Construction Quality Assurance Plan
Tailings Storage Facility and Waste Rock Dump
Grassy Mountain Mine

Malheur County, Oregon

Submitted to:

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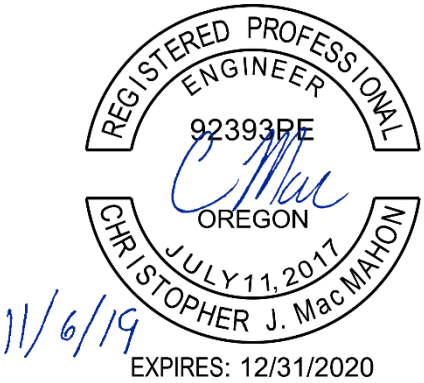
The following Construction Quality Assurance Plan has been prepared by the staff of Golder Associates Inc. under the professional supervision of the engineers whose signatures appear herein.

This Plan is presented to Calico Resources USA Corp. and has been prepared in accordance with generally accepted profession engineering principles and practices.

Golder Associates Inc.



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Document Revisions

Date	Revision	Comment
November 6, 2019	0	Issued Final

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APPENDIX

1.0 INTRODUCTION

This Construction Quality Assurance (CQA) Plan has been prepared by Golder Associates Inc. (Golder) on behalf of Calico Resources USA Corp. (Calico). This CQA Plan describes the program used to verify and document that earthwork construction, geomembrane installation, gravity pipe installation, and structural concrete installation for the Grassy Mountain Tailings Storage Facility (TSF) and Waste Rock Dump (WRD) are conducted in accordance with the Technical Specifications and the Drawings included in the Contract Documents for the Project.

This Plan is intended as summary of the Technical Specifications prepared as part of the Grassy Mountain TSF and WRD construction-level design presented as Appendix C in the Grassy Mountain Mine consolidated Permit Application.

Quality Control (QC) is a planned system of activities, or the use of such a system, whose purpose is to provide a level of quality that meets the requirements of the Technical Specifications and the Owner's needs. The objective of QC is to provide a work product that is safe, adequate, dependable, and economical. The overall system involves integrating the quality factors of several related steps including: the proper specification to meet the Owner's needs, production to meet the full intent of the Technical Specifications, inspection to determine whether the resulting material, product, service, etc. is in accordance with the Technical Specifications. In practice, QC refers to those procedures, criteria, and tests employed by the Quality Control Team to confirm the Work meets industry standards of practice and complies with the approved Design Drawings, Technical Specifications, and the CQA Plan. This plan does not address quality control procedures, criteria and/or tests employed by the Contractor.

Quality Assurance (QA) is a planned system of activities whose purpose is to provide assurance that the overall quality control program is in fact being effectively implemented. The system involves evaluating the adequacy and effectiveness of the overall Quality Control program and implementing corrective measures where necessary. For a specific material, product, service, etc., this involves verifications, audits, and the evaluation of the quality factors that affect the specification, production, inspection, and use of the product, service, system, or environment. In practice, QA refers to those procedures, criteria, and tests required by the Owner or Engineer to confirm the Work performed by the Contractor is in compliance with the approved Design Drawings and Technical Specifications and any additional requirements of this Plan.

The inspection and testing activities addressed under this CQA Plan include the following:

- Excavation
  - Embankment Fill Borrow Areas
  - Reclaim Pond
  - Waste Rock Dump
  - Stormwater Diversion Channels
  - Geotechnical Explorations
- Fill Materials
  - Subgrade

  - Embankment Fill
  - Grading Fill
  - Prepared Subgrade
  - Drainage Layer
  - Filter Fill
  - Anchor Trench Backfill
  - Drain Gravel
  - Leak Detection Fill
  - Pipe Bedding Fill
  - Cable Bedding Fill
  - Riprap
  - Safety Berm Material
- Geosynthetic Materials
  - Geomembrane
  - Geotextile
  - Geosynthetic Clay Liner
  - Geonet
- Monitoring Systems
  - Vibrating Wire Piezometers
  - Underdrain Flow Rate Monitoring and Flumes
  - Survey Monuments
  - Inclinometers
  - Leak Detection
- Cast-in-place Concrete
- Gravity Piping and Valves

2.0 ORGANIZATION

This section of the CQA Plan describes the parties involved during construction.

Owner: The Owner is the individual, corporation, entity, public body, or authority with whom the Contractor has entered into the Agreement and for whom the Work is performed. For this Project, the Owner is Calico Resources USA Corp. (Calico).

Engineer of Record (EOR): Engineer, or EOR, is the representative appointed and authorized by the Owner. The Engineer is responsible for preparation of the Design Drawings and Technical Specifications and this CQA Plan for the Project. The Engineer is also responsible for the interpretation of those documents and for resolution of technical matters that arise during construction. For this Project, the Engineer is Golder Associates Inc. (Golder). The Engineer-of-Record for this project is Christopher J. MacMahon, PE from Golder's Reno, Nevada Office.

Resident Engineer (RE): The RE is the on-site representative of the Engineer and oversees the Quality Assurance Team. The RE is responsible for overseeing the completion of the Work in accordance with the Drawings, Technical Specifications, and this CQA Plan. Other responsibilities include documenting daily construction activities, review of material submittals, review of the Quality Control program, and acceptance of completed Work. The RE will work directly with the Engineer and oversee the Quality Assurance Team. For this project, the RE will be a senior field technician provided by Golder.

Earthworks Contractor: Party, independent of the Owner, whose primary responsibility is to ensure the TSF is constructed in accordance with the Drawings, Technical Specifications, and this CQA Plan developed by the Engineer and approved by the permitting agency. Other responsibilities include the performance of all construction activities (including Subcontractors) at the site including site facilities, administration, material purchasing (other than materials procured by the Owner and Geomembrane Contractor), material handling and storage, safety, supervision, construction Quality Control program, installation, and subcontracting. The Contractor is also responsible for informing the Owner, Engineer, and Quality Assurance Team of the scheduling and occurrence of all construction activities and shall be fully responsible for scheduling and coordinating the work of the Quality Control Team and Subcontractor(s). The Contractor is responsible for the protection of completed work until it is accepted by the Owner.

Geosynthetics Contractor: Party, independent of the Owner, contracted through the Owner or Earthworks Contractor, responsible for field handling, sorting, placing, seaming, ballasting (against wind), and other aspects of the geosynthetics installation, including geomembranes, geotextiles, geonet, and Geosynthetic clay liners. The Geosynthetics Contractor is also responsible for transportation of these materials to the site, unless otherwise directed by the Owner. In addition, the Geosynthetics Contractor is responsible for the protection of the materials once they arrive on site, until the Work is accepted by the Owner.

Quality Control Team (QCT): Party, independent from the Owner, contracted through the Owner or Earthworks Contractor, responsible for performing the earthwork and geomembrane Quality Control field and laboratory testing, observations, and inspections required by the Technical Specifications. The QCT shall be approved by the Owner and Engineer. The QCT shall have experience in testing earth fills, aggregates, concrete, and geosynthetics and be familiar with the test methods and standards as required in the Technical Specifications.

At a minimum, the QCT shall consist of the following personnel:

- QC Manager – Registered Professional Engineer licensed in the State of Oregon responsible for all QC material testing, observation, and reporting of all QC activities required by the Technical Specifications

- QC Field Technician(s) – Qualified field technicians responsible for performing all earthwork, geomembrane and concrete field sampling, testing, and observations required by the Technical Specifications
- QC Earthwork Testing Laboratory – Qualified geotechnical testing laboratory responsible for performing all geotechnical laboratory testing required by the Technical Specifications
- QC Geomembrane Testing Laboratory – Qualified geomembrane testing laboratory responsible for performing all geomembrane laboratory testing during manufacturing required by the Technical Specifications

At a minimum, the QCT shall be responsible for the following:

- Performing all QC geotechnical testing required by the Technical Specifications
- Performing all QC geomembrane testing as required by the Technical Specifications
- Performing all QC concrete testing as required by the Technical Specifications
- Procuring all material data sheets and certifications of manufactured materials used to complete the Work and submitting to the Engineer for approval as required by the Technical Specifications
- Formally submitting test results, observations, manufacturer certifications, and QC daily field reports to the Engineer as required by the Technical Specification
- Preparation of the Quality Control Report and shall be approved and sealed by the QC Manager

At a minimum, the QC Manager shall have the following responsibilities:

- Oversee the QC Technicians and review of testing and analytical procedures employed to perform the QC testing, observation, and reporting of all QC activities as required by the Technical Specifications
- Review of all QC test results, observations, and QC daily field reports for all QC activities as required by the Technical Specifications
- Reporting of all QC tests and daily field reports to the Engineer as required by the Technical Specifications
- Report identified deficiencies and proposed corrective action to the QAT

Quality Assurance Team (QAT): Party, independent from the Contractor and QCT, responsible for QA field and laboratory testing, observations, documenting activities required by the Technical Specifications. The QAT shall be contracted through the Owner and perform assigned duties at the direction of the RE and Engineer. The QCT shall have experience in testing earth fills, aggregates, concrete, and geosynthetics and be familiar with the test methods and standards as required in the Technical Specifications.

At a minimum the QAT shall consist of the following personnel:

- RE – On-site representative of the Engineer overseeing the QAT

- QA Field Technician(s) – Qualified field technicians responsible for performing all geotechnical and geomembrane QA sampling, testing, and observations required by the Technical Specifications and at the direction of the Engineer
- QA Geotechnical Laboratory - Qualified geotechnical testing laboratory responsible for performing geotechnical laboratory at the direction of the Engineer
- QA Geomembrane Laboratory – Qualified geomembrane testing laboratory responsible for performing all geomembrane laboratory conformance testing during manufacturing required by the Technical Specifications

At a minimum, the QAT shall be responsible for the following:

- Review and approval of manufacturer QC certificates and test results as required by the Technical Specifications
- Review and approval of QC test results, observations, and QC daily field reports
- Review and approval of compaction procedures for materials placed and compacted as required by the Technical Specifications
- Sampling and performing geomembrane conformance tests as required by the Technical Specifications
- Initiation of design changes or clarifications required by the Engineer or Contractor
- Verify that the Work is constructed in accordance with industry standards of practice, Technical Specifications, and the Owner's needs
- Prepare the Record of Construction Report and shall be approved and sealed by the Engineer

Geosynthetic Manufacturer (Manufacturer): The party responsible for manufacturing the geomembrane, geosynthetic clay liner, geotextile, and appurtenances.

Subcontractor: The Subcontractor is an entity or individual who has a direct contract with the Contractor for the performance of a part of the Work. The Subcontractor shall communicate with the Owner or Engineer through the Contractor. The Subcontractor shall adhere to the requirements of the Drawings, Technical Specifications, and this CQA Plan as it relates to the Subcontractor's part of the Work.

3.0 MEETINGS

3.1 General Preconstruction Activities

Prior to the start of construction, a preconstruction meeting shall be held among the Owner, the Engineer, RE, QCT, QAT, and the Contractor(s) responsible for completing the Work. If necessary, a separate preconstruction meeting shall be held upon mobilization of the Geosynthetics Contractor if they cannot attend the first preconstruction meeting. The topics covered at this meeting shall include, but not be limited to:

- Providing each party with all relevant Construction Documents and supporting information
- Familiarizing each Party with this site-specific CQA Plan, its role relative to accomplishing the intent of the design, as well as review of the Design Drawings and Technical Specifications

- Reviewing the responsibilities of each Party
- Reviewing lines of authority and communication for each Party
- Discussing the established procedures or protocols for construction, deficiencies, repairs, and retesting
- Reviewing methods of documenting and reporting inspection data
- Reviewing work area security and safety protocols
- Discussing procedures for the location and protection of construction materials, and for the prevention of damage of the materials from inclement weather or other adverse events
- Conducting a site walk to review site conditions as well as material staging and storage locations
- Discussing the construction plan, schedule, and procedures
- Clarifying installation, testing, and acceptance criteria and procedures

3.2 Progress Meetings

Progress meetings will be held throughout progress of the Work at least once per week unless more frequent meetings are required. The RE and/or the Contractor will make arrangements for meetings, prepare agenda with copies for participants, preside at meetings, record the minutes, and distribute copies of the minutes within three days to the participants and those affected by decisions made. At a minimum, progress meetings shall be attended by the RE, the Contractor, and major Subcontractors. The purpose of a progress meeting is to address the following items:

- Review minutes of previous meetings
- Review Work progress and schedule
- Field observations, problems, and decisions
- Identify problems that impede planned progress
- Review submittals schedule and status of submittals
- Review material availability and quality
- Plan Work activities and progress during succeeding work period
- Coordinate projected progress
- Discuss construction quality and work standards
- Discuss other issues relating to the work

3.3 Problem or Work Deficiency Meeting

A special meeting shall be held when, and if, a problem or deficiency is present or is anticipated. At a minimum, the meeting shall be attended by the RE and the Contractor. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- Define and discuss the problem or deficiency

- Review alternative solutions
- Implement an action plan to resolve the problem or deficiency

The meeting shall be documented by the RE. Copies of the meeting minutes shall be distributed within three days to participants and those affected by decisions made.

4.0 CONSTRUCTION QUALITY ASSURANCE REQUIREMENTS

4.1 General

This section of the CQA Plan describes the observations and testing activities that will be performed during construction. The scope of this section addresses the construction method, including material installation and the manufacture/fabrication as specified in the following Technical Specification sections:

- Section 01041 – Project Coordination
- Section 01050 – Field Engineering
- Section 01051 – Geotechnical Exploration
- Section 01400 – Quality Control and Assurance
- Section 02110 – Site Clearing and Stripping
- Section 02205 – Fill Materials
- Section 02211 – Rough Grading
- Section 02222 – Excavating
- Section 02223 – Filling
- Section 02272 - Geotextile
- Section 02272 – Geonet
- Section 02350 – Geosynthetic Clay Liner
- Section 02710 – Gravity Piping
- Section 02775 – Geomembranes
- Section 03110 – Concrete Formwork
- Section 03220 – Reinforcing Steel
- Section 03300 – Cast-in-Place Concrete
- Section 11207 – Parshall Flumes
- Section 17150 – Meters and Instrumentation

Acceptance criteria for construction work shall be as identified in the Technical Specifications. The RE will be on-site at all times while construction is ongoing, observing and documenting all relevant activities. QA shall consist of observing the work as construction proceeds and review of laboratory and field testing

performed by the QCT to ensure that the materials conform to the Specifications and construction performance specifications are achieved. The RE will also review the required Contractor/Subcontractor submittals as specified in the Technical Specifications.

The Engineer shall visit the site periodically as construction progress warrants. Such visits will be frequent enough to allow the Engineer to be fully knowledgeable of the construction methods and performance. The Engineer may then determine if QC/QA observation and testing activities are adequate to meet the requirements of this CQA Plan.

4.2 List of Applicable Methods

List of applicable methods (references) are provided in the Technical Specifications.

4.3 Sampling and Testing Requirements

The QC\QA sampling and testing requirements for the construction activities are summarized in the tables in Section 6.0.

5.0 GENERAL QUALITY CONTROL/ASSURANCE PROCEDURES

5.1 General Description

The QCT shall be responsible for implementing a QC program that satisfies the requirements of the Technical Specifications and this CQA Plan. The QAT shall be responsible for reviewing all QC field and laboratory test results, observations, and QC daily field reports and document that the project construction has been completed in conformance with the Technical Specifications, Design Drawings, and the CQA Plan.

For this Project, QA testing performed by the QAT will satisfy the QC testing requirements of the Project. If selected by the Contractor and approved by the Owner, the Contractor may elect to not perform field QC testing in solely rely on the QAT to document contractor QC. This does not eliminate the requirements of the Contractor from performing assigned Work in accordance with the Technical Specifications and Design Drawings.

5.2 Visual Observations

5.2.1 Quality Control Team

Visual observations shall be performed by the QCT that include, but not be limited to, the following:

- Compaction method for materials placed (placement, moisture conditioning, equipment type, number of passes) as required by the Technical Specifications
    - Adherence to the procedures established during the test fills (if any)
- Consistency of materials during processing and/or placement
- Deleterious material that may hinder proper construction
- Attention to areas where damage due to excess moisture, insufficient moisture, or freezing may have occurred
- Safe working procedures and construction methods

5.2.2 Quality Assurance Team

Visual observations shall be performed by the QAT that include, but no be limited to, the following:

- Compaction method for materials placed (placement, moisture conditioning, equipment type, number of passes)
  - Adherence to the procedures established during the test fills (if any)
- Proper material usage
- Reviewing QCT procedures for sampling, testing, observations, and documentation
- Approval of areas where Work has been completed
- Safe working procedures and construction methods

5.3 Defects and Repairs

5.3.1 Identification

If a defect is identified, the QCT shall determine the extent and the nature of the defect and notify the QAT immediately. If the defect is indicated by an unsatisfactory test result, the QAT shall determine the extent of the deficient area by additional QC tests, observations, review of records, or other means that the QAT deems appropriate.

5.3.2 Notification

After determining the extent and nature of the defect, the QAT shall promptly notify the Contractor. The QAT shall review the QCT's determination regarding the extent of the defect. If the QAT agrees with the QCT's determination, the Contractor shall be notified of the defect. If in the opinion of the QAT, disagrees with the QCT's determination, additional observations and testing may be required prior to notifying the Contractor.

5.3.3 Repairs and Retesting

Upon notification from the QAT, the Contractor shall correct all deficiencies to meet the Contract Documents. The QAT and QCT shall schedule appropriate retests when the Work deficiencies have been corrected. All retests by the QCT or QAT must verify that the deficiencies have been corrected before additional Work may be performed by the Contractor in the deficient area. The QAT shall observe any repair and report any noncompliance with the above requirements in writing to the Engineer.

5.4 Documentation

5.4.1 General

Proper documentation shall be maintained throughout the duration of the construction activities. The QCT will be responsible for ensuring that applicable forms and written records are completed daily. Originals of applicable forms and written documentation will be stored on-site and shall be made available for the QAT's review upon request. Copies of written documentation will be made each week and shall be sent to the QAT. Further details of typical documentation are presented below.

5.4.2 Daily Records

5.4.2.1 Quality Control Daily Reports

The QCT shall issue a typed daily report of activities. QC daily reports shall include the following:

- Date and shift
- List of organizations and their responsibilities
- List of equipment used for construction of Work
- Health and safety issues
- Summary of QC activities
  - Materials used for construction
  - Summary of samples taken, sample locations and elevations as appropriate, and test results
  - Test equipment calibrations
  - List of materials received
- Issues and problems encountered, and resolutions reached
- Summary of meetings and discussions (if any)
- QCT personnel hours, gear, and vehicles
- Photographs taken with a description

A template for daily reports is provided in Appendix A.

5.4.2.2 Quality Assurance Daily Reports

The QAT shall issue a typed daily report of activities. QA daily reports shall include the following:

- Date and shift
- Weather conditions
- List of organizations and their responsibilities
- List of equipment operating on-site
- Health and safety issues
- Summary of QC documentation review
- Summary of QC activities
- Issues and problems encountered, and resolutions reached
- Summary of meetings and discussions
- QAT personnel hours, personal protective equipment used, and vehicles
- Photographs taken with a description

A template for daily reports is provided in Appendix A.

5.4.3 Construction Reporting

5.4.3.1 Construction Quality Control Report

Following completion of construction, the QCT shall provide a Construction Quality Control Report by that will include the following:

- Description of Quality Control activities
- Summary of test results
- Copies of QC daily reports
- As-Built Survey documentation
- Color photographs of major project features

The Construction Quality Control Report shall be submitted to the Engineer within 14 days upon acceptance of the completed Work. The Construction Quality Control Report shall be sealed by a registered Professional Engineer, licensed in the State of Oregon certifying that the activities performed by the QCT have been performed in accordance with the Contract Documents.

5.4.3.2 As-built Survey Documentation

Following completion of construction, the Contractor shall provide As-built Survey Documentation of all Work performed by the Contractor that will include the following:

- Survey of all areas disturbed by the Contractor that pertain to the completion of the Work
- Survey of all structures, pipes, utilities, and other facilities that pertain to the completion of the Work

The As-built Survey Documentation shall be submitted to the Engineer within 14 days upon acceptance of the completed Work. The As-built Survey Documentation shall be sealed by a registered Professional Land Surveyor, licensed in the State of Oregon certifying that the surveys are in accordance with the Contract Documents.

5.4.3.3 Record of Construction Report

Following completion of Construction and receipt of the Construction Quality Control Report and As-built Survey Documentation, the Engineer shall prepare the Record of Construction report documenting the following:

- Description of construction activities
- Summary of test results
- Copies of QCT and Resident Engineer Daily Reports
- As-built Survey documentation
- As-built Drawings
- Critical correspondence pertaining to the Work including changes and clarifications to the Drawings

- Description of deviations from the Technical Specifications and justification for such changes
- Color photographs of major project features

The Record of Construction Report will be sealed by the Engineer, certifying that the facility has been constructed in accordance with the Contract Documents.

6.0 QUALITY CONTROL REQUIREMENTS

Table 1: Subgrade

Type	Parameter	Standard	Test Method	Frequency (units per test)	Comments
Subgrade Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	N/A	
	Sieve Analysis	N/A	ASTM D 6913	200,000 sq.ft of prepared surface	
	Atterberg Limits	N/A	ASTM D 4318	200,000 sq.ft of prepared surface	
	Moisture-Density Relationship	Modified Proctor	ASTM D 1557	500,000 sq.ft of prepared surface	
Subgrade Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	Continuous Monitoring	
	Scarification Depth	6 inches below	N/A	Continuous Monitoring	
	Field Density	90% of Max Dry Density as determined by ASTM D 1557	ASTM D 6938	50,000 sq.ft of prepared surface	
	Field Moisture Content	N/A	ASTM D 6938	50,000 sq.ft of prepared surface	May be collected during field density test
	Sand Cone Referee Density	N/A	ASTM D 1556	1 test per 10 field density tests	As required by the Engineer
	Laboratory Moisture Content	N/A	ASTM D 4643	1 test per 10 field moisture tests	As required by the Engineer

Table 2: Embankment Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Embankment Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	N/A		ASTM D 4318	5,000 cu.yds	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	5,000 cu.yds	- A maximum of any 1 sieve is allowed to be out of spec for an individual test - Maximum particle size shall be less than 2/3 loose lift thickness
		16 inch	100			
		12 inch	50 – 100			
		8 inch	30 – 100			
		¾ inch	0 – 80			
		No. 4	0 – 40			
		No. 200	0 – 15			
	Moisture-Density Relationship	Modified Proctor		ASTM D 1557	20,000 cu.yds	Per material type
Embankment Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Shall be placed in horizontal lifts
	Lift Thickness	12, 18, and 24-inch test fill		USACOE	Continuous Monitoring	Per test fill procedures described in Section 02223
	Field Density	92% of Max Dry Density as determined by ASTM D 1557		ASTM D 6938	2,000 cu.yds	
	Field Moisture Content	N/A		ASTM D 6938	Continuous Visual Monitoring	
	Sand Cone Referee Density	N/A		ASTM D 1556	N/A	
	Laboratory Moisture Content	N/A		ASTM D 2216 or D 4643	N/A	

Table 3: Grading Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Grading Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 15		ASTM D 4318	5,000 cu.yds	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	5,000 cu.yds	
		6 inch	100			
		¾ inch	20 – 100			
		No. 4	10 – 70			
		No. 40	0 – 40			
		No. 200	0 – 30			
	Moisture-Density Relationship	Modified Proctor		ASTM D 1557	20,000 cu.yds	Per material type
Grading Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Shall be placed in horizontal lifts
	Lift Thickness	Soil Fill: Maximum 12-inch thick loose lift Rock Fill: 12, 18, and 24-inch test fill		USACOE	Continuous Monitoring	Per test fill procedures described in Section 02223
	Field Density	92% of Max Dry Density as determined by ASTM D 1557		ASTM D 6938	1,000 cu.yds	
	Field Moisture Content	N/A		ASTM D 6938	Continuous Visual Monitoring	
	Sand Cone Referee Density	N/A		ASTM D 1556	N/A	
	Laboratory Moisture Content	N/A		ASTM D 2216 or D 4643	N/A	

Table 4: Prepared Subgrade

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Prepared Subgrade Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 20		ASTM D 4318	5,000 cu.yds	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	5,000 cu.yds	
		3 inch	100			
		¾ inch	70 – 100			
		No. 4	20 – 100			
		No. 40	0 – 60			
		No. 200	0 – 50			
	Moisture-Density Relationship	Modified Proctor		ASTM D 1557	15,000 cu.yds	Per material type
Prepared Subgrade Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Shall be placed in horizontal lifts
	Lift Thickness	Maximum 12-inch thick loose lift On slopes steeper than 20% maximum 18-inch lifts measured perpendicular to slope		N/A	Continuous Monitoring	May be placed in a single 6-inch lift if the underlying Embankment Fill is free of coarse material. Lift thickness shall be approved by Engineer.
	Field Density	92% of Max Dry Density as determined by ASTM D 1557		ASTM D 6938	1,000 cu.yds	
	Field Moisture Content	N/A		ASTM D 6938	Continuous Visual Monitoring	
	Sand Cone Referee Density	N/A		ASTM D 1556	N/A	
	Laboratory Moisture Content	N/A		ASTM D 2216 or D 4643	N/A	

Table 5: Drainage Layer

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Drainage Layer Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 10		ASTM D 4318	5,000 cu.yds	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	5,000 cu.yds	
		3 inch	100			
		¾ inch	50 – 100			
		No. 4	20 – 50			
		No. 40	0 – 25			
		No. 200	0 – 15			
	Moisture-Density Relationship	N/A		N/A	N/A	
	Hydraulic Conductivity	5 x 10^{-3} cm/sec or faster		ASTM D 5856	2 per material type	
Drainage Layer Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Only Low Ground Pressure (LGP) tracks allowed for material spreading
	Lift Thickness	Single 18-inch thick loose layer		N/A	Continuous Monitoring	Not Compacted
	Field Density	N/A		N/A	N/A	
	Field Moisture Content	N/A		N/A	N/A	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 6: Filter Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Filter Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 10		ASTM D 4318	3,000 cu.yds	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	3,000 cu.yds	
		8 inch	100			
		3 inch	70 – 100			
		¾ inch	30 – 90			
		No. 40	0 – 25			
		No. 200	0 – 15			
	Moisture-Density Relationship	N/A		N/A	N/A	
	Hydraulic Conductivity	5×10^{-4} cm/sec or faster		ASTM D 5856	2 per material type	
Filter Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Only Low Ground Pressure (LGP) tracks allowed for material spreading.
	Lift Thickness	Single 6-inch thick loose lift		N/A	Continuous Monitoring	Not Compacted
	Field Density	N/A		N/A	N/A	
	Field Moisture Content	N/A		N/A	N/A	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 7: Anchor Trench Fill

Type	Parameter	Standard	Test Method	Frequency (units per test)	Comments
Anchor Trench Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	Continuous Monitoring	
	Atterberg Limits	N/A	ASTM D 4318	N/A	
	Sieve Analysis	N/A	ASTM D 6913	500 cu.yds	
	Moisture-Density Relationship	N/A	N/A	N/A	
Anchor Trench Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	Continuous Monitoring	
	Lift Thickness	Maximum 12-inch-thick loose lifts	N/A	Continuous Monitoring	
	Field Density	N/A	N/A	Continuous Monitoring	Hand guided or bucket compacted
	Field Moisture Content	N/A	N/A	Continuous Monitoring	
	Sand Cone Referee Density	N/A	N/A	N/A	
	Laboratory Moisture Content	N/A	N/A	N/A	

Table 8: Drain Gravel

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Drain Gravel Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 10		ASTM D 4318	200 cu.yds or 3 per material type	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	200 cu.yds or 3 per material type	
		2 inch	100			
		¾ inch	50 – 80			
		No. 4	15 – 50			
		No. 200	0 – 5			
	Moisture-Density Relationship	N/A		N/A	N/A	
Drain Gravel Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Only LGP track-mounted equipment allowed on Drain Gravel
	Lift Thickness	6-inch above and laterally around perforated pipe		N/A	Continuous Monitoring	Not Compacted
	Field Density	N/A		N/A	N/A	
	Field Moisture Content	N/A		N/A	N/A	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 9: Leak Detection Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Leak Detection Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Native borrow material or process Waste Overburden
	Atterberg Limits	PI ≤ 15		ASTM D 4318	2 per material type	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	2 per material type	
		1 inch	100			
		¾ inch	75 – 100			
		⅜ inch	20 – 55			
		No. 200	0 – 10			
	Moisture-Density Relationship	N/A		N/A	N/A	
Leak Detection Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Only track-mounted equipment allowed on Leak Detection Fill
	Lift Thickness	8 inch above and laterally around perforated pipe		N/A	Continuous Monitoring	Hand placed below spring line of pipe
	Field Density	N/A		N/A	N/A	
	Field Moisture Content	N/A		N/A	N/A	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 10: Pipe Bedding Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Pipe Bedding Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 20		ASTM D 4318	200 lineal feet or 2 per material type	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	200 lineal feet or 2 per material type	
		2 inch	100			
		¾ inch	70 – 100			
		No. 4	20 – 70			
		No. 40	0 – 35			
		No. 200	0 – 25			
	Moisture-Density Relationship	Modified Proctor		ASTM D 1557	200 lineal feet or 3 per material type	Per material type
Pipe Bedding Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Shall be placed in horizontal lifts
	Lift Thickness	Maximum 6-inch thick loose lift		N/A	Continuous Monitoring	
	Field Density	92% of Max Dry Density as determined by ASTM D 1557		ASTM D 6938	100 lineal feet	Only hand-guided, mechanical tampers, or hand-guided vibratory rollers shall be used around pipes
	Field Moisture Content	N/A		N/A	Continuous Monitoring	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 11: Cable Bedding Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Cable Bedding Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	N/A		ASTM D 4318	2 per material type	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	2 per material type	Screened Drainage Layer or Native Alluvium
		⅜ inch	100			
	Moisture-Density Relationship	smooth and non-yielding		ASTM D 1557	N/A	
Cable Bedding Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Lift Thickness	6-inch loose lift below cables 12-inch loose lift above cables		N/A	Continuous Monitoring	Hand guided-compaction equipment only
	Field Density	Visually documentation of a smooth and non-yielding surface		N/A	Continuous Monitoring	
	Field Moisture Content	N/A		N/A	Continuous Monitoring	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 12: Riprap

Type	Parameter	Standard					Test Method	Frequency (units per test)	Comments
Riprap Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials					N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 20					N/A	N/A	
	Sieve Analysis	**Riprap D50**	**8”**	**12”**	**16”**	**28”**	ASTM D 5519	2 per material type	
			Rock Size (in.)						
		D_{100}	12	18	24	42			
		D_{85}	10	14	20	36			
		D_{50}	8	12	16	28			
		D_{15}	3	4	6	12			
	Moisture-Density Relationship	N/A					N/A	N/A	
Riprap Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials					N/A	Continuous Monitoring	Shall be placed in horizontal lifts
	Lift Thickness	1.5 x D_{50}					N/A	Continuous Monitoring	
	Field Density	N/A					N/A	Continuous Monitoring	Track-walked or bucket compacted
	Field Moisture Content	N/A					N/A	N/A	
	Sand Cone Referee Density	N/A					N/A	N/A	
	Laboratory Moisture Content	N/A					N/A	N/A	

Table 13: Safety Berm Material

Type	Parameter	Standard	Test Method	Frequency (units per test)	Comments
Safety Berm Material Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	Continuous Monitoring	
	Atterberg Limits	N/A	N/A	N/A	
	Sieve Analysis	N/A	N/A	N/A	
	Moisture-Density Relationship	N/A	N/A	N/A	
Safety Berm Material Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	Continuous Monitoring	
	Lift Thickness	N/A	N/A	N/A	Shall be placed by loader, dozer or grader
	Field Density	N/A	N/A	N/A	Uncompacted
	Field Moisture Content	N/A	N/A	N/A	
	Sand Cone Referee Density	N/A	N/A	N/A	
	Laboratory Moisture Content	N/A	N/A	N/A	

Table 14: Textured Geomembrane Required Minimum Properties (Per GRI-GM13)

Parameter	Test Value		Test Method (ASTM)	Manufacturer Quality Control Frequency (units per test)
	60 mil	80 mil		
Thickness mils (min avg.)	57 mil	76 mil	D 5994	Per roll
Thickness (Minimum 8 of 10)	-10% (54 mil)	-10% (72mil)		
Lowest individual for any of the 10 values	-15% (51 mil)	-15% (68 mil)		
Asperity Height	16 mil	18 mil	D 7466	Every 2nd roll*
Density (g/cc) min.	0.940	0.940	D 1505/D 792	200,000 lb
Tensile Properties (min. avg.)*				
Yield Strength (lb/in)	126	168	D 6693 Type IV	20,000 lb
Break strength (lb/in)	90	120		
Yield Elongation (%)	12	12		
Break Elongation (%)	100	710		
Tear Resistance (lbs) (min. ave)	42	56	D 1004	45,000 lb
Puncture Resistance (lbs) (min. ave)	90	120	D 4833	45,000 lb
Stress Crack Resistance (hr)*	500 hr	500 hr	D 5397	Per GRI GM-10
Carbon Black Content (%)	2.0-3.0	2.0-3.0	D 4218*	20,000 lb
Carbon Black Dispersion*	See Notes*	See Notes*	D 5596	45,000 lb
Oxidative Induction Time (OIT)				
Standard OIT (minutes), or	100	100	D 3895	200,000 lbs
High Pressure OIT (HP OIT) (minutes)	400	400	D 5885	
Oven Aging at 85°C (min. avg.)*)			D5721	Per each formulation
a. Std OIT (% retained after 90 days) min. avg. or;	55	55	D 3895	
b. HP OIT (% retained after 90 days) min avg.	80	80	D 5885	
UV Resistance (min ave)*			D5721	Per each formulation
a. Std. OIT (min. avg.), or	N.R.	N.R.	D 3895	
b. HP OIT (min. avg.) (% ret. after 1600 hrs)*	50%	50%	D 5885	

*Refer to Notes presented in Table 02775-1 of Section 02775 in the Technical Specifications

Table 15: HDPE Geomembrane Seam Properties Wedge and Extrusion Welds (per GRI GM-19a)

Parameter	Textured HDPE Test Values		Test Method (ASTM)	Testing Frequency (units per Test)	Comments
	60 mil	80 mil			
Seam Shear Strength (lbs/in) minimum*	120	160	D 6392	500 LF per machine	Peel and Shear seams must fail in the Film Tear Bond mode*
Lowest Individual Seam Shear Strength of 5 tests (lbs/in)*	96	128			
Shear elongation at break (%)	50	50			
Seam Peel Strength (lbs/in) minimum*	91 for hot wedge 78 for extrusion	121 for hot wedge 104 for extrusion			
Lowest Individual Seam Peel Strength of 5 tests (lbs/in)*	73 for hot wedge 62 for extrusion	97 for hot wedge 83 for extrusion			
Peel separation (%)	25	25			

*Refer to Notes presented in Table 02775-2 of Section 02775 in the Technical Specifications

Table 16: Geomembrane Conformance Testing

Property	Test Value	Test Method (ASTM)	Testing Frequency (units per Test)
Thickness (mils)	See Table 13	D 5199	2,000,000 sq. ft. per liner type, or per resin lot, whichever is greater (each test)
Compound Density (g/cc)	See Table 13	D 1505	
Tensile Strength (Both yield and ultimate strength and elongation, as specified)	See Table 13	D 6693	
Carbon Black Content (%)	See Table 13	D 4218	

Table 17: Minimum Average Roll Values For Reinforced Geofilm Related GCL Material (per GRI-GCL3)

Property	ASTM Test Method	Value	Comments
Cap Geosynthetic			Material Data Sheets shall be provided to the Engineer per Section 01300 of the Technical Specifications
Type	-	Non-woven	
Weight	ASTM D 5261	6.0 oz/sq.yd.	
Carrier Geosynthetic			
Type	-	Woven	
Weight	ASTM D 5261	3.0 oz/sq.yd.	
Geofilm			
Thickness	ASTM D 5199/ D 5994	4 mil	
Break Tensile Strength (MD & XMD)	ASTM D 882	12 lb/in	
Clay Properties			
Clay Type	-	80% or more montmorillonite	
Bentonite Mass at 0% Moisture*	ASTM D 5993	0.75 psf	
Maximum Allowable Moisture Content	ASTM D 5993	35%, by weight	
Swell Index	ASTM D 5890	24 ml/2g min	
Fluid Loss	ASTM D 5891	18 ml max	
GCL Composite Properties			
GCL Permeability*	ASTM D 6766	5×10^{-10} cm/sec max at 5.0 psi	
Tensile Strength in Machine Direction	ASTM D 6768	23 lb/in	
Peel Strength	ASTM D 6496	2.1 lb/in	
Geofilm Durability*	ASTM D 5721	80% strength	
Internal Shear Strength	ASTM D 6243	150 psf typical	

*Refer to Notes presented in Table 02350-2 of Section 02350 in the Technical Specifications

Table 18: Minimum Average Roll Values For Geotextile Material (per GRI-GT12a)

Parameter	ASTM Test Method	Value	Testing Frequency	Comments
Weight	D 5261	12 oz/sq.yd.	1 per material type, or as requested by the Engineer	Material Data Sheets shall be provided to the Engineer per Section 01300 of the Technical Specifications
Grab Tensile	D 4632	300 lb		
Grab Tensile Elongation	D 4632	50%		
Trapezoidal Tear Strength	D 4533	115 lb		
Puncture (CBR) Strength	D 6241	800 lb		
UV Resistance (at 500 hrs)	D 7238	70% strength retained		
Apparent Opening Size	D 4751	No. 100 Sieve (0.15 mm)		

*Refer to Notes presented in Table 02272-1 of Section 02272 in the Technical Specifications.

Table 19: Minimum Average Roll Values for Geonet Material (per GRI-GN4)

Parameter	ASTM Test Method	Value	Testing Frequency	Comments
Thickness* (min. ave.)	D 5199	200 mil	1 per material type, or as requested by the Engineer	Material Data Sheets shall be provided to the Engineer per Section 01300 of the Technical Specifications
Density* (min. ave.)	D 1505/D 792	0.950 g/cm*		
Carbon Black Content (%)	D 1603/D 4218	1.5-3.0%		
Tensile Strength* (MD)	D 7179	180 lb/in		
Compressive Strength* (min. ave.)	D 6364	120		
Transmissivity*	D 4716	5.0 gal/min-ft		

*Refer to Notes presented in Table 02273-1 of Section 02273 in the Technical Specifications.

Table 20: Cast-In-Place Concrete

Type	Parameter	Test Value	Test Method (ASTM)	Testing Frequency	Comments
Cast-In-Place Concrete (Reinforced)	Compressive strength	4,000 psi at 28 days	C 39	4 Standard 6-inch diameter by 12-inches long test cylinders for every 50 yards of concrete poured or for each pour, whichever is greater	One at 7 days, one at 14 days, and one at 28 days, one reserve
	Maximum aggregate size	3/4-inch	C 136		
	Slump	3 to 5 inches	C 143	Every 50 yards of concrete poured or for each pour, whichever is greater	
	Air Entrainment (%)	4 to 6%	C 233	Every 50 yards of concrete poured or for each pour, whichever is greater	
Lean Mix Concrete (unreinforced)	Compressive strength	2,000 psi at 28 days	C 39	4 Standard 6-inch diameter by 12-inches long test cylinders for every 50 yards of concrete poured or for each pour, whichever is greater	One at 7 days, one at 14 days, and one at 28 days, one reserve
	Maximum aggregate size	1.5-inch	C 136		
	Slump	3 to 5 inches	C 143	Every 50 yards of concrete poured or for each pour, whichever is greater	

APPENDIX A

Example of CQA Daily Field Report

DAILY FIELD REPORT

DATE: **PROJECT NO.**

REPORT NO.
FILE TO:

GRASSY MOUNTAIN TSF CONSTRUCTION

Table 1: Present at Site

Organization	Responsibility

Table 2: Equipment Present at Site

Qty	Type	Make/Model	Notes

Health and Safety

■

Construction Activity Summary

■

QA/QC Activity Summary

■

Issues and Resolution

■

Meetings and Discussions Summary

■

Signature
First and Last Name
Title

Total Hours On-site:
Field Equipment:
Vehicle:

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Photographs

Description

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