the Contractor unless otherwise specified.

G. Identify variations from Contract Documents and product or system limitations which may be detrimental to successful performance of the completed Work.

H. Provide space for the Owner's Engineer review signature.

I. Revise and resubmit, identify all changes made since previous submission.

J. Distribute copies of reviewed submittals as appropriate. Instruct parties to promptly report any inability to comply with provisions.

K. Submittals not requested may not be recognized or processed.

1.4 SUBMITTALS

A. Construction Schedule
1. Submit initial baseline schedule in duplicate within 7 days after date established in Notice to Proceed.
2. Revise and resubmit as required.
3. Submit revised schedules with each Application for Payment, identifying changes since previous version.
4. Show complete sequence of construction activity, identifying Work of separate stages and other logically grouped activities.
5. Indicate estimated percentage of completion for each item of Work at each submission.

B. Laboratory/Field Data
1. Submit material data sheets, prequalification testing, and additional testing (if required) for all liner components, aggregates, and erosion and sediment control components.
2. Submit analytical laboratory testing data for borrow source soils.
3. Submit compaction testing results.

C. Health and Safety Plan
1. Submit to Owner and Owner's Engineer for review. Plan must meet at a minimum OSHA and EPA approved general HASP guidance.
2. After review, produce copies and distribute in accordance with the above requirements and for record document purposes described in close out procedures.
3. The Notice to Proceed will not be given by the Owner until the final Health and Safety Plan has been received.
4. Submit copies of recognition of reading: signature pages of Health and Safety Plan and certificates of training.
5. No employee will be allowed on site without proper documentation of applicable health and safety training.

D. Daily Activity/Quality Reports
1. Submit Daily field reports/activity reports/quality reports for the previous day, on a daily basis.

E. Close-Out Submittals
1. Submit Post Job Submittals and Close-out Submittals to the Owner's Engineer following completion of the Work.
2. Submit all final submittals prior to final payment application. Application will not be processed until the Owner's Engineer has received the submittals.
3. All test and inspections logs, manifests, bills of lading, receipts of materials.

4. Final Survey.
5. Final Red-line Drawings.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 40 00 – QUALITY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes quality requirements.

B. Construction Materials Testing necessary to satisfy Contractor internal quality control procedures and to control the Work is the sole responsibility of the Contractor.

1.2 CONTRACTOR QUALITY CONTROL

A. Establish quality control for all work elements.

B. Keep a competent representative or superintendent in charge of the work who shall have full authority to direct the Work. Give the Work the constant attention necessary to facilitate the progress and cooperate with Owner, and with other contractors authorized to perform work adjacent to or within the physical limits of the work area. Provide experienced management, supervisory and key personnel as required to complete the Work.

C. Provide a quality control system to perform inspections, tests, and rework in the event of failure of items of work in compliance with the Contract provisions.

D. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship, to produce Work of specified quality.

E. Comply fully with manufacturers' instructions, including each step, in sequence and with all Quality Assurance/Quality Control (QA/QC) requirements of these Specifications for this Work.

F. Should manufacturers' instructions conflict with the Contract Documents, request clarification from Engineer before proceeding.

G. Contractor is responsible for intermediate surveying and grade checks to maintain design grades as shown in the Drawings.

H. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

I. Should specified reference standards conflict with the Contract Documents, request clarification from Engineer before proceeding.

J. Neither observations by the Owner’s Engineer, nor inspections, or approvals by other than the Owner and Owner’s Engineer, shall relieve the Contractor from his obligation to perform the Work in accordance with the requirements of the Contract Documents.

K. Provide personnel, equipment, tools and materials to comply with quality control testing of each Section.

L. Cooperate with construction quality assurance officer and provide assistance as requested.

M. Notify Owner's Engineer at least 24 hours in advance about tasks or activities which may require the CQA officer to be present (subgrade inspection, soil testing, etc.).

N. Furnish incidental labor and facilities:
1. To provide access to work to be measured/tested.
2. To facilitate inspections.

1.3 INSPECTION SERVICES

A. Prior to beginning Work, review the Contract requirements, drawings, submittals, received materials and the project work site.

B. An initial inspection shall be performed as soon as a representative segment of the particular item of work has been accomplished. Initial inspection shall include review of tests, examination of the quality of workmanship, a review for omissions or dimensional errors, and approval or rejection of the initial segment of the Work.

C. Follow-up inspections shall be performed as necessary and shall include continued testing and examinations to ensure continued compliance with the Contract requirements.

D. The Engineer will provide a construction quality assurance (CQA) officer to perform specified inspections.

E. The CQA officer will perform inspections and other services specified in individual Sections and as required by the Engineer.

F. CQA officer will complete a daily report and logs on prescribed forms.

1.4 QUALITY ASSURANCE TESTING

A. Provide assistance as required to Engineer for the collection of soil samples for environmental testing at the borrow source.

1.5 SUBMITTALS

A. Submit in accordance with Section 01 33 00, Submittal Procedures.

B. Daily Quality Control Reports.

C. Results of all completed testing.

D. Submit written reports of tests and engineering data electronically for review.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 01 78 00 – CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

This section covers project closeout items including closeout procedures, final cleaning, project record documents, and project certifications.

1.2 RELATED SECTIONS

A. Section 01 11 00 – Summary of Work (to be submitted at a later date)

B. Section 01 33 00 – Submittal Procedures

C. Section 01 50 00 – Temporary Facilities and Controls (to be submitted at a later date)

1.3 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 the Engineer's review.

B. Provide submittals that are required by governing authorities or other authorities.

1.4 FINAL CLEANING

A. Execute final cleaning prior to final project assessment.

B. Remove waste and surplus material, rubbish, and construction facilities from the site.

1.5 PROJECT RECORD DOCUMENTS

A. Maintain on-site one set of the following record documents; record actual revisions to the Work:
   1. Drawings
   2. Specifications
   3. Addenda
   4. Change Orders and other modifications to the Contract
   5. Health and Safety Plan

B. Ensure entries are complete and accurate, enabling future reference by Owner.

C. Store record documents separate from documents used for project.

D. Record Documents and Drawings: Legibly mark in red each item to record actual construction. Items to be shown include:
   1. Survey coordinates (horizontal and vertical) of underground utilities and appurtenances where modified.
   2. Field changes of dimensions and detail.
   3. Details not on original Contract Drawings.

E. Delete Engineer's title block and seal from all documents.

1.6 PRODUCT CERTIFICATIONS

A. Provide original or duplicate notarized copies.

B. Execute and assemble documents from Subcontractors, suppliers, vendors, etc.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 02 21 00 – SURVEYING

PART 1 - GENERAL

1.1 SUMMARY

A. Intermediate and milestone surveys shall be in accordance with the lines and grades shown on the Drawings or as directed by the Engineer.

B. The Engineer will subcontract a Professional Land Surveyor licensed in the State of Colorado to complete milestone construction surveys for the project.

C. The Owner will identify site reference points, survey control, and benchmarks (if applicable) as shown on the drawings at the preconstruction meeting.

D. The Surveyor shall establish all baselines for the location of the principal component parts of the work together with a suitable number of benchmarks. Surveyor shall develop and make all detail surveys necessary for construction.

E. Contractor is responsible for any intermediate surveying and grade checks necessary prior to completion of each milestone.

F. The Owner/Engineer reserves the right to request verification surveys to confirm the work completed by the Contractor. The Engineer may also check all, or any portion of the work and the Surveyor shall afford all necessary assistance to the Owner and/or Engineer in carrying out such checks. Any necessary corrections to the work shall be immediately made by the Contractor. Such checking by the Owner and Engineer shall not relieve the Contractor of any responsibilities for the accuracy or completeness of their work.

G. Survey data to be provide in AutoCAD Civil3D format 2019 format (or later) showing cogo point numbers, elevation and description.

H. Survey point data is to be collected at sufficient frequency to provide an accurate and representative depiction of finished grading conditions. At a minimum, slopes are to be surveyed every 50 feet at the top, mid-point, and toe, and all slope benches shall be presented.

1.2 RELATED SECTIONS:

A. Construction Quality Assurance (CQA) Plan

B. Division 31 Section – 31 20 00 Earthwork

C. Division 31 Section – 31 23 24 Closure Turf Installation

1.3 DEFINITIONS

A. As-Built/Redline Drawings – A set of drawings, or markup of drawings which depicts the actual as-built conditions of the completed construction, which provides the user with a permanent record of each project feature.

B. Record Drawings – A set of drawings which depicts the final conditions of a certifiable construction component to be submitted to the Agency for approval. Developed by the Engineer.

1.4 SUBMITTALS

A. Qualifications of the surveyor that will provide intermediate surveys performed by the Contractor.

B. Intermediate survey data sets in AutoCAD Civil3D format 2019 (or later).

C. Raw survey data files.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 SURVEY REQUIREMENTS

A. The horizontal datum shall be referenced to the Colorado Central State Plane Coordinate System, NAD83 or as approved by the Engineer. Elevations shall be reported in North Geodetic Vertical Datum 1929(NGVD 29) (feet above mean sea level). Survey shall include and tie into local monuments HR-6 and HR-7. Survey shall be extended through and checked through monuments HR-6 and HR-7.

B. Elevation of existing ground and appurtenances are believed to be reasonably correct but are not guaranteed to be absolute and therefore are presented only as an approximation. Any error or apparent discrepancy in the elevations or coordinates shown or omissions of data required for accurately accomplishing the stake out survey, immediately notify the Engineer.

C. Construction tolerances shall comply with the requirements of the specifications.

D. Survey information shall be provided electronically by Owner at start of project and electronically by the Surveyor at the end of the project.

E. Establish permanent benchmarks (in accordance with Owner's standard) on site as needed, referenced to established control points. Record locations, with horizontal and vertical data, on Project Record Documents.

F. Establish elevations, lines, and levels. Locate and lay out by instrumentation or similar appropriate means.

G. Periodically verify layouts by same means.

H. Notify the Engineer 72 hours in advance of estimated completion of the following conditions to schedule and complete milestone surveys:

1. <u>Landfill</u>:

Milestone 1. Landfill Surface, prior to cover system installation
Milestone 2. Final Site Conditions

2. <u>Bottom Ash Area</u>:

Milestone 1. Bottom of Excavation
Milestone 2. Final Site Conditions

3. After completion of embankments, complete intermediate survey of completed grades to provide complete as-built data and to verify the top of grade is at the grades and slopes specified the plans.

END OF SECTION

SECTION 31 05 16 –AGGREGATES

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers requirements for aggregates for construction of temporary access roads, riprap for outlet areas and drainage controls where needed.

1.2 RELATED SECTIONS

A. Division 31 Section – 31 20 00 “Earthwork”

B. Division 31 Section – 31 05 19.13 “Geotextiles”

1.3 REFERENCES

A. ASTM International
   1. ASTM C 136 – Sieve Analysis of Fine and Coarse Aggregates
   2. ASTM D 75 – Practice for Sampling Aggregates
   3. ASTM D 2434 – Laboratory Hydraulic Conductivity at Specified Density

B. Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction.

C. AASHTO
   1. M 43 - Standard Specification for Sizes of Aggregate for Road and Bridge Construction

1.4 SUBMITTALS

A. Provide material characteristic testing results and certificates that show materials meet Specification requirements.

B. Provide shipping information, Bill of Ladings, and weights of aggregate received on-site.

1.5 DELIVERY, HANDLING, AND STORAGE

A. Aggregate shall be stored at designated locations.

B. Aggregate shall be transported, placed, and stored in a manner so as to prevent contamination, segregation and excessive wetting. Materials which have become contaminated or segregated will not be permitted in the performance of the work and shall be removed from the site.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Stone Aggregates - Contractor shall install stone in accordance with the CDOT Standard Specifications, Latest Edition, and as shown on the Drawings. Location and thickness shall be as shown on the Drawings.

B. Rip Rap - Rip rap shall meet the requirements and gradations as defined by the CDOT Standard Specifications, Latest Edition. Location and thickness shall be as shown on the Drawings. The Contractor shall place the Class of rip rap shown on the Contract Drawings. The stone for rip rap shall consist of stone or recycled concrete from an approved source and comply with CDOT Section 506 and the gradation in Table 31 05 16-1.

Table 31 05 16-1 Riprap

Stone Size d50[1] (Inches)	Percent of Material Smaller than Typical Stone[2]	Typical Stone Dimensions[3] (Inches)	Typical Stone Weight[4] (Pounds)
6	70-100 50-70 35-50 2-10	12 9 6 2	85 35 10 0.4
9	50 20 10 5	15 12 9 3	160 85 35 1.3
12	140 60 30 10	21 18 12 4	440 275 85 3
18	275 110 55 20	30 24 18 6	1280 650 275 10
24	650 260 130 40	42 33 24 9	3500 1700 650 35

Notes:
[1] d50 = nominal stone size.
[2] based on typical rock mass.
[3] equivalent spherical diameter.
[4]Based on a specific gravity = 2.5

PART 3 - EXECUTION

3.1 STONE AGGREGATE

A. Contractor shall install stone in accordance with the CDOT Standard Specifications, Latest Edition, and as shown on the Drawings. Location and thickness shall be as shown on the Drawings.

B. For temporary and permanent access roads and construction entrances, the aggregate shall be placed on geotextile fabric and compacted to the required thickness as shown in the Drawings.

3.2 RIP RAP

A. The type, dimensions and locations for each type of rip rap shall be as shown on the Drawings.

B. During placing, rip rap shall be graded so that the smaller stones are uniformly distributed throughout the mass. The Contractor may place the riprap by mechanical methods, augmented by hand placing where necessary or ordered by the Engineer. The placed rip rap shall form a properly graded, dense, neat layer of stone. The placed rip rap shall have a minimum depth as indicated on the Drawings.

3.3 PLACEMENT

A. For aggregate placement directly over geotextile, extreme caution shall be exercised by the Contractor to prevent damage. Follow geosynthetic manufacturer's recommendations for maximum drop heights. Repair of all damage resulting from aggregate installations shall be made at no cost to the Owner.

3.4 FIELD QUALITY CONTROL

A. The CQA Officer will be responsible for monitoring the placement and/or compaction of the aggregate materials.

B. Stone Aggregate shall be placed to within ±0.1 ft. of the total thickness shown in the contract drawings, or as directed by the CQA Officer.

C. Riprap shall be placed into final position as directed by the CQA Officer to achieve the desired result with total thickness within ±0.2ft.

END OF SECTION

SECTION 31 05 16 - CLOSURETURF® SAND INFILL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Specifications for approved Sand Infill Component of the patented ClosureTurf® System.

B. Related Sections:
1. Section – 31 05 20.10 “ClosureTurf® MicroSpike Geomembrane”
2. Section – 31 23 13 "ClosureTurf® Subgrade Preparation”
3. Section – 31 05 16 "Aggregates”
4. Section – 32 18 13 “ClosureTurf® Installation”

PART 2 - PRODUCTS

2.1 DESCRIPTION

Sand Infill Component of the ClosureTurf® System shall meet the fine aggregate angularity, specific gravity and grain size distribution as specified by WatershedGeo in this Specification.

A. Fine aggregate angularity shall be tested in accordance with ASTM C 1252 / AASHTO T 304, Standard Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading). Method A. Method A uncompacted void content shall be greater than or equal to 40%.

B. Sand infill specific gravity shall be tested in accordance with ASTM C 128 / AASHTO T 84, Standard Test Method for Relative Density (Specific Gravity) and Absorption of Fine Aggregate. Bulk oven-dry specific gravity shall be greater than or equal to 2.40.

C. Sand infill grain size distribution shall be tested in accordance with ASTM C 136 / AASHTO T 27, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates. The grain size distribution shall be as prescribed in Table 1 and presented in Figure 1.

Table 1. Sand Infill Grain Size Distribution

		3/8" (9.5 mm)	≤	100%
90%	≤	#4 (4.75 mm)	≤	100%
50%	≤	#8 (2.36 mm)	≤	85%
25%	≤	#16 (1.18 mm)	≤	65%
10%	≤	#30 (0.60 mm)	≤	45%
0	≤	#50 (0.30 mm)	≤	30%
0	≤	#100 (0.15 mm)	≤	10%
0	≤	#200 (0.075 mm)	≤	5%

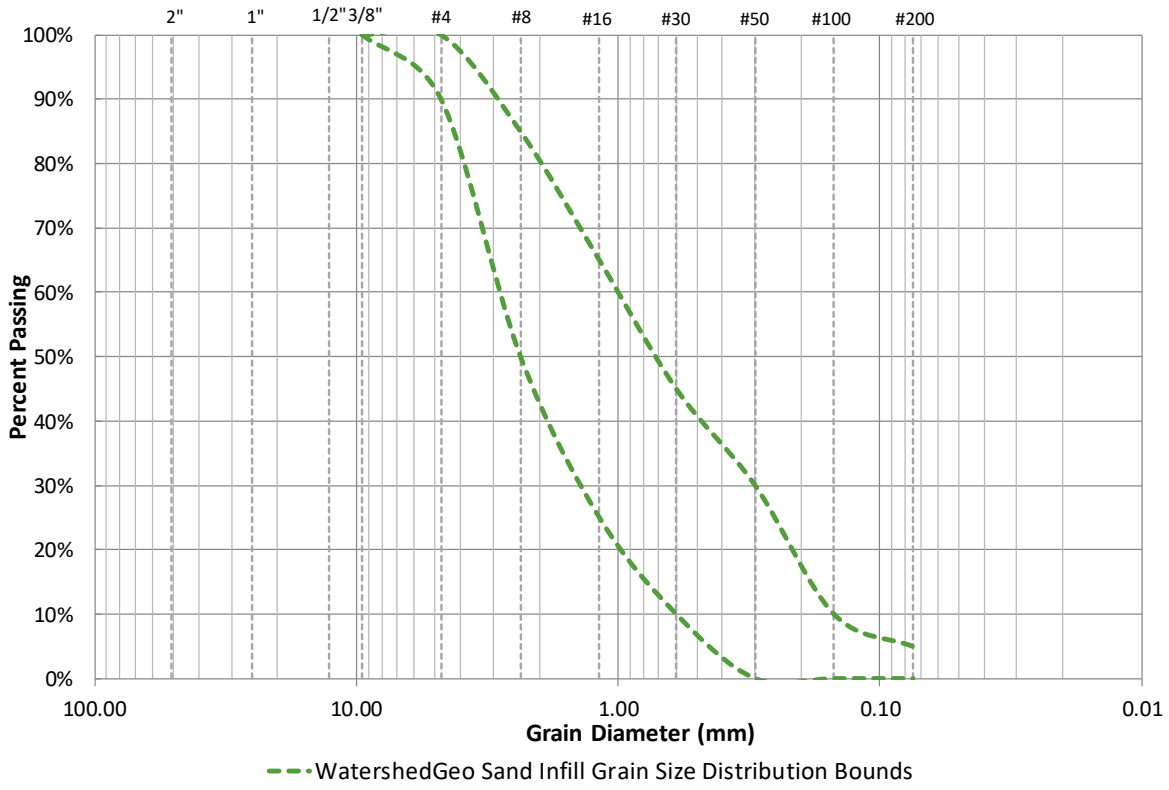


Figure 1: ClosureTurf® Specified Infill Grain Size Distribution

D. Documentation of sand infill conformance with ASTM C 136 / AASHTO T 27, ASTM C 128 / AASHTO T 84 and ASTM C 1252 / AASHTO T 304 shall be submitted to the CQAO.

E. Subsequent to initial verification of specification conformance, sand infill shall have grain size distribution conformance verified and documented for each 175 cubic yards to be installed.

F. Replacement sand used for future maintenance shall be tested and verified to conform with the grain size distribution shown in Figure 1.

PART 3 - EXECUTION

3.1 Placement of Sand Infill is included in Section 32 18 13 – Installation of ClosureTurf®.

END OF SECTION

SECTION 31 05 19.13 – GEOTEXTILES

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish and install all Geotextiles, including all necessary and incidental items to complete the installation in accordance with the Drawings, Specifications, and Manufacturer's guidance.

B. Geotextile shall be used beneath all aggregates used in temporary access roads, construction entrances, and beneath riprap ditches and outlets.

C. Related Sections:
1. Section – 31 25 00 "Erosion and Sediment Control"
2. Section – 31 05 16 "Aggregates"

D. References:
1. ASTM D 792 - Specific Gravity (Relative Density) and Density of Plastics by Displacement.
2. ASTM D 1117 - Methods of Testing Nonwoven Fabrics.
3. ASTM D 4354 - Sampling of Geosynthetics for Testing.
4. ASTM D 4355 - Deterioration of Geotextile from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
5. ASTM D 4491 - Water Permeability of Geotextile by Permittivity.
6. ASTM D 4533 - Trapezoidal Tearing Strength of Geotextile.
7. ASTM D 4595 - Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
8. ASTM D 4632 - Grab Breaking Load and Elongation of Geotextile.
9. ASTM D 4716 - Standard Test Method for Constant Head Hydraulic Transmissivity (In-plane Flow) of Geotextile and Geotextile Related Products.
10. ASTM D 4751 - Determining Apparent Opening Size of Geotextile.
11. ASTM D 4873 – Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.
12. ASTM D 5199 - Measuring Nominal Thickness of Geosynthetics.
13. ASTM D 5261 – Standard Test Method for Measuring Mass per Unit Area of Geotextile.
14. ASTM D 6241 –Static CBR Puncture
15. GRI GT13 – Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate.

1.2 SUBMITTALS

A. Submit Manufacturing Quality Control (MQC) data (Material Certifications) for geotextile to be used.

B. Submit Geotextile Manufacturer(s) Qualifications per Section 1.3 (A).

1.3 QUALIFICATIONS

A. The Geotextile Manufacturer(s) Qualifications - shall be a specialist(s) in the manufacture of polyester and/or polypropylene geotextile and have produced and manufactured a minimum of 5 million ft^2 of said geotextile that was used in successful installations.

1.4 MATERIAL LABELING, DELIVERY, STORAGE, AND HANDLING

A. Labeling – Each roll delivered to the site shall be wrapped individually in relatively impermeable and opaque protective covers and labeled by the Manufacturer. The label will identify the following:
   1. Manufacturer's Name
   2. Product Identification
   3. Length and Width
   4. Roll Number

B. During all periods of shipment and storage, all Geotextiles shall be protected from direct sunlight, temperature greater than 140°F, water, mud, dirt, dust, and debris.

C. To the extent possible, the Geotextile shall be maintained wrapped in heavy-duty protective covering until use. Geotextile delivered to the project site without protective covering shall be rejected. After the protective covering has been removed, the Geotextile shall not be left uncovered for longer than three (3) calendar days, under any circumstances.

D. Delivery - Rolls will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading. The Engineer will perform a visual inspection of all delivered rolls to ensure there has been no damage during shipping.

E. Storage and protection:
   1. Unloading, on-site handling, and storage of the Geotextile are the responsibility of the Installer.
   2. The Contractor shall provide on-site storage area(s) for Geotextile rolls from time of delivery until installation.
   3. Store and protect Geotextile from mud, dust, water, exposure to ultraviolet light, heat, and other sources of damage.

F. Handling
   1. The Contractor and Installer shall handle all rolls in such a manner to ensure they are not damaged in any way.
   2. Preserve integrity and readability of geotextile roll labels.

PART 2 - PRODUCTS

2.1 GEOTEXTILE

A. Separator Geotextile to be used in roadway applications shall be a minimum 8-ounce per square yard woven synthetic fabric consisting of staple or continuous filament polyester or polypropylene manufactured in a manner accepted by the Engineer and the Owner. Separator geotextile shall be Mirafi 600x or approved equal.

B. Geotextile for roadway and construction entrances shall be Class D and conform to the properties listed using the test methods listed in Table 31 05 19-1. The Contractor shall be responsible for timely submittals of all confirmation test data for geotextiles.

Table 31 05 19-1 Geotextile Fabrics

		Requirements Classes						
Property	Test Method	A	B	C	D	S	F	G
AOS, Metric Sieve, µm, Max.	ASTM D4751	300	300	300	212	600	850	850
Grab Tensile, N, Min.	ASTM D4632	330	400	580	800	800	400	400
% Elongation @ Failure, Min.	ASTM D4632	--	--	50	50	--	--	--
% Elongation @ 200 N, Max.	ASTM D4632	--	--	--	--	--	--	50
Burst Strength, N, Min.	ASTM D3787	440	620	930	1290	1390	--	--
Puncture, N, Min.	ASTM D4833	110	130	180	330	330	--	--
Trapezoid Tear Strength, N, Min.	ASTM D4533	110	130	180	220	220	--	--
Permittivity, Sec^{-1}, Min.	ASTM D4491	1.0	1.0	1.0	1.0	0.2	0.01	0.01
Grab Tensile Strength Retained after weathering 150 h, UVA lamps, %, Min	ASTM D4632 ASTM G154	70	70	70	70	70	--	--
Grab Tensile Strength Retained after weathering 500 h, UVA lamps, %, Min	ASTM D4632 ASTM G154	--	--	--	--	--	70	70

2.2 MANUFACTURING QUALITY CONTROL

A. The Contractor shall provide Manufacturer Quality Control methods and test data for the material shipped to the project site as outline under Paragraph 1.2 – Submittals of these Specifications. Any additional testing to verify the material quality is to be completed by the Contractor at no additional expense to the Owner.

2.3 QUALITY ASSURANCE

A. At the option of the Engineer, representative samples of Geotextiles shall be obtained and tested by a qualified laboratory to assure that the material properties conform with these Specifications.

B. Conformance testing of the Geotextiles shall include, but not be limited to, the following properties:
   1. Mass Per Unit Area (ASTM D5261)
   2. Thickness (ASTM D5199)
   3. Grab Tensile Strength/Elongation (ASTM D4632)
   4. Trapezoidal Tearing Strength (D 4533)
   5. Puncture Resistance (ASTM D4833 or D6241)
   6. UV Resistance (ASTM D4355)
   7. Burst Strength (ASTM D3786)

C. The Engineer may add to, remove or revise the test methods used for determination of conformance properties to allow for use of improved methods.

D. All Geotextile conformance test data shall meet or exceed requirements outlined in Table 31 05 19.13-1 of these Specifications prior to installation. Any materials that do not conform to these requirements shall be retested or rejected at the direction of the Engineer.

E. Geotextile that is rejected shall be removed from the project site and replaced at the Contractor's expense. Sampling and conformance testing of the Geotextile supplied as replacement for rejected material shall be performed by the Engineer at Contractor's expense.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prevent damage to Geotextile during placement, i.e. removal of stones or sharp objects from surface that could damage the geotextile.

B. Significant holes and depressions (i.e. those that would allow water to pond on the surface) shall be filled prior to Geotextile installation.

3.2 INSTALLATION

A. Geotextile installation shall be the responsibility of the Contractor. Any damaged or unacceptable material shall be replaced at no additional cost to the Owner.

B. Place geotextile as shown on Drawings. Geotextiles with defects, holes, tears, evidence of deterioration or other damage shall not be allowed.

C. The Geotextiles shall be placed smooth and free of excessive wrinkles.

D. When the Geotextiles are placed on slopes, the upslope fabric portion shall be lapped such that it is the upper or exposed Geotextile.

E. Geotextiles shall be temporarily secured in a manner accepted by the Engineer prior to placement of overlying materials.

F. It shall be the Contractor's responsibility to secure and protect any exposed geotextile during deployment. The number of sandbags or extent of other methods necessary to protect the work shall be determined by and at the expense of the Contractor.

G. In the absence of specific requirements shown on the Drawings, the following shall be used for overlaps of adjacent rolls of Geotextile:

GEOTEXTILE TYPE/ APPLICATION	OVERLAP OF ADJACENT ROLLS[(1)] (INCHES)	TRANSVERSE END OVERLAP (INCHES)
Separator-Roadway Applications	12 min	24 min

[(1)] Overlaps may be reduced if adjacent panels are sewn or heat bonded where approved by the Engineer.

H. Any Geotextile that is torn or punctured shall be repaired or replaced as directed by the CQA Consultant by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same type of Geotextile placed over the failed areas and shall overlap the existing Geotextile a minimum of 24-inches from any point of the rupture.

3.3 PROTECTION

A. Do not drive vehicles directly on installed fabric. Damage to the geotextile and/or underlying components of the liner system shall be the responsibility of the Contractor.

B. Any Geotextile that is subjected to excessive sediment buildup on its surface during construction shall be replaced by the Contractor prior to placement of overlying material.

END OF SECTION

SECTION 31 05 20.10 - CLOSURETURF® MicroSpike Geomembrane

PART 1 - GENERAL

1.1 SUMMARY

A. Product specifications for ClosureTurf® MicroSpike geomembrane.

B. Related Sections:
1. Section – 31 05 16.1 “ClosureTurf® Sand Infill”
2. Section – 31 23 13 "ClosureTurf® Subgrade Preparation”
3. Section – 32 18 13 “ClosureTurf® Installation”

1.2 REFERENCES

A. ASTM D 792 – Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement

B. ASTM D 1004 – Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting

C. ASTM D 1238 – Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer

D. ASTM D 3895 – Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

E. ASTM D 4218 – Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique

F. ASTM D 4833 – Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products

G. ASTM D 5199 – Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes

H. ASTM D 5397 – Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test

I. ASTM D 5596 – Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

J. ASTM D 5994 – Standard Test Method for Measuring Core Thickness of Textured Geomembrane

K. ASTM D 6392 – Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

L. ASTM D 6693 – Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

M. ASTM D 7466 – Standard Test Method for Measuring Asperity Height of Textured Geomembrane

N. GRI-GM13 – Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

O. GRI-GM17 – Test Methods, Test Properties, and Testing Frequency and for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes

1.3 DEFINITIONS

A. Lot: A quantity of resin (usually a rail car) used in the manufacture of geomembranes. Finished roll will be identified by a roll number traceable to the resin lot used.

B. ClosureTurf® System: A patented four component system consisting of a Watershed Geosynthetics specific gas management system (not applicable), a structured geomembrane (HDPE), an engineered turf, and a specified grade of sand infill.

C. Construction Quality Assurance Officer (CQAO): The Owner's Representative, performing duties as outlined in these specifications.

D. Engineer: The individual or firm responsible for the design and preparation of the project's Contract Drawings and Specifications.

E. Contractor: The party responsible for field handling, transporting, storing, deploying, seaming, temporary restraining (against wind), and installing the geomembrane.

F. Geomembrane Manufacturer: The party responsible for manufacturing the geomembrane rolls.

G. Geosynthetic Quality Assurance Laboratory (Testing Laboratory): Party, independent from the Owner, Manufacturer and Installer, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, usually under the direction of the Owner.

H. Panel: Area of a geomembrane that will be seamed in the field that is larger than 100 ft^2.

I. Patch: Area of a geomembrane that will be seamed in the field that is less than 100 ft^2.

J. Subgrade Surface: Soil layer surface which immediately underlies the geosynthetic material(s).

1.4 SUBMITTALS

A. Furnish the following product data, in writing, to the Engineer prior to installation of the geomembrane:

1. Resin Data shall include the following:
   a. Certification stating that the resin meets the specification requirements in **Table 2.1**.
2. Geomembrane Roll:
   a. Statement certifying no recycled polymer and no more than 10% rework of the same type of material is added to the resin (product run may be recycled).

B. The Installer shall furnish the following to the Engineer and Owner prior to installation:
1. Installation layout drawings
   a. Must show proposed panel layout including field seams and details.
   b. Must be approved prior to installing the geomembrane.
2. Approved drawings will be for concept only and actual panel placement will be determined by site conditions.
3. Installer's Geosynthetic Field Installation Quality Assurance Plan

C. The Installer will submit the following to the Engineer upon completion of installation:
1. Certificate stating the geomembrane has been installed in accordance with the Contract Documents.
2. Material and installation warranties.
3. As-built geomembrane panel drawings that include:
   a. panel locations;
   b. panel identification numbers;
   c. geomembrane roll numbers for each panel;
   d. seam caps;
   e. destructive sample locations; and
   f. location of repairs greater than 12 inches

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with these Specifications and the CQA Plan.

B. Friction Angle Requirements and Testing
1. The effective interface shear strength envelope at the interface between the geomembrane and the materials in direct contact with the geomembrane shall be verified by performing interface friction testing on representative materials to be used for construction of the liner system.
2. The interface frictional resistance shall be determined by direct shear tests in general accordance with ASTM D5321.
3. The interfaces and/or soil shall be tested saturated with water.

C. The Manufacturer shall sample and test the HDPE geomembrane material, at minimum frequencies specified. General manufacturing procedures shall be performed in accordance with the Manufacturer's internal quality control guide and/or documents.

D. All non-conductive geomembrane sheets shall be continuously spark tested during manufacturing.
   1. The spark tester shall be capable of detecting defects or pinholes less than 10 mils in diameter.
   2. All necessary repairs to the geomembrane shall be made by the manufacturer at the factory before shipment.
   3. The manufacturer shall provide written certification to the Owner and/or Engineer that all the geomembrane rolls delivered to the project were continuously spark tested and do not contain pinhole defects.

E. The Engineer shall examine the rolls upon delivery to the site and report and deviations from these Specifications to the Contractor.

F. If a geomembrane sample fails to meet the quality control requirements of this Section, the Contractor and/or Engineer shall require that the Geomembrane Manufacturer sample and test each roll manufactured in the same lot or batch, or at the same time, as the failing roll. Additional sampling and testing shall be completed at no additional cost to the Owner. Sampling and testing of rolls shall continue until a pattern of acceptable test results is established.

G. Any geomembrane sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to the Owner. At the Geomembrane Manufacturer's discretion and expense, additional testing of individual rolls may be performed to more closely identify noncomplying rolls and to quality individual rolls.

1.6 QUALIFICATIONS

A. Manufacturer
   1. Geomembrane shall be manufactured by AGRU America, Inc. or approved equal.
   2. Manufacturer shall have manufactured a minimum of 10,000,000 square feet of polyethylene geomembrane during the last year.

B. Installer
   1. Installer shall have installed a minimum of 5,000,000 square feet of HDPE geomembrane during the last 5 years.
   2. Installer shall have worked in a similar capacity on at least 10 projects similar in complexity to the project described in the contract documents, and with at least 250,000 square feet of HDPE geomembrane installation on each project.
   3. The Installation Supervisor shall have worked in a similar capacity on projects similar in size and complexity to the project described in the Contract Documents.
   4. The Installer shall provide a minimum of one Master Seamer for work on the project.
      a. Must have completed a minimum of 1,000,000 square feet of geomembrane seaming work using the type of seaming apparatus proposed for the use on this Project.

1.7 MATERIAL LABELING, DELIVERY, STORAGE AND HANDLING

A. Labeling – Each roll of geomembrane delivered to the site shall be labeled by the Manufacturer. The label will identify:

a. Manufacturer's name
b. Product identification
c. Thickness
d. Length
e. Width
f. Roll number

B. Delivery – Rolls of liner will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

C. Storage – The on-site storage location for geomembrane material, provided by the Contractor to protect the geomembrane from punctures, abrasions and excessive dirt and moisture should have the following characteristics:
   a. Level (no wooden pallets)
   b. Smooth
   c. Dry
   d. Protected from theft and vandalism
   e. Adjacent to the area being lined

D. Handling – Materials are to be handled so as to prevent damage.

1.8 WARRANTY

A. Material shall be warranted, on a pro-rata basis against Manufacturer's defects for a period of 1 year from the date of geomembrane installation.

B. Installation shall be warranted against defects in workmanship for a period of 1 year from the date of geomembrane completion.

PART 2 - PRODUCTS

2.1 GEOMEMBRANE PROPERTIES

A. Material shall be smooth, textured or structured polyethylene geomembrane as shown on the drawings. Geomembrane shall be flat die-cast extruded.

B. Resin
   1. Resin shall be new, first quality, compounded and manufactured specifically for producing geomembrane.
   2. Natural resin (without carbon black) shall meet the following requirements:

Table 1 - Raw Material Properties

Property	Test Method	HDPE	LLDPE
Density (g/cc)	ASTM D792, Method B	≥0.932	≥0.915
Melt Flow Index (g/10 min)	ASTM D 1238 (190/2.16)	≤1.0	≤1.0

C. Geomembrane Rolls
   1. Do not exceed a combined maximum total of 1 percent by weight of additives other than carbon black.
   2. Geomembrane shall be free of holes, pinholes as verified by on-line electrical detection, bubbles, blister, excessive contamination by foreign matter, and nicks and cuts on roll edges.
   3. Geomembrane material is supposed to be in roll form. Each roll is to be identified with labels indicating roll number, thickness, length, width and manufacturer.
   4. All liner sheets produced at the factory shall be inspected prior to shipment for compliance with the physical property requirements listed in Section 2.1.D and be tested by an acceptable method of inspecting for pinholes.
   5. All geomembrane shall contain edge markings which shall denote the name of the manufacturer, the product thickness, the year of manufacture and the length of the roll. These markings shall occur at uniformly spaced intervals throughout the entire length of the roll.

D. Textured surface and structured surface geomembrane shall contain a smooth surface on each edge. Otherwise, texturing shall be uniform from edge to edge and roll to roll. Textured geomembrane shall be manufactured with an embossed surface to ensure uniformity of texture. Geomembrane shall meet the requirements shown for HDPE MicroSpike® in the following table:

Table 2 - AGRU HDPE MicroSpike® Textured Geomembrane

Tested Property	Test Method	Frequency	Minimum Average Value				
			30 mil	40 mil	60 mil	80 mil	100 mil
Thickness, (min. average) mil (mm) Lowest individual reading (-10%)	ASTM D5994	every roll	30 (0.75) 27 (0.68)	40 (1.0) 36 (0.90)	60 (1.5) 54 (1.35)	80 (2.0) 72 (1.8)	100 (2.5) 90 (2.25)
Density, g/cm³	ASTM D792 Method B	200,000 lb	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction) Strength at Break, lb/in-width (N/mm) Strength at Yield, lb/in-width (N/mm) Elongation at Break, % Elongation at Yield, %	ASTM D6693, Type IV Dumbell, 2 ipm G.L. 2.0 in (51 mm) G.L. 1.3 in (33 mm)	20,000 lb	 66 (11) 66 (11) 350 12	 88 (15) 88 (15) 350 12	 132 (23) 132 (23) 350 12	 176 (31) 176 (31) 350 12	 220 (38) 220 (38) 350 12
Tear Resistance, lb (N)	ASTM D1004	45,000 lb	23 (102)	30 (133)	45 (200)	60 (267)	72 (320)
Puncture Resistance, lb (N)	ASTM D4833	45,000 lb	60 (267)	90 (400)	120 (534)	150 (667)	180 (801)
Carbon Black Content, % (Range)	ASTM D4218	20,000 lb	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D5596	45,000 lb	Note[1]	Note[1]	Note[1]	Note[1]	Note[1]
Asperity Height, mil (mm)	ASTM D7466	second roll	20 (0.5)	20 (0.5)	20 (0.5)	18 (0.45)	18 (0.45)
Notched Constant Tensile Load, hr	ASTM D5397, App.	200,000 lb	500	500	500	500	500
Oxidative Induction Time, min	ASTM D 3895, 200° C; O2, 1 atm	200,000 lb	>140	>140	>140	>140	>140

NOTES:

- [1] Dispersion only applies to near spherical agglomerates. 10 views shall be Category 1 or 2.
- All AGRU geomembranes have dimensional stability of ±2% when tested according to ASTM D1204 and LTB OF <-77° C when tested according to ASTM D746.

E. Extrudate Rod or Bead
   1. Extrudate material shall be made from same type resin as the geomembrane.
   2. Additives shall be thoroughly dispersed.
   3. Materials shall be free of contamination by moisture or foreign matter.

PART 3 - EXECUTION

3.1 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:
   1. Gauges showing temperatures in apparatus such as extrusion welder or fusion welder shall be present.
   2. An adequate number of welding apparati shall be available to avoid delaying work.
   3. Power source must be capable of providing constant voltage under combined line load.

3.2 DEPLOYMENT

A. Assign each panel a simple and logical identifying code. The coding system shall be subject to approval and shall be determined at the job site.

B. Visually inspect the geomembrane during deployment for imperfections and mark faulty or suspect areas.

C. Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:
   1. Geomembranes shall be installed according to site-specific specifications.
   2. Unroll geomembrane using methods that will not damage geomembrane and will protect underlying surface from damage (spreader bar, protected equipment bucket).
   3. Place ballast (commonly sandbags) on geomembrane which will not damage geomembrane to prevent wind uplift.
   4. Personnel walking on geomembrane shall not engage in activities or wear shoes that could damage it. Smoking will not be permitted on the geomembrane.
   5. Do not allow heavy vehicular traffic directly on geomembrane. Low ground pressure, rubber-tired vehicles are acceptable.
   6. Protect geomembrane in areas of heavy traffic by placing protective cover over the geomembrane.

D. Sufficient material (slack) shall be provided to allow for thermal expansion and contraction of the material.

3.3 FIELD SEAMING

A. Seams shall meet the following requirements:
   1. To the maximum extent possible, orient seams parallel to line of slope, i.e. down and not across slope.
   2. Minimize the number of field seams in corners, odd-shaped geometric locations and outside corners.
   3. Slope seams (panels) shall extend a minimum of five-feet beyond the grade break into the flat area.
   4. Use a sequential seam numbering system compatible with panel numbering system that is agreeable to the CQAO and Installer.
   5. Panels shall overlap by three (3) to six (6) inches prior to welding for double fusion and 6 inches for extrusion welding.
   6. Seams shall be welded to the outside edge of panels placed in anchor trenches.
   7. Fishmouths or wrinkles at seam overlaps shall be cut, overlapped and patched.
   8. Seams shall be welded only when ambient temperature is between 41ºF and 110ºF as measured six (6) inches above the geomembrane surface.
   9. All welds on completion of the work shall be tightly bonded. Any area showing excessive scuffing, puncture or distress shall be replaced.
   10. Ensure that:
      a. Seaming personnel have the required certifications;
      b. Overlap meets the requirements;
      c. Seaming area is clean;
      d. Seaming equipment is available and onsite and meets the project specifications;

e. Weather conditions for seaming are acceptable;
f. All seaming procedures outlined in the specifications are followed;
g. Panels are properly positioned to minimize wrinkling and any wrinkled areas are properly seamed; and
h. Equipment for testing seams is onsite.

11. Provide necessary documentation to CQAO to verify the above items.

B. During Welding Operations
1. Provide at least one Master Seamer who shall provide direct supervision over other welders as necessary.

C. Extrusion Welding
1. Hot-air tack adjacent pieces together using procedures that do not damage the geomembrane.
2. Welding apparatus shall be free of heat-degraded extrudate before welding.
3. Geomembrane surface shall be abraded a maximum of ¼ inch beyond the weld bead area, using a disc grinder, or equivalent, not more than one hour before extruding seam.
4. The ends of all seams, which are more than five (5) minutes old, shall be ground when restarting the weld.
5. Grinding depth shall not exceed ten (10) percent of the liner thickness.
6. Use apparatus equipped with gauges giving temperature in apparatus and at nozzle.
7. Provide documentation of extrudate to CQAO and certify that extrudate is compatible with specifications and is comprised of same resins as geomembrane.
8. Maintain a minimum of one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.
9. Purge extruder prior to beginning seam until all heat-degraded extrudate has been removed from the barrel.
10. Place electric generator on smooth base. Place smooth insulating plate or fabric beneath hot welding apparatus after use.
11. Clean geomembrane surfaces by disc grinder or equivalent.
12. The geomembrane surface shall be clean of grease, dirt, moisture, dust, debris or other foreign material.
13. Solvents or adhesives shall not be used unless the product is approved in writing by the Engineer.

D. Hot Wedge Seaming:
1. Welding apparatus shall be automated and equipped with gauges indicating applicable temperatures and seaming speed.
2. Clean seam area of dust, mud, moisture and debris immediately ahead of hot wedge welder.
3. Protect against moisture build-up between sheets.
4. Edges of cross/tie seams shall be ground smooth including (top and bottom) prior to welding.
5. Maintain a minimum of one spare operable seaming apparatus on-site. Equipment used for seaming shall not damage geomembrane. Protect geomembrane from damage in heavily trafficked areas.
6. Place electric generators on smooth base. Place smooth insulating plate of fabric beneath hot welding apparatus after use.

3.4 FIELD QUALITY CONTROL

A. Trial Welds - Geomembrane:
1. Trial welds shall be performed to verify welding equipment operations and performance of seaming methods and conditions.
2. Minimum of two (2) trial welds per day per welder and welding apparatus shall be made, one made prior to the start of work and one completed at mid-shift.
3. Welds shall be made under the same surface and environmental conditions as the production welds (i.e., in contact with geomembrane subsurface and similar ambient temperature).
4. The CQAO will observe all trial seams and associated testing. No production seams will be allowed until each seamer and seaming equipment has passed the test seam as verified by the CQAO. A sample from each trial weld shall be retained and labeled with the date, ambient temperature, number of seaming unit, seamer, and pass or fail description.

B. Trial Weld Testing - Geomembrane:
1. Sample shall be at least 4 feet long and 24-inches wide, with the seam centered lengthwise.
2. Minimum four (4), 1-inch-wide test strips shall be cut from the trial weld. Specimens shall be tested in the field for peel and shear, two each, using a digital tensiometer meeting the destruction seaming requirements. Note: peel specimens for double hot wedge welds must be tested on each weld.
3. Remaining sample shall be properly labeled and retained for future testing.
4. Seaming apparatus or seamer shall not be accepted and shall not be used for seaming until deficiencies are corrected and a successful trial seam is achieved.
5. Trial weld speciments shall pass when the results shown in the following table for HDPE are achieved in both peel and shear test:

Table 3 - Minimum Weld Values for HDPE Geomembranes

Property	Test Method	30 (0.75)	40 (1.0)	60 (1.5)	80 (2.0)	100 (2.5)	120 (3.0)
Peel Strength (fusion), ppi (kN/m)	ASTM D 6392	45 (197)	60 (263)	91 (398)	121 (530)	151 (661)	181 (793)
Peel Strength (extrusion), ppi (kN/m)	ASTM D 6392	39 (170)	52 (225)	78 (340)	104 (445)	130 (570)	156 (680)
Shear Strength (fusion & ext.), ppi (kN/m)	ASTM D 6392	57 (250)	80 (350)	120 (525)	160 (701)	200 (876)	240 (1050)

a. The break, when peel testing, occurs in the liner material itself, not through peel separation (FTB)
b. The break is ductile.

6. Repeat the trial weld, in its entirety, when any of the trial weld samples fail in either peel or shear.
7. No welding equipment or welder shall be allowed to perform production welds until equipment and welders have successfully completed trial weld.
8. Seaming shall not proceed when an ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. Installer shall demonstrate that acceptable seaming can be performed by completing acceptable trial welds.

C. Defects and Repairs
1. Examine all seams and non-seam areas of the geomembrane for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

2. Repair and non-destructively test each suspect location in both seam and non-seam areas. Do not cover geomembrane at locations that have been repaired until test results with passing values are available.

3.5 FIELD QUALITY ASSURANCE

A. Manufacturer and Installer shall participate in and conform to all terms and requirements of the Owner's quality assurance program. Contractor shall be responsible for assuring this participation.

B. Quality assurance requirements are as specified in this Section and in the CQA Plan.

C. Non-Destructive Seam Testing:

Non-destructive tests shall be conducted on all field seams over their full length using a vacuum test unit, air pressure (for double fusion seams only), or other approved methods. Testing shall be carried out as the seaming progresses and not at completion of all seaming.

1. Each seam shall be numbered or otherwise designated. The location, date, test unit, name of tester, and outcome of all non-destructive testing will be recorded by the Liner Contractor and given to the Owner through the CQAO.
2. The CQAO will observe all testing. All defects found during tests shall be numbered and marked immediately after detection. All defects found shall be repaired, retested and remarked to indicate a completion of the repair and acceptability.
3. Vacuum testing shall conform to the following requirements and in accordance with ASTM D5641:
    a. The equipment shall consist of two (2) vacuum box assemblies consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a port hole or valve assembly, a vacuum gauge, a vacuum pump assembly equipped with a pressure control, a rubber pressure/vacuum hose with fittings and connections, a soapy solution and an applicator.
    b. Testing shall conform to the following procedure: Brush soapy solution on geomembrane (approximately 12"x36"). Place vacuum box over the wetted seam area. Close bleed valve and open vacuum valve, and ensure that a leak-tight seal is created. Apply a vacuum of approximately five (5) psi. Examine the geomembrane through the viewing window for the presence of soap bubbles for not less than fifteen (15) seconds. All areas where soap bubbles appear shall be marked and repaired as described in this Section. If no bubble(s) appear after fifteen (15) seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum three (3) inches overlap, and repeat process.
4. Air Pressure Testing (for double seam with an enclosed space) shall conform to the following requirements and in accordance with ASTM D5820:
    a. The equipment shall consist of an air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining pressure between thirty and thirty-five (30-35) psi and mounted on a cushion to protect the geomembrane, a rubber hose with fittings and connections, a sharp hollow needle, or other approved pressure feed device, and a gauge with an accuracy of one (1) psi.
    b. Testing shall conform to the following procedure: Seal both ends of the seam to be tested. Insert needle or other approved pressure-feed device into the channel created

by the double-wedge weld. Energize the air pump to a minimum pressure between 30-35 psi, close the valve, and sustain the pressure for at least five (5) minutes. If pressure loss exceeds two (2) psi, locate faulty area and repair as described in this Section. Remove seal on the opposite end of the seam to release air. If blockage is present, locate and test seam on both sides of blockage. Remove needle or other approved pressure-feed device and patch area by extrusion welding.

5. Spark Testing: For those extrusion welded seams which are unable to be tested by a vacuum box, the spark test method shall be used with a copper wire placed 1/8" under the top sheet overlap and a Holiday detector operating at 20,000 volts.

D. Destructive Test Sampling:
   1. Collect destructive test samples at a minimum frequency of one test per 500 linear feet of seam length or as directed by CQAO. Sample locations will be identified by the CQAO anywhere within the 500-foot section. Test locations shall be determined during seaming. Locations may be prompted by appearance of excess heating, contamination, offset welds, or suspected defect. The CQAO shall not notify the Liner Contractor in advance of selecting locations where seam samples will be taken.
   2. Cut samples at locations designated by the CQAO as the seaming progresses to conduct field testing and obtain laboratory test results before the geomembrane is covered.
      a. Each destructive seam test sample shall be numbered.
      b. Each sample number, seam number, location of sample along the seam, and the reason for the destructive seam test shall be recorded on the test sample by the liner Quality Control Officer.
   3. Immediately repair all holes in the geomembrane resulting from destructive sampling. The continuity of the repair shall be vacuum tested in accordance with this Section.
   4. The destructive sample shall be eighteen (18) inches wide by thirty-six (36) inches long with the seam centered lengthwise. The sample shall be cut into three (3) equal parts for distribution to the Liner Contractor, one part for onsite QC testing and one part to Owner's Representative for QA laboratory testing.
   5. Onsite field QC testing shall be conducted in accordance with ASTM D6392 and GRI GM 19:
      a. Provide onsite peel and shear test results to CQAO.
      b. Peel and shear test results shall meet the criteria listed in the table below.
   6. Laboratory Testing (By Owner's Construction Manager's Laboratory):
      a. Destructive samples shall be tested in peel and shear (ASTM D6392 and GRI GM 19). Both sides of the weld will be tested in peel.
      b. All tests shall exhibit a Film Tearing Bond (FTB) type of separation in which the geomembrane material tears before the weld.
      c. At least five (5) coupons shall be tested by each test method. Four out of five strip specimens in peel and shear should meet or exceed the values below. The fifth must meet or exceed 80% of the given values.
      d. Test results will be provided within 24 hours after receiving samples.
      e. Geomembrane seams shall meet the criteria shown in **Table 3**.

E. Destructive Test Failure:
   1. One of two options shall be followed:
      a. Option 1: Reconstruct the failed seam between two adjacent passed test locations.
      b. Option 2: Offset the failed test 10 feet in both directions and resample the seam. If both offset samples pass, reconstruct the seam between the passed sample locations.

If one or both samples fail, offset the previous samples an additional 10 feet (pass or fail) in the same directions and retest. Continue this procedure until both offsets pass. Reconstruct the seam between the two passed samples. The final two passed samples must be equidistant from the original failed sample, unless the end of the seam is encountered.

2. Reconstruction methods shall include cap stripping of seam or replacing seam with a new one (1) foot wide panel and welding in place.

F. Acceptable seams shall be bounded by two locations from which samples have passed destructive and non-destructive tests. For reconstructed seams exceeding fifty (50) feet, a sample taken from within the reconstructed seam shall also pass destructive testing. Whenever a sample fails, additional testing may be required for seams that were welded by the same welder and welding apparatus or were welded during the same shift.

3.6 DEFECTS AND REPAIRS

A. All seam and non-seam areas of the synthetic membrane liner shall be inspected for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter.

B. The surface of the synthetic membrane liner shall be clean at the time of inspection. Brooming and/or washing of the synthetic membrane liner surface shall be required if the amount of surface dust or mud inhibits inspection.

C. Defective seams shall be repaired by cap stripping of seam or replacing seam with a new one (1) foot wide panel and welding in place. Tears, pinholes, blisters, large holes, undispersed raw materials and contamination by foreign matter shall be repaired by patches. Each patch shall be numbered. Patches shall be round or oval in shape, made of the same synthetic membrane material and extend a minimum of six (6) inches beyond the edge of defects.

D. The number of each patch, date, location, patcher and test outcome shall be recorded by the Liner Contractor and the record provided to the CQAO.

E. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than 1/2 hour prior to the repair.
   1. Patches or caps shall extend at least six (6) inches beyond the edge of the defect, and all corners of material to be patched and the patches shall be rounded to a radius of at least four (4) inches.
   2. The geomembrane below large caps shall be cut to avoid water or gas collection between the two sheets.

F. Repairs shall be verified using the following procedure:
   1. Each patch repair shall be non-destructively tested using methods specified in this Section.
   2. Destructive testing may be required at the discretion of the CQAO.

3.7 GEOMEMBRANE ACCEPTANCE

A. Liner Contractor shall retain all Ownership and responsibility for the geomembrane until Final Completion of the Work.

B. Owner's Construction Manager, Engineer and CQAO will accept the geomembrane installation when the installation is finished and all required documentation from the Geotextile Contractor has been received and approved, and verification of the adequacy of all field seams and repairs, including associated testing, is complete.

END OF SECTION

SECTION 31 11 00 – CLEARING AND GRUBBING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Clearing, grubbing and stockpiling of stumps, roots, rootballs (as required) and brush within the limits of excavation and construction for the landfill and borrow source area as shown on the Drawings.

B. Stripping and stockpiling topsoil, if identified, or soil suitable to support vegetative growth.

C. Stripping and stockpiling topsoil.

1.2 RELATED SECTIONS

A. Section 31 20 00 Earth Moving

B. Section 31 25 00 Erosion and Sediment Control

C. Construction Stormwater Management Plan (SWMP)

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Provide all equipment necessary to accomplish clearing, grubbing, stripping and stockpiling activities.

PART 3 - EXECUTION

3.1 GENERAL

A. Follow and comply with construction SWMP.

B. Place cleared and/or grubbed material at location identified by Owner.

3.2 CLEARING

A. Cut, remove or clear trees (≤ 6-inches) and brush required to be removed. DO NOT remove vegetation outside the limits of work/excavation.

B. Cut large diameter trees at ground surface.

3.3 GRUBBING

A. Grub stump, roots and grasses required to be removed in the work/excavation areas. Prior to removing rootballs confirm with Owner's Engineer.

3.4 REMOVAL AND DISPOSAL

A. Clearing and Grubbing materials and debris free from CCR that cannot be mulched, chipped or is not approved by the Owner for onsite disposal, shall be disposed off site by the Contractor a ta properly permitted disposal facility approved by Owner. Contractor shall provide Owner with the location of the proposed disposal facilities and submit related manifest documents.

END OF SECTION

SECTION 31 20 00 – EARTHWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish all labor, equipment and materials required to complete all work associated with vegetation removal, excavation, compaction of in-place fill soils, and other related and incidental work as required to complete the work shown on these drawings and specified herein.

B. Backfill stone, soil, stockpiling topsoil and any excess suitable material in designated areas, providing on-site borrow from suitable sources, in-place compaction of backfill and subgrades for landfill and roadways, shoring and bracing, disposing all unsuitable materials, site grading other related and incidental work as required to complete the work shown on the Drawings and specified herein. The work shall include, but not be limited to:
   1. Provide required submittals,
   2. Excavate soil, CCR, waste material to the lines and grades shown on the Drawings,
   3. Prepare and maintain subgrades for temporary roadways and other related construction,
   4. Dewater and maintain all excavations and the surface of all grading and earthwork,
   5. Dispose of all debris, unsuitable and excess soils at properly permitted on site or off-site locations.

1.2 RELATED SECTIONS

A. Section 01 33 00 – Submittal Procedures

B. Section 31 11 00 – Clearing and Grubbing

C. Section 31 25 00 – Erosion and Sediment Control

1.3 REFERENCES

A. ASTM International:
   1. ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
   2. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
   3. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort
   4. ASTM D2167 – Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
   5. ASTM D2937 – Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
   6. ASTM D6938 – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 00: Submittal Procedures:

1. Prepare and submit descriptive information on excavation methods and equipment to be used, including excavation, stockpiling, hauling, backfilling, compaction and measurement methods and schedule for the work.
2. Name and location of all material suppliers.
3. Certificates from manufacturers attesting that drainage stone materials to be used meet specified requirements and conform to CDOT Specifications at least 14 days in advance of use for approval by the Owner and the Engineer. Provide certified test reports for riprap and crushed stone materials to be used for erosion control, slope armoring or protection, as required by these Specifications.
4. List of proposed and disposal sites for debris, refuse and excess or unsuitable materials and all required permits for use of those sites, if applicable.
5. List of proposed equipment to be used in earthmoving, placement, and compaction operations.

B. If excavation support (shoring) is required, provide the following submittals to the owner:
1. Plans, sketches, and/or details,
2. Supporting calculations prepared by a registered Professional Engineer,
3. Description of the materials and shoring system to be used,
4. Indication of whether any components will remain after filling or backfilling, and
5. Indication of the sequence and method of installation.

1.5 PRODUCT HANDLING

A. CCR shall be excavated and managed in accordance with EPA regulations.

B. Soil and wastes shall be excavated, transported, placed, and stored in a manner to prevent contamination, segregation and excessive wetting. Materials which have become contaminated or segregated will not be permitted in the performance of the work and shall be removed from the site.

C. Develop and maintain stockpiles as shown on the Drawings for each material classification and end use specified. Place materials only in designated stockpiles. Prevent mixing or fouling by other materials.

D. Off-site crushed stone aggregate shall be transported, stored, and placed in a manner to prevent contamination by or mixing with on-site soils or wastes.

E. All loads of imported soils and aggregate required for construction shall be trimmed and covered, and vehicle shelf areas shall be kept clean. The Contractor is responsible for compliance with all State and local regulations regarding hauling.

F. The Contractor shall maintain on-site roadways used for hauling. Such maintenance shall include, but not be limited to watering, grading, leveling and replacement of road base in areas where excessive damage or rutting is evident.

PART 2 - PRODUCTS

2.1 ROCK FILL/CRUSHED CONCRETE

A. Rock Fill/crushed concrete shall consist of on-site stockpiled, processed or excavated material consisting of durable, well graded cobbles, crushed concrete, and rock fragments placed in a manner that provides a firm, stable re-graded areas at locations agreed upon with Owner and Engineer.

B. Rock Fill shall be free from organic materials, debris, or other deleterious materials.

C. Crushed Concrete

1. Crushed Concrete Backfill or Imported Aggregate Stone Backfill – material shall be free of deleterious materials including but not limited to rebar, other metal, and demolition debris, and meet the requirement of Colorado CDOT Specification 703.04.

Table 703-2
CLASSIFICATION FOR AGGREGATEBASE COURSE

Sieve Size	Mass Percent Passing Square Mesh Sieves						
	LL not greater than 35			LL not greater than 30			
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
150 mm (6")			100				
100 mm (4")		100					
75 mm (3")		95-100					
60 mm (2 ½")	100						
50 mm (2")	95-100			100			
37.5 mm (1 ½")				90-100	100		
25 mm (1")					95-100	100	100
19 mm (3/4")				50-90		95-100	
4.75 mm (#4)	30-65			30-50	30-70	30-65	
2.36 mm (#8)						25-55	20-85
75 µm (#200)	3-15	3-15	20 max	3-12	3-15	3-12	5-15
NOTE: Class 3 material shall consist of bank or pit run material.							

2. Stone backfill may be comprised of either imported material or concrete rubble generated from demolition.
3. All imported material shall consist of natural earthen material obtained from a permitted commercial source. Material shall be free of debris, organics, and pollutants.
4. All demolished concrete that is to be reused for on-site fill shall be clean, free of visual stains, and shall be beneficially reused in accordance with governing regulations in the State of Colorado.
5. Concrete to be processed for use as structural fill shall be crushed to a gradation in conformance with applicable CDOT requirements for structural base course with a maximum dimension of 2-inches, or a sieve/gradation in general conformance with the tables above.

2.2 AGGREGATE MATERIALS

A. Aggregate materials, including stone and rip rap shall be as defined in Section 31 05 16-Aggregates.

2.3 EQUIPMENT

A. Provide equipment necessary to excavate, stockpile and load borrow soil.

B. Provided equipment suitable to meet compaction requirements.

C. Provide water truck, as needed.

D. Provide equipment required to move and handle materials for the landfill.

PART 3 - EXECUTION

3.1 GENERAL STOCKPILE REQUIREMENTS

A. Borrow soils if needed, which are designated for stockpiling shall be placed within a designated stockpile area (safe distance from loading/traffic areas).

B. All stockpiled materials shall be placed with a side slopes no steeper than 2:1 horizontal to vertical in a manner that promotes runoff and minimizes erosion.

C. Cover, as required, or maintain erosion control measures.

3.2 VEGETATIVE LAYER EXCAVATION/STOCKPILE REQUIREMENTS

A. After grubbing, strip surficial soil and continue excavating to reach soil suitable for use as fill.

B. Stockpile materials safe distances from loading areas.

C. Cover stockpile and/or use measures to prevent erosion.

3.3 CCR AND WASTE EXCAVATION/PLACEMENT

A. CCR to be excavated from the Bottom Ash Area must maintain slopes no greater than 4H:1V and no less than 5%.

B. CCR to be disposed of in the landfill must maintain slopes no greater than 4H:1V and no less than 5%.

3.4 GENERAL SITE GRADING

A. All disturbed areas outside of roads or structures shall be uniformly graded to the lines, grades, and elevations shown on the Drawings. Finished surfaces shall be reasonably smooth, compacted, and free from irregular surface changes. Unless otherwise specified, the degree of finish shall be that ordinarily obtainable from either box blade or scraper operations. Areas shall be finished to a smoothness suitable for application of vegetative soil.

B. All re-graded areas shall be finished to reasonably uniform surfaces acceptable for hydroseed and mulching operations. All protruding roots and other objectionable vegetation shall be removed from re-graded areas.

C. Protect re-graded areas from damage by freezing temperatures, frost, rain, accumulated water, or construction activities and as directed by the Engineer.

3.5 COMPACTION

A. Compact backfill, crushed stone, aggregate base, placed wastes, and re-graded areas in accordance with the requirements of this Section. The densities specified herein refer to percentages of maximum density as determined by the noted test methods. Compaction of materials on the project shall be in accordance with the following schedule:

	Density % Std. Proctor (D698)	Density % Mod. Proctor (D1557)	Max. Lift Thick-ness as Compacted (Inches)	Range from Optimum Moisture Content %
Aggregate/Crushed Concrete Backfill	*	*	12	N/A
Rip Rap Bedding	*	*	6	N/A
Re-graded Areas	85	N/A	12	-1/+4
Ash/Waste	90	N/A	6	+/- 2%

*Material to be compacted to a degree acceptable to the Engineer/CQA Officer by use of a vibratory compactor and/or proof-rolling.

B. Field density tests will be made by the CQA Officer. The CQA Officer will notify the contractor if densities fail.

C. Recompact areas as necessary to meet specified density.

3.6 DISPOSAL OF SURPLUS MATERIALS, TRASH AND DEBRIS

A. Remove trash, and debris, and dispose at an approved off-site landfill.

3.7 EARTHWORK TOLERANCES

A. Earthwork shall be constructed to the lines and grades as shown on the Drawings. Maximum allowable deviation from the lines and grades, as shown on the Drawings are shown in the following table.

B. Landfill

Allowable Deviation from the Lines and Grades

1.	Horizontal Geometry, Location	± 1.0 ft
2.	Finished Grade Surface Elevation	± 0.40 ft
4.	Finished Grade Slope, when expressed in percent (vertical/horizontal x 100)	± 0.5%

C. The Contractor shall verify lines, grades, and thickness of key components of construction. A combination of direct measurement, excavation and measurement and survey methods will be employed by the Engineer for Quality Assurance purposes. The Contractor shall cooperate with the Engineer during quality assurance measurements and shall add or remove soil as required to meet earthwork tolerances presented above. CQA measurements conducted by the Owner or Engineer shall not replace the As-Built Surveys that are the responsibility of the Contractor.

END OF SECTION

SECTION 31 23 13 - CLOSURETURF® SUBGRADE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Prepared subgrade for the installation of the ClosureTurf® System.

B. Related Sections:
1. Section – 31 05 20.10 “ClosureTurf® MicroSpike Geomembrane”
2. Section – 31 05 16 "ClosureTurf® Sand Infill”
3. Section – 32 18 13 “ClosureTurf® Installation”
4. Section – 31 20 00 “Earthwork”

PART 2 - PRODUCTS

A. Not Used

PART 3 - EXECUTION

3.1 PREPARATION

A. Subgrade Preparation:
1. Subgrade shall be substantially smooth, uniform, firm and free from rocks or other debris. Surface shall be inspected and accepted prior to installation of Closure Turf® system (see Section 017319).
2. No rocks or protrusions greater than 1 inch in diameter shall be exposed at the subgrade surface.
3. Approved subgrade shall be capable of supporting the weight of geosynthetics installation equipment.
4. Daily inspect subgrade to determine that no changes have occurred that would render the subgrade unacceptable.

B. Non-Conforming Work:
1. Subgrade not meeting specifications either before or during deployment of the ClosureTurf® components shall be reported to the Owner’s Representative and immediately corrected.

3.2 INSPECTION

A. The subgrade shall be inspected and accepted prior to installing the ClosureTurf® Components:
1. The geotextile installer and CQAO shall walk and inspect the area to receive the ClosureTurf® Components. The geotextile installer shall be responsible and/or provide the following:

a. Geotextile installer shall provide in writing that the prepared surface on which the geomembrane component will be installed is acceptable.
b. Keep the accepted subgrade surface in a condition conducive to the deployment of all ClosureTurf® components.
c. Identify any part of the subgrade that becomes non-compliant to the specifications during the course of construction.
d. Immediately submit written report to Owner's Representative if subgrade condition becomes unacceptable.

END OF SECTION

SECTION 31 25 00 – EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Erosion and Sediment Controls required to complete the construction and closure of the Landfill.

1.2 REFERENCES

A. Section 31 11 00 – Clearing and Grubbing

B. Section 31 20 00 – Earthwork

C. Section 32 92 19 – Hydroseeding

1.3 DEFINITIONS

A. Erosion - A process of detachment and transport of soil particles by erosive agents.

B. Sediment - Soil that has already been eroded and is a mixture of soil particles and aggregates some of which may be suspended in stormwater flow and/or may migrate to undesirable areas downstream of the drainage areas.

C. Erosion Control - The prevention or minimization of erosion and sediment production to prevent degradation of water quality to the receiving stream.

D. Sediment Control - The trapping of suspended soil particles to prevent degradation of water quality to the receiving stream.

E. Erosion Control Mat (ECM) – A nonstructural method and cover material developed to control erosion and provide soil stability until vegetation can be established. ECMs are made of biodegradable materials or synthetics for short-term or long-term use.

F. Riprap - A layer of rock or aggregate placed over an erodible soil surface to protect the soil surface from the erosive forces of water.

G. Straw Wattle – a tubular netting structure filled with agricultural straw designed to slow water velocity and filter/trap sediment.

H. Check Dam - Small temporary or permanent dam constructed across a drainage ditch, hose discharge point, swale or channel to lower the speed of concentrated flows.

I. Turf Reinforcement Mat (TRM) - A non-structural method and cover material developed to control erosion and provide soil stability until vegetation can be established. TRMs are made of stabilized synthetics for permanent reinforcement.

1.4 SUBMITTALS

A. Manufacturer's product data for all erosion and sediment control products to be used on site.

1.5 DELIVERY, HANDLING AND STORAGE

A. During shipment and storage of erosion control materials, wrap in relatively impermeable and opaque protective covers. Storage area shall be such that erosion control materials are protected from mud, dirt, dust, debris, moisture, and exposure to the sunlight and heat. Handling, storage, and care of erosion control materials on-site are the responsibility of the Contractor prior to, during, and after their installation. Contractor shall be liable for all damages to erosion control materials.

1.6 WARRANTY

A. Provide a warranty that after 6 months at least 90% of the vegetation (grass and plantings) will be established and healthy.

B. After 6 months the restored areas will be inspected for erosion rills. If erosion is observed over 10% of these areas, they shall be repaired by the Contractor at no cost to the Owner.

C. Erosion control blanket shall have a manufacturer's longevity of 12 months.

PART 2 - PRODUCTS

2.1 EROSION CONTROL BLANKET

A. Erosion control blanket shall be North American Green 575 or approved equal. It shall be a short-term single net blanket of 100% agricultural straw. Provide staples and other products recommended by manufacturer.

B. Use erosion control blanket on the side slopes and top of closed cells surface repairs.

2.2 EROSION CONTROL MAT

A. Erosion control turf reinforcement mat (TRM) shall be Landlok 300 by Propex or approved equal. It shall be a permanent TRM constructed of 3D woven homogenous polypropylene yarns.

B. Use TRM on repaired cells side slopes and drainage.

PART 3 - EXECUTION

3.1 STORM WATER MANAGEMENT PLAN

A. The Contractor shall review the project Storm Water MANAGEMENT Plan (SWMP). The Contractor shall sign the NPDES permit Notice of Intent (NOI) prior to Construction and the Notice of Termination (NOT) at completion of Construction. Contractor may not fully demobilize from the site until the Owner has determined that the NOT may be signed and submitted.

3.2 INSTALLATION

A. Erosion Control Matting - Some channels will require multiple widths of matting, with two widths being the most commonly used. Unroll the matting starting at the upper end of the channel, allowing a 4" overlap of matting along center of channel. The sequence of construction should be as follows or per the manufacturer's suggested installation procedures:
   1. Prepare the ground surface by mechanical means and/or rake.
   2. Hydroseed and fertilize the area.
   3. Unroll erosion control mat with netting side up. Do not stretch. Make sure net is relaxed on the surface to allow conformance to the ground surface.
   4. Anchor the mat by placing the pins at 4-ft. ± 1-ft. intervals in adjacent panel overlap areas. Note: Be sure the pins are well secured in the ground. Size of the pins 4- to 6-inch U-shaped type, depending on the ground condition. Wood pegs may be used if preferred.
   5. Overlap end of the rolls and adjacent panel sides from 2 to 6 inches.
   6. Anchor the top, bottom and any end of roll overlaps.
   7. The protective matting can be laid over sprigged areas where small grass plants have been planted. Where ground cover is to be planted, lay the protective matting first and then plant through the matting according to the landscape design.
   8. Water lightly after installation if possible; this will enhance grass growth and interlock the fibers into the soil.
   9. Permanent seed should be utilized in conjunction with the erosion control mats.

B. Silt Fencing
   1. Silt fencing shall be installed as detailed on the Erosion and Sedimentation Control drawing located in the contract drawings. Install with the posts to the downstream direction and the fabric to the upstream direction. The fabric shall be anchored below grade approximately 6 inches. Replace and compact soil in anchor trench to restore to original grade.

C. Straw Wattles
   1. Straw wattles shall be installed as detailed on the Erosion and Sedimentation Control drawing located in the contract drawings.
   2. Wattles shall be installed in 2-inch deep trenches and with uniform contact to the competent subgrade.
   3. Wattles are to be staked every 4 feet or in accordance with manufacturer directions. Overlaps at seams and staking of seams shall be in accordance with manufacturer's directions.

4. Straw wattles are to be continually inspected and maintained throughout the duration of the project. Sediment buildup shall be removed after the depth of sediment reaches half of the height of the wattle.
5. Wattles are to remain in service until vegetation is fully established in accordance with the permanent seeding specification of Section 32 92 19 Hydroseeding.

D. Riprap
1. Place geotextile filter fabric as shown on the project drawings in accordance with manufacturer's recommendations. Place riprap in areas as shown on the project drawings.
2. Geotextile Placement
    a. Geotextile shall be placed on the soil surface prior to installation of riprap material.
    b. Geotextile shall be placed in accordance with the manufacturer's recommendations.
    c. Geotextile shall be anchored on both sides a minimum of 1 foot.
    d. Geotextiles shall overlap a minimum of 2 feet. Geotextile shall be overlapped, if necessary, in the direction of the flow.
3. Riprap Placement:
    a. Place geotextile loosely on prepared surface and secure as necessary. Geotextile shall be overlapped, if necessary, in the direction of the flow.
    b. Place stone riprap to produce reasonably well graded mass of stone with minimum practicable percentage of voids. Place by method preventing segregation of various sizes of stone. Rearrange or shape material to prescribed section after placement and add additional material if sections indicate such to be necessary in opinion of the Engineer or the Construction manager. Larger stones shall be well distributed throughout mass and finished protection shall be free from pockets of small stones and clusters of large stones. Fill holes or open spots to produce well graded protection.
    c. All material shall be placed and distributed so that there will be no large accumulations of either the larger or smaller sizes of rock.
    d. Riprap shall not be placed or dropped from a height greater than 24”.

E. Rock Check Dams
1. Rock shall be installed where indicated on the project drawings or as directed by the Engineer. Rock shall be placed to grade over a non-woven geotextile fabric.

F. Turf Reinforcement Mat - The sequence of construction should be as follows or per the manufacturer’s suggested installation procedures:
1. Subgrade shall be uniform and smooth. Remove all rocks, clods, vegetation or other objects so the installed mat will have direct contact with soil surface.
2. Prepare seedbed by loosening the top 2-3 in (50-75 mm) minimum of soil. Incorporate amendments such as lime and fertilizer and/or wet the soil, if needed. Do not mulch areas where mat is to be placed.
3. Unroll mat and place in the upstream direction. Overlap adjacent rolls in the upstream direction.
4. Anchor TRM by placing anchoring devices at 12-inch intervals along the edges of the TRM. Anchoring devices should be wire staples, metal pins, or nails that are 6 to 12-inches in length.

5. Overlap end of the rolls and adjacent panel sides from 2 to 6 inches.
6. Anchor the top, bottom and any end of roll overlaps.
7. Seed and fill with soil for enhanced performance.

3.3 QUALITY CONTROL

A. Check finished grade, dimensions and staple spacing of erosion control blankets.

3.4 MAINTENANCE

A. The Contractor shall inspect all erosion control devices every 7 days and immediately after each rainfall event of 0.5 inches or greater during construction. Any deficiencies shall be immediately corrected by the Contractor. In addition, the Contractor shall make a daily review in areas where construction activity changes the earth contour and drainage runoff, to ensure that erosion control devices are properly located for effectiveness. Where deficiencies exist, additional erosion control devices shall be installed as approved or directed by the Engineer. These daily checks shall be reported on the Contractor's daily reports.

B. Excessive sediment deposits shall be removed as determined by the Engineer. Any sediment deposits remaining in place after erosion control devices are no longer required shall be dressed to conform to the existing grade and the area top-soiled, seeded, fertilized, and mulched as required. Replace damaged silt fencing as long as sediment control is required.

C. Contractor shall repair all areas with rills and gullies caused by erosion.

END OF SECTION

SECTION 32 18 13 - CLOSURETURF® INSTALLATION

PART 1 - GENERAL

1.1 SUMMARY

A. Furnishing, installing, sampling and testing ClosureTurf® System.

B. Related Sections:
1. Section – 31 05 20.10 “ClosureTurf® MicroSpike Geomembrane”
2. Section – 31 23 13 "ClosureTurf® Subgrade Preparation”
3. Section – 31 05 16 "Aggregates”

1.2 REFERENCES

A. ASTM D 792 – Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement

B. ASTM D 1004 – Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting

C. ASTM D 1204 – Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature

D. ASTM D 1238 – Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer

E. ASTM D 1505 – Standard Test Method for Density of Plastics by Density-Gradient Technique

F. ASTM D 1603 – Standard Test Method for Carbon Black Content in Olefin Plastics

G. ASTM D 1693 – Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics

H. ASTM D 1907 – Standard Test Method for Linear Density of Yarn (Yarn Number) by the Skein Method

I. ASTM D 2256 – Standard Test Method for Tensile Properties of Yarns by the Single-Strand Method

J. ASTM D 3218 - Standard Specification for Polyolefin Monofilaments

K. ASTM D 3895 – Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

L. ASTM D 4218 – Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique

M. ASTM D 4833 – Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products

N. ASTM D 5261 – Standard Test Method for Measuring Mass per Unit Area of Geotextiles

O. ASTM D 5321 – Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

P. ASTM D 5323 – Standard Test Method for Determination of 2% Secant Modulus for Polyethylene Geomembranes

Q. ASTM D 5397 – Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test

R. ASTM D 5596 – Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

S. ASTM D 5617 – Standard Test Method for Multi-Axial Tension Test for Geosynthetics

T. ASTM D 5721 – Standard Practice for Air-Oven Aging of Polyolefin Geomembranes

U. ASTM D 5885 – Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry

V. ASTM D 5994 – Standard Test Method for Measuring Core Thickness of Textured Geomembrane

W. ASTM D 6392 – Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

X. ASTM D 6693 – Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

Y. ASTM D 6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

Z. ASTM D 7007 – Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials

AA. ASTM C 150 – Standard Specification for Portland Cement

BB. ASTM C 387 – Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar

CC. ASTM D 1335 – Standard Test Method for Tuft Bind of Pile Yarn Floor Coverings

DD. ASTM D 1577 – Standard Test Methods for Linear Density of Textile Fibers

EE. ASTM D 4595 – Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method

FF. ASTM D 5793 – Standard Test Method for Binding Sites per Unit Length or Width of Pile Yarn Floor Coverings

GG. ASTM D 5823 – Standard Test Method for Tuft Height of Pile Floor Coverings

HH. ASTM D 5848 – Standard Test Method for Mass Per Unit Area of Pile Yarn Floor Coverings

II. ASTM D 6241 – Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

JJ. American Concrete Institute (ACI) – 306R-10 Guide to Cold Weather Concreting

KK. GRI-GM11 – Accelerated Weathering of Geomembranes Using a Fluorescent UVA Device

LL. GRI-GM12 – Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gage

MM. GRI-GM17 – Test Methods, Test Properties, and Testing Frequency and for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes

NN. GRI-GM19 – Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

OO. IAGI – International Association of Geosynthetics Installers – HDPE and LLDPE Geomembrane Installation Specification

1.3 DEFINITIONS

A. Batch: A quantity of resin, usually the capacity of one railcar, using in the fabrication of HDPE or LLDPE geomembrane rolls. The finished rolls are identified by a roll number corresponding to the resin batch used.

B. ClosureTurf® System: A patented four component system consisting of a Watershed Geosynthetics specific gas management system (not applicable), a structured geomembrane (LLDPE), an engineered turf, and a specified grade of sand infill.

C. Construction Quality Assurance Officer (CQAO): The Owner's Representative, performing duties as outlined in these specifications.

D. Contractor: The party responsible for field handling, transporting, storing, deploying, seaming, temporary restraining (against wind), and installing the geomembrane.

E. Extrudate: HDPE material produced in the form of a rod used by the geomembrane contactor to extrusion weld panels of geomembrane together.

F. Geomembrane: A synthetic lining material that is a component of the ClosureTurf® System. Used as the primary barrier to infiltration and exfiltration of covered materials.

G. Geomembrane Manufacturer: ClosureTurf® is a patented system and is the intellectual property of Watershed Geosynthetics, LLC.

H. Geomembrane Subsurface: Material surface upon with geomembrane will be placed.

I. Geotextile: Non-woven or woven polypropylene geotextile.

J. Panel: A general reference to a unit area of either the Structured Geomembrane (LLDPE or HDPE), or the Engineered Turf component of the ClosureTurf® System.

K. Quality Assurance: A planned and systematic pattern of procedures and documentation to ensure that items of work or services meet the requirements of the contract documents.

L. Quality Assurance Laboratory: Responsible for conducting laboratory tests on samples of geomembrane obtained at the site, provided by the Owner's Construction Manager.

M. Quality Control: These actions provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the contract documents.

N. N.Quality Control Laboratory: Third party laboratory responsible for conducting laboratory tests on samples of geomembrane obtained at the site, provided by the Contractor.

O. O.Subgrade: In situ or prepared soil/other surface supporting the geomembrane

1.4 SUBMITTALS

A. GEOSYNTHETICS INSTALLER
1. Submit the following as it relates to the geomembrane component and the engineered turf component:
    a. The proposed geosynthetics installer shall be an approved ClosureTurf® installer.
    b. Shop drawings indicating panel layout and field seams seven (7) calendar days prior to installation of geomembrane component.
    c. ClosureTurf® Installation schedule seven (7) calendar days prior to installation.
    d. Installation capabilities (include with Work Plan or CQA Plan), including:
        1) Information on seaming, testing and deployment equipment proposed for this project;
        2) Average daily production anticipated for this project; and
        3) Construction Quality Control (CQC) procedures.
    e. Signed subgrade acceptance certificates for the area to be covered by the geomembrane component prior to installation.
    f. Resumes of:
        1) Project designated geosynthetics seaming supervisor;
        2) CQC supervisor if other than above;
        3) All personnel who will perform seaming operations.
    g. Verify in writing that geosynthetics installer's personnel meet the following:
        1) CQC supervisor and the master geomembrane seamer:

a) Shall have installed at least 5,000,000 square feet of like geosynthetics components.

2) CQC supervisor and the engineered turf fusion seamer:
   a) Shall have installed at least 5,000,000 square feet of geomembrane materials.
3) Geotextile seamers:
   a) Shall have installed at least 1,000,000 square feet of like materials.
4) All other geosynthetic installer seaming personnel:
   a) Shall have seemed at least 1,000,000 square feet of polyethylene geomembrane.
   b) Personnel who have seemed less than 1,000,000 square feet of polyethylene geomembrane will be allowed to seam only under the direct supervision of the master geomembrane seamer or CQC supervisor.

B. SAND INFILL INSTALLER:
1. Submit to ClosureTurf® manufacturer a 10-pound sample of proposed sand infill 10 days prior to installation.
2. Submit particle size data sheets for:
   a. Sand infill used as ClosureTurf® Component; and
   b. If material changes are noted/observed.
      1) Sand Infill Testing Parameters:
      Section 310516 – ClosureTurf® Sand Infill

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1.5 MATERIAL LABELING, DELIVERY, STORAGE, AND HANDLING

A. Conform to the manufacturer's recommendations to prevent damage.

B. Deliver materials to the site after approval of required submittals.

1. Delivery and Acceptance Requirements – Engineered Turf Component:
   a. Manufacturer’s name
   b. Product identification
   c. Lot number
   d. Roll number
   e. Roll dimensions
2. Observe and document the following:
   a. Engineered turf is wrapped in rolls with protective covering;
   b. Components are protected from any outside source that could degrade or damage the product.

C. Storage and Handling Requirements:
1. On-Site Storage:
   a. Store in identified location onsite.
   b. Store on level prepared surface (not on wooden pallets) graded to drain away from ClosureTurf® components.
   c. Stack per Manufacturer's recommendation but no more than three rolls high.

2. On-Site Handling:
   a. Installer is responsible for storage and transporting material from storage area to installation area.
   b. Use appropriate handling equipment recommended by Manufacturer.
   c. Dragging panels on ground surface will not be permitted.
   d. Do not fold geomembrane component material.
3. Packaging and Waste Management:
   a. Installer shall be responsible for proper containment, collection and disposal of:
      1) Waste and packaging.
      2) All waste products produced by the installation of the ClosureTurf® System.
4. Installer shall accept or reject prepared subgrade in writing.

PART 2 - PRODUCTS

2.1 MATERIAL

A. ENGINEERED TURF – Furnish Engineered Turf Component manufactured by Argu America or approved equal and conforming to the following tables:

Table 1 - Engineered Turf Specifications

ENGINEERED TURF COMPONENT (CT)

Product Data	Test Method	Values
Yarn Type	N/A	Polyethylene, Fibrillated
Yarn Color	N/A	Olive Green, Play Green, Tan
Yarn Weight (Total Product Weight)	ASTM D5261 (sample size, 1 yd²)	≥20 oz. / sq. yd. (≥ 32 oz. / sq. yd.)
Tensile Strength of Yarn	ASTM D2256	15 lbs. min.
CBR Puncture	ASTM D6241	1,500 lb. (MARV)
Tensile Product (MD/XD)	ASTM D4595	2,100 MD / 1,600 XD lb/ft (MARV)
Interface Friction between ClosureTurf CT and MicroSpike®	ASTM D5321	21°, min. Peak*
Engineered Turf Fiber UV Stability	ASTM G147	>60% retained tensile strength at 100 yrs. (projected)
Backing System UV Stability (Exposed)	ASTM G154 Modified Cycle 1., UVA340	110 lbs./ft. retained tensile strength at 6,500 hrs (projected)
Aerodynamic Evaluation	GTRI Wind Tunnel	120 mph with max. uplift of 0.12 lb/sf
Rainfall Induced Erosion	ASTM DG459	Infill Loss 0.1% at G in./hr. Rainfall
Steady State Hydraulic Overtopping (ClosureTurf® w/ HydroBinder®)	ASTM D7277/D7276	5 ft. overtopping resulting in 29 ft/s velocity and 8.8 psf shear stress for Manning's *n* value of 0.02
Full Scale Wave Overtopping Test Cumulative Volume (ClosureTurf® with HydroBinder®)	Colorado State University Wave Simulator	165,000 ft³/ft
Full Scale Wave Overtopping Test Discharge (ClosureTurf® with HydroBinder®)	Colorado State University Wave Simulator	4.0 ft³/s/ft
HydroBinder® Infill Mix	ASTM C387 / ASTM C109	3/4 in. infill 5,000 psi (min. at 28 days)

*Engineered Turf/Geomembrane interface. Geomembrane/subgrade interface is site specific and should be evaluated per Engineer's requirements.

Table 2 - Standard Roll Dimensions

	Thickness		Width		Length		Area (approx.)		Weight (avg.)	
	mil	mm	ft.	m	ft.	m	ft²	m²	lbs	kg
MicroSpike®	40	1.0	23	7	750	229	17,250	1,603	~3,900	~1,770
Turf Component	N/A	N/A	15	4.6	300	91.44	4,500	418	~1,000	~454

B. SAND INFILL – See Section 31 05 16.1 – "ClosureTurf® Sand Infill"

PART 3 - EXECUTION

3.1 ENGINEERED TURF COMPONENT DEPLOYMENT

A. Prior to installation of Engineered Turf Component:
   1. ClosureTurf® geomembrane component has been seamed, tested, approved.
   2. The supporting surface (e.g., the geomembrane) is substantially free of debris or large scraps.

B. During deployment of Engineered Turf verify the following:
   1. Record any defects, locations of defects and resolution (i.e., panel rejected, patch installed, etc.).
   2. That repairs are made in accordance with the specifications.
   3. Equipment used does not damage the turf or underlying geomembrane.
   4. Panels are deployed from the top of the slope in a way that the Engineered Turf filaments are pointing upslope after deployment is complete.
   5. Turf is anchored to prevent movement by the wind (Liner Contractor is responsible for any damage resulting to or from windblown Engineered Turf).
   6. Turf remains substantially free of contaminants.
   7. Turf is laid substantially smooth.
   8. That on slopes, the turf is secured with sandbag anchoring at the top of the slope after deployment.
   9. That the first panel deployed has the turf filaments facing upward.
   10. That subsequent panels are deployed turf side down, and on top of the previous panel. (Sewing Method Only)
   11. That after seaming each panel, it is flipped onto the geomembrane component with care to avoid pulling of tufts in the drainage studs. (Sewing Method Only)
   12. A single stitch prayer type seam is constructed using a Newlong sewing machine or equivalent. (Sewing Method Only)
   13. The thread will be 207 Polyester or equivalent.
   14. Sewing will occur between the 1st and 2nd row of tufts on both sides of panel.

3.2 ENGINEERED TURF COMPONENT FUSION SEAMING METHOD

A. Techniques for Fusion Seaming Engineered Turf will be as follows:
   1. Engineered Turf fusion seaming device will be a DemTech VM20/4/A fusion welder only.
   2. Fusion seams shall be overlapped a minimum of 5 inches.
   3. Frayed or loose geotextile strands shall be cut off or removed.
   4. Demonstrate the preparation methods and equipment utilized for removal of the selvage from the outside edge of the rolls of turf (i.e. trimming & cutting devices).
   5. Mechanical or hot knife trimming and cutting devices shall be utilized for selvage trimming.
   6. Demonstrate and control the fraying of geotextile strands when performing the removal of selvage.
   7. Any damage that occurs due to production seaming shall be repaired.

3.3 EQUIPMENT ON THE TURF

A. During installation on slopes exceeding 15%, no equipment shall be allowed until Sand Infill is in place. On slopes less than 15% ATV type equipment will be allowed prior to Sand Infill if tire pressure is less than 5 psi.

B. After Sand Infill placement is complete. Limit traffic to temporary loads with ground contact pressure less than 35 psi for slopes greater than 15%. On slopes less than 15% limit traffic to temporary loads with ground contact pressure less than 85 psi.

3.4 SAND BALLAST INFILL PLACEMENT

A. Sand infill that is placed between the tufts of the Engineered Turf Component:
   1. The sand infill layer will be placed to a ½ inch minimum thickness not to exceed ¾ inch thick.
   2. Verify final thickness of sand infill at a rate of 20 times per acre.

B. Place ClosureTurf® Sand Infill to grain size specified in Section 310516.

C. Verify and document the following:
   1. Sand Infill shall be worked into the Engineered Turf between the synthetic yarn blades.
   2. Sand Infill shall be placed and spread using a conveyor systems and/or express blowers.
   3. During placement of Sand Infill ensure that previously installed ClosureTurf® components are not displaced or damaged.
   4. Do not place Sand Infill with snow or ice on the Engineered Turf component.

3.5 INSTALLATION ACCEPTANCE

A. The Geotextile Installer retains all ownership and responsibility for the ClosureTurf® system until acceptance by the Owner.
   1. After all ClosureTurf® components are deployed, seamed, has passed required testing successfully, and any repairs are made:
      a. The completed installation will be inspected by the CQAO and the geotextile installer supervisor.
      b. Damage and/or defects found during this inspection shall be repaired.
      c. The installation will not be accepted until it meets the requirements of these specifications and any applicable State, Federal or Local Regulations.
   2. Required independent testing laboratory and field tests have been completed, reviewed and approved.
   3. Required documentation has been received, reviewed and approved.
   4. As built record drawings have been submitted.
   5. Any other submittals are complete and accepted by the Owner's Representative.

END OF SECTION

SECTION 32 92 19 – HYDROSEEDING

PART 1 - GENERAL

1.1 SUMMARY

A. This work consists of seeding and fertilizing all areas disturbed by the construction activities. All disturbed areas that are not otherwise covered by other means (i.e. outside of the landfill cover footprint, or as noted in the plans) shall be hydroseeded in accordance with the specifications below.

1.2 REFERENCES

A. Section – 31 05 13 Cover System Construction

B. Section – 31 11 00 Clearing and Grubbing

C. Section – 31 20 00 Earthwork

D. Section – 31 25 00 Erosion and Sediment Controls

1.3 DEFINITIONS

A. Finish Grade - Elevation of finished surface of vegetative layer.

B. Vegetative Layer – Vegetative layer shall be soils representative of productive soils in the project area and capable of supporting vegetation.

1.4 SUBMITTALS

A. A minimum of 10 days prior to its use, the Contractor shall submit the following to the Engineer for review:
   1. Provide product data for each type of product indicated.
      a. Permanent Seed Mixture.
      b. Fertilizers.
   2. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
   3. Landscape installer qualifications.

1.5 QUALITY ASSURANCE

A. Landscape Subcontractor Qualifications: Subcontractor shall have a minimum of five years of experience of producing substantially similar Work and shall show evidence of at least five satisfactory installations. Provide adequate supervision by a qualified foreman.

B. Source Quality Control:
   1. General: Ship turf materials with certificates of inspection as required by governmental authorities. Comply with governing regulations applicable to turf materials.
   2. Analysis and Standards: Package standard products with Manufacturer's certified analysis. For other materials, provide analysis by recognized laboratory made in accordance with methods established by the Association of Official Analytical Chemists, wherever applicable or as further specified.

C. Engineer will observe procedures and determine successful turf establishment.

1.6 DELIVERY, HANDLING, AND STORAGE

A. Delivery of Materials:
   1. Do not deliver seed until site conditions are ready for planting.
   2. Deliver packaged materials in containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable. Protect materials from deterioration during delivery.
   3. Furnish seed in sealed, standard containers.

B. Storage of Materials:
   1. Store and cover materials to prevent deterioration. Remove packaged materials which have become wet or show deterioration or water marks from the project site.
   2. Seed that is wet or moldy or that has been otherwise damaged in transit or storage is not acceptable. Replace at no cost to the Owner.

PART 2 - PRODUCTS

2.1 HYDROSEEDING

A. Hydroseeding shall consist of mixing and applying seed, commercial fertilizer, water management gel, polyacrylamide tackifier, and mycorrhizal inoculum with paper or wood fiber and water. Seed shall be uniformly spread over the area at the rates specified in Table 32 92 19-1 below:

Table 32 92 19-1 Seeding

Species	Pounds pure live seed (PLS) per acre
Alkali Sacaton, *Sporobolus airoides*	0.41
Western Wheatgrass, *Pascopyrum smithii*	9.60
Slender Wheatgrass (Pryor), *Elymus trachycaulus*	3.27
Blue Grama, *Bouteloua gracilis*	0.49
Sideoats Grama, *Bouteloua curtipendula*	1.82
Green Needlegrass, *Nassella viridula*	1.93
Yellow Indiangrass, *Sorghastrum nutans*	1.02
Total	**18.54**

B. Except for named varieties, all seed shall be from sources native to Colorado and be adapted to the site.

C. Weed seed content shall not be over 0.25 percent and free of noxious weeds.

D. All seed shall be furnished in bags or containers clearly labeled to show the name and address of the supplier, the seed name, the lot number, net mass (weight), origin, the percent of weed seed content, the guaranteed percentage of purity and germination, PLS of each seed species, and total pounds of PLS in the container.

E. Paper or wood fiber shall be mixed and applied with the seed in accordance with the manufacturer's recommendations. Include fertilizer and lime in the seeding slurry for application during hydro-seeding operations as required.

F. Mixing of materials for application with hydro-seeding equipment shall be performed in a tank with a built-in continuous agitation system of sufficient operating capacity to produce a homogeneous mixture and a discharge system which will apply the mixture at a continuous and uniform rate.

G. A dispersing agent may be added to the mixture provided additive will not affect germination.

H. Any mixture containing polyacrylamide tackifier shall not be applied during any rainy weather or when soil temperatures are below 41° F or if the wind speed is above 10 miles per hour.

2.2 FERTILIZER (IF USED)

A. Commercial Fertilizer: Complete fertilizer of neutral character, with a minimum of 75 percent nitrogen derived from natural organic sources or urea form; 40-50 percent of the nitrogen shall be water soluble, available phosphoric acid derived from superphosphate, bone, or tankage. Potash derived from muriate of potash, containing 60 percent potash. Fertilizer shall be uniform in composition, free-flowing and suitable for application with approved equipment. Provide fertilizer with the following percentages of available plant nutrients:

1. For vegetated areas, provide fertilizer with not less than 4 percent phosphoric acid and not less than 2 percent potassium, and the percentage of nitrogen required to provide not less

than 1.5 pounds of actual nitrogen per 1000 square feet of turf. Provide nitrogen in a form that will be available to the lawn during the initial period of growth. .

2.3 WATER

A. Clean, fresh, and free of substances or matter capable of inhibiting vigorous growth of grass.

PART 3 - EXECUTION

3.1 SOIL TESTING AS NEEDED

A. Collect representative samples of the surface soil from each area to be seeded and submit the samples to a qualified soil testing laboratory to obtain recommendations for fertilizer and lime and other additives as needed.

3.2 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
   1. Landscape Installer shall verify that no foreign or deleterious material or liquid has been deposited in soil within a planting area.
   2. Do not mix or place soils or soil amendments in frozen, wet, or muddy conditions.
   3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by the Engineer and replace with new planting soil.

3.3 HYDROSEEDING

A. Slurry preparation shall be completed onsite.
   1. Water, mulch, fertilizer, binder and other ingredients shall be added to the tank simultaneously so that the finished load is a homogenous mix of the specified ingredients.
   2. Seed shall be added last and shall be discharged within 2 hours. Loads held over 2 hours will be recharged with 1/2 the seed rate before application.
   3. Once fully loaded, the complete slurry shall be agitated for 3-5 minutes to allow for uniform mixing

B. All hydroseed applications are to be applied in a sweeping motion to form a uniform application and form a mat at the specified rates.

C. Unused loads: If mixture remains in tank for more than 8 hours it shall be removed from the job site.

3.4 CLEANUP AND PROTECTION

A. Remove non-degradable erosion-control measures after grass establishment period.

B. Remove all wrappers and waste materials generated during seeding.

3.5 INSPECTION AND ACCEPTANCE

A. When the turf work is completed, including maintenance, Engineer will make an inspection to determine acceptability.

B. All areas at the time of inspection shall have a minimum grass cover density of 70%.

C. Seeded areas will be acceptable provided all requirements, including maintenance, have been complied with, and a healthy, uniform, close stand of the specified grass is established, free of weeds, bare spots and surface irregularities.

END OF SECTION

AECOM
1601 Prospect Parkway
Fort Collins, Colorado 80525, USA
T +1-970-483-8878
www.aecom.com

Project name: Colorado Springs Utilities Coal Combusion Residuals Landfill 30% Design

Project ref:

RE: Proposed Landfill Drainage and Perimeter Ditch Evaluation

From: Steve Walker, PE

Date:
12/18/2023

Memo

The purpose of this memo is to evaluate the volume and peak flows of stormwater runoff from the proposed 30% landfill closure design at the Clear Spring Ranch Coal Combustion Residual (CCR) landfill site, owned and operated by Colorado Springs Utilities. Closure of the landfill will be done using an engineered turf system cap, which will generate stormwater runoff that must be conveyed and discharged into the stormwater retention dam pond east of the landfill. This memo demonstrates the amount of stormwater anticipated and evaluates the proposed stormwater perimeter ditch designed to convey flows to the retention dam pond.

Regulations

This proposed facility is being designed in accordance with the Colorado Department of Public Health and Environment's Hazardous Materials and Waste Management Division 6 CCR 1007-2, Part 1, Regulations Pertaining to Solid Waste Sites and Facilities. Section 2.1.6 requires that the stormwater conveyance system be designed to collect the 25-year, 24-hour storm event, and control the 100-year, 24-hour storm event:

> *Sites and facilities shall, design, construct, and maintain: (a) A run-on control system to prevent flow onto the active facility during the peak discharge from a 25-year, 24-hour storm, and (b) A run-off control system to: (1) collect the water volume resulting from a 25-year, 24-hour storm event and (2) control the water volume resulting from a 100-year, 24-hour storm event. (See also Section 2.5.7).*

Section 2.5.7 indicates that closed landfills must control the 100-year, 24-hour storm event:

> *Permanent surface water diversion structures remaining after closure shall control run-on and run-off from the 100 year, 24-hour storm event.*

Additionally, the facility shall comply with the United States Environmental Protection Agency (USEPA) 40 CFR 257 Subpart D - Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments (CCR Rule). The stormwater run-on and run-off controls are described in Section 257.81, which indicates the following:

> *a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain:*

(1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and

(2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.

For the CCR landfill, the stormwater run-on and run-off is controlled by a perimeter ditch that extends around the facility.

It has been determined that the closure design for the CCR landfill will incorporate infrastructure that will handle the 100-year, 24-hour storm event. This will satisfy both the State and Federal regulations for CCR landfill closures.

Stormwater Modeling

HydroCAD version 10.00-16 was used to evaluate stormwater runoff, channel flows, and culvert performance. HydroCAD is a stormwater modeling program based on the hydrology techniques developed by the Soil Conservation Service, combined with other accepted hydrology and hydraulics methods. These modeling techniques are used to generate hydrographs for a given watershed, allowing the user to verify that a given drainage system is adequate for the area under consideration, or to predict where flooding or erosion is likely to occur. For this modeling effort, the Soil Conservation Service TR-20, also known as the Unit Hydrograph Method, was used to develop hydrographs for the landfill site.

For the CCR landfill, the primary focus was to determine the peak stormwater runoff expected to be generated during the 100-year, 24-hour storm, determine the direction of flow from the landfill into the perimeter channels, and to evaluate the ditch geometry, slope, and surface treatment.

The following parameters were used in the model:

- Curve Number, CN, for the closed landfill = 98
- 100-year rainfall depth = 5.22 inches
- Time of Concentration, Tc = 10 minutes (used for all sections of the landfill as a minimum)
- Type II, 24-hour Rainfall Distribution used for hydrograph development

The curve number of 98 was chosen because the proposed landfill cover will be an engineered turf cover over an impermeable liner. One-half inch of sand infill will be spread across the cover as ballast. The system will produce considerable runoff in a short period of time during large storms, since there is no infiltration layer.

The rainfall depth was obtained using the National Oceanic and Atmospheric Administration's Atlas 14 Point Precipitation Frequency Estimates for Colorado, for the 24-hour, 100-year reoccurrence.

The Time of Concentration used was 10 minutes, which is a practical conservative minimum used for development of the hydrograph.

Perimeter Channel Evaluation

The landfill area was divided into 6 drainage subcatchments, as follows:

Area Name	Node ID in Model	Area (Acres)
Landfill West Face	S1	7.09
Landfill NW Face	S2	8.13
Landfill NE Face	S3	9.35
Landfill East Face	S4	6.77
Landfill SW Face	S5	11.31
Landfill SE Face	S6	13.16

Table 1: Landfill Subcatchments

Landfill West Face, Landfill NW Face, and Landfill NE Face will drain into a common channel, comprised in the model of the west perimeter ditch, the NW perimeter ditch, and the NE perimeter ditch. This channel will ultimately flow through a twin 48-inch culvert to the existing collector ditch into the retention dam pond. The proposed channel will have a 6-foot bottom width, 2:1 side slopes, and a 3 foot depth.

The Landfill East Face will drain into the East Face Channel, and through a twin 24-inch culvert, which will discharge into the existing collector ditch and ultimately into the retention dam pond. The channel will have a 4-foot bottom width, 2:1 side slopes, and a 2 foot depth.

The Landfill SW Face and Landfill SE Face will drain into a common channel, comprised in the model of the SW Perimeter Ditch and the SE Perimeter Ditch. The Landfill SW Face will discharge through a twin 30-inch culvert, into an existing collector ditch south of the landfill. The Landfill SE Face area will drain through a twin 36-inch culvert, into the collector ditch south of the landfill. The collector ditch flows into the retention dam pond. The channel will have a 6-foot bottom width, 2:1 side slopes, and a 3 foot depth.

The performance of the various channel segments is summarized in the table below. In all sections, the perimeter channel is able to collect and convey the 100-year, 24-hour storm event. Figure 1 shows perimeter channel locations and direction of flow.

Ditch Section	100-Yr Storm Depth (feet)	100-Yr Peak Flow (CFS)	100-Yr Peak Velocity (FPS)
West Perimeter Ditch	0.9	46	6.29
NW Perimeter Ditch	1.6	95	6.16
NE Perimeter Ditch	2.2	149	6.20
East Face Channel	1.81	44	2.82
SW Perimeter Ditch	1.24	73	6.71
SE Perimeter Ditch	1.49	85	6.18

Table 2: Perimeter Channel Section Performance

Culverts

It is anticipated that there will be four culverts placed at various locations around the landfill perimeter channel, each of which will discharge into an existing collector ditch that leads to the retention dam pond. Considerations for the culvert selection include the ability to pass the 100-year, 24-hour storm event without creating a headwater elevation higher than 1.5 times the culvert diameter; maintaining at

least 18 inches of cover over the culvert; ease of maintenance and ability to clean if necessary; and selection of culvert materials that will hold up indefinitely during and after the post-closure period.

For the culverts, HDPE SDR17 pipe was modeled. For calculation purposes, this would be the equivalent of an ADS N-12 pipe or similar. HDPE pipe has been shown to be long-lasting and durable, and would be a recommended choice for this site. The only other accpetable option would be reinforced concrete pipe (RCP). RCP is durable and long-lasting, but has slightly less favorable drainage properties, and may be more susceptible to infiltration over time.

The culvert configurations make use of a "twin" pipe culvert for each of the crossings. This is to help ensure adequate cover under the perimeter access road.

The following table summarizes culvert locations, sizes, and tributaries:

Culvert ID	Culvert Configuration	Material	Drainage Area (Ac)
Culvert 1 (C1)	Twin 48-inch	HDPE SDR17	24.6
Culvert 2 (C2)	Twin 24-inch	HDPE SDR17	6.8
Culvert 3 (C3)	Twin 30-inch	HDPE SDR17	13.2
Culvert 4 (C4)	Twin 36-inch	HDPE SDR17	11.3

Table 3: Culvert Information

Culverts were evaluated in the HydroCAD model by routing each contributing drainage area and associated channel through the culvert. Peak elevation and flow through the culvert was determined for the 100-year, 24-hour storm. Culvert performance is summarized below.

Culvert ID	Peak Flow (CFS)	Peak Elev. (MSL)	Upstream Depth (FT)	Ratio HW/Diameter
Culvert 1	143	5451.42	3.42	0.86
Culvert 2	40	5445.73	2.73	1.37
Culvert 3	71	5455.49	3.49	1.40
Culvert 4	82	5445.95	2.95	0.98

Table 4: Culvert Performance

In all cases, the headwater depth is less than 1.5 times the culvert diameter, for the 100-year, 24-hour storm.

Figure 1 shows the stormwater drainage map, and includes proposed culvert locations and direction of flow through the perimeter channel.

Erosion Control and Energy Dissipation

All of the channel sections surrounding the CCR landfill will be covered with engineered turf, which will also be used to cover the landfill. The landfill cover system will extend through the perimeter channel and will be anchored approximately 2' beyond the outer edge of the channel. With the use of an engineered turf liner, erosion becomes much less of a concern. Riprap may be placed at culvert inlet approaches and at all outlets to dissipate energy as required. Most of the 100-year velocities are

approximately 6 feet per second, which is within the appropriate range for the turf-covered and/or riprap lined channels.

The perimeter channel will be designed to catch runoff from the landfill only. The access road, which will circumnavigate the closed landfill, will act as a "barrier" and prevent off-site stormwater from entering the landfill perimeter channel. As such, the only anticipated sedimentation that may collect in the channel will be from migration from ballast sand. Occasional maintenance may be required to remove relatively small amounts of ballast sand from the channel. This would likely occur every 3 to 5 years, and will require the use of hand tools or very small equipment, to prevent damage to the liner system under the engineered turf.

Summary

Based upon the results of the HydroCAD modeling, the perimeter channels are appropriately sized and will convey the 100-year, 24-hour storm, as required by the CDPHE and USEPA regulations. Culverts will convey stormwater flows from the perimeter channels to the main collector channels, which discharge into the Clear Spring Ranch stormwater retention dam pond. The culverts described in this memo will adequately drain the perimeter channels up to the 100-year, 24-hour storm.

References

1. HydroCAD User Guide, Version 10.00-16, available with the HydroCAD program
2. National Oceanic and Atmospheric Administration's Hydrometeorological Design Studies Center Precipitation Frequency Data Server (NOAA Atlas 14-Point Precipitation Frequency Estimates, CO); PF Map: Contiguous US (noaa.gov)
3. Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division 6 CCR 1007-2, PART 1, Regulations Pertaining to Solid Waste Sites and Facilities

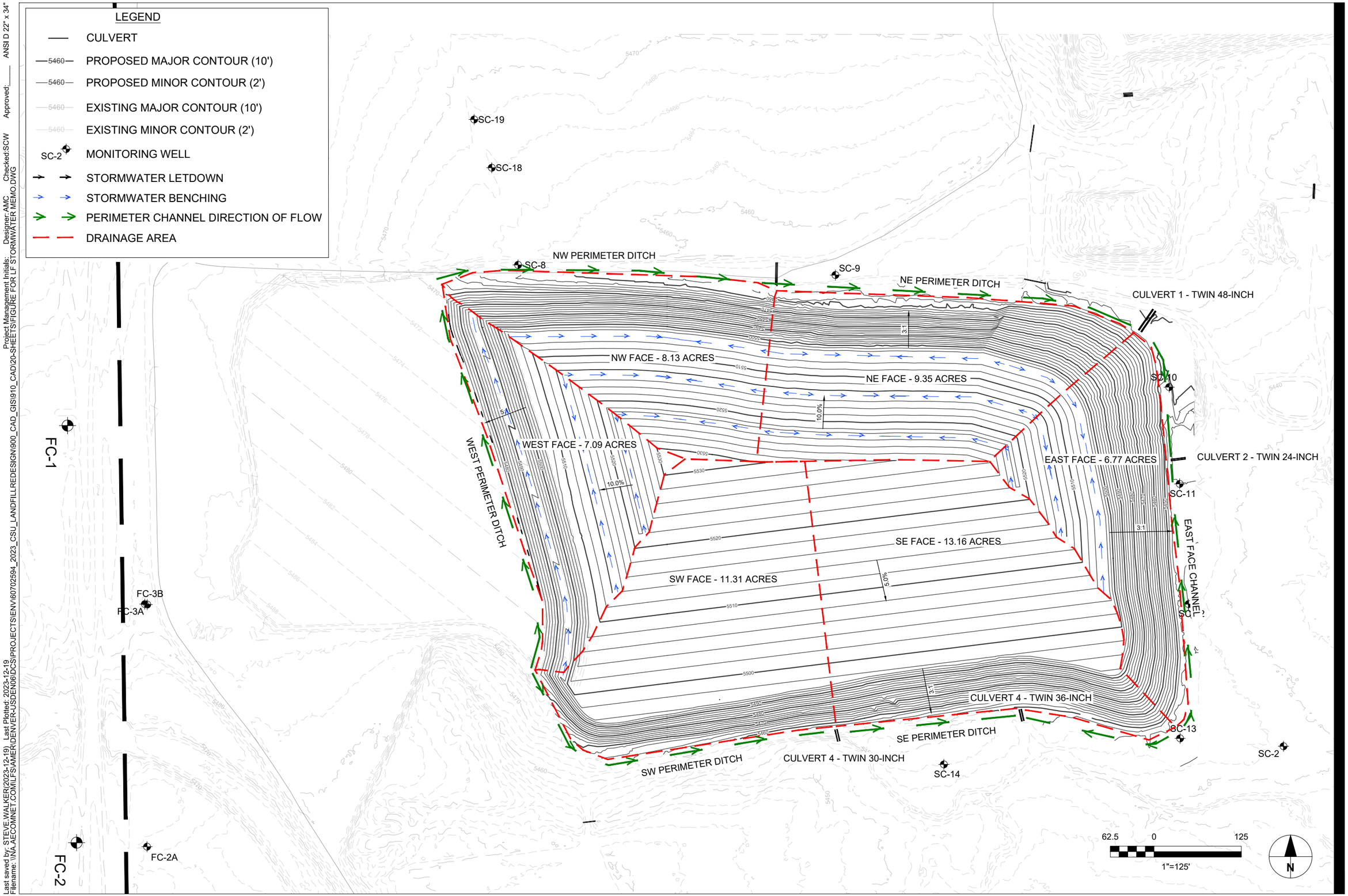
Attachments

A. HydroCAD Summary Report

B. NOAA Rainfall Estimates using the Atlas 14 Point Precipitation Frequency Estimates for Colorado

FIGURE 1

CCR Landfill Drainage Map



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Project Management Initials: Designer: AMC Checked:SCW Approved: ANSI D 22" x 34"

AECOM

Figure: 1

CCR LANDFILL CLOSURE
STORMWATER MANAGEMENT PLAN

CCR Landfill Closure Plan
Colorado Springs Utilities Clear Spring Ranch Facility
El Paso County, Colorado
Project No.: 60702594 Date: 12-18-2023

ATTACHMENT A

HydroCAD Summary Report

Subcat Reach Pond Link

Routing Diagram for Landfill CSU drainage
Prepared by AECOM, Printed 11/20/2023

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
6.770	98	East Face (S4)
9.350	98	NE Face (S3)
8.130	98	NW Face (S2)
13.160	98	SE Face (S6)
11.310	98	SW Face (S5)
7.090	98	West Face (S1)
55.810	**98**	**TOTAL AREA**

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	C1	5,448.00	5,447.00	85.0	0.0118	0.010	48.0	0.0	0.0
2	C2	5,443.00	5,442.00	50.0	0.0200	0.010	24.0	0.0	0.0
3	C3	5,452.00	5,451.50	50.0	0.0100	0.010	30.0	0.0	0.0
4	C4	5,443.00	5,442.00	60.0	0.0167	0.010	36.0	0.0	0.0

Summary for Subcatchment S1: Landfill West Face

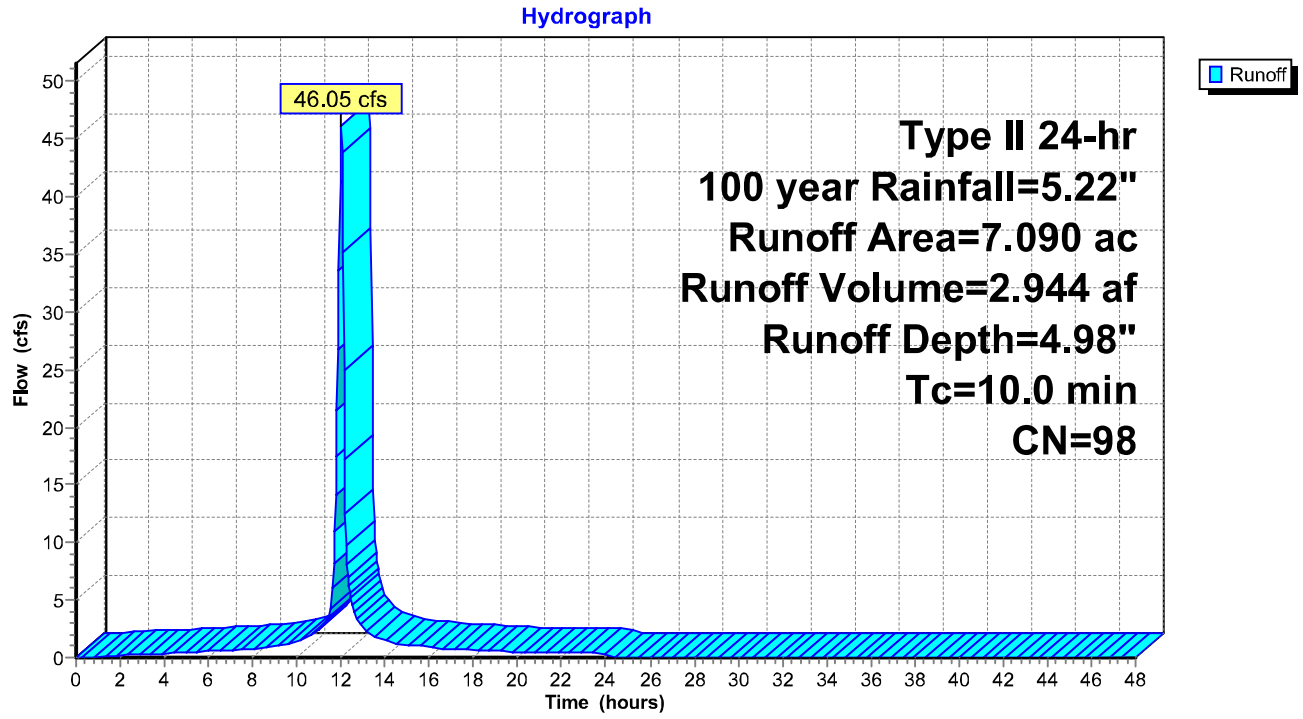
Runoff = 46.05 cfs @ 12.01 hrs, Volume= 2.944 af, Depth= 4.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs
Type II 24-hr 100 year Rainfall=5.22"

	Area (ac)	CN	Description
*	7.090	98	West Face
	7.090		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment S1: Landfill West Face



Summary for Subcatchment S2: Landfill NW Face

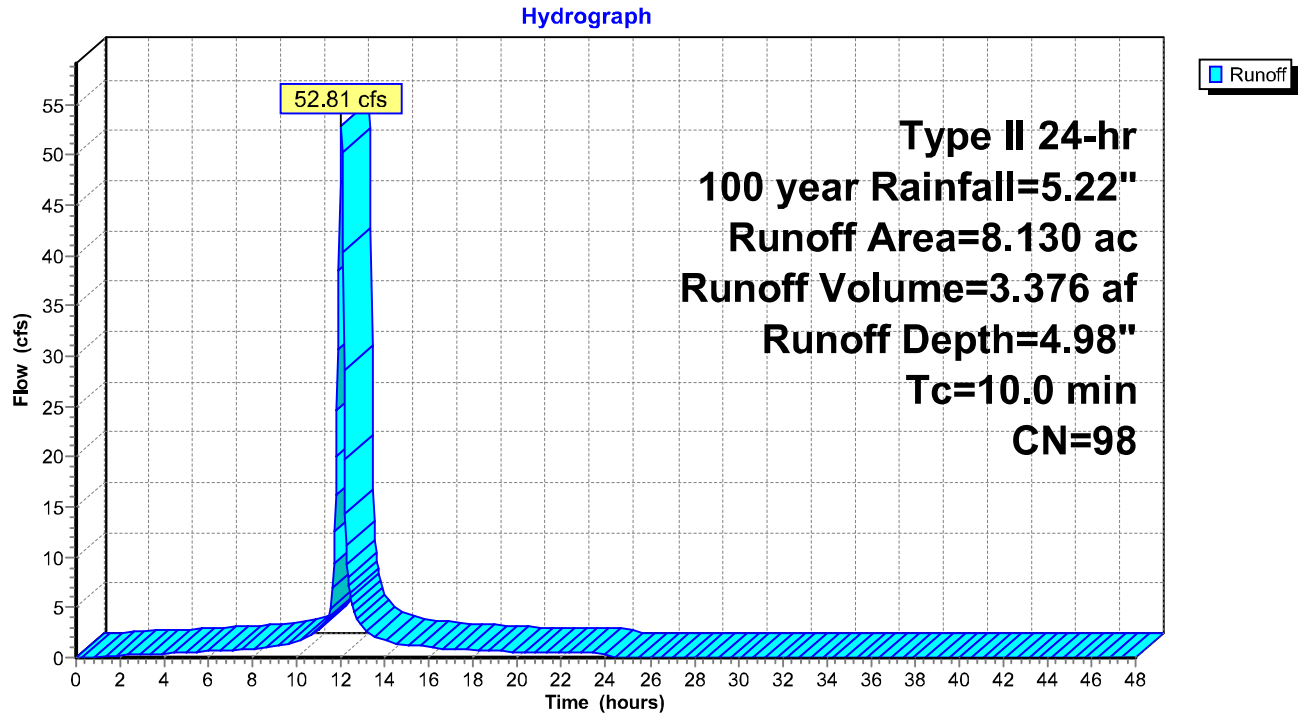
Runoff = 52.81 cfs @ 12.01 hrs, Volume= 3.376 af, Depth= 4.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs
Type II 24-hr 100 year Rainfall=5.22"

	Area (ac)	CN	Description
*	8.130	98	NW Face
	8.130		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry, Direct**

Subcatchment S2: Landfill NW Face



Summary for Subcatchment S3: Landfill NE Face

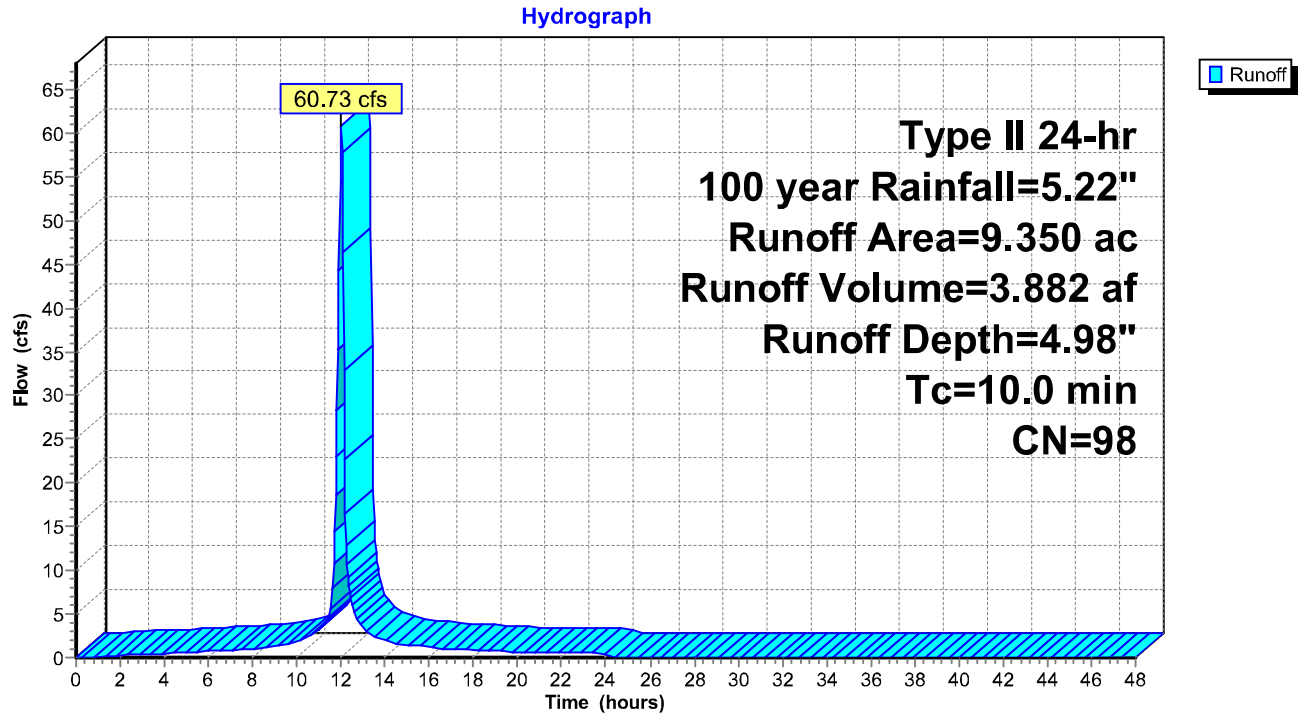
Runoff = 60.73 cfs @ 12.01 hrs, Volume= 3.882 af, Depth= 4.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs
Type II 24-hr 100 year Rainfall=5.22"

	Area (ac)	CN	Description
*	9.350	98	NE Face
	9.350		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment S3: Landfill NE Face



Summary for Subcatchment S4: Landfill East Face

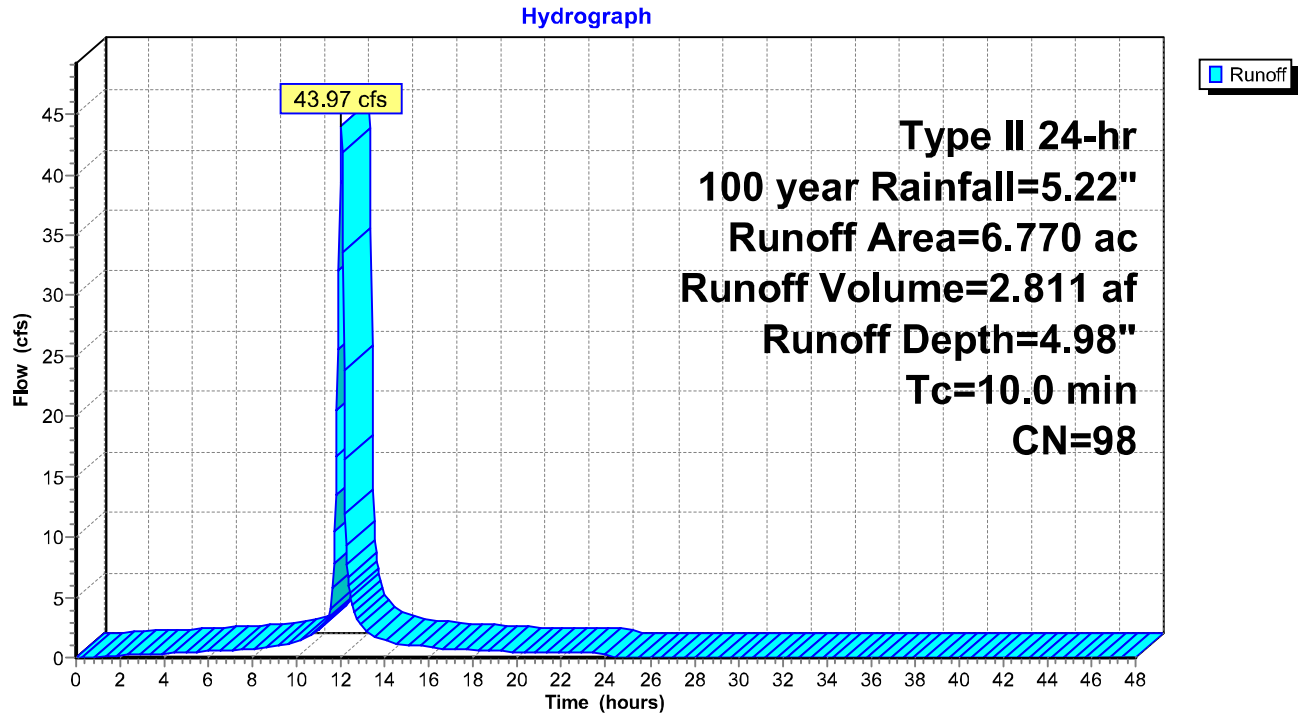
Runoff = 43.97 cfs @ 12.01 hrs, Volume= 2.811 af, Depth= 4.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs
Type II 24-hr 100 year Rainfall=5.22"

	Area (ac)	CN	Description
*	6.770	98	East Face
	6.770		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment S4: Landfill East Face



Summary for Subcatchment S5: Landfill SW Face

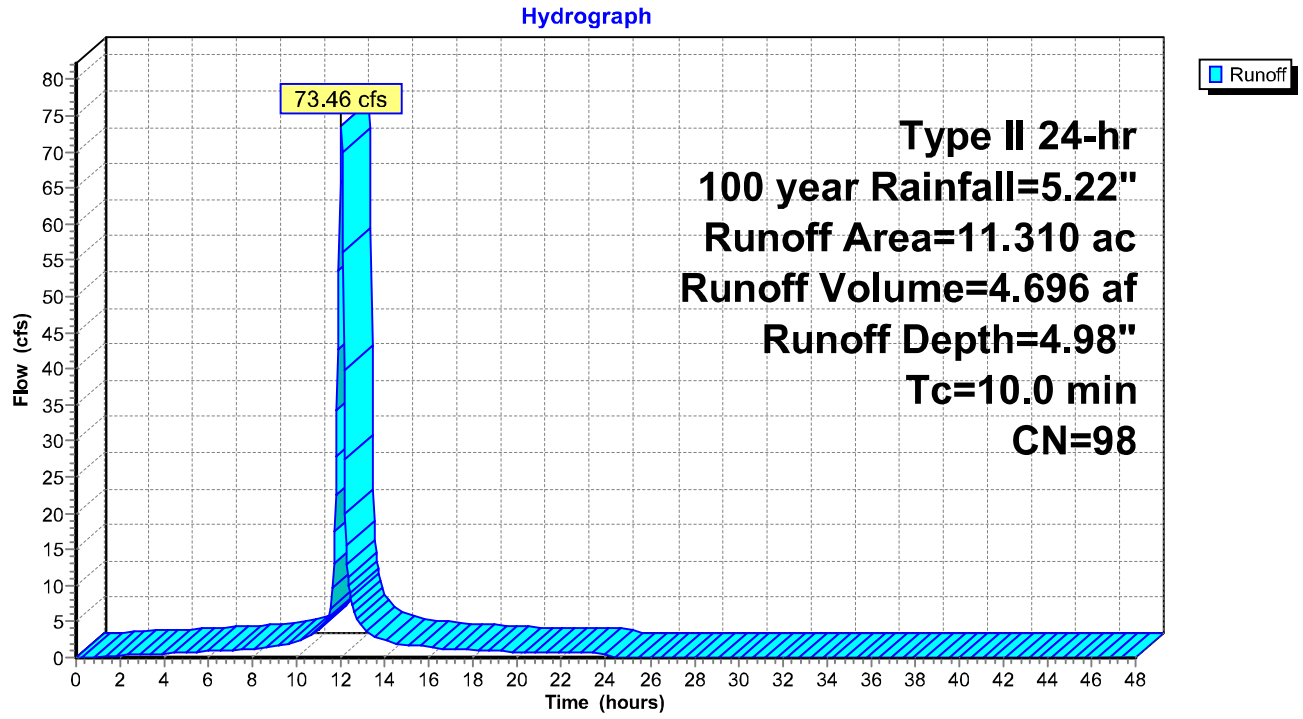
Runoff = 73.46 cfs @ 12.01 hrs, Volume= 4.696 af, Depth= 4.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs
Type II 24-hr 100 year Rainfall=5.22"

	Area (ac)	CN	Description
*	11.310	98	SW Face
	11.310		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment S5: Landfill SW Face



Summary for Subcatchment S6: Landfill SE Face

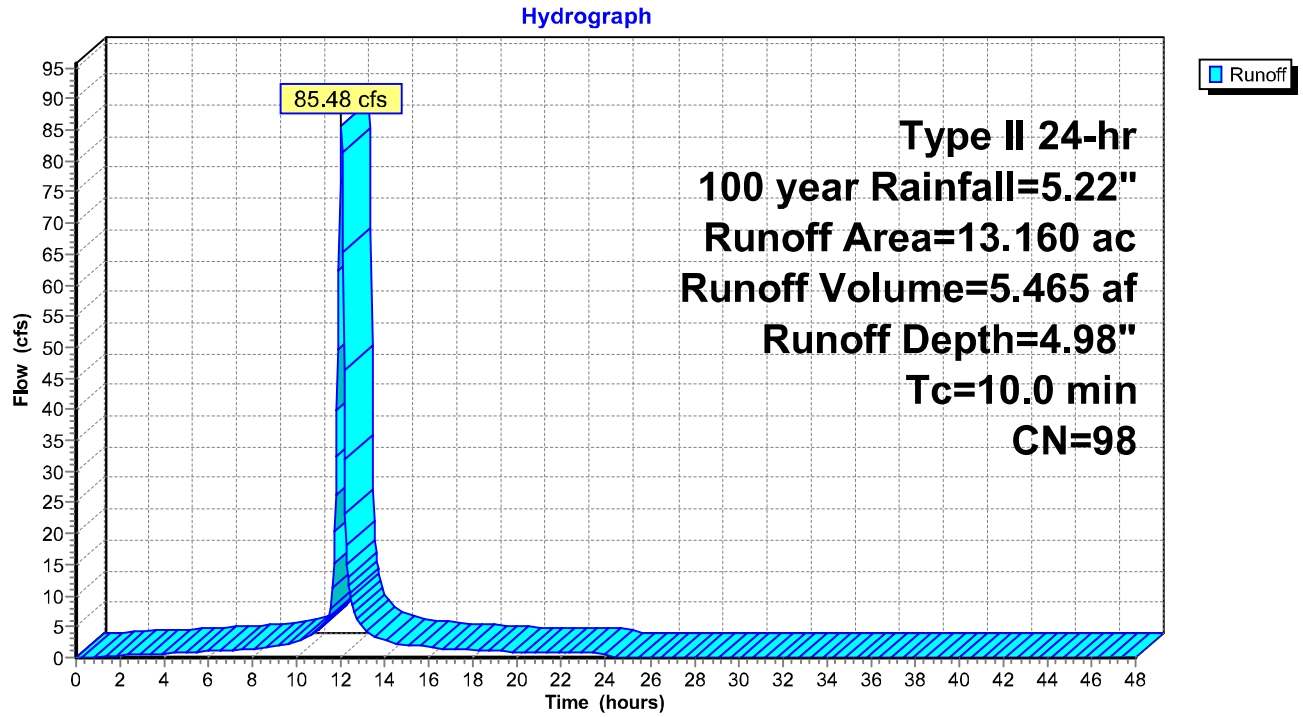
Runoff = 85.48 cfs @ 12.01 hrs, Volume= 5.465 af, Depth= 4.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs
Type II 24-hr 100 year Rainfall=5.22"

	Area (ac)	CN	Description
*	13.160	98	SE Face
	13.160		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment S6: Landfill SE Face



Summary for Reach R1: West Perimeter Ditch

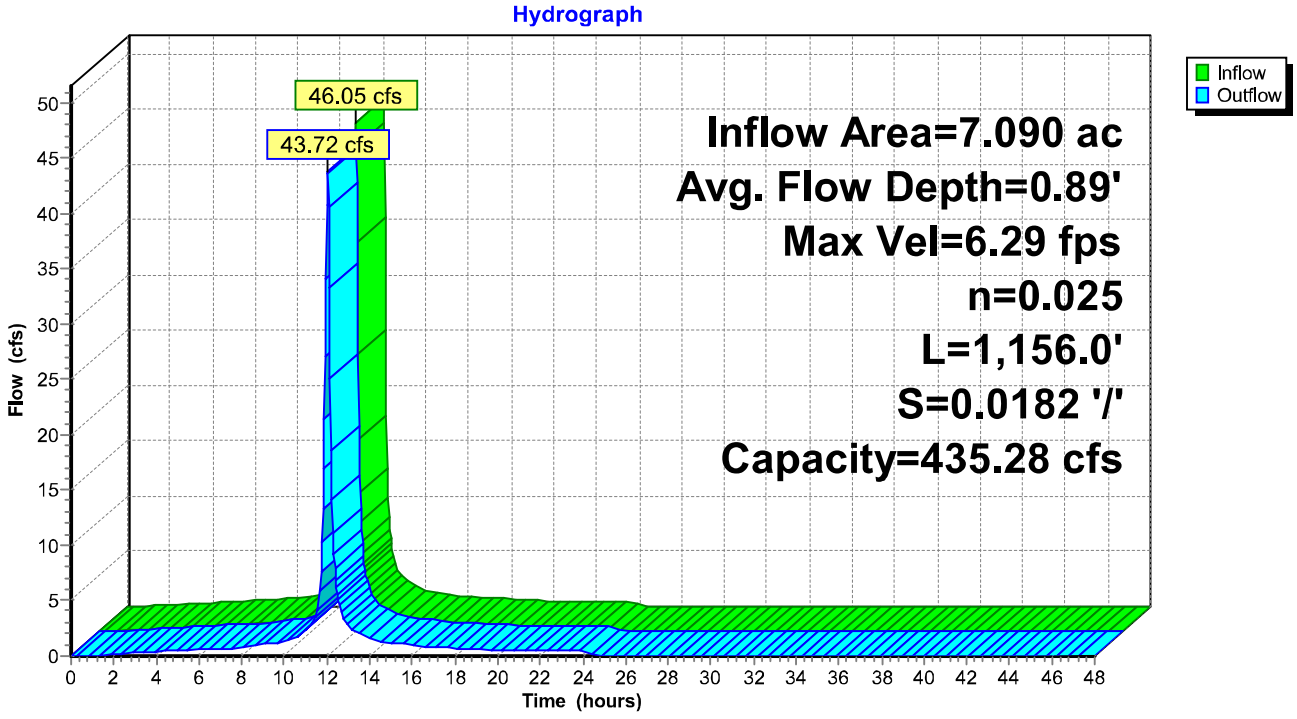
Inflow Area = 7.090 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 46.05 cfs @ 12.01 hrs, Volume= 2.944 af
Outflow = 43.72 cfs @ 12.04 hrs, Volume= 2.944 af, Atten= 5%, Lag= 1.9 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Max. Velocity= 6.29 fps, Min. Travel Time= 3.1 min
Avg. Velocity = 1.49 fps, Avg. Travel Time= 13.0 min

Peak Storage= 8,035 cf @ 12.04 hrs
Average Depth at Peak Storage= 0.89'
Bank-Full Depth= 3.00' Flow Area= 36.0 sf, Capacity= 435.28 cfs

6.00' x 3.00' deep channel, n= 0.025
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 1,156.0' Slope= 0.0182 '/'
Inlet Invert= 5,485.00', Outlet Invert= 5,464.00'

Reach R1: West Perimeter Ditch



Summary for Reach R2: NW Perimeter Ditch

[62] Hint: Exceeded Reach 127R OUTLET depth by 0.72' @ 12.08 hrs

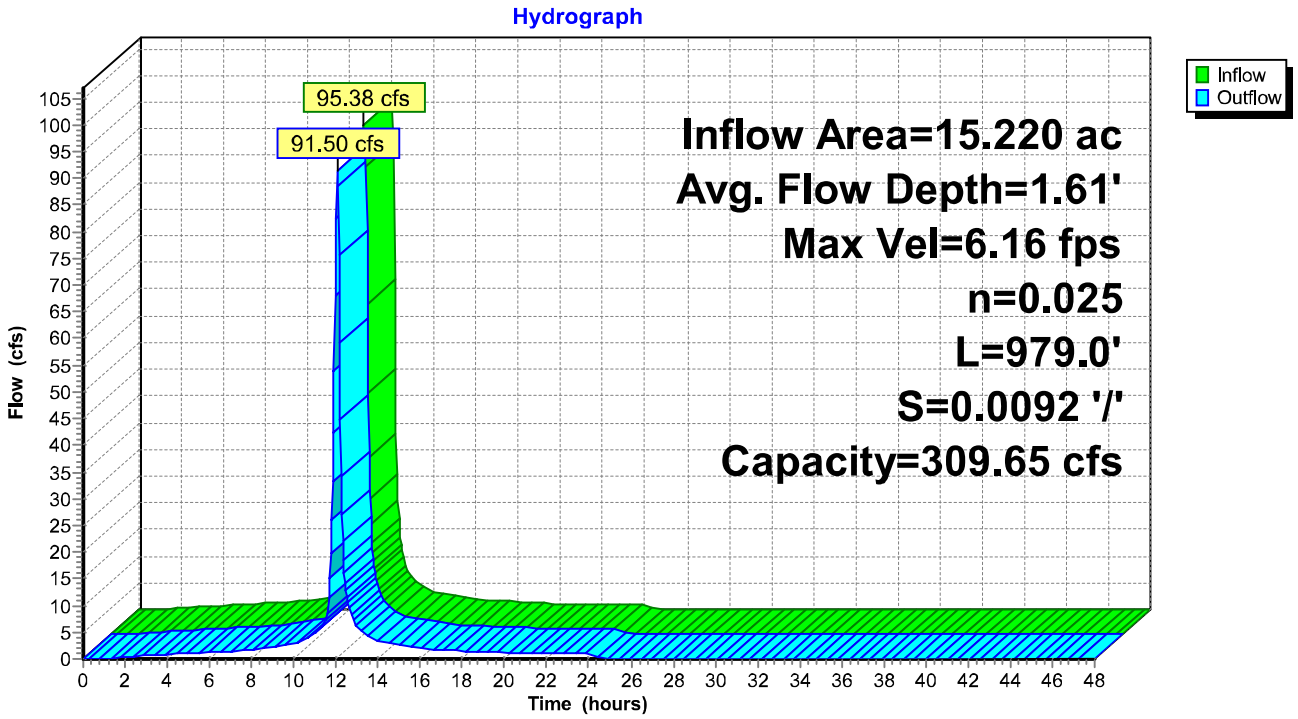
Inflow Area = 15.220 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 95.38 cfs @ 12.02 hrs, Volume= 6.320 af
Outflow = 91.50 cfs @ 12.05 hrs, Volume= 6.320 af, Atten= 4%, Lag= 1.7 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Max. Velocity= 6.16 fps, Min. Travel Time= 2.7 min
Avg. Velocity = 1.49 fps, Avg. Travel Time= 10.9 min

Peak Storage= 14,535 cf @ 12.05 hrs
Average Depth at Peak Storage= 1.61'
Defined Flood Depth= 3.00' Flow Area= 36.0 sf, Capacity= 309.65 cfs
Bank-Full Depth= 3.00' Flow Area= 36.0 sf, Capacity= 309.65 cfs

6.00' x 3.00' deep channel, n= 0.025
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 979.0' Slope= 0.0092 '/'
Inlet Invert= 5,464.00', Outlet Invert= 5,455.00'

Reach R2: NW Perimeter Ditch



Summary for Reach R3: NE Perimeter Ditch

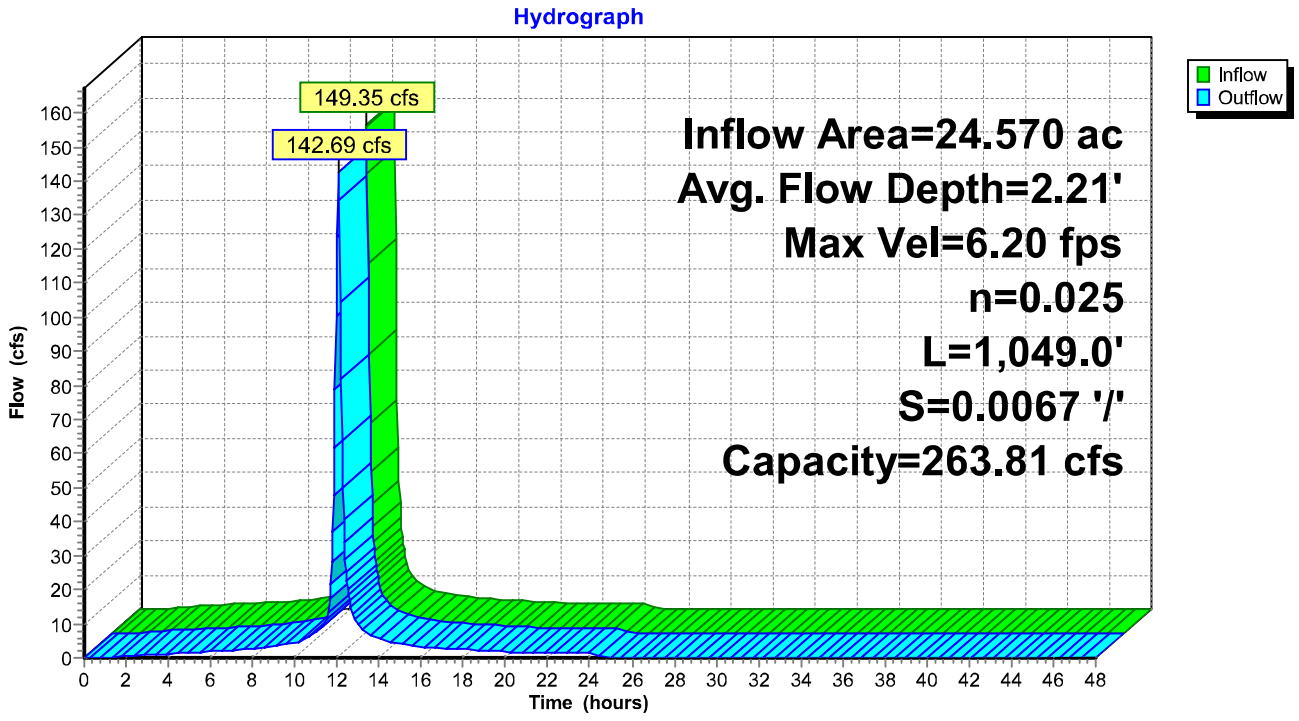
[62] Hint: Exceeded Reach 50R OUTLET depth by 0.62' @ 12.12 hrs

Inflow Area = 24.570 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 149.35 cfs @ 12.03 hrs, Volume= 10.202 af
Outflow = 142.69 cfs @ 12.06 hrs, Volume= 10.202 af, Atten= 4%, Lag= 1.9 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Max. Velocity= 6.20 fps, Min. Travel Time= 2.8 min
Avg. Velocity = 1.51 fps, Avg. Travel Time= 11.6 min

Peak Storage= 24,093 cf @ 12.06 hrs
Average Depth at Peak Storage= 2.21'
Bank-Full Depth= 3.00' Flow Area= 36.0 sf, Capacity= 263.81 cfs

6.00' x 3.00' deep channel, n= 0.025
Side Slope Z-value= 2.0 '/' Top Width= 18.00'
Length= 1,049.0' Slope= 0.0067 '/'
Inlet Invert= 5,455.00', Outlet Invert= 5,448.00'



Summary for Reach R4: Main Channel to Impoundment

Inflow Area = 24.570 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 142.69 cfs @ 12.06 hrs, Volume= 10.202 af
Outflow = 136.98 cfs @ 12.10 hrs, Volume= 10.202 af, Atten= 4%, Lag= 2.0 min

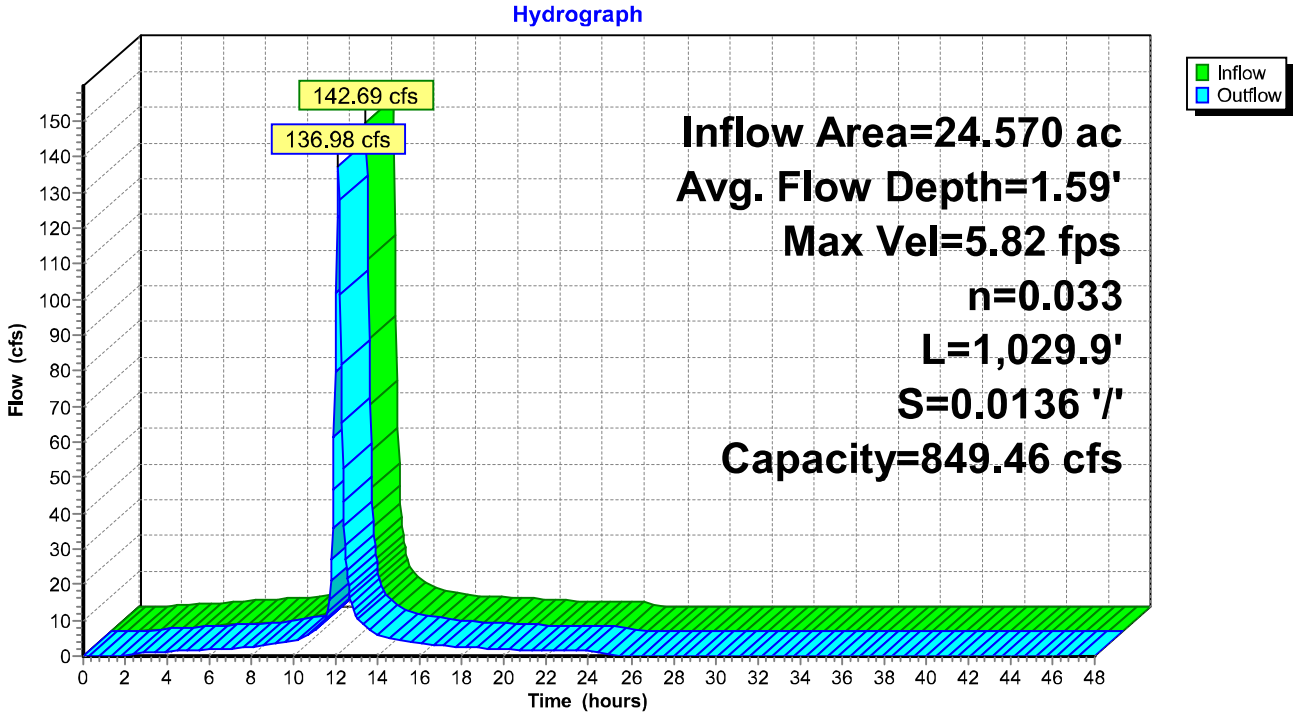
Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Max. Velocity= 5.82 fps, Min. Travel Time= 3.0 min
Avg. Velocity = 1.37 fps, Avg. Travel Time= 12.6 min

Peak Storage= 24,188 cf @ 12.10 hrs
Average Depth at Peak Storage= 1.59'
Bank-Full Depth= 4.00' Flow Area= 88.0 sf, Capacity= 849.46 cfs

10.00' x 4.00' deep channel, n= 0.033
Side Slope Z-value= 3.0 '/' Top Width= 34.00'
Length= 1,029.9' Slope= 0.0136 '/'
Inlet Invert= 5,447.00', Outlet Invert= 5,433.00'

‡

Reach R4: Main Channel to Impoundment



Summary for Reach R5: Main Channel to Impoundment

[62] Hint: Exceeded Reach R4 OUTLET depth by 7.54' @ 12.28 hrs

Inflow Area = 31.340 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 174.56 cfs @ 12.09 hrs, Volume= 13.014 af
Outflow = 152.10 cfs @ 12.15 hrs, Volume= 13.014 af, Atten= 13%, Lag= 4.1 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Max. Velocity= 5.32 fps, Min. Travel Time= 6.4 min
Avg. Velocity = 1.40 fps, Avg. Travel Time= 24.4 min

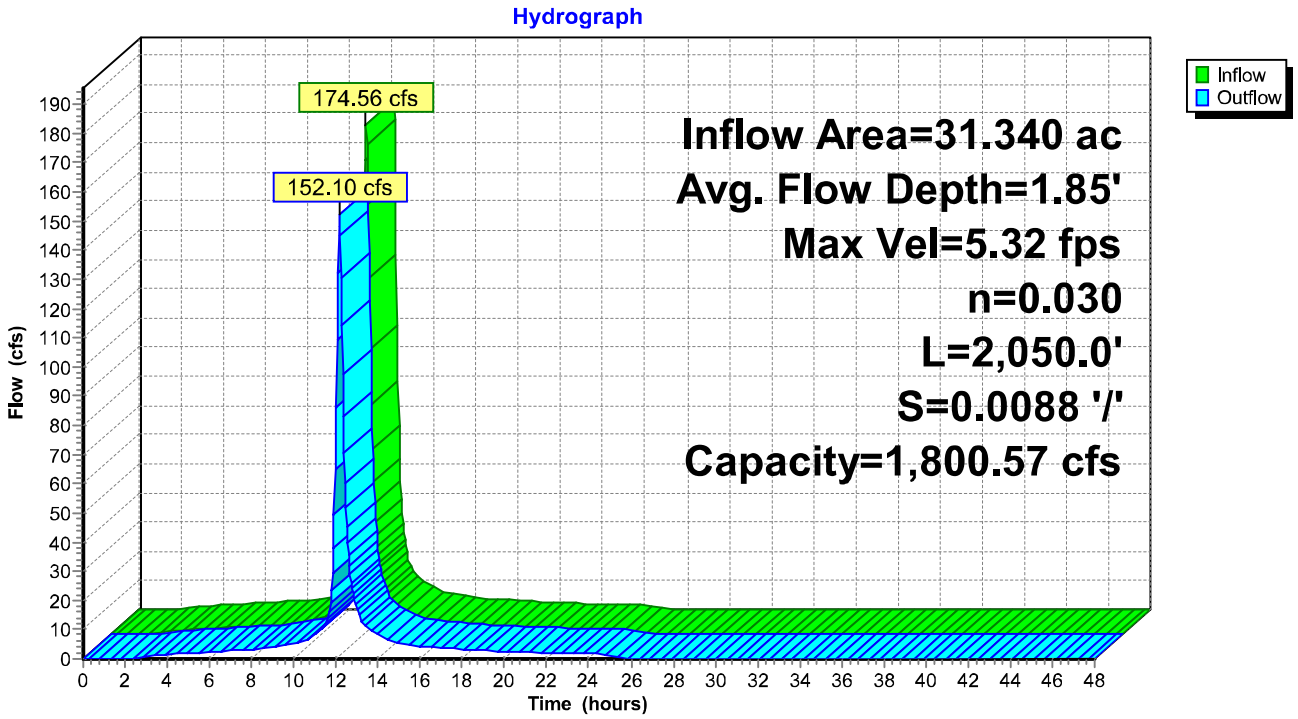
Peak Storage= 58,598 cf @ 12.15 hrs
Average Depth at Peak Storage= 1.85'
Bank-Full Depth= 6.00' Flow Area= 160.0 sf, Capacity= 1,800.57 cfs

Custom cross-section, Length= 2,050.0' Slope= 0.0088 '/' (101 Elevation Intervals)
Constant n= 0.030 Earth, grassed & winding
Inlet Invert= 5,440.00', Outlet Invert= 5,422.00'

Offset (feet)	Elevation (feet)	Chan.Depth (feet)
0.00	5,434.00	0.00
8.00	5,430.00	4.00
16.00	5,428.00	6.00
24.00	5,428.00	6.00
32.00	5,430.00	4.00
40.00	5,434.00	0.00

Depth (feet)	End Area (sq-ft)	Perim. (feet)	Storage (cubic-feet)	Discharge (cfs)
0.00	0.0	8.0	0	0.00
2.00	32.0	24.5	65,600	177.51
6.00	160.0	42.4	328,000	1,800.57

Reach R5: Main Channel to Impoundment



Summary for Reach R6: East Face Channel

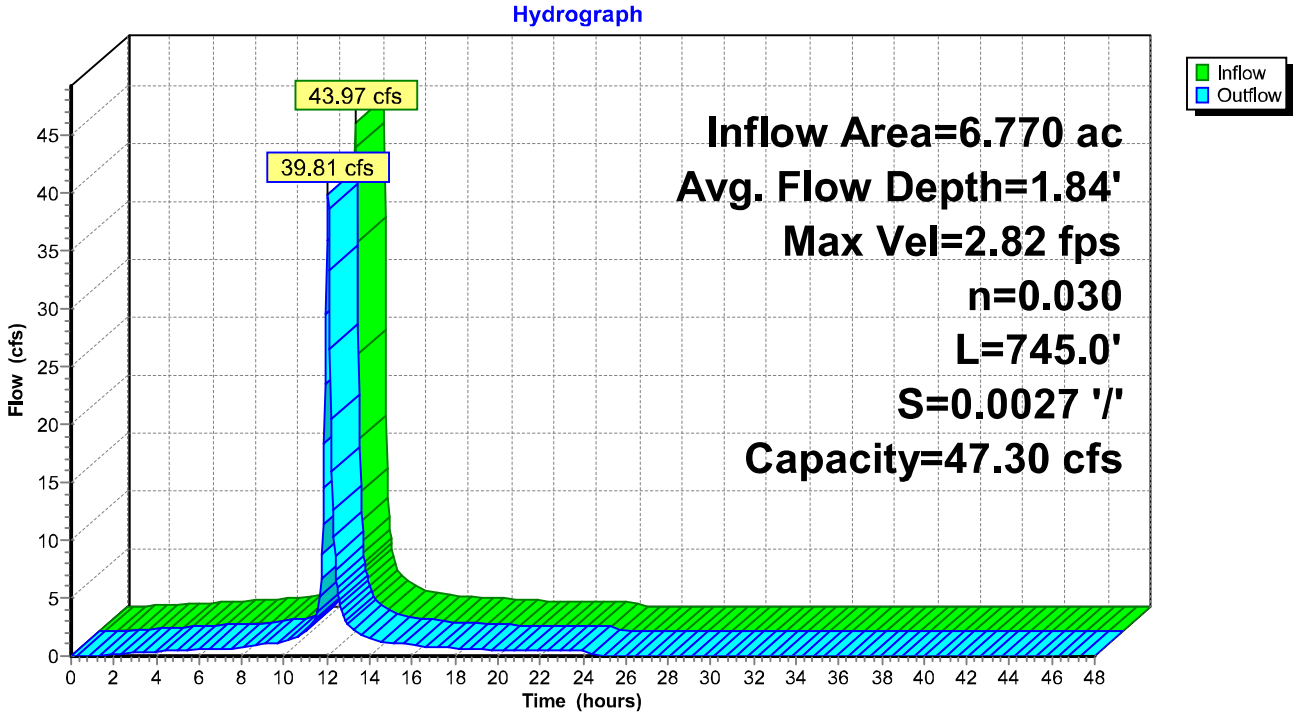
Inflow Area = 6.770 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 43.97 cfs @ 12.01 hrs, Volume= 2.811 af
Outflow = 39.81 cfs @ 12.05 hrs, Volume= 2.811 af, Atten= 9%, Lag= 2.6 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Max. Velocity= 2.82 fps, Min. Travel Time= 4.4 min
Avg. Velocity = 0.67 fps, Avg. Travel Time= 18.4 min

Peak Storage= 10,505 cf @ 12.05 hrs
Average Depth at Peak Storage= 1.84'
Bank-Full Depth= 2.00' Flow Area= 16.0 sf, Capacity= 47.30 cfs

4.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 12.00'
Length= 745.0' Slope= 0.0027 '/'
Inlet Invert= 5,444.00', Outlet Invert= 5,442.00'

Reach R6: East Face Channel



Summary for Reach R7: SW Perimeter Ditch

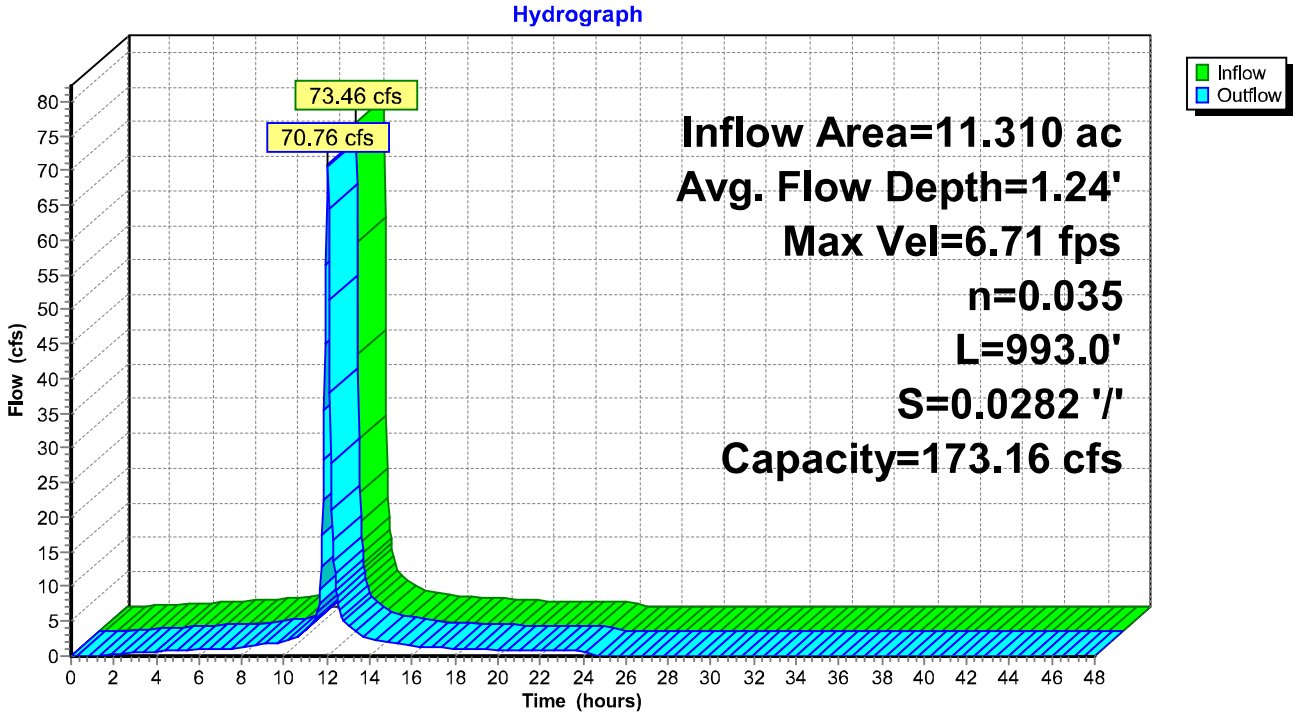
Inflow Area = 11.310 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 73.46 cfs @ 12.01 hrs, Volume= 4.696 af
Outflow = 70.76 cfs @ 12.04 hrs, Volume= 4.696 af, Atten= 4%, Lag= 1.7 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Max. Velocity= 6.71 fps, Min. Travel Time= 2.5 min
Avg. Velocity = 1.56 fps, Avg. Travel Time= 10.6 min

Peak Storage= 10,475 cf @ 12.04 hrs
Average Depth at Peak Storage= 1.24'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 173.16 cfs

6.00' x 2.00' deep channel, n= 0.035
Side Slope Z-value= 2.0 '/' Top Width= 14.00'
Length= 993.0' Slope= 0.0282 '/'
Inlet Invert= 5,480.00', Outlet Invert= 5,452.00'

Reach R7: SW Perimeter Ditch



Summary for Reach R8: SE Perimeter Ditch

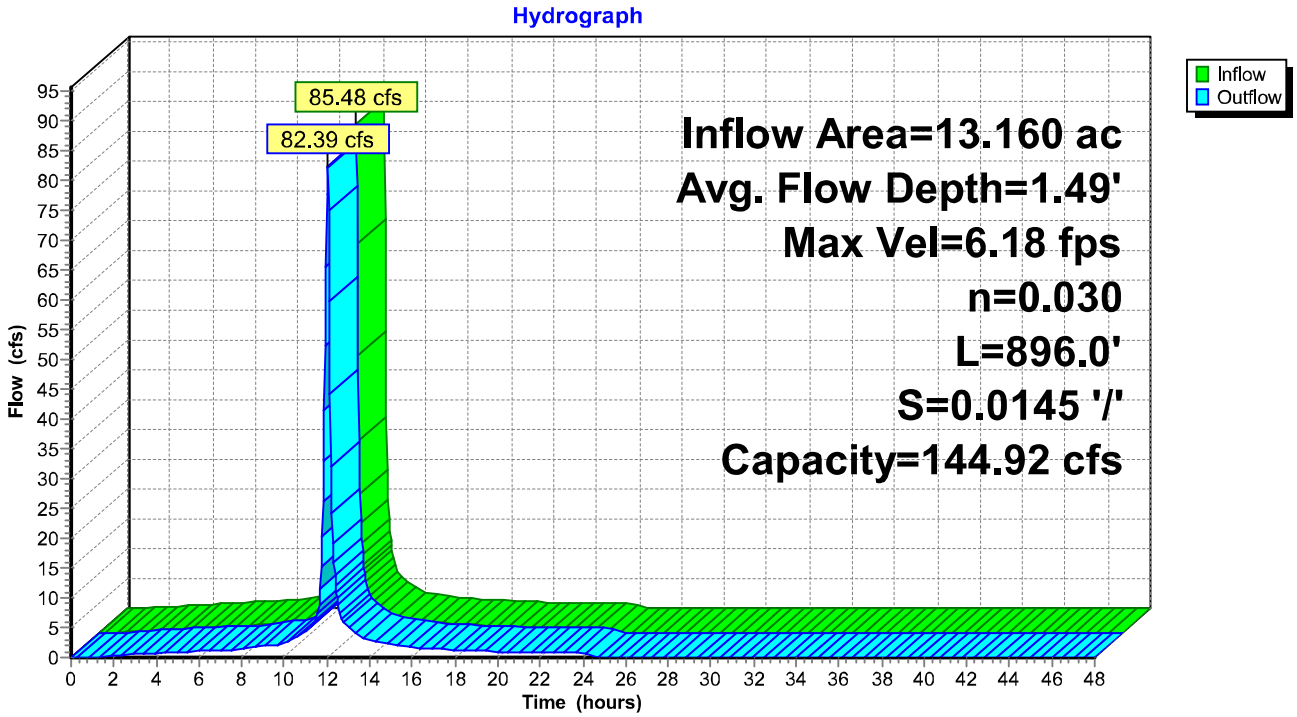
Inflow Area = 13.160 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 85.48 cfs @ 12.01 hrs, Volume= 5.465 af
Outflow = 82.39 cfs @ 12.04 hrs, Volume= 5.465 af, Atten= 4%, Lag= 1.6 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Max. Velocity= 6.18 fps, Min. Travel Time= 2.4 min
Avg. Velocity = 1.45 fps, Avg. Travel Time= 10.3 min

Peak Storage= 11,945 cf @ 12.03 hrs
Average Depth at Peak Storage= 1.49'
Defined Flood Depth= 3.00' Flow Area= 34.0 sf, Capacity= 284.33 cfs
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 144.92 cfs

6.00' x 2.00' deep channel, n= 0.030
Side Slope Z-value= 2.0 '/' Top Width= 14.00'
Length= 896.0' Slope= 0.0145 '/'
Inlet Invert= 5,456.00', Outlet Invert= 5,443.00'

Reach R8: SE Perimeter Ditch



Summary for Reach R9: South Channel to Res

Inflow Area = 13.160 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 82.39 cfs @ 12.04 hrs, Volume= 5.465 af
Outflow = 71.56 cfs @ 12.09 hrs, Volume= 5.465 af, Atten= 13%, Lag= 3.3 min

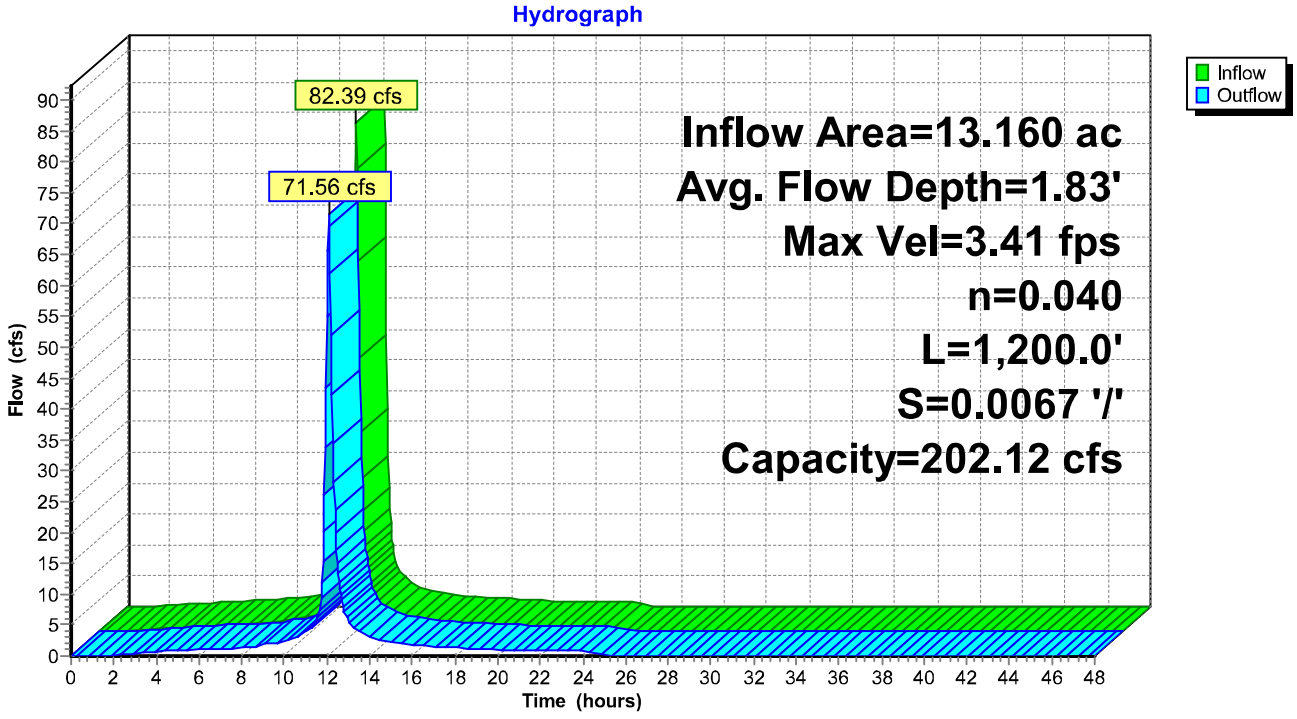
Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Max. Velocity= 3.41 fps, Min. Travel Time= 5.9 min
Avg. Velocity = 0.82 fps, Avg. Travel Time= 24.5 min

Peak Storage= 25,150 cf @ 12.09 hrs
Average Depth at Peak Storage= 1.83'
Bank-Full Depth= 3.00' Flow Area= 45.0 sf, Capacity= 202.12 cfs

6.00' x 3.00' deep channel, n= 0.040
Side Slope Z-value= 3.0 '/' Top Width= 24.00'
Length= 1,200.0' Slope= 0.0067 '/'
Inlet Invert= 5,440.00', Outlet Invert= 5,432.00'

‡

Reach R9: South Channel to Res



Summary for Pond C1: Twin 48-inch

[57] Hint: Peaked at 5,451.42' (Flood elevation advised)
[62] Hint: Exceeded Reach 128R OUTLET depth by 1.21' @ 12.08 hrs

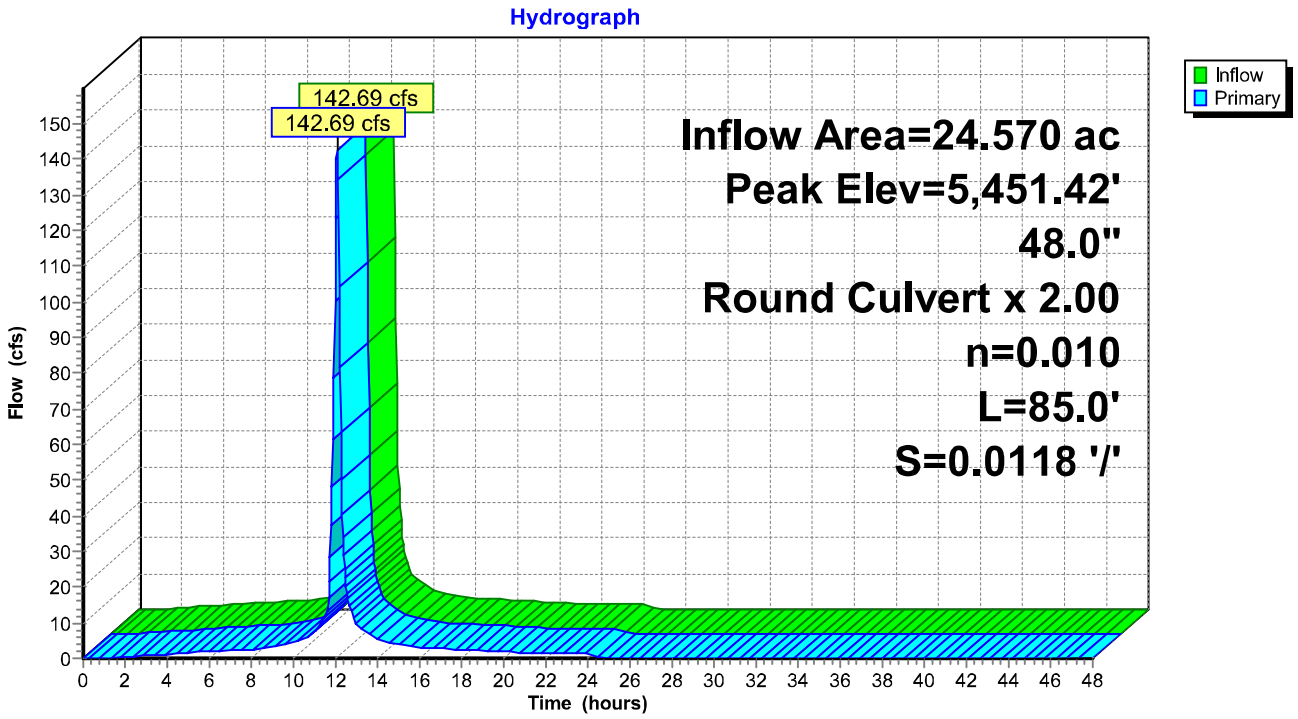
Inflow Area = 24.570 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 142.69 cfs @ 12.06 hrs, Volume= 10.202 af
Outflow = 142.69 cfs @ 12.06 hrs, Volume= 10.202 af, Atten= 0%, Lag= 0.0 min
Primary = 142.69 cfs @ 12.06 hrs, Volume= 10.202 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Peak Elev= 5,451.42' @ 12.06 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	5,448.00'	**48.0" Round Culvert X 2.00** L= 85.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 5,448.00' / 5,447.00' S= 0.0118 '/' Cc= 0.900 n= 0.010, Flow Area= 12.57 sf

Primary OutFlow Max=140.77 cfs @ 12.06 hrs HW=5,451.39' TW=5,448.55' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 140.77 cfs @ 8.35 fps)

Pond C1: Twin 48-inch



Summary for Pond C2: Twin 24-inch

[57] Hint: Peaked at 5,445.73' (Flood elevation advised)
[62] Hint: Exceeded Reach R6 OUTLET depth by 1.88' @ 12.04 hrs

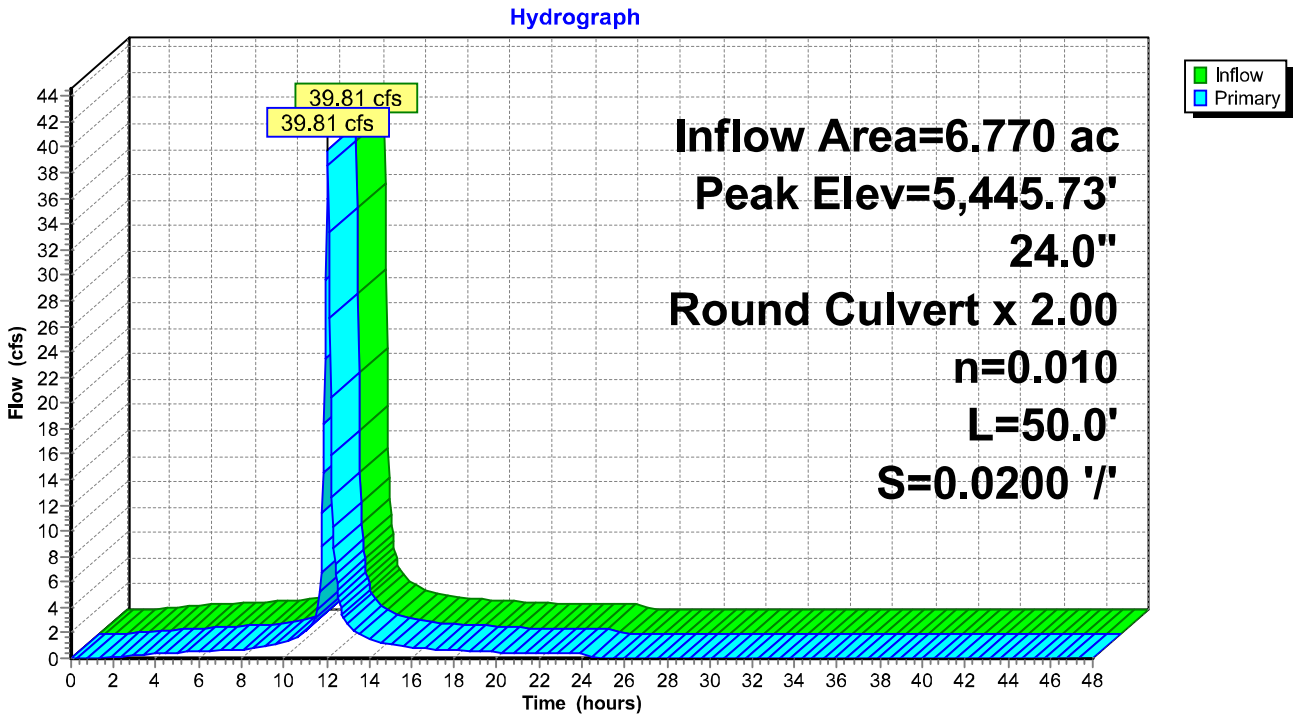
Inflow Area = 6.770 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 39.81 cfs @ 12.05 hrs, Volume= 2.811 af
Outflow = 39.81 cfs @ 12.05 hrs, Volume= 2.811 af, Atten= 0%, Lag= 0.0 min
Primary = 39.81 cfs @ 12.05 hrs, Volume= 2.811 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Peak Elev= 5,445.73' @ 12.05 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	5,443.00'	**24.0" Round Culvert X 2.00** L= 50.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 5,443.00' / 5,442.00' S= 0.0200 '/' Cc= 0.900 n= 0.010, Flow Area= 3.14 sf

Primary OutFlow Max=39.33 cfs @ 12.05 hrs HW=5,445.69' TW=5,441.62' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 39.33 cfs @ 6.26 fps)

Pond C2: Twin 24-inch



Summary for Pond C3: Twin 30-inch Culvert

[57] Hint: Peaked at 5,455.49' (Flood elevation advised)
[62] Hint: Exceeded Reach R7 OUTLET depth by 2.24' @ 12.04 hrs

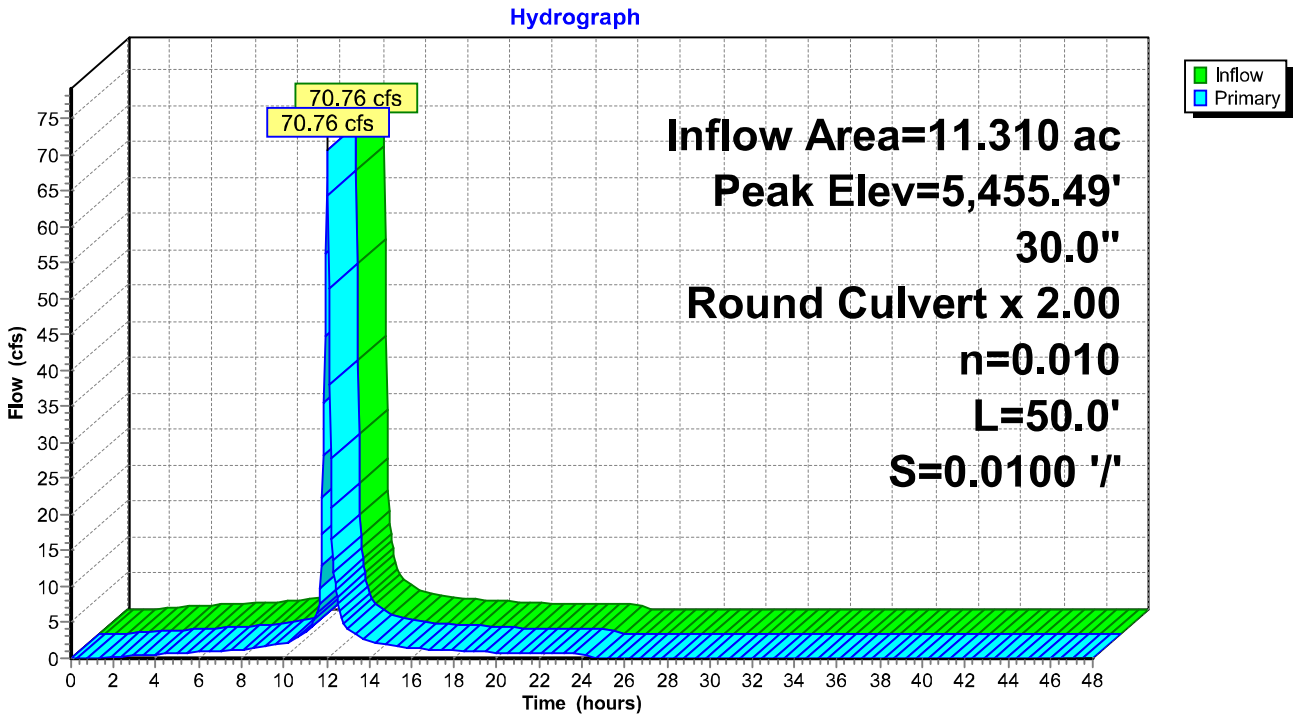
Inflow Area = 11.310 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 70.76 cfs @ 12.04 hrs, Volume= 4.696 af
Outflow = 70.76 cfs @ 12.04 hrs, Volume= 4.696 af, Atten= 0%, Lag= 0.0 min
Primary = 70.76 cfs @ 12.04 hrs, Volume= 4.696 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Peak Elev= 5,455.49' @ 12.04 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	5,452.00'	**30.0" Round Culvert X 2.00** L= 50.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 5,452.00' / 5,451.50' S= 0.0100 '/' Cc= 0.900 n= 0.010, Flow Area= 4.91 sf

Primary OutFlow Max=70.25 cfs @ 12.04 hrs HW=5,455.46' (Free Discharge)
1=Culvert (Inlet Controls 70.25 cfs @ 7.16 fps)

Pond C3: Twin 30-inch Culvert



Summary for Pond C4: Twin 36-inch

[57] Hint: Peaked at 5,445.95' (Flood elevation advised)
[62] Hint: Exceeded Reach 81R OUTLET depth by 1.46' @ 12.04 hrs

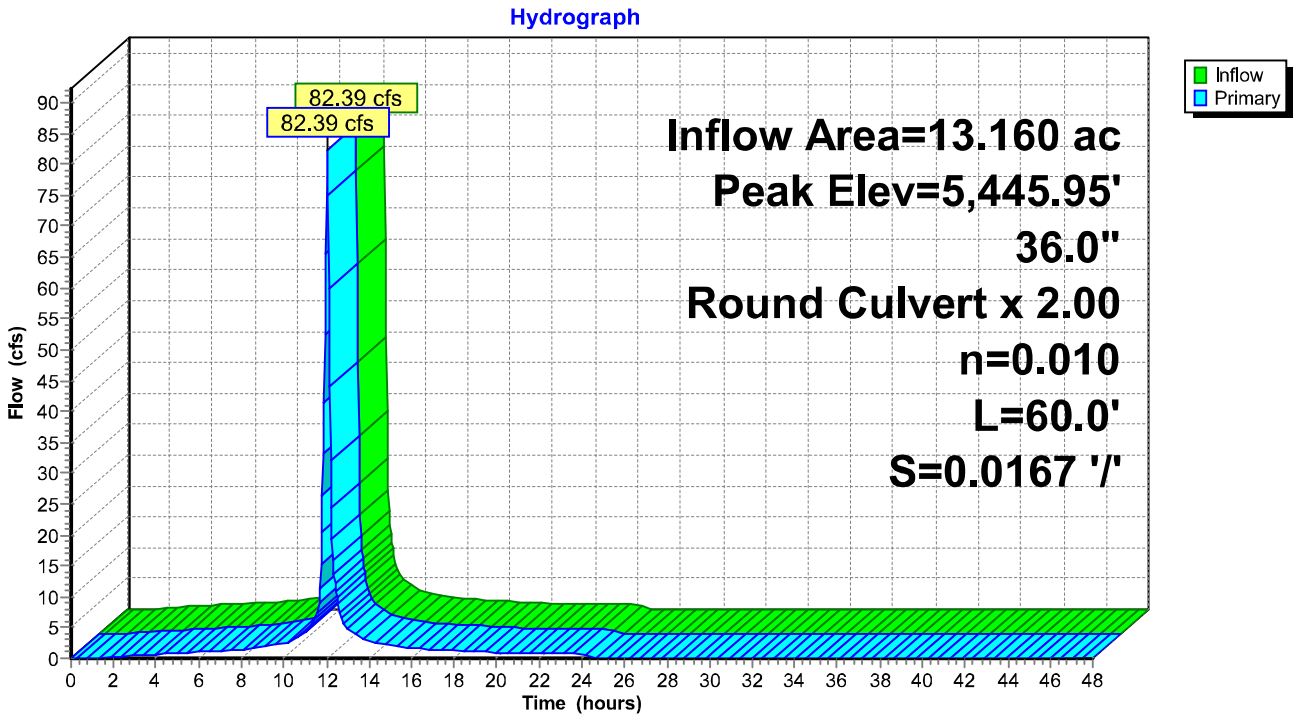
Inflow Area = 13.160 ac,100.00% Impervious, Inflow Depth = 4.98" for 100 year event
Inflow = 82.39 cfs @ 12.04 hrs, Volume= 5.465 af
Outflow = 82.39 cfs @ 12.04 hrs, Volume= 5.465 af, Atten= 0%, Lag= 0.0 min
Primary = 82.39 cfs @ 12.04 hrs, Volume= 5.465 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.04 hrs / 3
Peak Elev= 5,445.95' @ 12.04 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	5,443.00'	**36.0" Round Culvert X 2.00** L= 60.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 5,443.00' / 5,442.00' S= 0.0167 '/' Cc= 0.900 n= 0.010, Flow Area= 7.07 sf

Primary OutFlow Max=81.83 cfs @ 12.04 hrs HW=5,445.93' TW=5,441.73' (Dynamic Tailwater)
1=Culvert (Inlet Controls 81.83 cfs @ 5.83 fps)

Pond C4: Twin 36-inch



ATTACHMENT B

NOAA Rainfall Estimates using the Atlas 14 Point Precipitation Frequency Estimates for Colorado

NOAA Atlas 14, Volume 8, Version 2
Location name: Colorado Springs, Colorado, USA*
Latitude: 38.6823°, Longitude: -104.7269°
Elevation: 5580 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.262 (0.212-0.330)	0.313 (0.253-0.395)	0.406 (0.326-0.513)	0.490 (0.391-0.623)	0.618 (0.479-0.831)	0.726 (0.546-0.988)	0.842 (0.608-1.18)	0.968 (0.667-1.40)	1.15 (0.755-1.71)	1.29 (0.823-1.94)
10-min	0.384 (0.310-0.483)	0.459 (0.370-0.579)	0.594 (0.477-0.751)	0.718 (0.572-0.912)	0.905 (0.702-1.22)	1.06 (0.799-1.45)	1.23 (0.891-1.72)	1.42 (0.976-2.04)	1.68 (1.11-2.50)	1.89 (1.20-2.84)
15-min	0.468 (0.378-0.590)	0.560 (0.451-0.706)	0.724 (0.582-0.916)	0.875 (0.698-1.11)	1.10 (0.856-1.48)	1.30 (0.975-1.76)	1.50 (1.09-2.10)	1.73 (1.19-2.49)	2.05 (1.35-3.05)	2.31 (1.47-3.46)
30-min	0.664 (0.536-0.837)	0.794 (0.640-1.00)	1.03 (0.825-1.30)	1.24 (0.991-1.58)	1.57 (1.22-2.11)	1.84 (1.39-2.51)	2.14 (1.54-2.99)	2.46 (1.69-3.55)	2.92 (1.92-4.34)	3.29 (2.09-4.94)
60-min	0.850 (0.686-1.07)	0.999 (0.805-1.26)	1.28 (1.03-1.62)	1.55 (1.24-1.97)	1.98 (1.54-2.68)	2.35 (1.78-3.22)	2.77 (2.00-3.89)	3.22 (2.22-4.67)	3.88 (2.56-5.80)	4.43 (2.82-6.65)
2-hr	1.04 (0.840-1.30)	1.20 (0.975-1.51)	1.53 (1.24-1.93)	1.86 (1.49-2.35)	2.39 (1.88-3.24)	2.86 (2.18-3.91)	3.39 (2.48-4.76)	3.98 (2.78-5.76)	4.85 (3.24-7.21)	5.58 (3.58-8.32)
3-hr	1.14 (0.924-1.42)	1.30 (1.06-1.62)	1.64 (1.33-2.06)	2.00 (1.61-2.51)	2.59 (2.06-3.51)	3.12 (2.40-4.27)	3.73 (2.75-5.24)	4.42 (3.11-6.38)	5.45 (3.66-8.08)	6.31 (4.08-9.37)
6-hr	1.30 (1.07-1.62)	1.47 (1.20-1.82)	1.84 (1.50-2.29)	2.24 (1.81-2.79)	2.91 (2.34-3.95)	3.54 (2.74-4.82)	4.25 (3.16-5.94)	5.07 (3.60-7.29)	6.29 (4.28-9.30)	7.33 (4.79-10.8)
12-hr	1.48 (1.21-1.82)	1.67 (1.37-2.06)	2.09 (1.71-2.58)	2.53 (2.05-3.14)	3.26 (2.63-4.37)	3.93 (3.06-5.31)	4.70 (3.52-6.51)	5.57 (3.98-7.94)	6.86 (4.70-10.1)	7.96 (5.25-11.7)
24-hr	1.66 (1.37-2.02)	1.92 (1.58-2.35)	2.43 (2.00-2.98)	2.93 (2.40-3.62)	3.73 (3.00-4.92)	4.44 (3.46-5.90)	5.22 (3.92-7.13)	6.09 (4.38-8.57)	7.36 (5.08-10.7)	8.42 (5.61-12.3)
2-day	1.86 (1.55-2.26)	2.21 (1.84-2.69)	2.84 (2.35-3.47)	3.43 (2.82-4.20)	4.32 (3.47-5.60)	5.07 (3.97-6.66)	5.89 (4.44-7.94)	6.78 (4.90-9.42)	8.04 (5.59-11.5)	9.07 (6.11-13.1)
3-day	2.02 (1.68-2.44)	2.38 (1.98-2.88)	3.04 (2.52-3.69)	3.66 (3.02-4.46)	4.60 (3.71-5.94)	5.40 (4.24-7.06)	6.26 (4.75-8.42)	7.21 (5.25-10.0)	8.57 (5.99-12.2)	9.68 (6.56-13.9)
4-day	2.17 (1.81-2.62)	2.53 (2.11-3.06)	3.20 (2.66-3.87)	3.82 (3.16-4.65)	4.79 (3.89-6.19)	5.63 (4.44-7.35)	6.53 (4.98-8.77)	7.53 (5.50-10.4)	8.97 (6.30-12.8)	10.1 (6.90-14.6)
7-day	2.60 (2.18-3.12)	2.97 (2.49-3.57)	3.66 (3.06-4.41)	4.32 (3.59-5.22)	5.34 (4.35-6.84)	6.22 (4.93-8.07)	7.18 (5.51-9.58)	8.24 (6.07-11.3)	9.77 (6.92-13.9)	11.0 (7.57-15.8)
10-day	2.97 (2.50-3.55)	3.38 (2.84-4.04)	4.13 (3.46-4.95)	4.82 (4.02-5.82)	5.90 (4.82-7.51)	6.81 (5.42-8.79)	7.81 (6.01-10.4)	8.90 (6.58-12.2)	10.5 (7.45-14.8)	11.7 (8.10-16.7)
20-day	3.94 (3.33-4.67)	4.52 (3.82-5.36)	5.51 (4.64-6.57)	6.39 (5.35-7.65)	7.66 (6.26-9.60)	8.70 (6.94-11.1)	9.79 (7.57-12.8)	11.0 (8.14-14.8)	12.6 (9.00-17.5)	13.8 (9.65-19.6)
30-day	4.72 (4.00-5.57)	5.44 (4.61-6.44)	6.65 (5.62-7.89)	7.68 (6.45-9.16)	9.12 (7.44-11.3)	10.3 (8.19-12.9)	11.4 (8.84-14.8)	12.6 (9.40-16.9)	14.2 (10.2-19.7)	15.5 (10.9-21.8)
45-day	5.70 (4.86-6.71)	6.60 (5.61-7.78)	8.05 (6.83-9.52)	9.25 (7.80-11.0)	10.9 (8.88-13.4)	12.1 (9.70-15.2)	13.4 (10.4-17.2)	14.6 (10.9-19.4)	16.2 (11.7-22.3)	17.4 (12.3-24.4)
60-day	6.56 (5.59-7.69)	7.58 (6.46-8.91)	9.22 (7.83-10.9)	10.5 (8.91-12.5)	12.3 (10.1-15.0)	13.6 (10.9-16.9)	14.9 (11.6-19.1)	16.2 (12.1-21.4)	17.8 (12.9-24.3)	19.0 (13.5-26.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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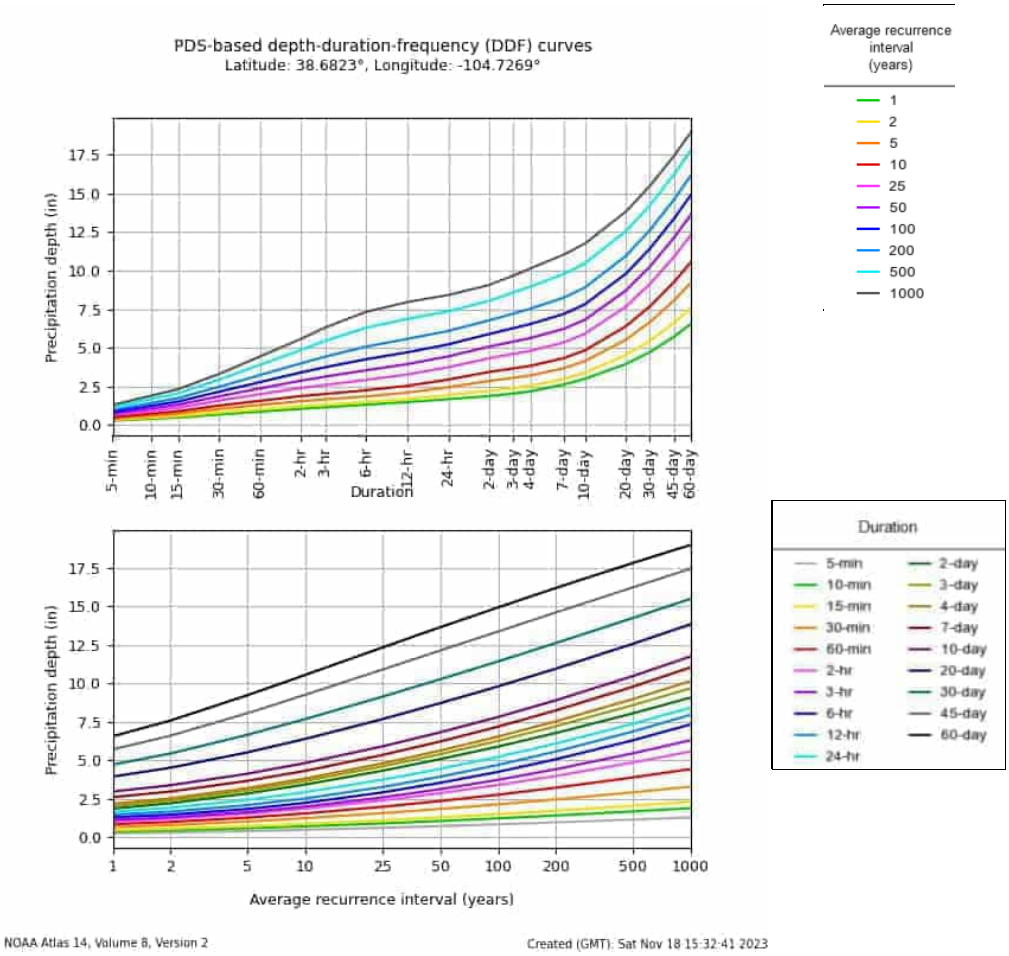
PF graphical



NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Sat Nov 18 15:32:41 2023

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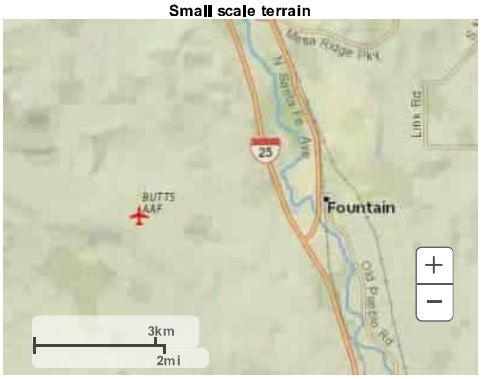
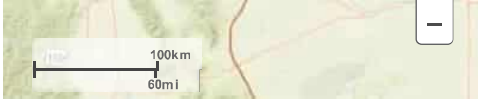
Maps & aerials

Small scale terrain

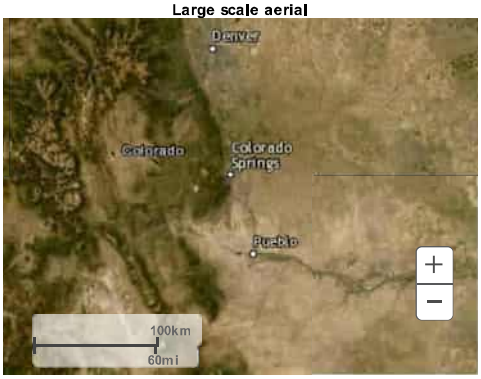


Large scale terrain

Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Job	**Colorado Springs Utilities**	Project No.	**60702594**	Sheet	**1** of **5**
Description	**Slope Stability Assessment - Revised**	Computed by	**KKM**	Date	**12/18/2023**
		Checked by	**VKG**	Date	**12/18/2023**

PURPOSE

The project site is a Coal Combustion Residual (CCR) landfill at the Colorado Spring Ranch, located to the southwest of Interstate 25 and Ray Nixon Road in El Paso County, Colorado. AECOM previously completed a slope stability assessment for this landfill based on the proposed redesign configuration in September 2023. The purpose of this revised stability analysis is to evaluate the slope stability of the landfill based on the updated configuration as shown in the draft 30% design drawings issued by AECOM, dated December 13, 2023. The following sections briefly present the available background information, methodology of our analysis and the corresponding results.

The subject landfill design is currently in the preliminary stage and the current analysis is intended to support the initial planning and design based on the proposed landfill configuration shown in the CCR Landfill Redesign draft 30 % drawings, prepared by AECOM and dated December 13, 2023. Based on the review of these drawings, the proposed final configuration of this landfill will be 70-80 feet in overall height from the surrounding native ground surface and it's critical (steepest) side slope will be 3Horizontal:1Vertical (3H:1V). For this analysis, the cap system was assumed to be a 12-inch-thick intermediate cover overlaid by an engineered turf cap system, which includes 1-2 inches engineered turf, overlying 0.5 inch thick sand infill, followed by AGRU 40-MIL Microspike geomembrane.

AVAILABLE BACKGROUND INFORMATION:

The following documents, pertaining to the subject site, have been provided to and reviewed by AECOM:

- Report entitled "Geotechnical Testing Services – Ash Landfill Investigation, Clear Spring Ranch Facility", prepared by Kleinfelder and dated August 24, 2009. This report summarized the limited geotechnical field and laboratory testing conducted on the CCR waste at this landfill.

- Report entitled "Geotechnical Engineering Services - Ash Landfill Slope Stability Investigation, Colorado Spring Ranch Facility", prepared by Kleinfelder and dated November 17, 2009. This report summarized slope stability assessment of the landfill based on the parameters derived from the above referenced geotechnical testing.

The above referenced geotechnical investigation included density tests taken within the CCR waste at selected test pit locations with a nuclear density gauge at a probe depth of 8 inches. Samples of bottom and fly ash were taken at each of these test location for laboratory testing, but it was not possible to perform accurate testing due to accelerated hardening of these ash materials since they were placed in the landfill. No borings revealing the profile of the waste mass or underlying foundation materials were obtained.

APPROACH AND METHODOLOGY:

Scope of the above referenced geotechnical testing program by Kleinfelder was limited to only near surface nuclear density gauge testing performed within test pits excavated on top of the landfill at that time, and it only provided rudimentary data on the CCR waste. Given the volume of the modeled landfill configuration (70-80 feet in overall height), a rigorous stability assessment requires information of the deeper subsurface conditions of the CCR waste as well as the foundation soils underlying the waste.

Due to absence of such data, it is unreasonable to estimate the available factors of safety of landfill side slopes for the modeled configuration. Therefore, AECOM completed a parametric analysis, in which the critical properties of the materials were back analyzed to just meet the minimum factor of safety requirements.

The stability assessment was conducted for the Cross Section B, as shown in the below figure. This cross section is oriented through the high point (Elev. 5531 ft) of the landfill, and it also includes the critical side slope of 3H:1V on both sides.

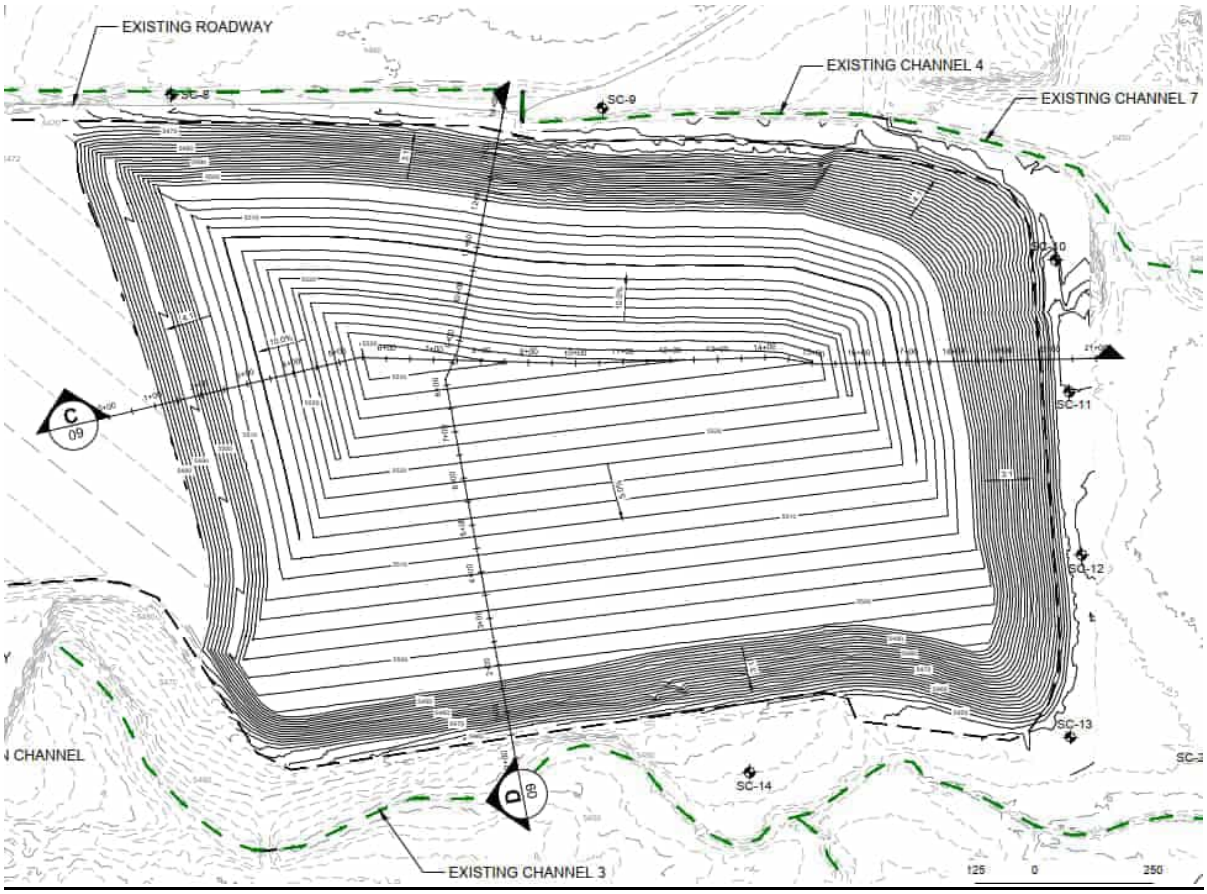


Figure: CCR Landfill Proposed Closure Grading Plan

The objective of the parametric back analysis was to estimate the critical material parameters required to achieve the minimum required factor of safety in the following conditions:

- **Static, Steady State Condition** – This case analyzes the landfill under long-term conditions, using effective shear strength parameters. The minimum required factor of safety per USEPA CCR Rule for this case is 1.50 or higher.

- **Seismic Condition** – This case incorporated a horizontal seismic coefficient (kh) selected to be representative of expected loading during the design earthquake event. The design earthquake event for this site is one with a 2% probability of exceedance in 50 years (approximately 2,500-year recurrence interval). A seismic coefficient of 0.156 was estimated for this site using the USGS Unified Hazard Tool to obtain the Peak Ground Acceleration (PGA) for the bedrock and then further corrected for the propagation through the overburden and the landfill materials. Supporting calculations are included in the attachments. This condition requires a minimum factor of safety of 1.00 or higher.

Analyses were performed using Spencer's Method which is a limit equilibrium slope stability analysis procedure satisfying both force and moment equilibrium. The computer program SLOPE/W 2016 by Geo-Slope International was utilized. The program analyzes a large number of potential slip surface geometries and identifies the geometry that results in a critical (i.e. lowest) factor of safety.

As all the exploration locations in the above referenced investigation by Kleinfelder were on top of the landfill and were limited to shallow depths, there is no information available regarding the foundation soils (native ground) at the base of the landfill, as well as the static groundwater level at this site. The static ground water level at this site was conservatively assumed at about 5 ft below the ground surface.

ANALYSES AND RESULTS

For the static-steady state condition, the analysis was first completed with reasonable properties for the foundation soils, and the strength parameters for the CCR waste were varied until the analysis would yield just to meet the minimum required factor of safety (1.5). The critical slip surface in this analysis was within the CCR waste, and a friction angle of 26.2 degrees for the CCR waste was required to achieve the factor of safety of 1.5. This friction angle is significantly lower (less than 65%) than the parameters obtained in the Kleinfelder's laboratory testing program.

With this parameter for the CCR waste, the steady state analysis was further continued by varying the parameters for the foundation soils until the critical slip surface would begin to extend into the foundation soils. This indicates a situation where the weakness of the foundation soils would begin to take part in the landfill instability. A minimum friction angle of 20.1 degrees was estimated to be required for the foundation soils. Unless the foundation soils are extremely weak, most of the native soils would possess this friction angle and capable to support the proposed CCR waste landfill configuration.

The pseudo static (seismic) analysis is generally performed using soil parameters in undrained condition. However, based on the findings from Kleinfelder's geotechnical report, the CCR waste is assumed to be cemented and in unsaturated condition. Therefore, effective parameters are also used for the CCR waste in this analysis. The CCR waste parameters were conservatively taken as 33% lower than the peak parameters obtained in the Kleinfelder's laboratory testing program. For the foundation soils, a relatively low undrained cohesion of 200 psf was assigned and then the frication angle was back analyzed for the minimum to achieve the required factor of safety of 1.0. The back analysis resulted in an undrained strength envelop of 16.2 degree friction angle and 200 psf cohesion for the foundation soils, which is typical for any medium stiff to stiff cohesive soils.

The following table summarizes the parameters resulted in in our parametric back analysis:

Table: Shear Strength Parameters Derived from Parametric Back Analysis

Material	Unit Weight (pcf)	Static, Steady State Condition (Effective Strength Parameters)		Seismic Condition (Total Strength Parameters)	
		Cohesion (psf)	Friction Angle (°)	Cohesion (psf)	Friction Angle (°)
CCR Waste	77.2	0	26.2	230	28
Clay Cap	125	0	28	0	28
Foundation Soils	126	0	20.1	200	16.2

CONCLUSION

The above analyses indicated that the minimum required strength parameters for the CCR waste are significantly lower than the parameters obtained in the Kleinfelder's laboratory testing program. The suggested minimum required parameters for the foundation soils are plausible for most of the soils, excluding very soft or deleterious materials. Therefore, as long as the foundation soils are not extremely weak, we believe that the proposed configuration of the landfill would meet the required factors of safety.

Attachments: Slope Stability Analysis Results (Slope/W Outputs)

Determination of Seismic Coefficient ($k_{h)}$

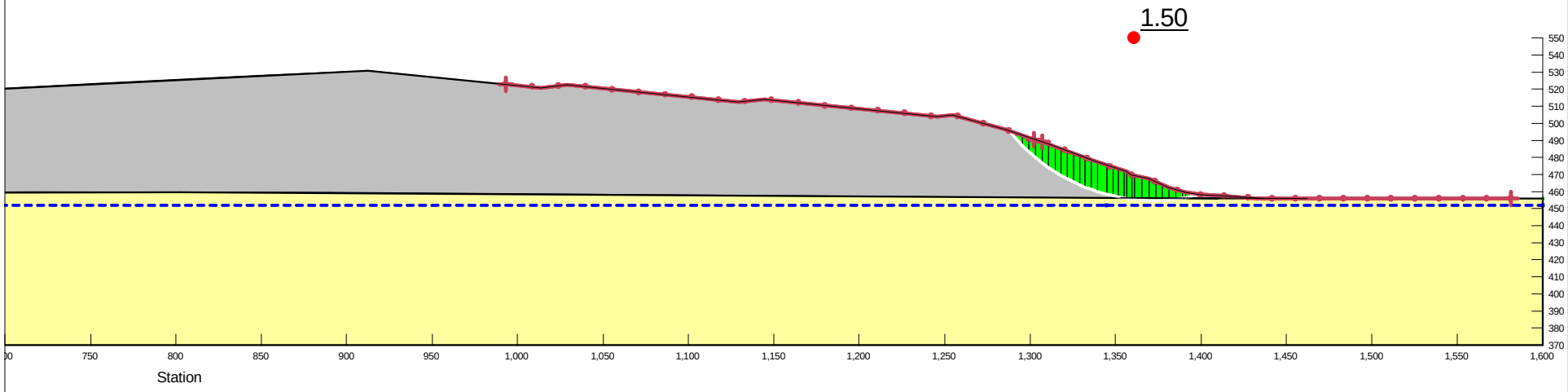
Slope Stability Analysis Results (Slope/W Outputs)

Cross Section B

Colorado Springs Utilities
Clear Springs Ranch
CCR Landfill Redesign

Cross Section B - Steady State - Back Analysis

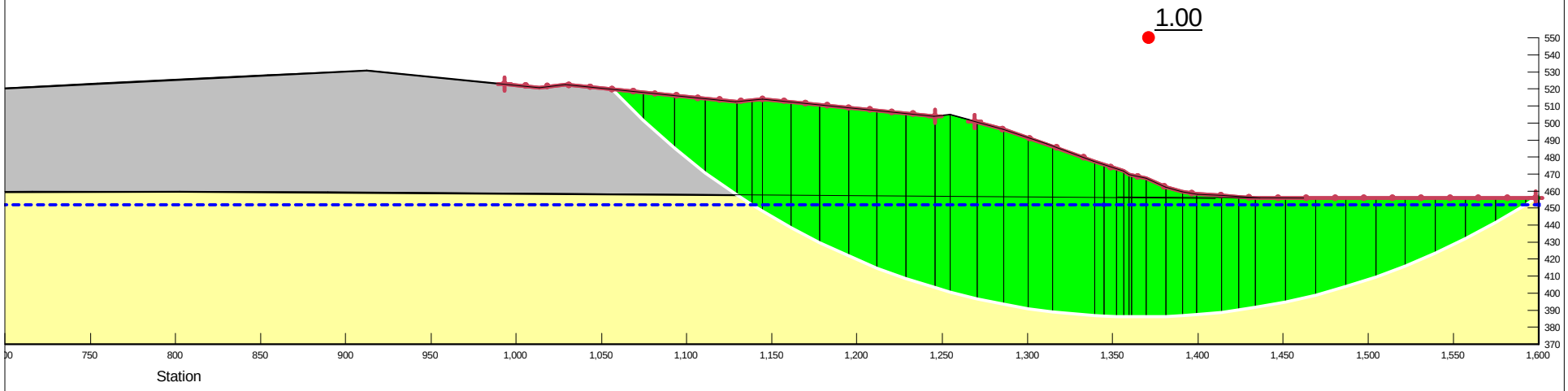
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
	CCR Waste - Back Analysis - Steady State	Mohr-Coulomb	77.2	0	26.2	1
	Foundation Soils Drained - Back Analysis	Mohr-Coulomb	120	0	20.1	1



Colorado Springs Utilities
Clear Springs Ranch
CCR Landfill Redesign

Cross Section B - Seismic Condition - Back Analysis

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
	CCR Waste - Seismic Condition	Mohr-Coulomb	77.2	230	28	1
	Foundtion Soil Undrained - Back Analysis	Mohr-Coulomb	120	200	16.2	1



Determination of Seismic Coefficient

U.S. Geological Survey - Earthquake Hazards Program

Unified Hazard Tool

Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the U.S. Seismic Design Maps web tools (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

Please also see the new USGS Earthquake Hazard Toolbox for access to the most recent NSHMs for the conterminous U.S. and Hawaii.

Input

Edition

Dynamic: Conterminous U.S. 2014 (update…

Spectral Period

Peak Ground Acceleration

Latitude

Decimal degrees

38.608

Time Horizon

Return period in years

2475

Longitude

Decimal degrees, negative values for western longitudes

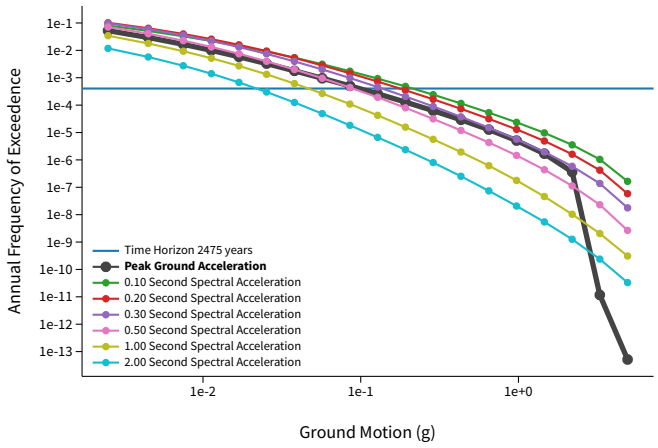
-104.713

Site Class

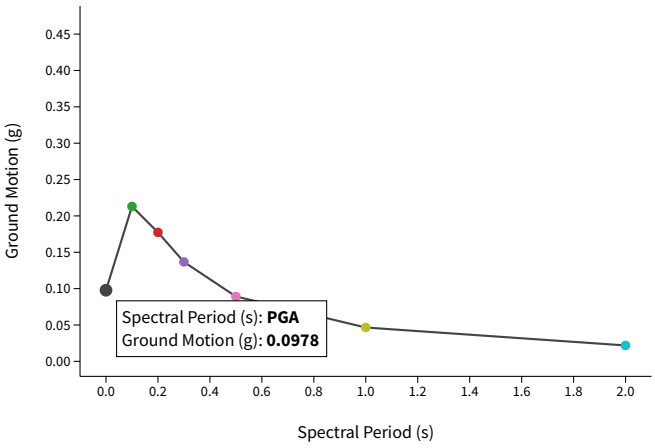
760 m/s (B/C boundary)

Hazard Curve

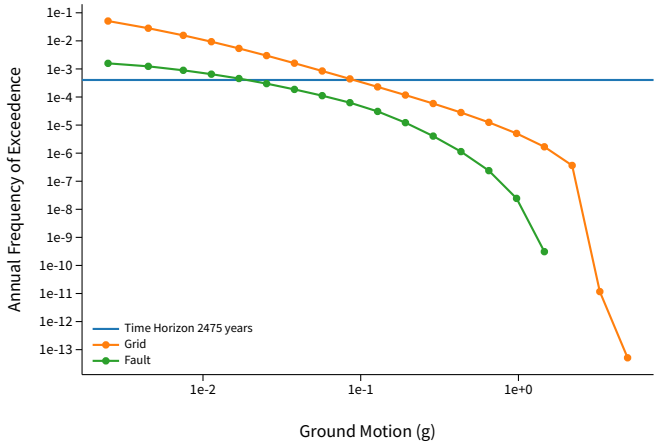
Hazard Curves



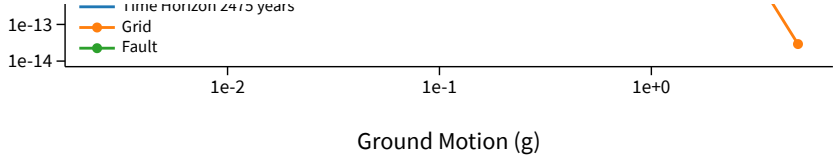
Uniform Hazard Response Spectrum



Component Curves for Peak Ground Acceleration



View Raw Data



View Raw Data

Seismic Site Class Determination

Due to absence of subsurface soil data, conservatively consider Site Class D.

IBC 2006 Table 1613.5.2
SITE CLASS DEFINITIONS

SITE CLASS	SOIL PROFILE NAME	AVERAGE PROPERTIES IN TOP 100 FEET, SEE SECTION 1613.5.5		
		Soil shear wave velocity, v_s (ft/s)	Standard penetration resistance, N	Soil undrained shear strength, s_u (psf)
A	Hard Rock	$v_s > 5{,}000$	N/A	N/A
B	Rock	$2{,}500 < v_s \le 5{,}000$	N/A	N/A
C	Very dense soil and soft rock	$1{,}200 < v_s \le 2{,}500$	$N > 50$	$s_u \ge 2{,}000$
D	Stiff soil profile	$600 \le v_s \le 1{,}200$	$15 \le N \le 50$	$1{,}000 \le s_u \le 2{,}000$
E	Soft soil profile	$v_s < 600$	$N < 15$	$s_u < 1{,}000$
E	--	Any profile with more than 10 feet of soil having the following characteristics: 1. Plasticity index PI > 20, 2. Moisture content $w \ge 40\%$, and 3. Undrained shear strength $s_u < 500$ psf		
F	--	Any profile containing soils having one or more of the following characteristics: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils. 2. Peats and/or highly sensitive clays (H > 10 feet of peat and/or highly organic clay where H = thickness of soil) 3. Very high plasticity clays (H > 25 feet with plasticity index PI > 75) 4. Very thick soft/medium stiff clays (H > 120 feet)		

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2, 1 pound per square foot = 0.0479 kPa. N/A = Not applicable

PGA Design Determination for Design Basis Event

Purpose

Determine the free-field, ground surface horizontal acceleration $(PGA)_{DESIGN}$ from $(PGA)_{ROCK}$

Method

Using IBC (2003) & NEHRP (2009), determie the site class for the free-field soils and F_{PGA} values to calculate $(PGA)_{DESIGN}$ from $(PGA)_{ROCK}$ where:

$$(PGA)_{DESIGN} = FPG_A \times (PGA)_{ROCK}$$

Solve

1) Use site class = **D**

2) For design basis event of 2,475 yrs, $(PGA)_{ROCK}$ = 0.0978 g

3) Select site coefficient F_{PGA} from Table 11.8-1:

Table 11.8-1 Site Coefficient F_{PGA}

Site Class	Mapped MCE Geometric Mean Peak Ground Acceleration, PGA				
	PGA ≤ 0.1	PGA = 0.2	PGA = 0.3	PGA = 0.4	PGA ≥ 0.5
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7				

Note: Use straight-line interpolation for intermediate values of PGA.

F_{PGA} = 1.6

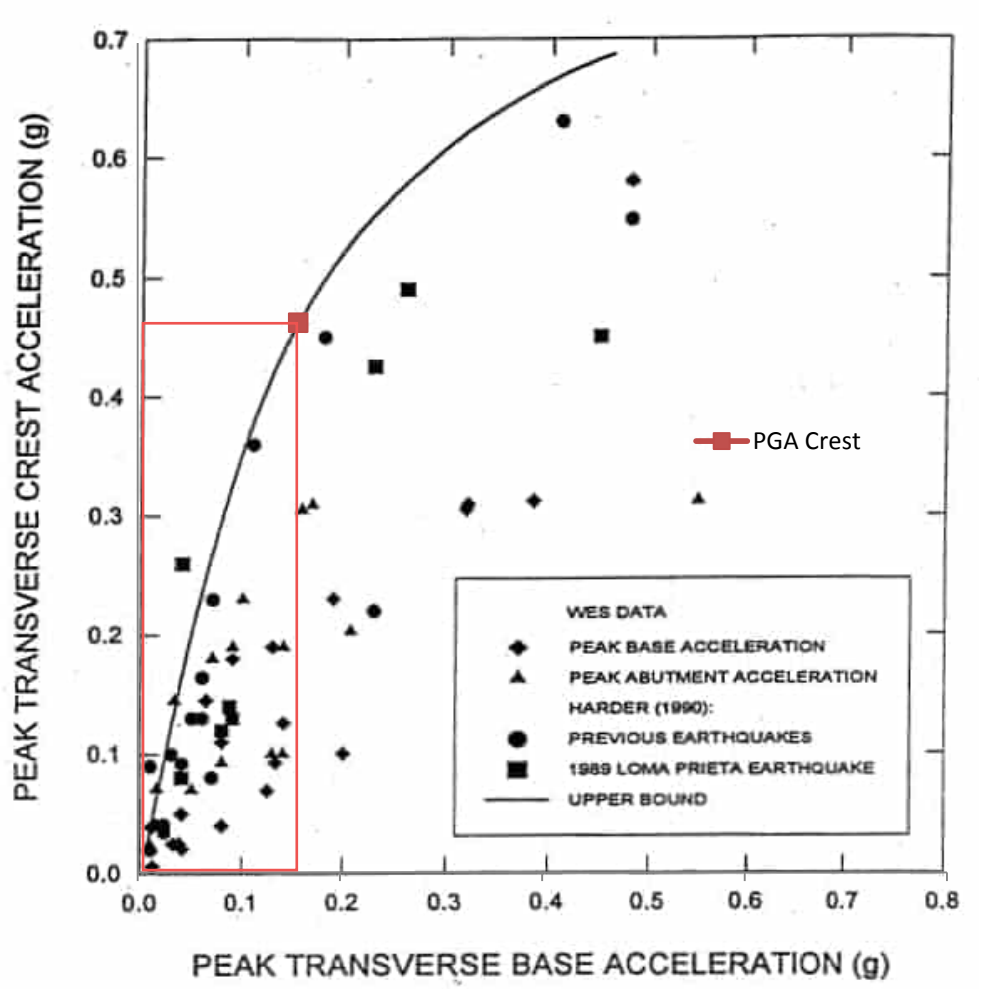
∴ **$(PGA)_{DESIGN}$ = 1.6 x 0.0978 = 0.1565 g**

Seismic Coefficient for Slope Stability Models

Estimation of Peak Transverse Crest Acceleration

Determine crest acceleration using Fig. 40 of Koester, Sharp, and Hynes (2000) and peak ground acceleration.

PGA Design = 0.156 g
PGA Crest = 0.46 g



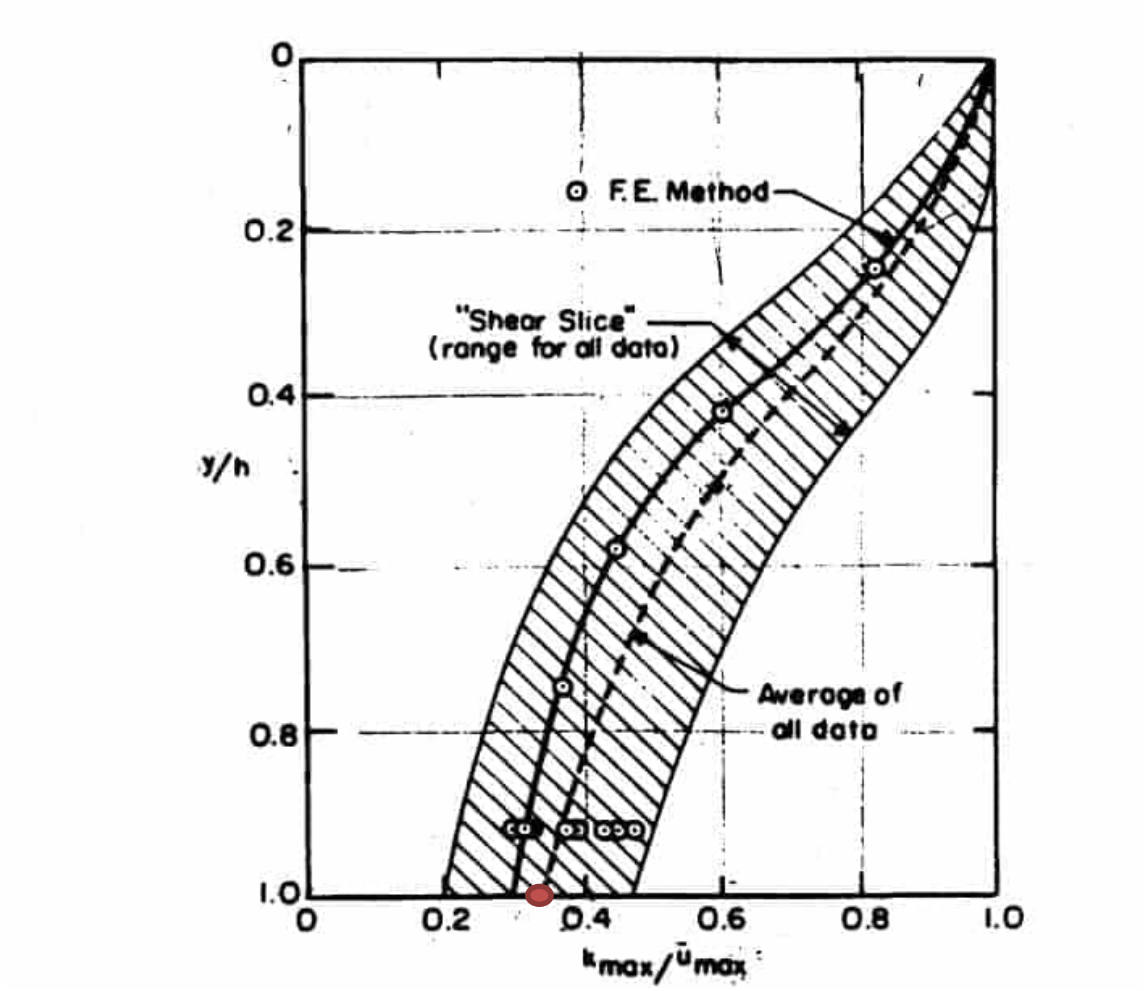
Seismic Coefficient

Using Makdisi and Seed (1978) Fig. 7, determine the maximum average acceleration:

$$k_{max} = \mathrm{PGA}_{CREST} \times \frac{k_{max}}{u_{max}}$$

PGA Crest = 0.46 g

k_{max}/u_{max} = 0.34



Variation of Maximum Acceleration Ratio with Depth of Sliding Mass

k_{max} = 0.1564

Select $k_{max} = k_h$ = **0.15**6

Appendix B
Web Soil Survey Information

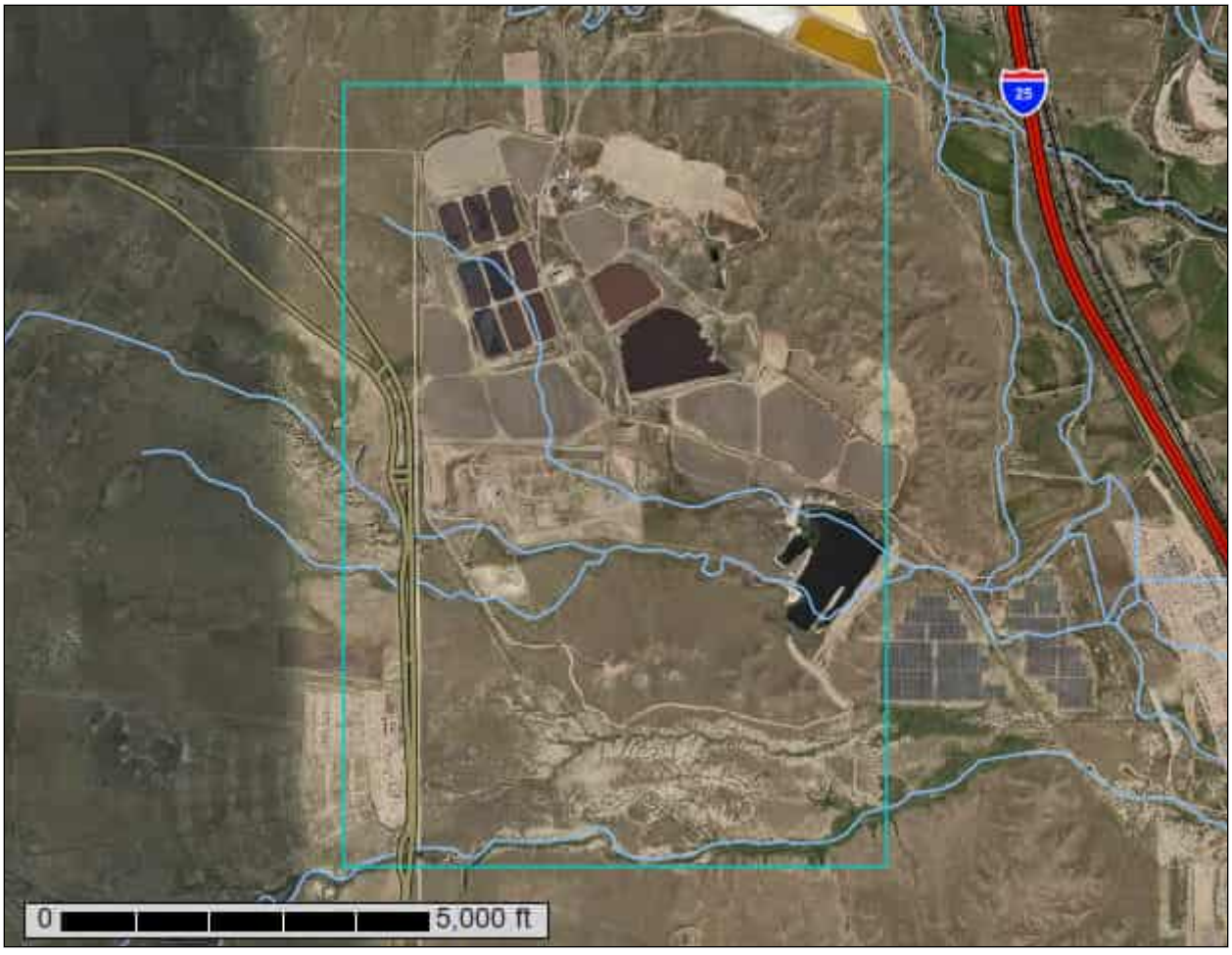
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for El Paso County Area, Colorado



August 27, 2024

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

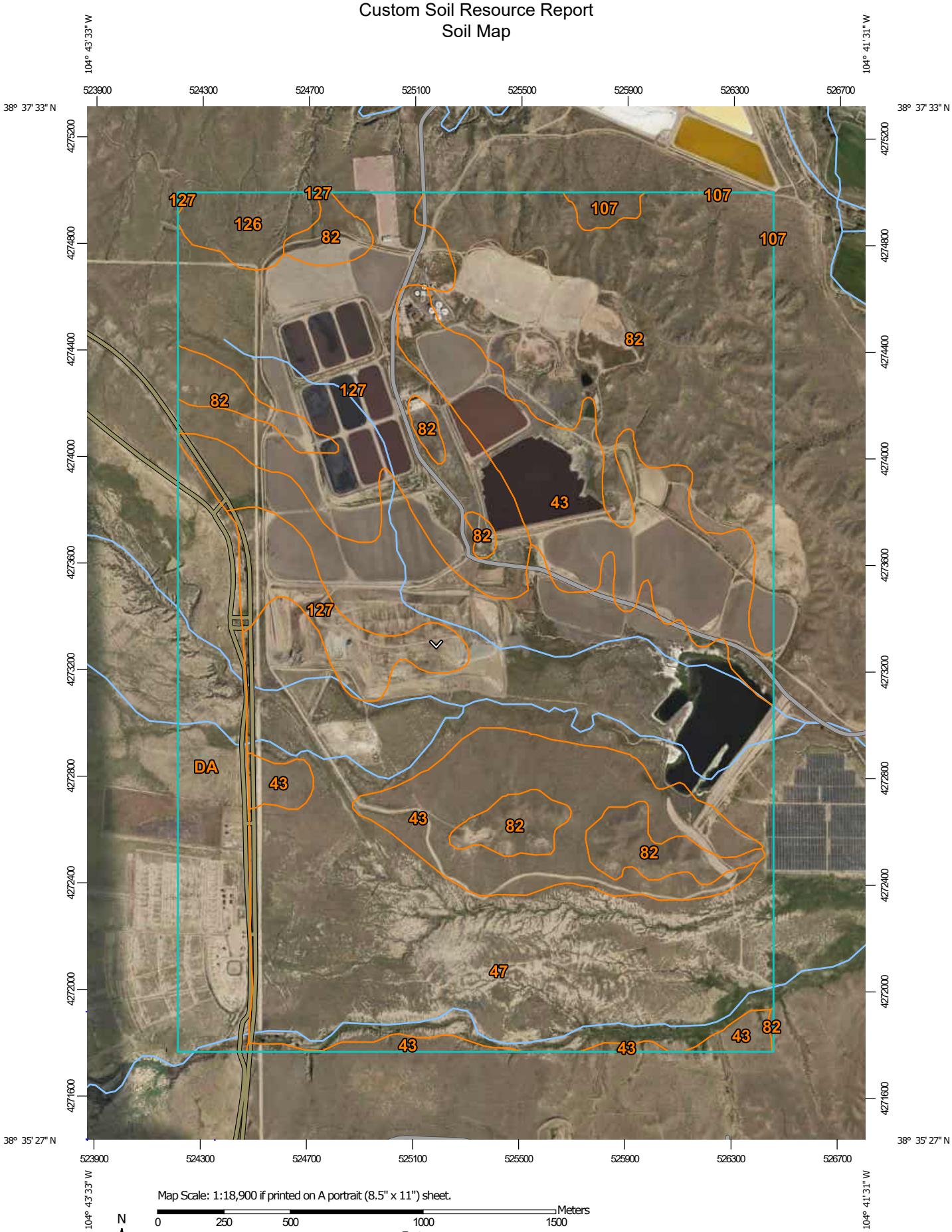
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:18,900 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 250 500 1000 1500

Feet
0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: El Paso County Area, Colorado
Survey Area Data: Version 21, Aug 24, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 14, 2018—Oct 20, 2018

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
43	Kim loam, 1 to 8 percent slopes	297.9	16.6%
47	Limon clay, 0 to 3 percent slopes	658.4	36.7%
82	Schamber-Razor complex, 8 to 50 percent slopes	381.6	21.3%
107	Wilid silt loam, 0 to 3 percent slopes	7.8	0.4%
126	Midway clay loam, dry, 1 to 15 percent slopes	28.0	1.6%
127	Midway-Razor clay loams, dry, 1 to 18 percent slopes	285.3	15.9%
DA	Denied access	135.9	7.6%
Totals for Area of Interest		**1,795.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not

mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

El Paso County Area, Colorado

43—Kim loam, 1 to 8 percent slopes

Map Unit Setting

National map unit symbol: 368k
Elevation: 5,300 to 5,600 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 135 to 155 days
Farmland classification: Not prime farmland

Map Unit Composition

Kim and similar soils: 98 percent
Minor components: 2 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kim

Setting

Landform: Fans, hills
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Calcareous loamy alluvium

Typical profile

A - 0 to 6 inches: loam
C - 6 to 60 inches: loam

Properties and qualities

Slope: 1 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water supply, 0 to 60 inches: High (about 9.6 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: R069XY006CO - Loamy Plains
Hydric soil rating: No

Minor Components

Other soils

Percent of map unit: 1 percent
Hydric soil rating: No

Pleasant

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

47—Limon clay, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 368p
Elevation: 5,200 to 6,200 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 135 to 155 days
Farmland classification: Not prime farmland

Map Unit Composition

Limon, occasionally flooded, and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Limon, Occasionally Flooded

Setting

Landform: Flood plains, alluvial fans
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey alluvium derived from shale

Typical profile

A - 0 to 4 inches: clay
AC - 4 to 12 inches: silty clay
C - 12 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: Occasional
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Very slightly saline to moderately saline (2.0 to 8.0 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water supply, 0 to 60 inches: High (about 9.9 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: R069XY033CO - Salt Flat
Hydric soil rating: No

Minor Components

Other soils

Percent of map unit: 4 percent
Hydric soil rating: No

Pleasant

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

82—Schamber-Razor complex, 8 to 50 percent slopes

Map Unit Setting

National map unit symbol: 369y
Elevation: 5,500 to 6,500 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 135 to 170 days
Farmland classification: Not prime farmland

Map Unit Composition

Schamber and similar soils: 55 percent
Razor and similar soils: 43 percent
Minor components: 2 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Schamber

Setting

Landform: Breaks
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Alluvium derived from granite and/or colluvium derived from granite and/or eolian deposits derived from granite

Typical profile

A - 0 to 5 inches: gravelly loam
AC - 5 to 15 inches: very gravelly loam
C - 15 to 60 inches: very gravelly sand

Properties and qualities

Slope: 8 to 50 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water supply, 0 to 60 inches: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: R069XY064CO - Gravel Breaks
Hydric soil rating: No

Description of Razor

Setting

Landform: Breaks
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Clayey slope alluvium over residuum weathered from shale

Typical profile

A - 0 to 3 inches: clay loam
Bw - 3 to 9 inches: clay loam
Bk - 9 to 31 inches: clay
Cr - 31 to 35 inches: weathered bedrock

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 40 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Moderately saline to strongly saline (8.0 to 16.0 mmhos/cm)
Sodium adsorption ratio, maximum: 15.0
Available water supply, 0 to 60 inches: Low (about 5.5 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R069XY047CO - Alkaline Plains
Other vegetative classification: ALKALINE PLAINS (069AY047CO)
Hydric soil rating: No

Minor Components

Other soils

Percent of map unit: 1 percent
Hydric soil rating: No

Pleasant

Percent of map unit: 1 percent
Landform: Depressions
Hydric soil rating: Yes

107—Wilid silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2qnmq
Elevation: 4,000 to 6,200 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 125 to 175 days
Farmland classification: Prime farmland if irrigated

Map Unit Composition

Wilid and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wilid

Setting

Landform: Interfluves
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loess and/or eolian deposits

Typical profile

A - 0 to 6 inches: silt loam
Bt - 6 to 10 inches: silty clay loam
Btk - 10 to 30 inches: silty clay loam
Bk1 - 30 to 44 inches: silty clay loam
Bk2 - 44 to 79 inches: silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.60 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (0.5 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 4.0
Available water supply, 0 to 60 inches: High (about 10.2 inches)

Interpretive groups

Land capability classification (irrigated): 3e
Land capability classification (nonirrigated): 4c
Hydrologic Soil Group: C
Ecological site: R069XY006CO - Loamy Plains
Forage suitability group: Loamy (G069XW017CO)
Other vegetative classification: Loamy (G069XW017CO), Loamy Plains #6 (069XY006CO_2)
Hydric soil rating: No

Minor Components

Minnequa

Percent of map unit: 5 percent
Landform: Pediments, ridges
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Side slope, talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R069XY006CO - Loamy Plains
Other vegetative classification: Loamy (G069XW017CO)
Hydric soil rating: No

Almagre

Percent of map unit: 5 percent
Landform: Interfluves
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R069XY006CO - Loamy Plains
Other vegetative classification: Loamy (G069XW017CO), Loamy Plains #6 (069XY006CO_2)
Hydric soil rating: No

Manzanola

Percent of map unit: 5 percent
Landform: Drainageways, depressions
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear, concave
Across-slope shape: Linear
Ecological site: R069XY006CO - Loamy Plains
Other vegetative classification: Clayey (G069XW001CO), Loamy Plains #6 (069XY006CO_2)
Hydric soil rating: No

126—Midway clay loam, dry, 1 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2t520
Elevation: 3,700 to 6,400 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 130 to 170 days
Farmland classification: Not prime farmland

Map Unit Composition

Midway, dry, and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Midway, Dry

Setting

Landform: Ridges, hillslopes, pediments
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Slope alluvium and/or residuum weathered from shale

Typical profile

A - 0 to 3 inches: clay loam
AC - 3 to 9 inches: clay
C - 9 to 16 inches: paragravelly clay
Cr - 16 to 79 inches: bedrock

Properties and qualities

Slope: 1 to 15 percent
Depth to restrictive feature: 11 to 20 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.00 to 0.21 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 7.9 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water supply, 0 to 60 inches: Very low (about 2.2 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e

Hydrologic Soil Group: D
Ecological site: R069XY046CO - Shaly Plains
Hydric soil rating: No

Minor Components

Razor, dry
Percent of map unit: 10 percent
Landform: Pediments, hillslopes
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Base slope, side slope
Down-slope shape: Linear
Across-slope shape: Convex
Ecological site: R069XY047CO - Alkaline Plains
Hydric soil rating: No

Manzanola
Percent of map unit: 5 percent
Landform: Fan remnants, hillslopes
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R069XY042CO - Clayey Plains
Other vegetative classification: Loamy Plains #6 (069XY006CO_2)
Hydric soil rating: No

127—Midway-Razor clay loams, dry, 1 to 18 percent slopes

Map Unit Setting
National map unit symbol: 2t52f
Elevation: 3,700 to 6,400 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 48 to 54 degrees F
Frost-free period: 130 to 170 days
Farmland classification: Not prime farmland

Map Unit Composition
Midway, dry, and similar soils: 46 percent
Razor, dry, and similar soils: 44 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Midway, Dry

Setting
Landform: Ridges, hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Convex

Across-slope shape: Convex
Parent material: Slope alluvium and/or residuum weathered from shale

Typical profile

A - 0 to 3 inches: clay loam
AC - 3 to 9 inches: clay
C - 9 to 16 inches: paragravelly clay
Cr - 16 to 79 inches: bedrock

Properties and qualities

Slope: 3 to 18 percent
Depth to restrictive feature: 11 to 20 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.00 to 0.21 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 7.9 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water supply, 0 to 60 inches: Very low (about 2.2 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R069XY046CO - Shaly Plains
Hydric soil rating: No

Description of Razor, Dry

Setting

Landform: Pediments, hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Convex
Parent material: Slope alluvium and/or residuum weathered from shale

Typical profile

A - 0 to 4 inches: clay loam
Bw - 4 to 15 inches: silty clay
Bky - 15 to 30 inches: clay
Cr - 30 to 79 inches: bedrock

Properties and qualities

Slope: 1 to 9 percent
Depth to restrictive feature: 20 to 39 inches to paralithic bedrock
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Low to moderately high (0.00 to 0.21 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Gypsum, maximum content: 5 percent
Maximum salinity: Very slightly saline to slightly saline (2.0 to 7.9 mmhos/cm)
Sodium adsorption ratio, maximum: 10.0
Available water supply, 0 to 60 inches: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: D
Ecological site: R069XY047CO - Alkaline Plains
Hydric soil rating: No

Minor Components

Manzanola

Percent of map unit: 9 percent
Landform: Fan remnants, hillslopes
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R069XY042CO - Clayey Plains
Other vegetative classification: Loamy Plains #6 (069XY006CO_2)
Hydric soil rating: No

Rock outcrop

Percent of map unit: 1 percent
Hydric soil rating: No

DA—Denied access

Map Unit Composition

Denied access: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

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Appendix C
Appended CQA Plan

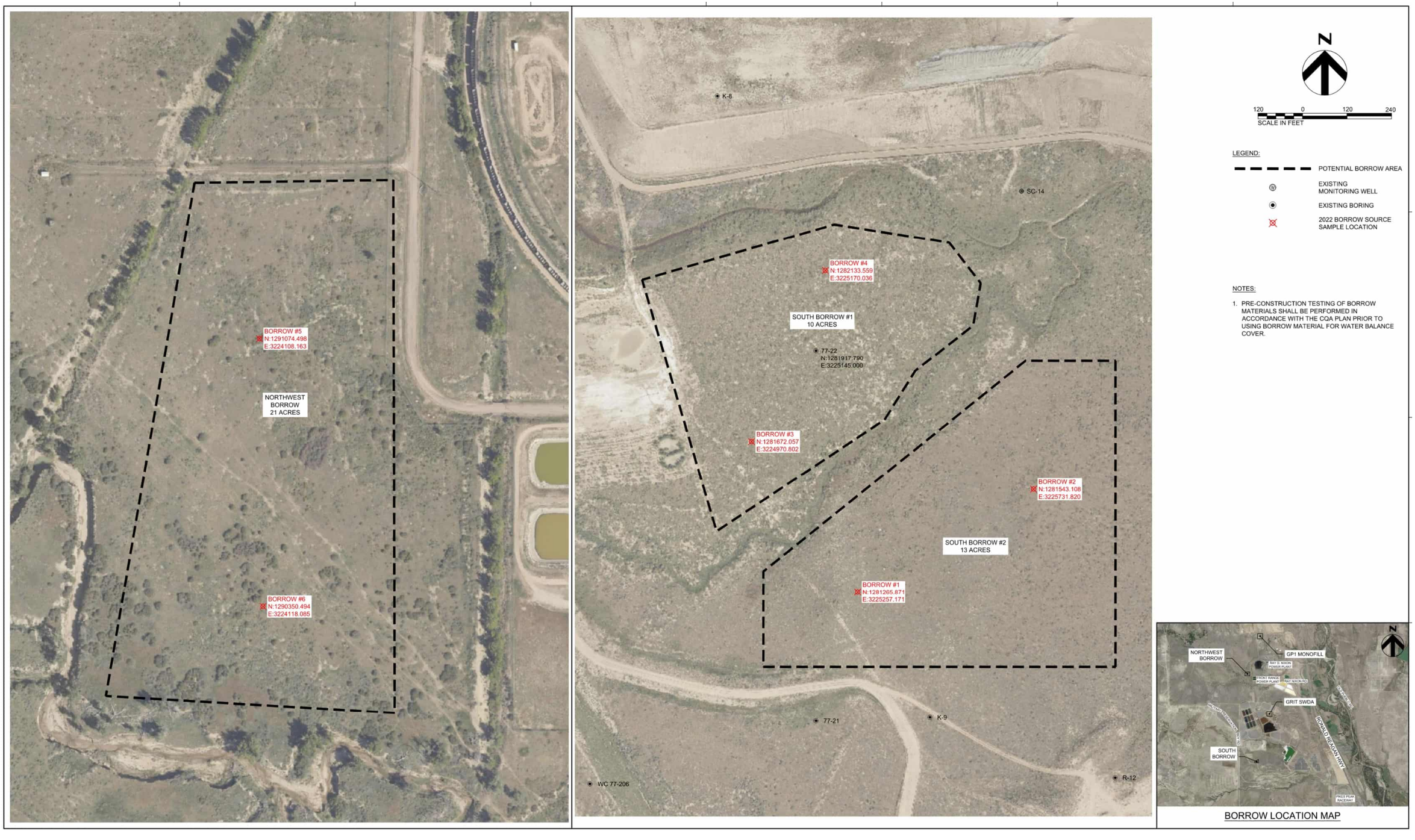

Figure 3: Potential Borrow Source Location Map

APPENDIX A

Borrow Source Investigation Results and USDA Textural Triangle

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1670 Broadway, Suite 3400, Denver, CO 80202-4824
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Table 3
Borrow Source Test Results Summary

Colorado Springs Utilities
Grit Solid Waste Disposal Area

Borrow Source 1

Date Sampled: 9/23/2022				Moisture	USCS		Hydrometer (USDA)			Atterberg Limits			Standard Proctor		K (cm/s)[1]
Location ID	Depth (ft bgs)	Lithology	USCS	Content (%)	Sand (%)	Fines (%)	Sand (%)	Silt (%)	Clay (%)	LL	PL	PI	MDD (pcf)	OMC (%)	
Borrow #1	0-5	Tan Lean Clay	CL	7	9	90	23	40	36	38	15	23	111.2	15.8	7.8E-09
	5-10	Brown Gray Lean Clay	CL	10.3	10	90	31	34	35	42	13	29	108.6	16.2	3.6E-08
	10-15	Dark Brown Lean Clay	CL	10	15	85	23	40	37	40	13	27	113.1	14.5	-
	15-20	silty CLAY w/ sand	CL	7.9	22	78	28	38	34	36	13	23	-	-	-

Borrow Source 2

Date Sampled: 11/3/2022				Moisture	USCS		Atterberg Limits			K (cm/s)[1]
Location ID	Depth (ft bgs)	Lithology	USCS	Content (%)	Sand (%)	Fines (%)	LL	PL	PI	
Borrow #2	0-5	Dark Brown Lean Clay	CL	6.1	5	95	32	14	18	1.1E-07
	5-10	Dark Brown Lean Clay	CL	9.2	1	99	31	14	17	4.4E-08
	10-15	Dark Brown Lean Clay	CL	7.3	9	91	32	13	19	3.3E-08
	15-20	Dark Brown Lean Clay	CL	7.6	3	97	33	15	18	1.8E-07

Borrow Source 3

Date Sampled: 9/23/2022				Moisture	USCS		Atterberg Limits			Standard Proctor		K (cm/s)[1]
Location ID	Depth (ft bgs)	Lithology	USCS	Content (%)	Sand (%)	Fines (%)	LL	PL	PI	MDD (pcf)	OMC (%)	
Borrow #3	0-7	Dark Brown Lean Clay	CL	15	4	96	44	17	27	106.2	18.5	5.90E-09
	7-12	Dark Brown Fat Clay	CH	16.7	3	97	52	15	37	106.3	19.5	1.30E-08
	12-15	Brown Gray Lean Clay	CL	17.9	7	93	42	15	27	106.5	18	5.90E-09
	15-20	Dark Brown Lean Clay w/ Sand	CL	20	21	79	31	16	15	112.2	14.5	1.30E-07

Borrow Source 4

Date Sampled: 9/23/2022				Moisture	USCS		Atterberg Limits			Standard Proctor		K (cm/s)[1]
Location ID	Depth (ft bgs)	Lithology	USCS	Content (%)	Sand (%)	Fines (%)	LL	PL	PI	MDD (pcf)	OMC (%)	
Borrow #4	0-5	Silty Clay w/ Sand	CL	13.1	4	96	42	16	26	-	-	
	5-10	Brown Fat Clay	CH	21.2	2	98	62	18	44	105	19.5	
	10-15	Brown Lean Clay	CL	23.3	11	89	30	16	14	113	14.5	2.10E-07

Borrow Source 5

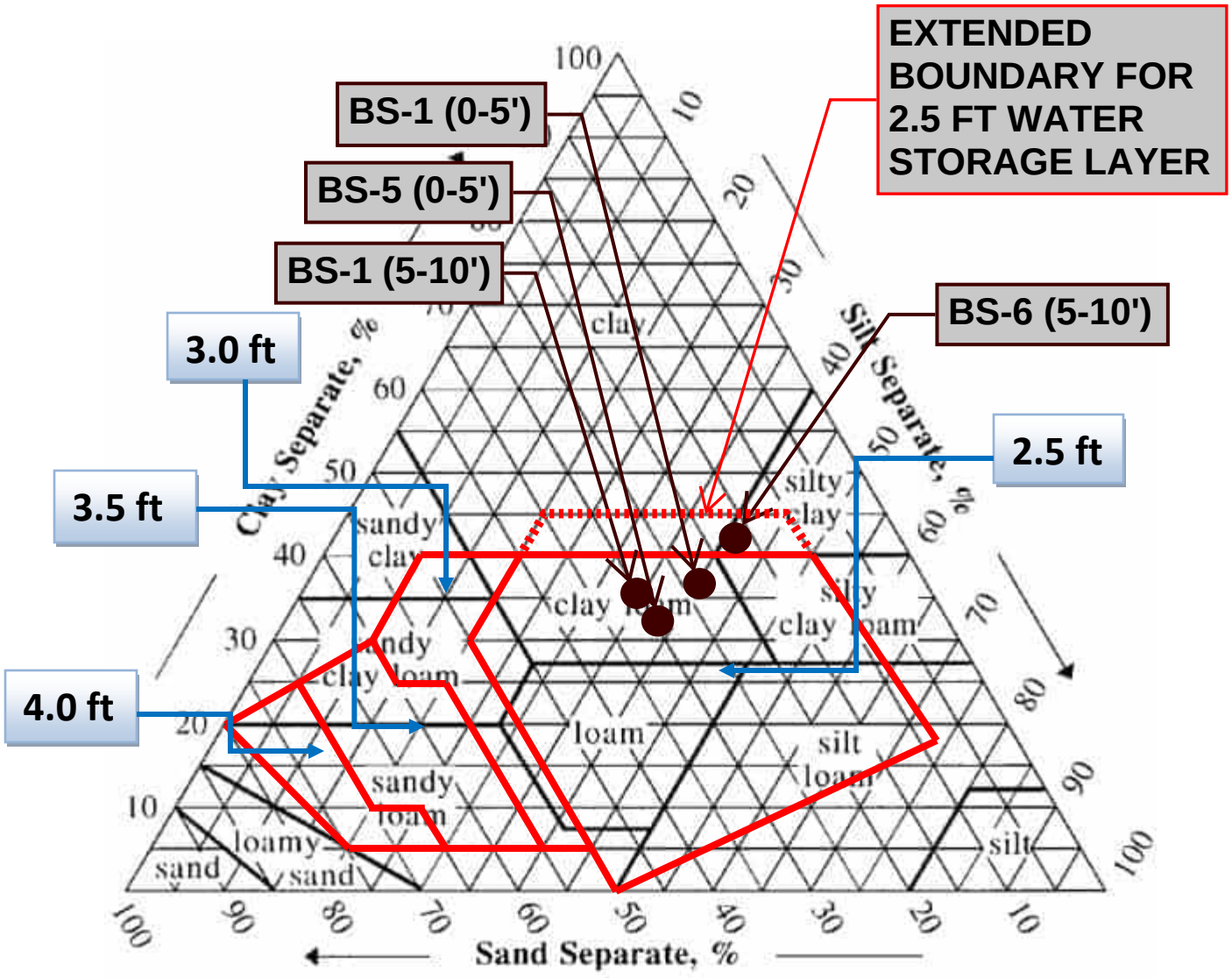
Date Sampled: 11/3/2022				Moisture	USCS		Hydrometer (USDA)			Atterberg Limits			Standard Proctor		K (cm/s)[1]
Location ID	Depth (ft bgs)	Lithology	USCS	Content (%)	Sand (%)	Fines (%)	Sand (%)	Silt (%)	Clay (%)	LL	PL	PI	MDD (pcf)	OMC (%)	
Borrow #5	0-5	Brown Lean Clay	CL	6.4	22	78	29	38	32	31	17	14	109.5	15.2	1.70E-07
	5-10	Brown Lean Clay	CL	13.3	3	97	-	-	-	45	17	28	101	20	1.40E-08
	10-15	Dark Brown Fat Clay	CH	15.1	7	93	-	-	-	52	17	35	102.2	18.5	7.80E-09
	15-20	Dark Brown Lean Clay	CL	19.5	12	88	-	-	-	31	14	17	104.5	18.6	1.70E-08

Borrow Source 6

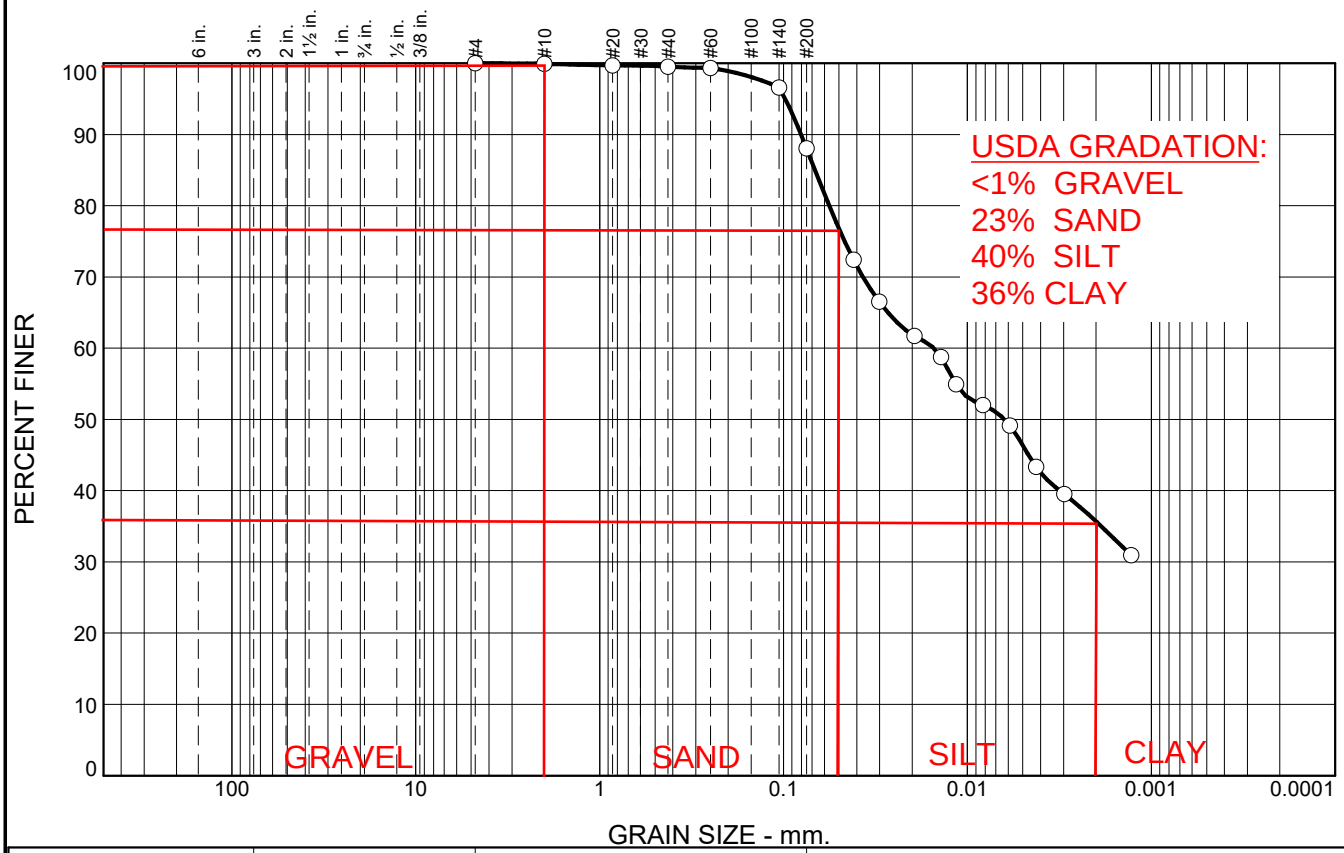
Date Sampled: 11/3/2022				Moisture	USCS		Hydrometer (USDA)			Atterberg Limits			Standard Proctor		K (cm/s)[1]
Location ID	Depth (ft bgs)	Lithology	USCS	Content (%)	Sand (%)	Fines (%)	Sand (%)	Silt (%)	Clay (%)	LL	PL	PI	MDD (pcf)	OMC (%)	
Borrow #6	0-5	Dark Brown Lean Clay	CL	26.1	11	89	-	-	-	36	21	15	-	-	-
	5-10	Dark Brown Lean Clay	CL	10.2	9	91	17	42	41	31	14	17	111.8	12.9	8.70E-08
	10-15	Dark Brown Lean Clay	CL	17.3	5	95	-	-	-	44	17	27	106	18.2	1.80E-08
	15-20	Dark Brown Lean Clay	CL	20.7	22	78	-	-	-	36	21	15	102	19	6.70E-08

(1) Hydraulic conductivity tested performed on sampled remoulded at 90% of maximum dry density, as determined by individual sample proctor.

Figure 2.2.1-4
Water Storage Layer Thicknesses for
Ecozone 3



Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	0.4	11.5	52.3	35.7

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	99.9		
#20	99.7		
#40	99.5		
#60	99.3		
#140	96.6		
#200	88.0		
0.0416 mm.	72.4		
0.0301 mm.	66.5		
0.0194 mm.	61.7		
0.0139 mm.	58.8		
0.0115 mm.	54.9		
0.0082 mm.	52.0		
0.0059 mm.	49.1		
0.0042 mm.	43.3		
0.0030 mm.	39.5		
0.0013 mm.	30.9		

* (no specification provided)

Material Description

Tan Lean Clay

Atterberg Limits (ASTM D 4318)

PL= 15 **LL=** 38 **PI=** 23

Classification

USCS (D 2487)= CL **AASHTO (M 145)=**

Coefficients

D_{90}= 0.0804 D_{85}= 0.0674 D_{60}= 0.0152
D_{50}= 0.0063 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: **Date Tested:** 02/11/23

Tested By: L. Lancaster / E. Arapi

Checked By: G. Anderson, PE

Title:

Source of Sample: BS-1 **Depth:** 0.0' - 5.0' **Date Sampled:** 09/23/22
Sample Number: A

Kleinfelder, Inc.

Irving, TX

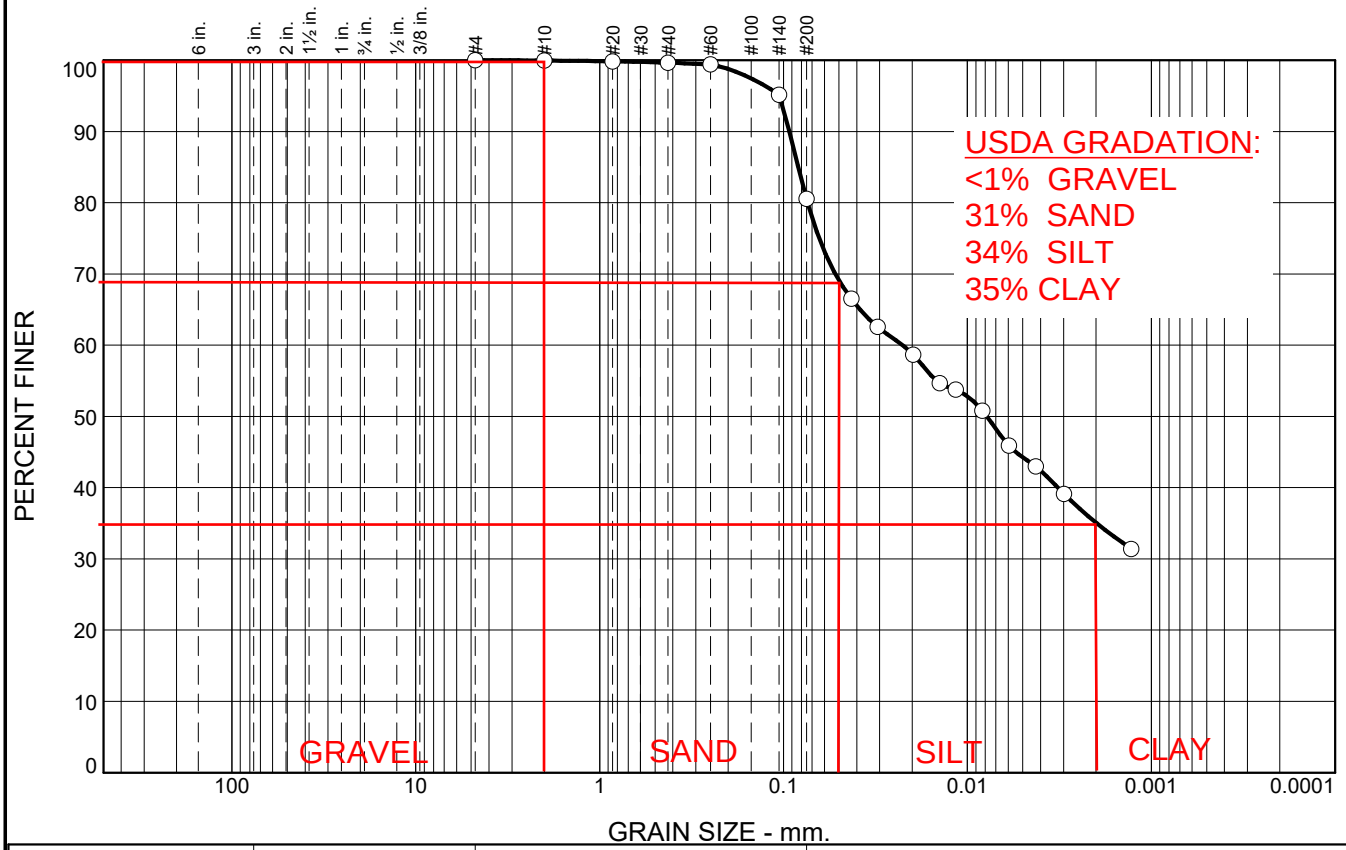
Client: Granite Engineering Group, Inc.

Project: Granite Engineering - Miscellaneous Lab Testing
PN: 222-133_CSU Grit Landfill

Project No: 20234005.001A **Figure**

Material Classification, unless data is available, is based on the ASTM D 2488 (Visual-Manual Procedures)
N.M. - Not Measured
N.P. - Not Plastic

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	0.2	19.2	45.4	35.1

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	99.9		
#20	99.8		
#40	99.7		
#60	99.4		
#140	95.2		
#200	80.5		
0.0428 mm.	66.5		
0.0308 mm.	62.6		
0.0197 mm.	58.7		
0.0142 mm.	54.7		
0.0116 mm.	53.8		
0.0083 mm.	50.8		
0.0060 mm.	45.9		
0.0043 mm.	43.0		
0.0030 mm.	39.1		
0.0013 mm.	31.4		

* (no specification provided)

Material Description

Brown Lean Clay with Sand

Atterberg Limits (ASTM D 4318)

PL= 13 **LL=** 42 **PI=** 29

Classification

USCS (D 2487)= CL **AASHTO (M 145)=**

Coefficients

D_{90}= 0.0930 D_{85}= 0.0832 D_{60}= 0.0225
D_{50}= 0.0078 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: N/A **Date Tested:** 02/11/23

Tested By: L. Lancaster / E. Arapi

Checked By: G. Anderson, PE

Title:

Source of Sample: BS-1 **Depth:** 5.0' - 10.0' **Date Sampled:** 09/23/22
Sample Number: B

Kleinfelder, Inc.

Irving, TX

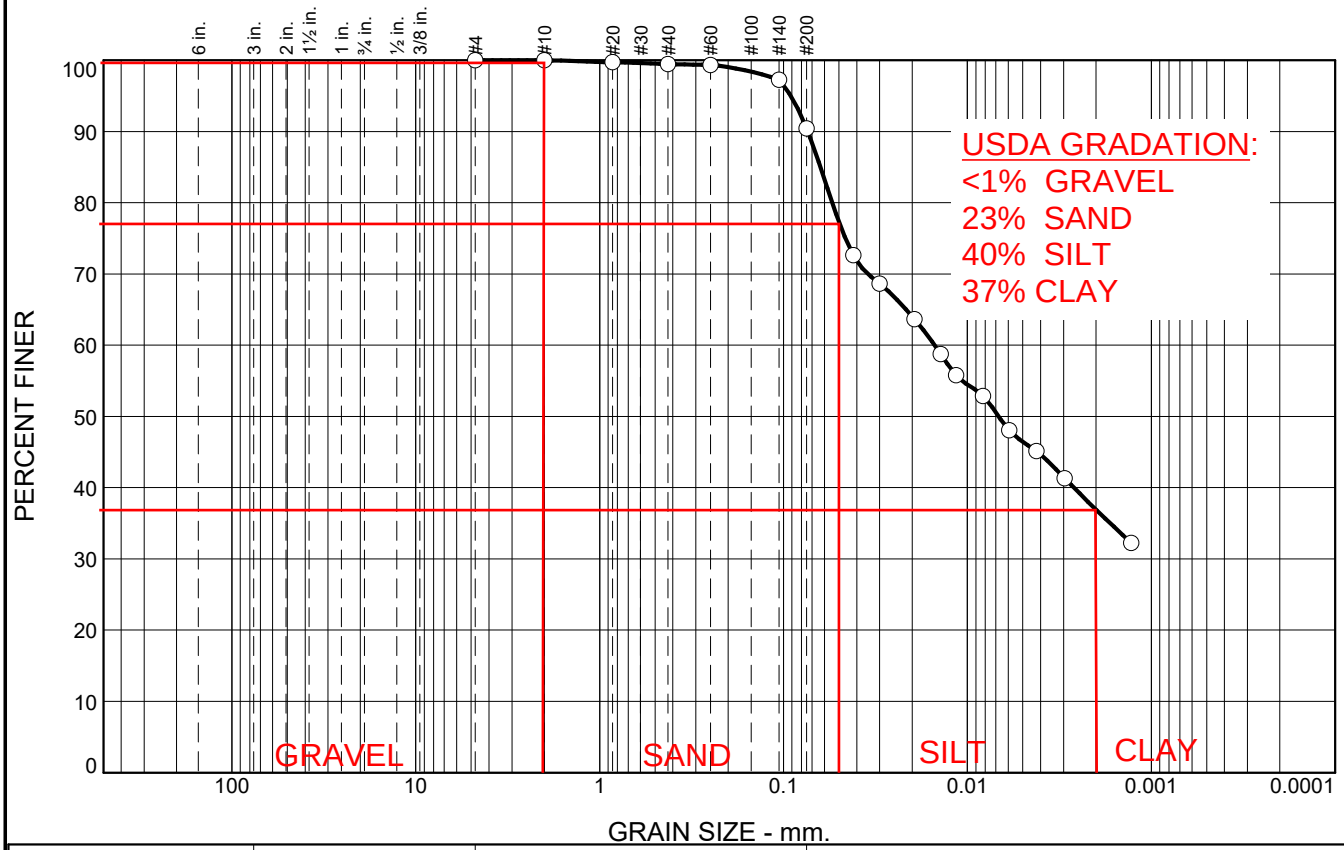
Client: Granite Engineering Group, Inc.

Project: Granite Engineering - Miscellaneous Lab Testing
PN: 222-133_CSU Grit Landfill

Project No: 20234005.001A **Figure**

Material Classification, unless data is available, is based on the ASTM D 2488 (Visual-Manual Procedures)
N.M. - Not Measured
N.P. - Not Plastic

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.5	9.0	53.6	36.9

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.7		
#40	99.5		
#60	99.4		
#140	97.3		
#200	90.5		
0.0418 mm.	72.6		
0.0301 mm.	68.7		
0.0194 mm.	63.7		
0.0140 mm.	58.8		
0.0115 mm.	55.8		
0.0082 mm.	52.9		
0.0059 mm.	48.0		
0.0042 mm.	45.1		
0.0030 mm.	41.3		
0.0013 mm.	32.2		

* (no specification provided)

Material Description

Dark Brown Lean Clay

Atterberg Limits (ASTM D 4318)

PL= 13 **LL=** 40 **PI=** 27

Classification

USCS (D 2487)= CL **AASHTO (M 145)=**

Coefficients

D_{90}= 0.0738 D_{85}= 0.0630 D_{60}= 0.0151
D_{50}= 0.0068 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: N/A **Date Tested:** 02/11/23

Tested By: L. Lancaster / E. Arapi

Checked By: G. Anderson, PE

Title:

Source of Sample: BS-1 **Depth:** 10.0' - 15.0' **Date Sampled:** 09/23/22
Sample Number: B

Material Classification, unless data is available, is based on the ASTM D 2488 (Visual-Manual Procedures)
N.M. - Not Measured
N.P. - Not Plastic

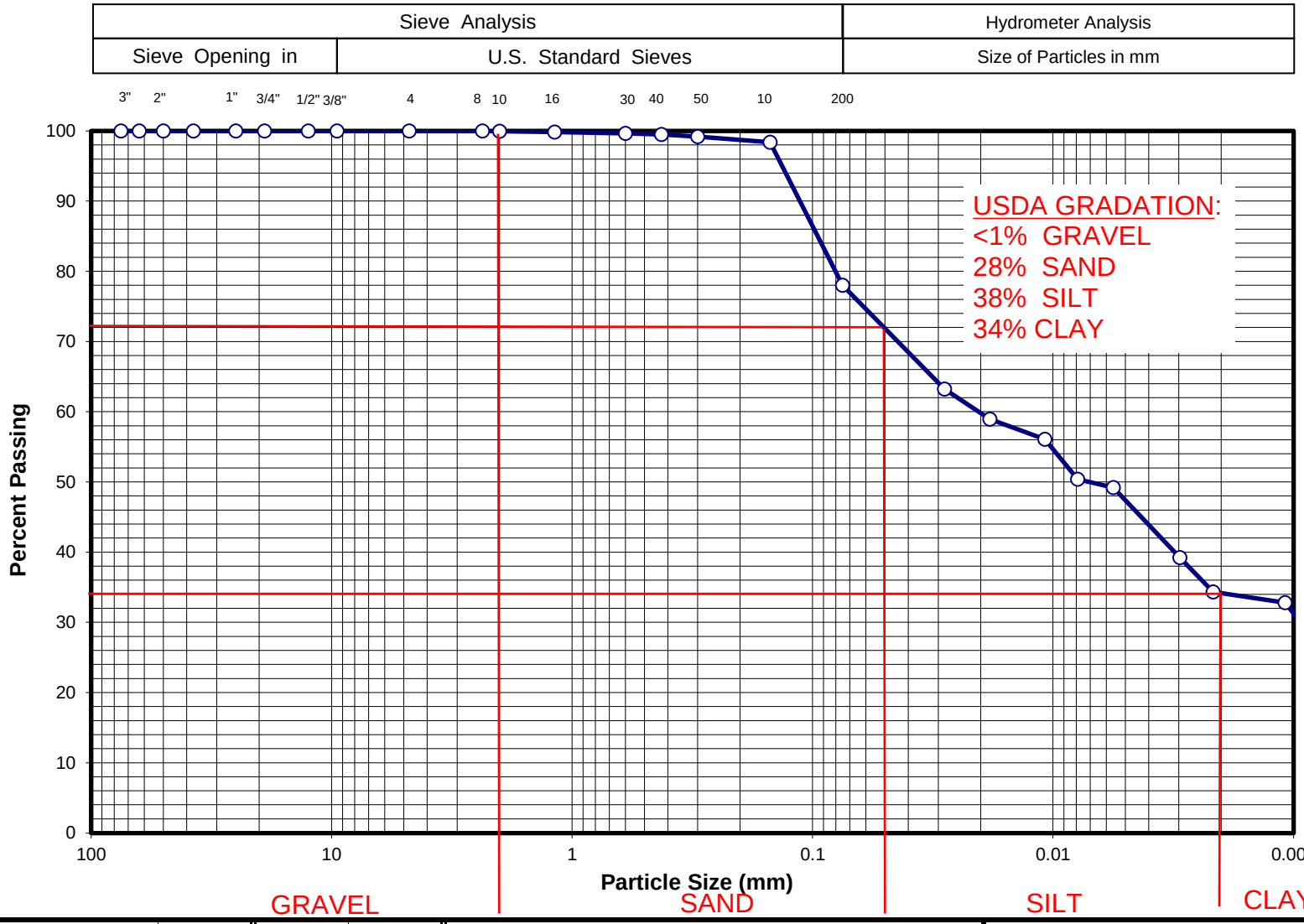
Kleinfelder, Inc.

Irving, TX

Client: Granite Engineering Group, Inc.

Project: Granite Engineering - Miscellaneous Lab Testing
PN: 222-133_CSU Grit Landfill

Project No: 20234005.001A **Figure**



Sieve Size	% Passing
3"	100
2 ½"	100
2"	100
1 ½"	100
1"	100
¾ "	100
½"	100
⅜"	100
#4	100
#50	99
#100	98
#200	78

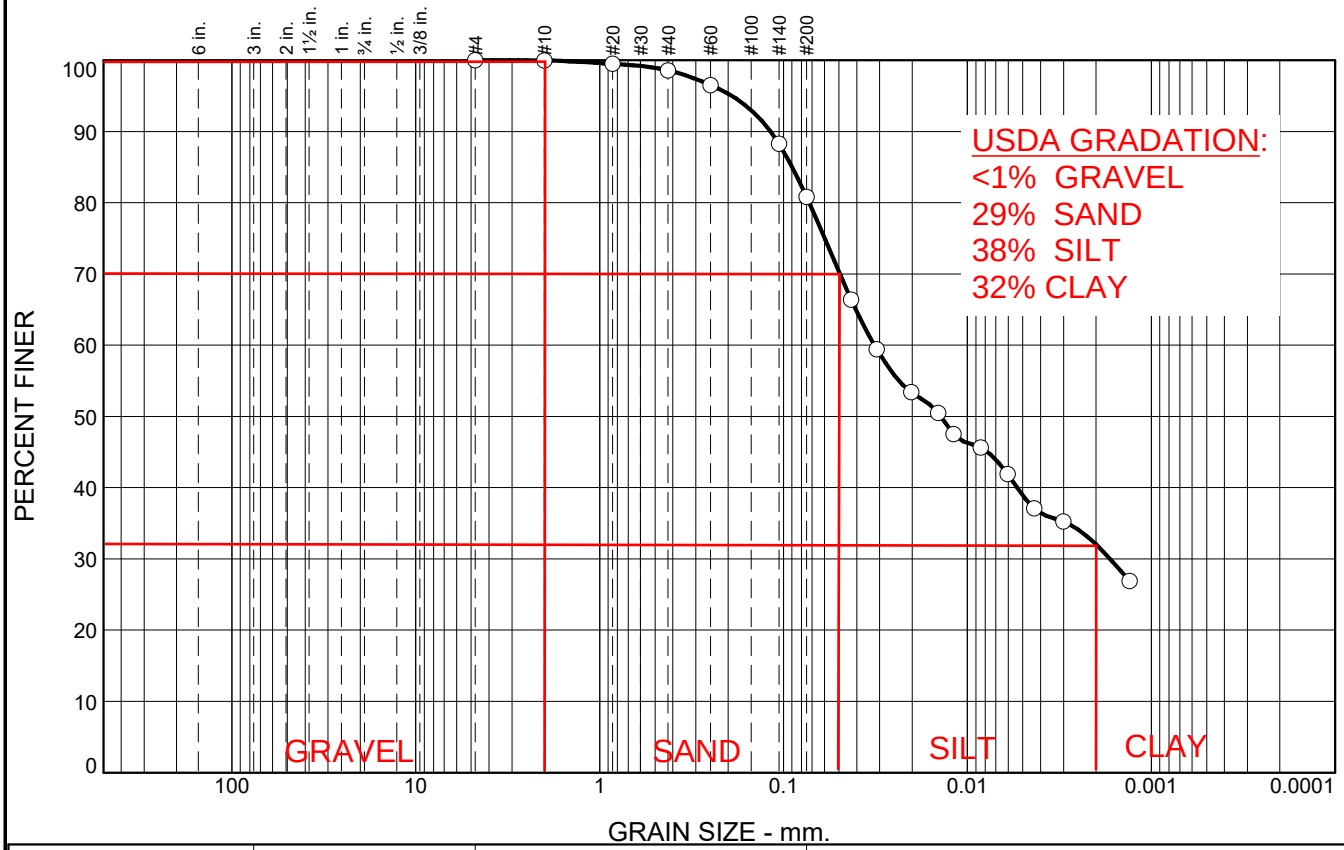
Gravel (%)	0	LL	36	Project Name:	CSU Grit Landfill
Sand (%)	22	PL	13	Sample ID:	BS-1
Fines (%)	78	PI	23	Sample Depth (ft.):	15'-20'
Sample Description:					

GRANITE ENGINEERING GROUP

SIEVE ANALYSIS

Drawn By:	SH	Project No.:	222-133
Checked By:	HML		
Date:	02/10/23	Figure No.:	-

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.4	17.8	48.8	32.0

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.5		
#40	98.6		
#60	96.5		
#140	88.3		
#200	80.8		
0.0429 mm.	66.4		
0.0312 mm.	59.4		
0.0202 mm.	53.4		
0.0144 mm.	50.5		
0.0119 mm.	47.5		
0.0085 mm.	45.6		
0.0060 mm.	41.9		
0.0043 mm.	37.1		
0.0030 mm.	35.3		
0.0013 mm.	26.9		

* (no specification provided)

Material Description

Brown Lean Clay with Sand

Atterberg Limits (ASTM D 4318)

PL= 17 **LL=** 31 **PI=** 14

Classification

USCS (D 2487)= CL **AASHTO (M 145)=**

Coefficients

D_{90}= 0.1179 D_{85}= 0.0898 D_{60}= 0.0321
D_{50}= 0.0139 D_{30}= 0.0017 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: N/A **Date Tested:** 02/11/23

Tested By: L. Landcaster / E. Arapi

Checked By: G. Anderson, PE

Title:

Source of Sample: BS-5 **Depth:** 0.0' - 5.0' **Date Sampled:** 09/23/22

Material Classification, unless data is available, is based on the ASTM D 2488 (Visual-Manual Procedures)
N.M. - Not Measured
N.P. - Not Plastic

Kleinfelder, Inc.

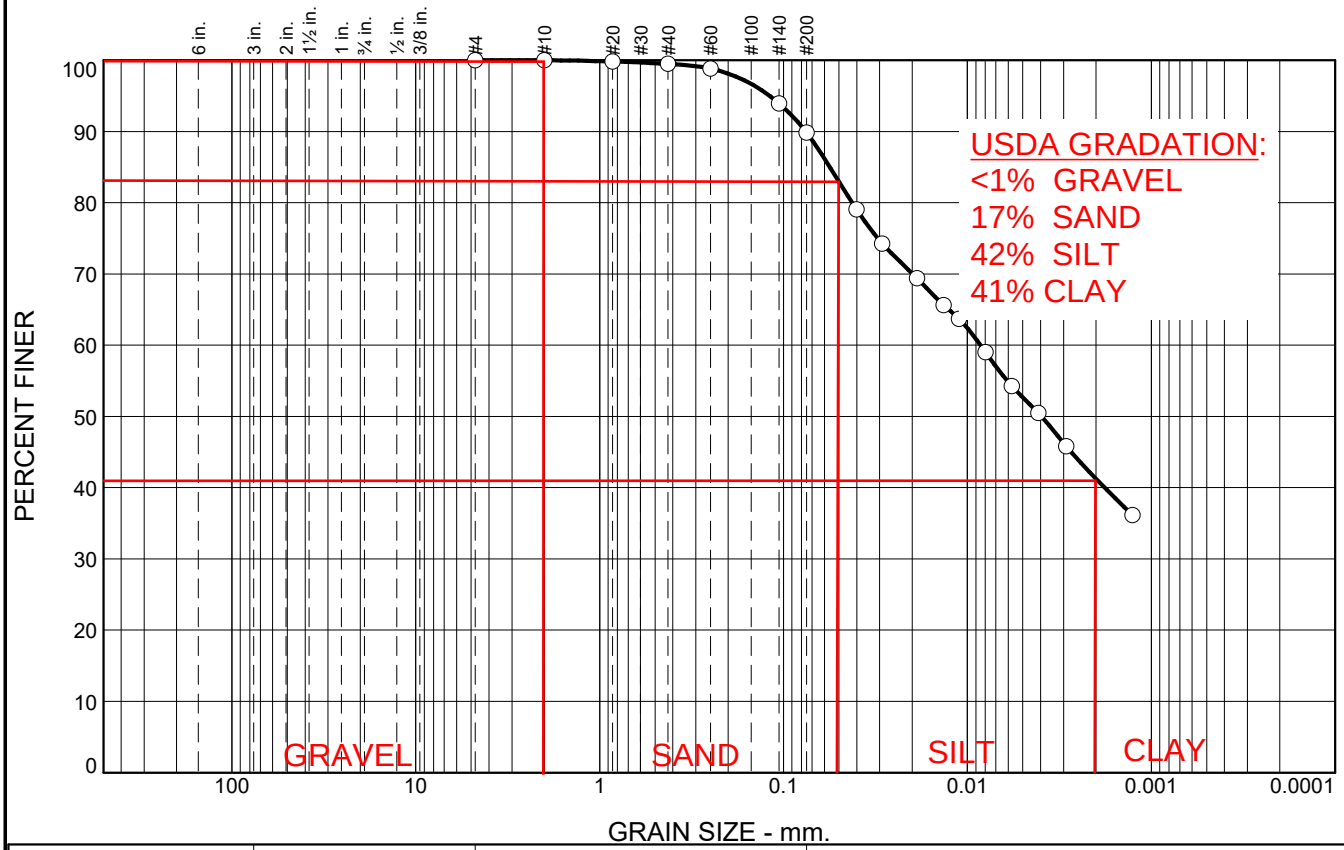
Irving, TX

Client: Granite Engineering Group, Inc.

Project: Granite Engineering - Miscellaneous Lab Testing
PN: 222-133_CSU Grit Landfill

Project No: 20234005.001A **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.5	9.7	48.6	41.2

TEST RESULTS

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
#4	100.0		
#10	100.0		
#20	99.8		
#40	99.5		
#60	98.8		
#140	94.0		
#200	89.8		
0.0402 mm.	79.1		
0.0290 mm.	74.2		
0.0188 mm.	69.4		
0.0135 mm.	65.6		
0.0111 mm.	63.7		
0.0080 mm.	59.0		
0.0057 mm.	54.3		
0.0041 mm.	50.5		
0.0029 mm.	45.8		
0.0013 mm.	36.2		

* (no specification provided)

Material Description

Brown Lean Clay

Atterberg Limits (ASTM D 4318)

PL= 14 **LL=** 31 **PI=** 17

Classification

USCS (D 2487)= CL **AASHTO (M 145)=**

Coefficients

D_{90}= 0.0759 D_{85}= 0.0560 D_{60}= 0.0085
D_{50}= 0.0040 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: N/A **Date Tested:** 02/11/23

Tested By: L. Lancaster / E. Arapi

Checked By: G. Anderson, PE

Title:

Source of Sample: BS-6 **Depth:** 5.0' - 10.0' **Date Sampled:** 09/23/22

Material Classification, unless data is available, is based on the ASTM D 2488 (Visual-Manual Procedures)
N.M. - Not Measured
N.P. - Not Plastic

Kleinfelder, Inc.

Irving, TX

Client: Granite Engineering Group, Inc.

Project: Granite Engineering - Miscellaneous Lab Testing
PN: 222-133_CSU Grit Landfill

Project No: 20234005.001A **Figure**