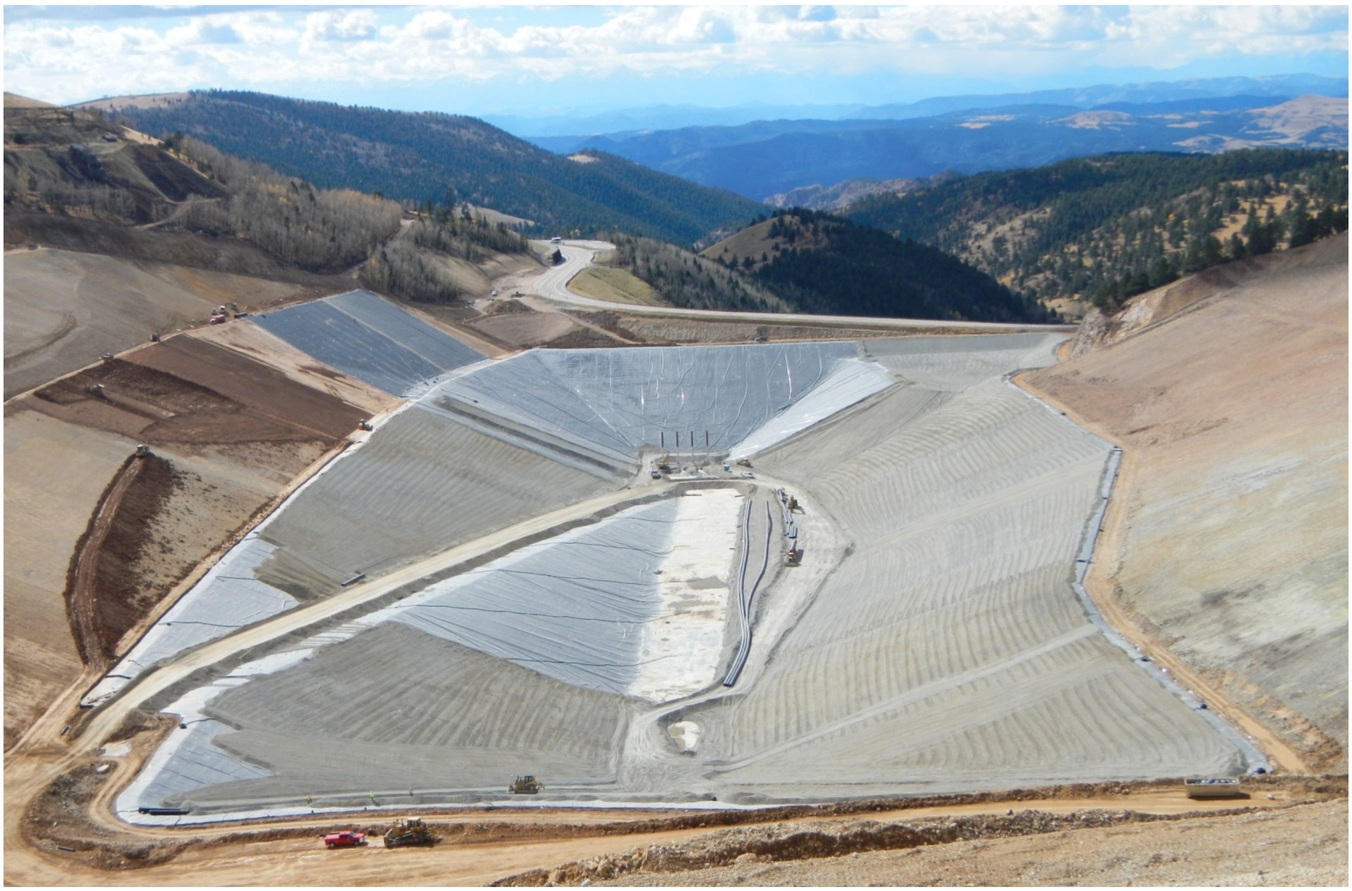
Cripple Creek & Victor Gold Mining Company
Squaw Gulch VLF Pregnant Solution Storage Area Project
Final Report
Quality Assurance Monitoring & Test Results
November 2014



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PROJECT REPORT ACRYONYMS

Abbreviation	Definition
ADR	Adsorption Desorption Recovery
ADS	Advanced Drainage System
AMEC	AMEC Environment and Infrastructure, Inc.
Ames	Ames Constriction, Inc.
ASTM	American Society for Testing and Materials
CC&V	Cripple Creek & Victor Gold Mining Company
cfs	Cubic Feet per Second
CP	Concrete Plugs
CPe	Corrugated Polyethylene
CQA	Construction Quality Assurance
CQC	Construction Quality Control
CRF	Cemented Rockfill
CSB	Coarse Shaft Backfill
DCF	Drain Cover Fill
DRMS	Division of Reclamation Mining and Safety
ECA	ECApplications, Inc.
HDPE	High Density Polyethylene
HVSCS	High Volume Solution Collection System
IFC	Issued for Construction
LDF	Leak Detection Fill
LGP	Low Ground Pressure
LLDPE	Linear Low Density Polyethylene
LVSCS	Low Volume Solution Collection System
MLRB	Mined Land Reclamation Board
psi	Pounds per Square Inch
PSSA	Pregnant Solution Storage Area
ROC	Record of Construction
SLF	Soil Liner Fill
SSF	Select Structural Fill
SGVLF	Squaw Gulch Valley Leach Facility
SSMS	Single-sided microspike
SF	Structural Fill
VLF	Valley Leach Facility
UF	Underdrain Fill

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1.0 INTRODUCTION

The Cripple Creek & Victor Gold Mining Company (CC&V) operates the Cresson Project; located in Teller County, Colorado, near the city of Victor. CC&V is owned and managed by AngloGold Ashanti (Colorado) Corp. (AngloGold Ashanti). The Cresson Project is a mining and ore processing facility which comprises surface mines, crushers, a lined Valley Leach Facility (VLF), gold recovery plant, and associated infrastructure, all of which were designed and constructed to meet or exceed the requirements established by C.R.S. §34 32 101 et seq. and regulations promulgated there under by the Mined Land Reclamation Board (MLRB).

The work associated with the Cresson Project is being performed under specific criteria established in Amendment No. 10 of Permit Number M-1980-244, as approved by the MLRB. This report documents the Construction Quality Assurance (CQA) and Construction Quality Control (CQC) services provided by AMEC Environment & Infrastructure (AMEC) from January 2013 through November 2014 for the Squaw Gulch Valley Leach Facility (SGVLF) Pregnant Solution Storage Area (PSSA), which is defined in Section 1.6. The general site location is presented on Figure 1, and the Construction and Geomembrane Installation Limits are presented on Figure 2.

1.1 Project Description

The initial Cresson VLF Project was designed in 1993 and constructed in phases since 1994 under Amendment Nos. 6, 7, 8, and 9 to Mining Permit M-1980-244. This certification report addresses the addition of approximately 32.83 acres (1.43 million slope adjusted square feet) plan area, a portion of the earthen and synthetically lined area to a new valley leach facility. This area is referred to as the SGVLF Pregnant Solution Storage Area (PSSA), and was designed to meet the criteria presented and approved in Amendment No. 10 of Permit Number M-1980-244.

Ames Construction Inc. (Ames) was the earthworks contractor for the Project. They performed construction activities from January 2013 through November 2014. Agru America manufactured the geomembrane used to construct the PSSA. Tensar manufactured the geogrid used in the underground workings remediation. ECApplications, Inc. (ECA) installed geomembrane liner from June 2014 through November 2014. Messrs. Ron Roberts, Ron DiDonato, Jeff Gaul, and Scott Redabaugh represented CC&V as the Construction Manager and Construction Superintendents, respectively. All quantities and testing frequencies presented in this report are current as of November 2014, which represents completion of the PSSA, as detailed in this report.

1.2 Construction Quality Assurance/Construction Quality Control

AMEC provided CQA and CQC monitoring and testing services, and prepared this report describing the results for the PSSA. As-built drawings and supporting CQA monitoring and testing documentation are presented in appendices attached to this report.

1.2.1 CQA Monitoring of Earthworks

AMEC provided CQC testing and CQA testing and monitoring of earthworks for the PSSA Project. CQA testing and monitoring of earthworks was provided for in-place materials in accordance with the AMEC Earthworks CQA Plan (Section 1400.1 of the project technical specifications; see Appendix E). The earthworks material specifications for this project are summarized in Table 3. CQC earthworks test results were provided to support the contractor during the manufacturing of materials and prior to material placement. The CQC test results are not included in this report as these tests were intended to assist the contractor in materials preparation rather than record testing. All CQA testing results are included.

AMEC provided CQA laboratory and field testing, and monitored earthworks construction activities as follows:

- Observe and document historic underground working remediation within the PSSA footprint, including verification that Ames excavated underground workings to the minimum specified dimensions and placed coarse shaft backfill (CSB), concrete plugs (CP), cemented rockfill (CRF), or structural fill (SF) as specified on the Issued for Construction (IFC) Drawings.
- AMEC monitored topsoil stripping, site grading, slope re-contouring and SF placement, to include lift thickness, moisture conditioning, temperatures, compactive effort, in-place nuclear density testing, and use of suitable SF materials. The materials were monitored during placement to confirm that the subgrade surface was unyielding, free from unsuitable and organic materials and was acceptable for soil liner fill (SLF) placement. AMEC performed CQA laboratory testing of grain size and Atterberg limits.
- Observe and document construction of the primary, secondary, and tertiary underdrains, including verification that Ames excavated the trenches to the minimum required dimensions and grades, and placed the materials according to the project technical specifications. AMEC performed CQA laboratory testing of grain size, Atterberg limits, and moisture content of underdrain fill (UF) and select structural fill (SSF).
- Observe and document the closure drain installation including the drilling process, abandoned holes, testing of the flow into the diatreme, CQA laboratory testing of all associated materials used during installation, and concrete testing.
- Observe and document SLF placement including observation of depth verification performed by Ames, grain size, moisture conditioning, and compaction of the material. AMEC performed in-place nuclear density and moisture testing and CQA laboratory testing of grain size, moisture content, Atterberg limits, Proctor, and

permeability. AMEC also provided visual monitoring of the SLF surface preparation and moisture conditioning for geomembrane placement to include a rolled, compacted surface free of desiccation cracks, abrupt grade changes, and sharp stones. Observation of excavation, backfill, and compaction of anchor trenches occurred as part of SLF placement.

- Observe and document low volume solution collection fill (LVSCF) placed between the primary and secondary geomembrane liners within the PSSA which included verification of lift thickness, grade control, identification and removal of deleterious materials, and observation of material placement to ensure that care was exercised to avoid geomembrane damage. In-place nuclear density-moisture testing of LVSCF was performed within the PSSA sump which serves as the foundation for the primary geomembrane liner and high volume solution collection system (HVSCS) risers. AMEC performed CQA laboratory testing of grain size, Atterberg limits, and Proctor.
- The installation of the low volume solution collection system (LVSCS) piping was observed to include verification the pipes were installed to the lines and grades to be most effective for collection.
- Observe and document drain cover fill (DCF) placement above the primary geomembrane within the PSSA to include verification of lift thickness, grade control, removal of deleterious materials, and that care was exercised in DCF placement to avoid geomembrane damage. AMEC performed CQA laboratory testing of grain size and Atterberg limits.
- Observe and document installation of HVSCS piping, riser base plates, Roscoe Moss louvered section and compression section.
- Monitored and documented the ambient air temperatures and the temperatures of the fill materials, including SLF, in accordance with the project technical specifications. The ambient air and fill temperatures monitored during fill activities are presented on Tables 1 and 2, respectively. Note: The ambient air and fill temperatures are reported through mid November 2014. Reporting of this data will continue in the Phase 1 ROC report.

1.2.2 CQA/CQC Monitoring of Geosynthetics Installation

AMEC provided CQA monitoring of geosynthetics used for the PSSA. CQA services consisted of performing geosynthetics inventory and checking quality control certifications prior to geosynthetics deployment. CQA activities were performed in accordance with the Geosynthetics CQA Plan (Section 1400.2 of the project technical specifications; located in Appendix E). Geosynthetics CQA activities included:

- Inventory of geosynthetic materials delivered to the project site
- Review and approval of manufacture and third party conformance certificates
- Observation of geotextile installation

- Observation and documentation of geomembrane installation
- Observation and documentation of trial welds
- Observation and documentation of defects and repairs
- Observation and documentation of destructive and non-destructive testing

1.3 Project Coordination

CQC and CQA activities were directed by the AMEC Project Resident. The Project Resident for the construction of the PSSA between January 2013 and October 2013 was Mr. Thorne Clark and for the period between November 2013 and November 2014, was Mr. Tim Burkhard. The Project Manager, Mr. Michael E. Nelson, PE, or his representatives Andrea L. Meduna, PE and/or Brett Byler, PE, made periodic site visits to resolve technical issues and to review AMEC activities. Appendix C presents a summary of the AMEC staff on-site during the construction period.

Representatives of CC&V, Ames, ECA, and AMEC conducted pre-construction, daily, and weekly coordination meetings throughout the construction period.

1.3.1 Daily Construction Summary Reports

AMEC prepared daily construction summary reports as well as photographic documentation (Appendix B) throughout the project to document the key elements of construction and the CQA activities. On-site CQA personnel and the Project Manager discussed construction activities on a regular basis; in addition, field personnel prepared daily observation reports. AMEC submitted these daily summary reports to CC&V. Daily reports are not included in this report, but were available for the Colorado Division of Reclamation Mining and Safety (DRMS) review during the course of the project.

1.3.2 Weekly Construction Summary Reports

AMEC prepared weekly construction summary reports which were submitted to CC&V and to the DRMS. Weekly reports from the period of January 2013 through November 2014 are presented in Appendix D.

1.4 Project Technical Specifications

All work was performed in accordance with the design plans and project technical specifications presented in Amendment No. 10 of Mining Permit M-1980-244 and subsequent revisions, as approved by DRMS. IFC Drawings relevant to the construction are presented in the Drawings section of this report, and project technical specifications are presented in Appendix E. Any deviations from the IFC drawings or project technical specifications are discussed in Section 7.0 of this report.

1.5 Record Survey Documentation

Ames provided the Record Drawings for the activities associated with the PSSA construction. A Colorado Registered Professional Land Surveyor prepared the record drawings presented in Appendix A. The Surveyor's professional license is presented in Appendix F. Ames also provided locations for SLF density tests, SLF depth verification, geomembrane panels, and destructive tests of geomembrane seams, which were used by AMEC to develop test summaries and the geomembrane panel as-built drawing (Drawing Nos. 8 and 9 in Appendix A).

1.6 Certification Boundary

Figure 2 presents the Construction and Geomembrane Installation Limits of the PSSA that is being certified by this report. The certification boundary coincides with the limits of the Project footprint and includes remediation of historic underground workings; site grading; closure drain installation, underdrain installation, SLF placement and compaction; installation of 100-mil single-sided microspike (SSMS) low linear density polyethylene (LLDPE) geomembrane and 100-mil smooth geomembrane LLDPE geomembrane; LVSCF placement; and DCF placement.

2.0 SUMMARY OF EARTHWORK CONSTRUCTION

Earthworks activities associated with the PSSA included the following:

- Historic underground workings remediation including excavation, confirmatory drilling, and installation of CSB, CP, or CRF.
- Site grading, including cut and placement of SF
- Blasting of materials for remediation of underground workings and site grading
- Primary, secondary, and tertiary underdrain construction, including trench excavation, installation of 12 oz./yd.^{2} geotextile, placement of UF and SSF
- Closure drain installation
- SLF installation, including placement and compaction, depth verification testing, and preparation of SLF surface for geomembrane deployment
- LVSCF placement over the secondary geomembrane layer beneath the primary geomembrane layer.
- DCF placement above the primary geomembrane layer and around the HVSCS

Ames generally used the following equipment during construction:

- Caterpillar D6 Low Ground Pressure (LGP) Dozer
- Caterpillar D7 LGP Dozer
- Caterpillar D8 LGP Dozer
- Caterpillar D9 LGP Dozer
- Caterpillar D9 Dozer
- Caterpillar D10 Dozer
- John Deere Skidsteer
- Caterpillar 750 Skidsteer
- Bobcat Skidsteer
- Caterpillar 950 Loader
- Caterpillar 988 Loader
- Caterpillar 992 Loader
- Caterpillar 993 Loader
- John Deere 544 Loader
- Caterpillar 14H Motor Grader

- Caterpillar CS563 Compactor
- Caterpillar CS663 Compactor
- John Deere 35D Excavator
- Caterpillar 312 Excavator
- John Deere 200 Excavator
- Caterpillar 304 Excavator
- Caterpillar 330 Excavator
- Caterpillar 345 Excavator
- Caterpillar 375 Excavator
- Caterpillar 385 Excavator
- John Deere 850 Excavator
- John Deere 120 Excavator
- Tamrock Track Mounted Drill
- Sandvik Track Mounted Drill
- Caterpillar 740 Haul Truck
- Caterpillar 773 Haul Truck
- Caterpillar 777 Haul Truck
- Water Trucks

Weather data for the PSSA construction activities from the period of January 2013 through end of PSSA construction November 2014 are presented in Table 1.

2.1 Underground Workings Remediation

Historic underground workings within the footprint of the PSSA were remediated following the recommended remediation plans presented on IFC Drawing No. A60 through A67 in the Drawings section of this report.

A figure and summary of the historic underground workings remediation is presented in Appendix O.1. The table shows the working identification, location (northing and easting), type of working, remediation quantities, and comments. The following sections provide a summary of the general remediation methods for the historic underground workings within the PSSA footprint.

2.1.1 Remediation of Shafts, Stopes, and Shallow Surface Pits

The following is a general approach used to remediate isolated shafts and shallow surface pits:

Open Workings:

For open workings, the excavations were backfilled with CSB to approximately 10 feet below the finished surface grade. The surface of the CSB was compacted using the shovel from a Caterpillar excavator. A minimum 3-foot-thick CP was cast into the shaft and allowed to cure for a minimum of 7 days. A minimum 7-foot-thick layer of CRF was then placed onto the CP. SF was then placed to the final grade as needed. In some cases, the excavation did not require placement of CSB prior to placement of the CP and CRF.

Collapsed Workings

For collapsed workings, collapsed materials were excavated to a depth of 25 feet below finished grade. The excavations were either backfilled with CSB to approximately 3 feet below the soil/bedrock interface or shaped for placement of a CP. The surface of the CSB was compacted using the shovel from a Caterpillar excavator. A minimum 3-foot-thick CP was cast into the shaft and allowed to cure for 7 days. A minimum 7-foot-thick layer of CRF was then placed over the CP. After the CRF was allowed to cure, SF was then placed to the final grade as needed.

Shallow Surface Pits

Shallow surface pits that were less than 25 feet below the final SLF grade were excavated to bedrock or pit termination. The pits were then backfilled with compacted SSF and SF to the bottom of the SLF layer. In some cases, shallow surface pits were completely removed during slope re-contouring and required no further remediation.

2.1.2 Remediation of Lateral/Inclines/Adits

A number of laterals and adits were identified within the PSSA footprint. Per the remediation recommendations, historic underground workings were identified within 50 feet of the existing grade elevation and remediated. Workings that were 50 feet or more below the final grade were not remediated.

Remediation for laterals and adits consisted of drilling nominal 3-inch-diameter blast holes into the crown pillar (the rock between the ground surface and the roof of the working) using a pneumatic hammer track drill rig. The blast holes were loaded and the crown pillars blasted into the void. For some of the shallower workings, the blasted material was excavated and replaced with compacted fill. For deeper blasted laterals that could not safely and fully be excavated, three layers of geogrid separated by a later of SSF was placed 15 feet beyond the mine working limits.

All blast holes that did not intercept the historic underground working or were not incorporated in the blast were completely grouted with bentonite slurry prior to blasting the crown pillar and remediating the working.

Historic underground working remediation activities within the PSSA were performed from February 2013 through May 2014.

2.2 Underdrains

2.2.1 Primary Underdrain System

Ames constructed approximately 1,467 feet of primary underdrain within the PSSA footprint. Record Drawing No. 3 shows the location of the primary underdrain. The cross-sectional dimensions of the Primary Underdrain were a nominal 5 feet wide by 3 feet deep, providing a cross-sectional area of 15 square feet, as shown on IFC Drawing A250. Ames excavated the primary underdrain trench to the minimum dimensions, and placed non-woven geotextile, corrugate polyethylene perforated pipe and UF in the trench. SSF was then placed over the geotextile to a minimum depth of 6 inches. The primary underdrain geosynthetic installation is discussed further in Section 3.1. Approximately 822 cubic yards of UF, 135 cubic yards of SSF, 1,467 feet of 6-inch-diameter corrugated polyethylene perforated (CPe) pipe, and 24,406 square feet of geotextile were used to construct the primary underdrain. The primary underdrain sloped at a minimum of 1 percent south beneath the PSSA and toe berm, flowing through a manhole and finally terminating at the underdrain ponds (see IFC Drawing A255 for additional detail).

2.2.2 Secondary Underdrain System

Ames constructed 908 feet of secondary underdrain. Record Drawing No. 3 shows the location of the secondary underdrain system. Details of the secondary underdrain system can be found on IFC Drawings A250 and A255 and a plan view of the location within the PSSA on IFC Drawing A300. The cross-section dimension of the secondary underdrain was 4 feet wide by 2 feet deep, providing a cross-sectional area of 8 square feet as shown on IFC Drawing A255. Ames excavated each secondary underdrain trench to the minimum dimensions, and placed geotextile and UF in the trench. SSF was then placed over the geotextile to a minimum depth of 6 inches. The secondary underdrain geosynthetic installation is discussed further in Section 3.1. Approximately 273 cubic yards of UF, 1,816 cubic yards of SSF, and 12,712 square feet of geotextile were used to construct the secondary underdrain.

2.2.3 Tertiary Underdrain System

Ames constructed 1,169 feet of tertiary underdrain. Record Drawing No. 3 shows the location of the tertiary underdrain system. Details of the tertiary underdrain system can be found on IFC Drawing A250. The cross-section dimension of the tertiary underdrain was 3 feet wide by 2 feet deep, providing a cross-sectional area of 6 square feet as shown on IFC Drawing A250. Ames excavated each tertiary underdrain trench to the minimum dimensions, and placed geotextile and UF in the trench. SSF was then placed over the geotextile to a minimum depth of 6 inches. The tertiary underdrain geosynthetic installation is discussed further in Section 3.1. Approximately 257 cubic yards of UF, 1,753 cubic yards of SSF, and 14,028 square feet of geotextile were used to construct the tertiary underdrain.

2.3 Closure Drain

A detailed design of the closure drain is provided in Appendix P of this report. The closure drain was originally described, conceptually, in the SGVLF Design Report (AMEC, 2011). At that time, the drain was preliminarily designed having five drilled shafts which extended a minimum of 10 feet into the diatreme formation. In the fall of 2013, AMEC further designed the Closure Drain. Based on in situ permeability testing of the diatreme, the project was revised to 12 drains to be installed into boreholes that penetrate the diatreme. Appendix P and Appendix Q outline the Closure Drain Design and Installation, respectively.

2.4 Site Grading

Prior to SF placement, Ames moisture conditioned and compacted the subgrade surface of the fill areas. AMEC monitored the preparation of the subgrade and verified that it met project technical specifications. With the exception of the south embankment, most of the site grading within the PSSA was in cut. In native ground, the in situ material was scarified to a depth of approximately 6 inches and SF placed. The SF material was placed in approximately 2-foot-loose lifts compacted with a minimum of four passes by a smooth drum vibratory roller. Ames placed approximately 1,951,986 cubic yards of SF for site grading in and around the Squaw Gulch VLF.

2.5 Subgrade Preparation

Prior to SLF placement, Ames moisture conditioned and compacted the entire surface of the 2013/2014 Squaw Gulch VLF with a smooth drum vibratory roller. The quality of the finished surface was maintained until SLF was placed.

2.6 Soil Liner Fill

Based on neat line survey, Ames placed and compacted approximately 53,074 cubic yards of SLF to the project technical specifications. Record Drawing No. 2 Appendix A presents the as-built surface of the SLF.

Ames processed the SLF for the PSSA Project construction from February 2013 through June 2014. The borrow material was worked through a custom-designed rotary mill and screen to remove oversized material from the SLF and to uniformly condition the material prior to stockpiling.

Ames began placing SLF for the PSSA June 2014 and completed placement in August 2014. The SLF was compacted to a minimum thickness of 12 inches by a smooth drum vibratory compactor. AMEC witnessed depth verification tests performed by Ames to confirm appropriate fill thickness. Areas where the SLF thickness was found to be non-compliant with the project technical specifications were re-worked and re-tested until the area was compliant. The depth verification is discussed further in Section 4.2.5. The specified minimum density was 95 percent of the maximum dry density at -2 percent to +3 percent of optimum moisture content as determined by standard Proctor tests performed by AMEC. Areas of the SLF that failed to meet the moisture density requirement were moisture conditioned, re-compacted, and re-tested until passing results were achieved.

2.7 PSSA Composite Liner System

The PSSA is a double geomembrane lined system with a secondary composite liner system and primary geomembrane layer separated by a LVSCF, as follows:

- The secondary composite liner system in the PSSA consists of a minimum of 12 inches of compacted SLF overlain by a layer of 100-mil SSMS LLDPE geomembrane (textured side down).
- The secondary geomembrane liner is covered by a minimum of 3 feet of LVSCF.
- The LVSCS was installed above the secondary geomembrane layer, including placement of the LVSCF, construction of the LVSCS sump, and installation of the solution collection piping. The LVSCS is discussed further in Section 2.8.
- The primary geomembrane liner consists of 100-mil smooth LLDPE geomembrane placed over the LVSCF.
- The HVSCS is installed over the primary geomembrane liner. The HVSCS consists of HVSCS piping, riser base plate, and DCF placed at a minimum of 2 feet thick. The HVSCS is discussed further in Section 2.9.

The installation of the geomembrane layers for the PSSA began June 2014 and completed October 2014. ECA installed approximately 1,423,778 square feet (neat line) of secondary (100-mil SSMS) and 1,423,241 square feet of primary (100-mil Smooth) geomembrane according to the project technical specifications.

Geomembrane installation for the PSSA is discussed further in Section 3.3. Ames anchored geomembrane in an anchor trench measuring 3 feet deep by 2 feet wide. Ames backfilled the anchor trenches with suitable anchor trench backfill material. In places where future geomembrane liner covers the anchor trench, SLF material was used to back fill the top 12 inches of the anchor trench. Ames placed anchor trench backfill in maximum 12-inch-thick-compacted lifts. Anchor trench backfill was compacted with a hand operated, minimum of 500 pound, vibratory compactor and "Jumping Jack" compactors to the project technical specifications.

2.8 Low Volume Solution Collection System

The LVSCS is comprised of LVSCF, perforated CPe solution collection piping, and the low volume solution collection riser pipes.

Ames installed the LVSCS riser pipes in August 2014, consisting of three 18-inch-diameter DR 11 high density polyethylene (HDPE) LVSCS riser pipes totaling 1,234 feet. Pipe sections were connected to each other by butt fusion welds. Laborers placed LVSCF under the pipe haunches and kept pipes in place during LVSCF placement.

Approximately 6,572 feet of 4-inch-perforated CPe piping was placed over the secondary geomembrane layer, prior to placement of LVSCF. Ames began installation of the 4-inch perforated CPe piping July 2014, and completed installation in August 2014. LVSCS pipe locations are shown on Record Drawing No. 5 in Appendix A. Ames began placing LVSCF on the secondary geomembrane layer within the PSSA in July 2014 and completed placement in September 2014. Ames processed LVSCF from June 2013 through September 2014 and placed approximately 158,772 cubic yards. In general, the LVSCF was placed in a minimum 3-foot-thick lift over the secondary geomembrane. LVSCF was placed around the LVSCS risers in a maximum 12-inch-loose lifts, and compacted using a hand-operated vibratory plate compactor in accordance to the project technical specifications.

2.9 High Volume Solution Collection System

The HVSCS is comprised of HVSCS piping, the HVSCS riser piping and foundation, and the HVSCS sump. The HVSCS riser is presented in IFC Drawings A330, A340, A345, A346, and A350; and the HVSCS piping layout and details are presented on IFC Drawings A400 and A410.

The HVSCS riser piping consists of four vertical risers with 24-inch outside diameter by 0.375-inch wall thickness carbon steel piping. Ames installed schedule 40 steel inlet pipe to connect the primary solution collection system piping to the vertical risers. Stainless steel Type 304 standard flow shutter screens with 0.25 inch slots, 20 foot minimum open screen section, 24-inch outside diameter by 0.375-inch wall manufactured by Roscoe Moss were installed as part of each vertical riser.

A 36-inch diameter DR 21 HDPE pipe was used as an equalizer pipe to connect the primary solution collection pipes at the entrance to the PSSA sump and to connect each riser. Ames installed approximately 72 feet of 36-inch diameter DR 21 HDPE equalizer pipe.

Each HVSCS riser foundation consists of a 10-foot by 10-foot by 1-inch steel base plate, a layer of conveyor belting, 3-inch-thick closed cell foam, and geocomposite clay liner. Ames installed approximately 400 square feet of each of these components.

Ames installed approximately 10,958 feet of 4-inch-diameter perforated CPe tertiary HVSCS pipe, 1,896 feet of 6-inch-diameter perforated CPe solution collection pipe, 2,032 feet of 12-inch-diameter CPe solution collection pipe, 1,564 feet of 24-inch-diameter perforated CPe solution collection pipe; 81 feet of 24-inch-diameter HDPE solution collection pipe, and 3,519 feet of 28-inch-diameter perforated DR 11 HDPE primary HVSCS pipe.

Ames began installing the perforated CPe HVSCS pipes in September 2014 and completed in November 2014. Pipe locations are shown on Record Drawing Nos. 6 and 7 in Appendix A. Ames placed DCF under the pipe haunches and kept pipes in place during DCF placement.

2.10 Drain Cover Fill

Ames began placing DCF September 2014 and completed placement November 2014. The DCF was processed by Ames from September 2013 through November 2014 by screening crushed are from the Cresson Project over a vibrating 1-½-inch screen to remove oversize material. Ames placed approximately 119,747 cubic yards (neat line) of DCF per the project technical specifications. The material was placed in a minimum 2-foot-thick lift over the geomembrane and in a 4-foot-thick lift where Caterpillar 740 haul trucks travelled over the geomembrane. During fill placement, Polyvinyl Chloride (PVC) grade markers were placed at grade breaks and on a maximum 50 foot wide by 50 foot long grid. After DCF placement, PVC grade markers were removed and Ames performed any additional final grading. Ames placed DCF in an uphill direction on any slopes steeper than 4H:1V.

3.0 GEOSYNTHETICS INSTALLATION

Geosynthetics installed consisted of geotextile and geomembrane. Non-woven geotextile (12 oz./yd^2) manufactured by TenCate Geosynthetics was used to construct the primary, secondary, and tertiary underdrains within the limits of the PSSA. The PSSA geomembrane liner system included 100-mil LLDPE Smooth and 100-mil SSMS LLDPE geomembrane manufactured by Agru America.

3.1 Underdrain System

Geosynthetics installation for the primary, secondary, and tertiary underdrains was performed by Ames and included deployment of 12-ounce-non-woven geotextile. Ames installed approximately 51,146 square feet of geotextile to construct the underdrains. Underdrain construction is discussed further in Section 2.2.

3.2 Closure Drain

Geosynthetics installation for the closure drain was performed by Ames and included deployment of 12-ounce-non-woven geotextile. Closure drain construction is discussed further in Section 2.3.

3.3 PSSA Geomembrane Liner System

Geomembrane installation activities for the PSSA geomembrane liner system include deployment; seaming; and non-destructive and destructive testing of 100-mil SSMS and 100-mil smooth LLDPE geomembrane. Ames anchored geomembrane at the limits of the PSSA in a minimum 2-foot-wide, by 3-foot-deep anchor trench. All geomembrane was placed on compacted and approved SLF for secondary geomembrane liner and approved LVSCF for primary geomembrane liner.

3.3.1 Secondary 100-mil LLDPE Single-Sided Microspike Geomembrane

The secondary geomembrane liner consisted of 100-mil SSMS LLDPE geomembrane placed textured side down. Secondary geomembrane panels were designated with an "S" for the secondary layer of liner followed by an individual panel number. Panels S-1 through S-409 were deployed yielding a total of 1,423,778 square feet of secondary geomembrane liner. See Record of Construction (ROC) Drawing No. 8 for the as-built panel layout in Appendix A.

3.3.2 Primary 100-mil LLDPE Smooth Geomembrane

The primary geomembrane liner consisted of 100-mil smooth LLDPE geomembrane. Primary geomembrane panels were designated with a "P" for the primary layer of geomembrane liner followed by an individual panel number. Panels P-1 through P-429 were deployed yielding a total of 1,423,241 square feet of primary geomembrane liner. See ROC Drawing No. 9 for the as-built panel layout in Appendix A.

3.4 High Volume Solution Collection System Riser Foundation

Geosynthetics installation for the High Volume Solution Collection System vertical riser pipe foundation was performed by Ames, and included deployment of geosynthetic clay liner; 3-inch-thick-closed cell foam; and salvaged conveyor belting.

4.0 EARTHWORK CQA TESTING AND MONITORING

The following sections summarize results of the earthwork CQA testing and monitoring performed by AMEC for the PSSA project.

AMEC performed CQA testing of in-place materials used for construction of the PSSA project. Table 4 presents specified and observed CQA testing frequencies. Figure 2 shows the construction and geomembrane installation limits and coordinate system used to locate tests.

In accordance with the AMEC Earthworks CQA Plan (Section 1400.1 of the project technical specifications in Appendix E), when an AMEC monitor observed deficiencies, the monitor determined the nature and extent of the problem and notified Ames and/or CC&V. AMEC then performed additional testing to define the extent of the deficient area. Ames corrected deficiencies to meet the requirements of the project technical specifications and AMEC re-tested the corrected area(s) prior to any additional related work. The following sections include discussions of the deficiencies encountered.

4.1 Results of Laboratory Soils Testing

AMEC performed laboratory testing of soils during all earthworks aspects of the PSSA construction at AMEC's on-site soils laboratory. To verify that the earthwork materials used during construction met project technical specifications, AMEC performed the following tests in accordance with the American Society for Testing and Materials (ASTM):

- Grain size distribution (ASTM D1140 for material finer than the No. 200 sieve, and ASTM C117 and C136 for coarse material)
- Moisture content (ASTM D2216)
- Atterberg limits (ASTM D4318)
- Standard Proctor compaction (ASTM D698)
- Permeability (ASTM D5084, Method D)
- In-place density testing (ASTM D6938)
- Soil description (ASTM D2488)
- Point load strength index (ASTM D5731, Method D)

The laboratory test results are summarized in Tables 5 through 11 and individual laboratory test results are presented in Appendix H.

4.1.1 Grain Size Distribution

AMEC analyzed the grain size distribution (gradation) of SF, SSF, leak detection fill (LDF), UF, SLF, LVSCF, and DCF. The results of the gradation analyses are presented in Appendix H.1 and summarized in Tables 5 through 11. Grain size distribution (gradation) was performed on CSB and the analyses are presented in Appendix O.5 and the individual test results presented in Appendix O.6.

AMEC performed 47 CQA gradations of SF. The actual testing frequency (approximately one test per 41,532 cubic yards) exceeded the minimum specified testing frequency of one test per 50,000 cubic yards. The SF CQA gradation results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 5.

AMEC performed two CQA gradations of SSF. The actual testing frequency (approximately one test per 3,550 cubic yards) exceeded the minimum specified testing frequency of one test per 50,000 cubic yards. The SSF CQA gradation results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 6.

AMEC performed one CQA gradations of LDF. The actual testing frequency (approximately one test per 1,814 cubic yards) exceeded the minimum specified testing frequency of one test per 10,000 cubic yards. The engineer approved Ames' request to use LVSCF in lieu of LDF, however the sample was still called LDF. The LDF CQA gradation results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 7.

AMEC performed 4 CQA gradations of UF. The actual testing frequency (approximately one test per 338 cubic yards) exceeded the minimum specified testing frequency of one test per 5,000 cubic yards. The UF CQA gradation results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 8.

AMEC performed 19 CQA gradations of SLF. The actual testing frequency (approximately one test per 2,793 cubic yards) exceeded the minimum specified testing frequency of one test per 4,000 cubic yards. The SLF CQA gradation results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 9.

AMEC performed 27 CQA gradations of LVSCF. The actual testing frequency (approximately one test per 5,880 cubic yards) exceeded the minimum specified testing frequency of one test per 10,000 cubic yards. The SLF CQA gradation results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 10.

AMEC performed 12 CQA gradations of DCF. The actual testing frequency (approximately one test per 9,979 cubic yards) exceeded the minimum specified testing frequency of one test per 20,000 cubic yards. The DCF CQA gradation results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 11.

4.1.2 Moisture Content

AMEC measured the moisture contents of SF, SSF, LDF, UF, SLF, LVSCF, and DCF as part of the CQA program. Moisture content data is presented in Tables 5 through 12. Note the oven moisture content testing for SLF is recorded on Table 12 under the heading of “Oven Moisture Content”.

4.1.3 Atterberg Limits

AMEC performed Atterberg limits testing of fill materials. All fill materials, with the exception of some SF and SLF, were non-plastic. The SF, SSF, LDF, UF, SLF, LVSCF, and DCF samples tested met project technical specifications for Atterberg limits. Atterberg limits test results are presented in Appendix H.1 and summarized on Tables 5 through 11.

AMEC performed 47 CQA Atterberg limits of SF. The actual testing frequency (approximately one test per 41,532 cubic yards) exceeded the minimum specified testing frequency of one test per 50,000 cubic yards. The SF CQA Atterberg limit results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 5.

AMEC performed two CQA Atterberg limit of SSF. The actual testing frequency (approximately one test per 3,550 cubic yards) exceeded the minimum specified testing frequency of one test per 50,000 cubic yards. The SSF CQA Atterberg limit results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 6.

AMEC performed one CQA Atterberg limit of LDF. The actual testing frequency (approximately one test per 1,814 cubic yards) exceeded the minimum specified testing frequency of one test per 10,000 cubic yards. The LDF CQA Atterberg limit results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 7.

AMEC performed 4 CQA Atterberg limit of UF. The actual testing frequency (approximately one test per 338 cubic yards) exceeded the minimum specified testing frequency of one test per 5,000 cubic yards. The UF CQA Atterberg limit results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 8.

AMEC performed 19 CQA Atterberg of SLF. The actual testing frequency (approximately one test per 2,793 cubic yards) exceeded the minimum specified testing frequency of one test per 4,000 cubic yards. The SLF CQA Atterberg limit results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 9.

AMEC performed 27 CQA Atterberg limit of LVSCF. The actual testing frequency (approximately one test per 5,880 cubic yards) exceeded the minimum specified testing frequency of one test per 10,000 cubic yards. The LVSCF CQA Atterberg limit results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 10.

AMEC performed seven CQA Atterberg limit of DCF. The testing frequency (approximately one test per 15,121 cubic yards) exceeded the minimum specified testing frequency of one test per 20,000 cubic yards. The DCF CQA Atterberg limit results met the project technical specifications; the results are presented in Appendix H.1 and summarized in Table 11.

4.1.4 Proctor Compaction Tests

Since the majority of the SF for the PSSA project contained more than 30 percent above the ¾-inch sieve, no proctor compaction tests were performed on the SF material. Per project technical specification 2200 Section 3.06, Subsection B, SF containing more than 30 percent above the ¾-inch sieve is placed using a method specification and cannot be tested using a Standard Proctor (due to the high rock content).

AMEC performed 19 CQA Standard Proctor compaction tests of SLF in order to compare in-place densities and moisture contents with laboratory derived values of maximum dry density and optimum moisture content. The actual testing frequency (approximately one test per 2,793 cubic yards) exceeded the minimum specified testing frequency of one test per 4,000 cubic yards. The SLF CQA compaction test results met the project technical specifications; the results are presented in Appendix H.2 and summarized in Table 9.

AMEC performed one standard Proctor compaction test of LVSCF in order to compare in-place densities and moisture contents with laboratory derived values of maximum dry density and optimum moisture contents beneath HVSCS riser base plates. There is no testing frequency for compaction testing for the LVSCF. The LVSCF CQA compaction test result is presented in Appendix H.2 and summarized in Table 10.

4.1.5 Permeability Tests

AMEC performed 19 permeability tests of SLF. The actual testing frequency (approximately one test per 2,793 cubic yards) exceeded the minimum specified testing frequency of one test per 4,000 cubic yards. Testing was performed with a flexible-wall permeameter with back-pressure saturation and a constant rate of flow (ASTM D5084, Method D). The SLF was re-compacted to the in-place density measured during nuclear density testing and the corresponding moisture content (as determined from oven-dried samples). The nuclear density value measured in the field was corrected for coarse particles according to ASTM D4718. Laboratory tests yielded coefficients of permeability for the CQA samples from 7.02×10^{-7} cm/sec to 4.14×10^{-8}

cm/sec, all of which meet or exceed the permeability specification of 1x10^{-6} cm/sec. The SLF CQA permeability limit results met the project technical specifications; the results are presented in Appendix H.3 and summarized in Table 9.

4.2 Field Testing and Monitoring

AMEC observed earthworks fill operations to verify lift thickness, adequate compaction, ambient air and fill temperatures and acceptable moisture conditions. Holes made in the SLF during testing were backfilled and tamped with fine bentonite powder. AMEC standardized the nuclear gauges at the start of each day according to ASTM D6938.

4.2.1 Underground Workings

AMEC monitored remediation of underground workings, including verification that excavations were performed to minimum required dimensions, and that CP, CRF, SF and course shaft backfill were installed as specified.

Concrete Plug and Cemented Rockfill

AMEC observed and documented testing of approximately 433 cubic yards of concrete for slump, air entrainment, temperature, placement time, and compressive strength. All tests met the compressive strength specification and the results are summarized in Appendix O.3 and individual concrete test reports located in Appendix O.4.

AMEC observed the placement of CRF, including verification of all batch tickets adhering to the approved mix design.

Coarse Shaft Backfill

AMEC observed and documented testing of 184 cubic yards of CSB and performed grain size distribution (gradations) and Atterberg limits on the material. AMEC performed 2 CQA gradation and Atterberg limit tests. No testing frequency is specified for CSB. The CQA earthworks testing summary is presented in Appendix O.5 and individual test reports are presented in Appendix O.6.

4.2.2 Underdrains

AMEC verified that the underdrains were constructed as specified in the IFC Drawings and project technical specifications. UF material was placed a minimum of 5 feet wide by 3 feet deep in the primary underdrain trenches; 2 feet deep by 4 feet wide in the secondary underdrain trenches; and 2 feet deep by 3 feet wide in the tertiary underdrain trenches. All oversized and unsuitable material was removed from the UF prior to final placement. AMEC monitored the installation of the geotextile in the underdrains, ensuring that the geotextile overlap was adequate, and a minimum of 6 inches of SSF placed on the top of the geotextile.

4.2.3 Closure Drains

AMEC verified that the closure drain was constructed in accordance to the Closure Drain Basis of Design Report (presented in Appendix P). All closure drain material testing was incorporated into the PSSA testing frequencies and quantities. All materials met project technical specifications.

4.2.4 Structural Fill

AMEC monitored subgrade preparation, including verification that Ames compacted the SF with a smooth drum vibratory compactor. It was also verified that Ames removed protruding rocks from the SF surface prior to SLF placement, the fill was moisture conditioned during placement, the final surface was smooth and unyielding prior to SLF placement.

The majority of the SF material contained more than 30 percent by weight larger than ¾ inch, and was placed by method specification per project technical specification 2200, Section 3.06 Subsection B. AMEC verified that the SF did not exceed 24 inches and that lifts were not larger than 1-½ times the maximum particle size. It was also verified that Ames made a minimum of four passes with a 10-ton static drum weight smooth drum vibratory roller.

4.2.5 Soil Liner Fill

Field testing for SLF included monitoring of placement and preparation of the finished SLF surface for geomembrane deployment, testing in-place moisture and density with a nuclear gauge, and monitoring depth verification.

Field Monitoring

AMEC observed SLF placement to verify lift thickness, adequate compaction, acceptable moisture conditions, final compacted thickness, and suitability for geomembrane deployment. AMEC CQA personnel identified angular particles, ruts, desiccation cracks on the SLF surface and brought these flaws to the attention of Ames for repair. Ames completed repairs by placing fines from the SLF processing plant or from temporary stockpiles of fine SLF to smooth and re-compact the fill surface in areas that were observed to be rough or inadequate for geomembrane deployment, as discussed in Section 2.6. AMEC and ECApplications approved the final surface of SLF prior to geomembrane deployment.

Moisture Density Test Results

AMEC performed a total of 175 in-place moisture-density tests of SLF. AMEC compared results of the field moisture content and density tests to the standard Proctor dry density and optimum moisture content values of material with similar gradation and plasticity characteristics. Proctor dry density and optimum moisture content values for samples with greater than 10 percent plus ¾ inch were tested to ASTM D4718 to facilitate direct comparison to nuclear density values. The actual moisture-density testing frequency of approximately one test per 303 cubic yards exceeded the minimum specified testing frequency of one test per 500 cubic yards per project technical specifications. Nuclear density tests performed for the PSSA are summarized in Table 12. Any failing areas were reworked, re-compacted, and re-tested to meet project technical specifications. The number of retests was not used to determine the testing frequency. Holes made in the SLF during testing were filled by tamping fine SLF or bentonite material into the holes, as specified.

Depth Verification

Ames performed depth verification using a drill, a total of 109 depth checks were performed to verify that the minimum 12-inch-compacted depth had been achieved. AMEC monitored the SLF depth verification tests and documented the results. Depth verification holes were filled using bentonite. All compacted SLF thicknesses as measured by the verification holes met or exceeded project requirements. The testing frequency of 3.3 holes per acre exceeded the minimum specified testing frequency of two holes per acre. The SLF depth verification results are presented in Table 13.

4.2.6 Low Volume Solution Collection Fill

AMEC provided visual monitoring of the LVSCF placement. One AMEC monitor and at least two Ames laborers were monitoring each dozer, unless two dozers were within approximately 50 feet of one another during placement. AMEC verified that wrinkles in the geomembrane did not fold over, that PVC grade markers were placed on a maximum 50-foot by 50-foot grid and at grade breaks, and that material met project technical specifications. AMEC continuously inspected secondary geomembrane liner during LVSCF placement, marked areas on the geomembrane liner for repair if required, and verified that all repairs were completed. After final grading, AMEC monitored the removal of the PVC grade markers.

Moisture Density Test Results

AMEC performed a total of 4 in-place moisture-density tests of LVSCF under the HVSCS risers. AMEC compared results of the field moisture content and density tests to the standard Proctor dry density and optimum moisture content values of material with similar gradation and plasticity characteristics. Proctor dry density and optimum moisture content values for samples with greater than 10 percent plus ¾-inch were tested to ASTM D4718 to facilitate direct comparison to nuclear density values. The actual moisture-density testing frequency was approximately one test per 39,692 cubic yards. There is no testing frequency specified for moisture-density on LVSCF. Nuclear density tests performed for the PSSA are summarized in Table 14.

4.2.7 Drain Cover Fill

AMEC provided visual monitoring of DCF placement. One AMEC monitor and at least two Ames laborers were present monitoring each dozer, unless two dozers were within approximately 50 feet of each other during placement. AMEC verified that wrinkles in the geomembrane did not fold over, that PVC grade markers were placed on a maximum 50-foot by 50-foot grid and at grade breaks, and that material met project technical specifications. AMEC continuously inspected primary geomembrane during DCF placement, marked areas for repair, if required, and verified that all repairs were completed to project technical specifications. After final grading, AMEC monitored removal of PVC grade markers

4.2.8 Temperature Monitoring

AMEC monitored ambient air temperatures every hour when temperatures were approaching freezing. The lowest and highest daily temperatures are summarized in Table 1.

During placement of fill materials, when the ambient air temperature was less than 32°F for longer than 1 hour in the previous 24 hours, AMEC was required to monitor the fill temperatures at depths of 3 inches and 6 inches, at a frequency of 6 tests per acre, and calculate the average fill temperature from the lower temperature of the 3 inch and 6 inch tests. AMEC verified that no frozen material was placed during the construction of the PSSA. Fill temperature monitoring in summarized in Table 2.

5.0 GEOSYNTHETICS QC SUBMITTALS

Geosynthetics QC submittals reviewed by AMEC included installation personnel résumés, geomembrane resin certificates, geomembrane roll certificates, welding rod certificates, and geotextile certificates. AMEC's inventory control, summarizing QC certification received for each roll of geomembrane liner received for the Project are presented in Appendix I.2 and Appendix I.3Appendix I. Geosynthetic material used for PSSA construction met project technical specifications.

5.1 Geomembrane Installation Personnel Résumés

AMEC reviewed the résumés of ECA installation personnel to verify the installation superintendent and the seaming personnel possessed sufficient geomembrane installation experience as required by the project technical specifications. Review of the installation personnel résumés indicated key personnel had sufficient experience to meet or exceed project technical specifications. Geomembrane personnel résumés are presented in Appendix I.1.

5.2 Geomembrane QC Documents

Geomembrane QC documents submitted by ECA to AMEC include resin supplier certificates and geomembrane manufacturer resin certificates, geomembrane roll certificates, and welding rod certificates. AMEC reviewed QC documents prior to geomembrane placement and verified the documentation was complete and the material properties and QC testing frequency required by the project technical specifications were met.

5.2.1 Resin QC Certificates

LLDPE polymer raw material (resin) QC certificates were provided by the resin manufacturer, Chevron Phillips Chemical Company, at a frequency of one per rail car shipment. Geomembrane used on this project was produced from six batches of resin. The geomembrane manufacturer also performed density and melt index tests of the resin supplied by Chevron Phillips Chemical Company to confirm material properties prior to geomembrane manufacture. AMEC verified these certificates prior to geomembrane placement and they are presented in Appendix I.6 and Appendix I.7. Note one of the six resin lots was used in production of both the smooth and SSMS LLDPE geomembrane liners.

5.2.2 Roll QC Certificates

ECA provided QC manufacturer certificates for each roll (approximately one every 10,000 square feet) of LLDPE geomembrane used for the project, exceeding the required minimum frequency of one per 150,000 square feet of geomembrane. AMEC reviewed the QC certificates to verify conformance testing of the geomembrane to meet the project requirements. Geomembrane was placed only when complete QC documentation was provided and AMEC determined the test results met or exceeded project technical specifications. The secondary 100-mil LLDPE SSMS geomembrane QC roll certificates are presented in Appendix I.4 and the primary 100-mil LLDPE smooth geomembrane QC roll certificates are presented in Appendix I.5.

5.2.3 Welding Rod QC Certificates

Welding rod certification consisted of resin QC documents for the resin used to manufacture the welding material for the Project. The welding material used for the PSSA was produced from six batches of resin. Not all resin lots used to produce the welding rod resin were from the same resin lots as the 100-mil SSMS and smooth LLDPE geomembrane. AMEC's review of the QC certification indicates the resin used to manufacture the welding material met project technical specifications. The welding rod QC certificates are presented in Appendix I.8.

5.3 Geotextile QC Documents

Geotextile, manufactured by TenCate was used during construction of the underdrain systems. AMEC's review of the QC certificates indicates the geotextile met project technical specifications. Geotextile QC certificates are presented in Appendix I.9.

6.0 GEOMEMBRANE CQA TESTING AND MONITORING

The following sections describe the CQA activities performed by AMEC for the geomembrane installed for the PSSA.

In accordance with the AMEC Geosynthetics CQA Plan (Section 01400.2 of the project technical specifications in Appendix E), when an AMEC monitor observed deficiencies, the monitor determined the nature and extent of the problem by performing additional testing to define the extent of the deficient area. ECA and/or CC&V were notified of the deficiency for repairs. ECA corrected deficiencies to meet the requirements of the project technical specifications, and AMEC re-tested the corrected deficiency prior to any additional related work.

CQA activities conducted by AMEC during the installation of the LLDPE geomembrane for the PSSA consisted of the following:

- Conformance sampling and testing of the geomembrane
- Observation and approval of the SLF surface prior to deployment of 100-mil SSMS LLDPE geomembrane
- Observation and documentation of geomembrane deployment, including verifying sheet thickness and overlap, documenting the approximate panel length and width, and documenting panel layout
- Observation of trial seam sample testing and documentation of results
- Observation and documentation of field seaming
- Identification of destructive seam sample test locations, observation of destructive seam sample testing, and documentation of test results
- Observation and documentation of geomembrane repairs
- Observation and documentation of non-destructive pressure testing of fusion seams and vacuum testing of extrusion seams and repairs

The following sections present a detailed description of each of the above activities.

6.1 Geomembrane Conformance Testing

Geomembrane manufactured by Agru America was installed at the PSSA. A TRI/Environmental (TRI) (AMEC subcontractor) representative sampled and performed geomembrane conformance testing at the Agru plant in Fernley, Nevada. Samples were sent to TRI's geosynthetic laboratory for conformance testing. Geomembrane rolls were not used on the project until approved by AMEC based on conformance test results.

Prior to the 100-mil LLDPE smooth and SSMS geomembrane arrival to site, AMEC performed 11 conformance tests on the smooth geomembrane, at a frequency of one test per 147,095 square feet. Eleven conformance tests were performed on the SSMS geomembrane, at a frequency of one test per 145,423 square feet. The minimum specified testing frequency of one test per 150,000 square feet was exceeded. Conformance testing for the 100-mil smooth and SSMS LLDPE geomembrane used to construct the PSSA's liner system met project technical specifications. Conformance test results are presented in Appendix L.

6.2 Deployment Monitoring

Geomembrane panel deployment monitoring performed by AMEC included:

- Observation of panel surface condition and panel overlap
- Assignment of panel numbers
- Verification of factory roll number and receipt of complete certification prior to allowing deployment
- Measurement of sheet thickness
- Documentation of deployed panel lengths
- Development of panel layout record drawing

Prior to the deployment of geomembrane, AMEC and ECA verified that the SLF surface was free of soft spots, protrusions, angular particles, abrupt grade changes, and loose soil. AMEC and ECA also verified the surface had been proof rolled and was free of desiccation cracks. Where the surface of the SLF did not meet project technical specifications, Ames repaired the area and re-compacted the surface. AMEC prepared SLF surface acceptance forms, after inspections of the finished surface; an Ames and AMEC representative signed the acceptance forms. The acceptance certificates are presented in Appendix G.

AMEC assigned each geomembrane panel a number. Secondary geomembrane panels were designated with a "S" for the secondary layer of liner followed by an individual panel number. Panels S-1 through S-409 were deployed. Primary geomembrane panels were designated with a "P" for the primary layer of geomembrane liner followed by an individual panel number. Panels P-1 through P-429 were deployed.

AMEC marked the panel designation and roll number directly on each panel after deployment. Ames surveyed all panel intersections and destructive seam sample locations. Using these points AMEC generated the record drawings for the primary and secondary geomembrane, showing the Project geomembrane panel layout and destructive testing locations. These are presented as Record Drawing Nos. 8 and 9 in Appendix A.

During geomembrane deployment, AMEC measured the geomembrane sheet thickness with calibrated callipers. Sheet thickness was measured at five random locations along the edge of each geomembrane panel. The average thickness specified for the 100-mil geomembrane exceeded 100 mils. Project technical specifications for 100-mil geomembrane required that the average of the five thickness measurements be no less than the 100 mils, and that no individual measurement be less than the nominal thickness minus 10 mils (i.e., 90 mils). The thickness monitoring provided by AMEC indicated that all of the panels met or exceeded project requirements.

AMEC personnel measured deployed panel lengths using a measuring wheel. Recorded lengths were approximate, and do not reflect any trimming or adjustments made for final placement or anchor trench lengths.

AMEC personnel observed the surface of each deployed panel and logged any penetration defects and marked them on the panel. Section 6.4 provides further discussion of repairs. AMEC confirmed the overlap of each panel with adjacent panels was sufficient for seaming; any insufficient panel overlaps were logged as defects and marked for correction.

Secondary and Primary LLDPE geomembrane liner deployment observations are presented in Appendix J.1 and Appendix K.1, respectively.

6.3 Seaming

The double wedge fusion weld was the principal seaming method employed by ECA for the PSSA. ECA fusion seamed (welded) geomembrane on the same day it was deployed. AMEC observed trial seam tests, monitored seaming equipment temperatures and speed, and provided visual observation of the seaming procedures. AMEC observed the entire lengths of all seams, patches, and other repairs either during seaming, or shortly after completion.

6.3.1 Trial Seam Monitoring

ECA performed trial seams to monitor the performance of the seaming apparatus and operator under actual site conditions. Each welding operator and his apparatus produced trial seams prior to the beginning of each day's seaming operation, after all work activity stoppages, and in the event that devices were disconnected from power and re-energized.

ECA cut 1-inch-wide samples (coupons) from each trial seam and tested the coupons with a field tensiometer. ECA tested each double wedge fusion trial seam twice for peel adhesion (peel) and once for bonded seam strength (shear). Tests were conducted on fusion welds on both the inner and outer tracks of each peel coupon. ECA tested each extrusion trial seam twice for peel and once for shear.

AMEC personnel observed trial seam sample testing and documented test results. Tensile testing of each trial seam coupon was observed to verify project yield strengths were met during shear testing and failure did not occur in the weld during peel testing. When trial seams did not meet project technical specifications, AMEC verified the welding apparatus was not used until two consecutive trial seams performed by the same technician/apparatus combination met project technical specifications. The trial seam test results for extrusion and fusion seaming are presented in Appendix J.2 for the secondary (100-mil LLDPE SSMS) geomembrane liner and Appendix K.2 for the primary (100-mil LLDPE Smooth) geomembrane liner. ECA used one tensiometer during the project and one spare tensiometer was maintained on site. Tensiometer certifications are presented in Appendix M. Figures 3 and 4 show the codes used to designate passing and failing test results.

6.3.2 Seaming Observations

AMEC personnel observed seams before, during, and after welding. Each seam was checked for adequate overlap prior to welding and to verify the seam area was dry and clean of any debris.

AMEC documented ECA personnel performing the seaming and the seaming equipment used. Following the completion of seaming and repairs, AMEC checked the full length of each seam to verify no additional repairs were required. In the event additional repairs were needed, AMEC marked the location on the geomembrane, documented the location, and ECA completed the repair. Once ECA completed repairs, an AMEC representative verified the repair met project technical specifications. All seams were inspected for quality and completion. AMEC personnel conducted a final walk through and inspection of the geomembrane surface and completed acceptance forms to verify completion of geomembrane liner per project technical specifications. The secondary and primary geomembrane liner acceptance notifications are presented in Appendix J.7 and Appendix K.7, respectively.

AMEC recorded observations made during seaming. The geomembrane layer and the fusion and extrusion welding met project technical specifications; and a summary is presented in Appendix J.3 for the secondary (100-mil LLDPE SSMS) geomembrane liner and Appendix K.3 for the primary (100-mil LLDPE Smooth) geomembrane liner.

6.4 Defect and Repair Observations

AMEC inspected geomembrane panels for damage that may have occurred during manufacture, transport, deployment, or installation as discussed in Section 6.2. Damage noted (during or after deployment) by AMEC was reported. AMEC observed all panels and seams to verify defects were repaired prior to DCF placement.

The summaries of defects and repairs, including the approximate locations of each repair, are presented in Appendix J.4 for the secondary (100-mil LLDPE SSMS) geomembrane liner and Appendix K.4 for the primary (100-mil LLDPE Smooth) geomembrane liner.

6.5 Destructive Testing

AMEC selected destructive test locations based on ECA's completion of welding for the geomembrane, various working conditions, and on seaming observations (e.g., suspicion of a defective weld). ECA obtained and tested 164 secondary geomembrane liner fusion seam destructive samples and 4 extrusion seam destructive samples. ECA obtained and tested 155 primary geomembrane liner fusion seam destructive samples and 4 extrusion seam destructive samples.

ECA constructed approximately 74,229 lineal feet of secondary geomembrane liner and 74,343 lineal feet of primary geomembrane liner fusion welded seams. The specified frequency of destructive testing was one test per 500 lineal feet of weld. AMEC identified, and ECA obtained, destructive samples from the panel seams at a frequency of one destructive test sample per 453 lineal feet of fusion welded seam for secondary geomembrane liner and one destructive test sample per 480 lineal feet of fusion welded seam for primary geomembrane liner. The actual test frequencies exceeded project requirements.

During the PSSA geomembrane liner portion of the project, extrusion welds were not used for seaming, only repairs.

The summaries of destructive test results for fusion seams of the secondary (100-mil LLDPE SSMS) geomembrane liner and primary (100-mil LLDPE Smooth) are presented in Appendix J.5 and Appendix K.5, respectively. Record Drawing Nos. 8 and 9 presented in Appendix A and shows the destructive test sample locations for secondary geomembrane and primary geomembrane respectively.

6.6 Non-Destructive Testing

ECA performed non-destructive seam testing on completed seams and geomembrane repairs. Non-destructive testing for seams included pressure testing fusion welded seams and vacuum testing extrusion-welded seams and repairs. AMEC monitored and documented the non-destructive testing.

Prior to pressure testing fusion seams, ECA heat sealed both ends of the air channel between the two tracks of the double-wedge weld. A pressure gauge was inserted in one end of the sealed channel; the channel was pressurized to approximately 30 pounds per square inch (psi) using an air pump. After pressure stabilization, AMEC monitored the gauge for a minimum of 5 minutes. The maximum allowable pressure drop was 3 psi over a 5 minute period. After the 5 minute period was completed, ECA cut the opposite end of the seam with the gauge left in place. If the gauge pressure dropped to zero, the seam was determined to be continuous. In cases where the seam was found to be discontinuous (evident by no pressure drop at gauge upon cutting the opposite end of the seam), the seam was subdivided into shorter sections until continuous seam sections were located and passing pressure tests were performed. Failed portions of the seam were capped.

If a pressure test failed, ECA checked the seam section for leakage, and repaired and re-tested the seam or capped it. If ECA was unable to find the leak, the seam was divided into two sections, each section being tested to locate the area of concern. This subdivision process was repeated until the leak location was identified. If the leak area was not located, ECA capped the seam and vacuum tested the repair.

ECA tested extrusion welded seam sections and repairs with a vacuum box. Prior to vacuum box testing, a soap and water solution was applied to the seam section. The vacuum box was placed over the seam area and energized with a pump capable of creating a vacuum of not less than 5 psi. ECA and AMEC observed the action of the vacuum on the seam for a minimum of 10 seconds. Each consecutively tested seam length was overlapped a minimum of 3 inches. If soap bubbles appeared, AMEC marked and documented the leak location. ECA repaired the leak and vacuum tested the repair. This procedure was also followed to test extrusion welds associated with repairs and patches.

The seam non-destructive test summaries (fusion pressure tests and extrusion vacuum tests) for the secondary (100-mil LLDPE SSMS) and primary (100-mil LLDPE Smooth) geomembrane liner are presented in Appendix J.6 and Appendix K.6, respectively.

AMEC personnel conducted a final walk through and inspection of the geomembrane surface and completed acceptance forms to verify completion of geomembrane liner prior to LVSCF placement over secondary geomembrane liner or DCF placement over the primary geomembrane liner. The secondary and primary geomembrane liner acceptance notifications are presented in Appendix J.7 and Appendix K.7, respectively.

7.0 Project Deviations

7.1 Drawing Deviations

During construction several drawing changes were made to clarify construction. A list of those changes are discussed below.

- IFC Drawings A204, A205, and A206, was which was originally issued for construction on January 7, 2013 were replaced with the same drawing numbers on February 13, 2014. The SGVLF PSSA Embankment and SGVLF Adsorption Desorption Recover (ADR) platform grading was revised.
- IFC Drawing A207 was added to the IFC set January 10, 2014 and revised on January 24, 2014 to provide additional detail to grading of the ADR Plant platform.
- IFC Drawing A240 revised the haul road design to include a turnout for haul trucks and widen the road to allow large truck traffic
- IFC Drawing A249 revised the Bench B alignment
- IFC Drawing A255 added additional details and clarifications to the underdrain ponds
- IFC Drawings A256, A265, A300, A310, A316, and A440 was updated to reflect the revised PSSA embankment revisions from sheet A204
- IFC Drawing A320 revised the liner limits
- IFC Drawing A330 revised the setting out data
- IFC Drawing A345 revised riser elevations
- IFC Drawing A350 revised the riser sections
- IFC Drawing A360 revised closure drain section
- IFC Drawing A400 removed extra 12-inch pipe around perimeter of the PSSA
- IFC Drawing A420 relocated the LVSCS

Localized changes in grading and alignments occurred throughout the PSSA during construction. These slight deviations have been recorded in the ROC drawings in Appendix A.

The above drawing additions, clarifications, or deviations do not effect the SQVLF design as permitted.

7.2 Project Technical Specification Deviations

During construction, requests were made by the contractor (Ames) to deviate from the project technical specifications, below is a summary of the project technical specification deviations.

- AMEC allowed the use of LVSCF material in place of LDF.

- The project technical specifications calls for all tensiometers used at the project to be calibrated within 60 days prior to the tensiometer arriving on-site for testing field samples. AMEC contacted Demtech regarding the self-calibrating machines and the industry standard of calibrations. AMEC accepted the calibration certificates from within the year the project started.

- The project technical specification states “The rolls (of liner) shall be stored on a prepared surface (not wooden pallets) and should not be stacked more than two rolls high”. AMEC allowed the rolls of liner to be stacked three rolls high provided safety measure were in place to prevent rolls from shifting at any time and personnel refrain from climbing on the rolls to access the lifting straps.

- The resin certificates provided for the welding rod do not match the resin lots used during production of the 100-mil SSMS and smooth LLDPE geomembrane; however, the resin lots that were used are acceptable per project technical specifications.

8.0 CONCLUSIONS

In accordance with our responsibilities as the Project Engineer and as the Quality Assurance Consultant for construction of the PSSA Project, and per the requirements of the various applicable DRMS approvals, AMEC attests that it observed and performed the required CQA activities during construction of the PSSA Project. Based on daily communications with AMEC personnel, observations made during on site visits, and review of the laboratory and field test results, AMEC attests that the PSSA Project was constructed in compliance with the design plans and project technical specifications as described in this document.

Sincerely,

AMEC Environment & Infrastructure, Inc.

Thorne Clark
Project Resident (January 2012 through October 2013)

Tim Burkhard
Project Resident (November 2013 through November 2014)

Andrea L. Meduna

Andrea L. Meduna, PE
Certifying Engineer

alm/ALM

FINAL CERTIFICATION

CRESSON PROJECT
QUALITY ASSURANCE
PREGNANT SOLUTION STORAGE AREA PROJECT
TELLER, COUNTY, COLORADO

I, Andrea L. Meduna, a Registered Professional Engineer in the State of Colorado, hereby certify that the construction of the Squaw Gulch Valley Leach Facility Pregnant Solution Storage Area Project was completed in compliance with the drawings and project technical specifications approved as part of Permit Number M-1980-244, Amendment No. 10 as well as subsequent changes as approved by the Office of Mined Land Reclamation.

AMEC Environment & Infrastructure, Inc.

COLORADO LICENSED
ANDREA L. MEDUNA
48325
11/19/2014
PROFESSIONAL ENGINEER

Andrea L Meduna

Andrea L. Meduna, PE CO. No. 48325

November 19, 2014

Date