CCR Landfill Final Cover Test Pad

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ABSTRACT

Final covers of coal combustion residuals (CCR) landfills sometimes incorporate geomembranes to control post-closure infiltration. To prevent puncture of the geomembrane, specifications may only allow a maximum particle size of 1-inch (2.5 cm) for cover soil, 0.5 in (1.3 cm) protrusions in the geomembrane subgrade, and low traffic loads. Larger adjacent particles typically require thicker protective geotextiles.

An integrated drainage system (IDS) geomembrane, which provides both a low permeability membrane and drainage space above the geomembrane, was proposed for use at a CCR landfill in West Virginia (WV). A final cover system test pad was constructed of 50 mil (1.25 mm) High Density Polyethylene (HDPE) IDS geomembrane, 8 oz/yd² (271 g/m²) nonwoven geotextile to prevent movement of soil into the drainage space, and cover soil for vegetative growth, to evaluate cost-saving construction specifications. The test pad was constructed to evaluate 1 in (2.5 cm) maximum subgrade protrusions, cover soil with a 9 in (23 cm) maximum particle size, and heavy traffic loads.

After placement of 3 ft (0.9 m) of cover soil using a low-ground-pressure dozer, a fully-loaded 45-ton (40.8 t) truck made 100 passes over part of the test pad to simulate its use as a temporary access road. Portions of the test pad were then exhumed. It was concluded that for the soils and rock types present at the subject site, subgrade protrusions up to 1 in (2.5 cm) were acceptable and rocks up to 9 in (23 cm) in the cover soils were also acceptable. Based on this test pad, the specifications were approved by WV Department of Environmental Protection (WVDEP). A second partial exhumation two years later confirmed the original test pad conclusions.

1.0 Background and Purpose

GAI Consultants, Inc. (GAI) is the engineer of record for an active landfill located in West Virginia and owned by a North American electric utility company. The landfill is permitted for disposal of fly ash, bottom ash, and synthetic gypsum by the WVDEP. The approximate surface area of the completed landfill will be 192 ac (77.7 ha).
A final cover system design was submitted to the WVDEP to meet the requirements of 40 Code of Federal Regulations Part 257.102, “Criteria for conducting the closure or retrofit of coal combustion residual (CCR) units”, published April 17, 2015 (EPA Rule).

The Geosynthetic Institute’s “Standard Guide for Constructing Test Pads to Assess Protection Materials Intended to Avoid Geomembrane Puncture” (GRI Guide GS11) provides guidance on methodology and construction of field test pads to assess puncture performance of geomembranes. Based on GRI GS11 (modified), a 46 ft (14.0 m) wide by 103 ft (31.4 m) long test pad, consisting of a lower and upper bench, and separated by a 3 horizontal to 1 vertical (3H:1V) slope, was constructed at the landfill site to establish appropriate specifications for the landfill final cover design and construction. Specifically, the test pad was to determine:

- Whether up to a 1 cm (2.5 cm) subgrade protrusion on a bench or 3H:1V slope would puncture the IDS geomembrane during final cover soil placement.
- Whether final cover soil with a 9 in (23 cm) maximum particle size would excessively damage the IDS geotextile or puncture the IDS geomembrane during placement on a bench or 3H:1V slope.
- Whether a 1 in (2.5 cm) subgrade protrusion on the bench would puncture the IDS geomembrane during trafficking of a fully-loaded 45-ton (40.8 t) truck with over 3 ft (0.9 m) of cover soil on the bench.
- Whether final cover soil with a 9 in (23 cm) maximum particle size would excessively damage the IDS geotextile or puncture the IDS geomembrane during trafficking of a fully-loaded 45-ton (40.8 t) truck driving over 3 ft (0.9 m) of cover soil on the bench.
- Whether placement of the final cover soil would meet compaction specifications if placed in a single lift, or whether it needed to be placed in two lifts.

Previous laboratory testing and slope stability analyses determined that a minimum 85% Standard Proctor (ASTM D 698) maximum dry density (SPMDD) within 3% of optimum moisture content (OMC +/- 3%) was required for the subgrade soil and final cover soil at the geosynthetic interfaces to achieve a veneer stability factor of safety against sliding of 1.5; therefore, 85% SPMDD at OMC +/- 3% was the minimum required density and moisture content range for subgrade soil and final cover soil.

The purpose of this paper is to describe the materials, procedures, and equipment used to construct the landfill final cover system test pad and the evaluations of the completed test pad.

2.0 Test Pad Description

2.1 Final Cover System

To meet the WVDEP permit and EPA Rule, the following design and construction components were used for the final cover system of the landfill (from the bottom up):

- A minimum 6 in (15 cm) thickness of soil overlying CCR on landfill slopes and intermediate benches;
50 mil (1.25 mm) HDPE IDS geomembrane;
- Minimum 8 oz/yd² (271 g/m²) non-woven geotextile (IDS geotextile);
- A 6 in (15 cm) diameter perforated bench collection pipe within American Association of State Highway and Transportation Officials (AASHTO) Number 57 aggregate and geotextile installed at the toe of slope (bench drain) to collect both bench and slope drainage;
- Minimum 18 in (0.46 m) thickness of final cover soil over the IDS geomembrane and geotextile; and
- Vegetation.

With the exception of vegetation, the final cover system components were included in the test pad.

The IDS geomembrane is manufactured to provide a studded drainage surface on the top side and a spiked friction surface on the bottom side. When covered with an IDS geotextile, a drainage layer is created between the IDS geotextile and IDS geomembrane sheet, as shown in Figure 1.

**Figure 1. Final cover system cross section. Note drainage space between geotextile and IDS geomembrane. (Not to scale, figure courtesy of Agru)**

The Agru America, Inc. (Agru) product Super Gripnet® 50 mil (1.25 mm) HDPE liner was selected as the IDS geomembrane and AgruTex 081, a nonwoven geotextile, was selected as the IDS geotextile for the test pad. Agru specifications require the IDS geotextile overlying Super Gripnet® IDS geomembrane be nonwoven.
Subgrade protrusions of 1 in (2.5 cm) and final cover soil rocks up to 9 in (23 cm) in maximum dimension were used in the test pad to determine whether these features would damage the IDS geotextile or puncture the IDS geomembrane.

The test pad was also used to evaluate placing cover soil in two lifts or a single lift, and the effect of construction traffic on the geosynthetics. Therefore, one-half of the test pad was constructed with the 12 in (30.5 cm) lift overlain by a 6 in (15 cm) lift (Figure 2), and the other half was constructed with 18 in (46 cm) of cover soil placed in one lift (Figure 3).

Presuming construction equipment may need to utilize the bench of the completed areas for access during placement of the final cover system, a temporary access road investigation was also performed. The investigation consisted of the placement of an additional 18 in (46 cm) of cover soil [3 ft (0.9 m) total] on the lower test pad bench, then trafficking the bench with a fully loaded 45 ton (40.8 t) articulated truck. Out of concern the test pad might fail with 1 in (2.5 cm) subgrade protrusions or 9 in (23 cm) cover soil rocks, a portion of the bench was constructed with cushion geotextile beneath the IDS geomembrane and cover soil with a maximum particle size of approximately 4 in (10 cm). The resulting combinations of materials tested in the various test pad subareas are presented on Table 1 and Figures 2, 3, 4, and 5.

Subgrade soil and cover soil were collected from the site stockpiles. These soils were typically clayey and contained significant portions of gravel and cobbles.

<table>
<thead>
<tr>
<th>Test Pad Portion</th>
<th>Maximum Angular Subgrade Protrusion in (cm)</th>
<th>Cover Soil Lift Thickness</th>
<th>Cover Soil Maximum Rock Size, First Lift in (cm)</th>
<th>Cushion Geotextile Between Subgrade and Geomembrane?</th>
<th>Tested as Haul Road?</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>1 (2.5)</td>
<td>12 (30.5)</td>
<td>6 (15)</td>
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</tr>
<tr>
<td>B</td>
<td>1 (2.5)</td>
<td>18 (46)</td>
<td>NA</td>
<td>No</td>
<td>No</td>
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<tr>
<td>C &amp; E</td>
<td>1 (2.5)</td>
<td>12 (30.5)</td>
<td>6 (15)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>D &amp; F</td>
<td>1 (2.5)</td>
<td>18 (46)</td>
<td>NA</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

NA = Not applicable
Figure 2. Test Pad Cross Section Subareas C, E, and A
Figure 3. Test Pad Cross Section Subareas D, F, and B

1. Unprocessed soil had rocks and woody material greater than 9 in (23 cm) in any dimension removed prior to placement.
Figure 4. 2016 Test Pad Schematic
Figure 5. Areas Exhumed in 2018
2.2  Test Pad Dimensions
It is recommended by GRI GS11 that the test pad width be at least 100% greater than the equipment width for each tested condition. The test pad was two geomembrane roll widths wide, minus overlaps to seam. As the roll width of Agru Super Gripnet® is 23 ft (7 m), the test pad was approximately 46 ft (14 m) wide. The Caterpillar D6N LGP crawler tractor (dozer) used on the test pad 8.2 ft (2.5 m) wide; therefore, the GS11 guidance on width was met for the use of the dozer.

The test pad length consisted of one 20 ft (6.1 m) wide upper bench, a 63 ft (19.2 m) slope length, plus one 20 ft (6.1 m) wide lower bench, for a total length of 103 ft (31.4 m). The slope length of 63 ft (19.2 m) exceeded the GS11 length requirement of 300% of the placement and compaction equipment length 12.3 ft (3.75 m). Each bench had a 5% backslope to control surface drainage. Test pad cross-sections are shown on Figures 2 and 3.

3.0  Test Pad Construction
The test pad was constructed in September and October of 2016.

3.1  Preparation
Prior to test pad construction, proposed subgrade and final cover soil were sampled and tested to determine gradation, Unified Soil Classification System (USCS) soil type, and Standard Proctor moisture-density curves. Subgrade soil classified as sandy lean clay with gravel (USCS CL) and was composed of 19% gravel, 24% sand, and 57% passing the No. 200 sieve (silt and clay). Final cover soil was classified as gravelly lean clay with sand (USCS CL) and was composed of 20% gravel, 18% sand, and 62% passing the No. 200 sieve. To account for the coarse particles larger than 0.75 in (1.9 cm), rock-corrected moisture-density curves were used.

At the test pad location, a 12 in (30.5 cm) thick soil cover had been placed over the CCR material but had not yet been vegetated. This existing soil served as the test pad subgrade.

3.2  Processed and Unprocessed Soil
To obtain final cover soil with a maximum particle size of 9 in (23 cm), roots and rocks larger than 9 in (23 cm) were removed while being loaded at the stockpile, and by hand and dozer after being dumped at the test pad site. This sub 9 in (23 cm) particle soil was referred to as “unprocessed soil”. Particles larger than 9 in (23 cm) that were removed from the unprocessed soil are shown on Photograph 1.
Photograph 1. Particles larger than 9 in (23 cm) removed from final cover soil prior to placement of “unprocessed soil”.

To prepare “processed” soil, a root rake was used at the stockpile (prior to delivery to the test pad) to remove rocks, roots, and woody material 4 in (10 cm) or larger in dimension. The root rake used for the test pad processed soil is shown in Photograph 2.

Photograph 2. Root rake used to remove particles larger than 4 in (10 cm) from “processed soil”.
3.3 Test Pad Subareas
The test pad layout is shown on Figure 4. The test pad was divided into subareas to allow testing of various combinations of conditions. The subgrade protrusion height, cover soil lift thickness, cover soil maximum rock size, and subareas with cushion geotextile are listed on Table 1. Test conditions for adjacent Subareas C and E were identical, and test conditions for adjacent Subareas D and F were identical.

3.4 Construction of Subgrade through Cover Soil
The following section describes how each subarea was constructed and tested.

3.4.1 Subgrade Preparation
After a ditch line was cut at the toe of the slope for bench drainage pipe installation, the slope and bench areas of the test pad subgrade were tracked with the dozer to loosen the subgrade soil. Water was applied to the loosened soil as needed to bring the subgrade within the required moisture specification. The subgrade was then proof-rolled with two passes of a Caterpillar CS563E Vibratory Smooth Drum Roller (smooth drum roller). Based on visual inspection, the proof-rolled subgrade surface did not appear to have any significant areas of flat stone faces that would prevent penetration of the liner spikes, and no depressions greater than 0.5 in (1.3 cm) were observed. The subgrade was tested using a nuclear density gauge and was determined to meet the specification of minimum 85% SPMDD at OMC +/- 3%.

3.4.2 Subgrade Protrusion Placement
Since proof-rolling resulted in a smooth subgrade, and one purpose of the test pad was to evaluate the effect of subgrade protrusions, AASHTO No. 57 angular, crushed stone aggregate was scattered over a small area within each subarea of the prepared subgrade, as shown on Photograph 3. One larger rock was also placed in each subarea near the No. 57 aggregate to create approximate 1 in (2.5 cm) protrusions. The center of each area of placed aggregate was surveyed so that it could be located during subsequent exhuming of the test pad.
3.4.3 IDS Geomembrane and IDS Geotextile Installation and Testing

The IDS geomembrane was installed over the prepared subgrade with the embossed spikes facing down against the subgrade soil, and the drainage stud side facing up. During IDS geomembrane installation, the liner installer cut handholds into the IDS geomembrane at two surveyed locations for deployment on the slope. The two roll-widths of liner were welded along the centerline of the test pad. After the seamed IDS geomembrane passed vacuum box seam testing, IDS geotextile was installed on top of the IDS geomembrane to create a drainage layer between the IDS geotextile and the IDS geomembrane. The IDS geotextile panels were installed parallel to the slope and sewn together.

3.4.4 Cover Soil Preparation

Large rocks were present in the cover soil, but it was unknown if or where they would contact the geosynthetics, and it was not planned to exhume the entire test pad. Therefore, a hard sandstone rock up to 9 in (23 cm) in maximum dimension was placed directly on the IDS geotextile within each subarea. These large rocks were placed in the same vicinity as the subgrade protrusions, but slightly offset. This would allow the effects of rocks both above and below the geosynthetics to be examined at the same exhumed location.
3.4.5 Placement of Cover Soil

A 12 in (30.5 cm) thick lift of processed soil was placed over the geosynthetics on Subareas C and E (bench areas). After the bench pipe was installed (Photograph 4), a 12 in (30.5 cm) lift of processed soil was then placed on the slope over Subarea A (Photograph 5). After compaction, a 6 in (15 cm) lift of processed soil was placed over the 12 in (30.5 cm) lift on Subareas C, E, and A, and a single 18 in (46 cm) lift of unprocessed soil was placed over areas D, F, and B. Plywood panels were placed to cover and protect geosynthetic edges.

Photograph 4. Bench pipe installation in No. 57 stone and geotextile envelope. The 9 in (23 cm) rocks (painted red) were placed on geotextile on the lower bench.
Photograph 5. Unprocessed soil placed over Subareas D and F and compaction of 12 in (30.5 cm) lift of processed soil over Subarea A.

3.4.6 Cover Soil Compaction and Testing

Each lift of cover soil received four passes from a Caterpillar D6N LGP crawler tractor (LGP dozer). The LGP dozer had a ground pressure of 4.8 psi (33.1 kPa), which met the proposed ground pressure specification of less than 5 psi (34.5). After compaction, GAI performed nuclear moisture-density tests on the cover soil. To determine the density near the bottom of the 18 in (46 cm) lift (near the soil-IDS geotextile interface), the uppermost 6 in (15 cm) of placed soil was scraped back, and the nuclear density gauge was placed in the resulting 6 in (15 cm) depressions. The cover soil nuclear density tests (locations shown on Figure 4) determined that not all cover soil in the 18 in (46 cm) lift (Subarea B) met compaction requirements.

4.0 Initial Evaluation

The test pad was initially evaluated immediately after construction, in September and October of 2016, based on the following methods:

Exhuming the cover soil and visual examination of the IDS Geotextile. After cover soil placement were completed, the soil cover was exhumed at the locations of the large stones and the IDS geotextile was visually assessed for punctures and tears.

Exhuming the IDS Geotextile and visual examination of the IDS Geomembrane. After the IDS geotextile was visually assessed, sections of the geotextile were cut and pulled back, and the upper surface of the IDS geomembrane was visually assessed.

The cover soil was exhumed from sloped Subareas A and B where the subgrade protrusions and large cover soil stones had been placed. GAI observed that the IDS geotextile was not torn at any of the exhumed locations.
After the cover soil was carefully removed and geotextile examined, the geotextile was manually cut and pulled back to expose the underlying IDS geomembrane. Visual observation of the exposed IDS geomembrane indicated subgrade protrusions, but the geomembrane had not been punctured at any of the exhumed locations (Photographs 6 and 7).

Photograph 6. Exposed IDS geomembrane at Subarea B after final cover soil was exhumed and IDS geotextile was removed.
Photograph 7. Exposed IDS geomembrane at Subarea A after final cover soil was exhumed and IDS geotextile was removed.

5.0 Temporary Access Road Construction and Investigation

An additional 18 in (46 cm) of non-processed soil was placed on lower bench Subareas C, D, E, and F, for a total cover thickness on the bench of 3 ft (0.9 m). A fully-loaded Cat 745C articulating truck with Michelin 29.5R25 tires at 65 psi (448 kPa) tire pressure then made passes over the bench with the 3 ft (0.9 m) thickness of cover (Photograph 8).
The contractor exhumed the locations on the trafficked bench where the large [up to 9 in (23 cm)] rocks had been placed on the IDS geotextile, and where protrusion stones had been placed on the subgrade. GAI observed the IDS geotextile was not torn at any of the exhumed locations. The exhumed IDS geotextile was then manually cut and pulled back to expose the IDS geomembrane. Protrusions were visible in the IDS geomembrane, but the IDS geomembrane was not punctured at any of the exhumed locations. The exhuming activities are shown Photographs 9 through 13. After the exhumed locations were observed, the geotextile was patched (locations shown on Figure 4) and cover soil replaced.
Photograph 9. Exhuming unprocessed cover soil from Subarea D.

Photograph 10. Large rock at Subarea D did not damage the geotextile.
Photograph 11. Exhuming cover soil from large rock location at Subarea D.
No tearing or damage of geotextile was observed.
The geotextile is being cut to allow observation of the geomembrane.
Photograph 12: No geomembrane puncture was observed due to the large cover soil rock or the subgrade protrusions in Subarea D.

Photograph 13. Exposed IDS geomembrane at Subarea C at location of placed No. 57 stone on prepared subgrade.

After construction, soil samples were collected from processed and unprocessed soil on the test pad. Processed and unprocessed soils both classified as USCS CL soil.

6.0 2016 Follow-up Test Pad Activities.
Because not all Subarea B locations met compaction specifications, three additional passes were made over Subarea B a few weeks later and additional nuclear density testing was performed.
A portion of the cover soil over Subarea B was then exhumed to determine whether unprocessed soil compacted by additional passes on the slope damaged the geotextile. The excavator punctured the geotextile and geomembrane while removing the cover soil (Photograph 14), but no damage to the exhumed geotextile and geomembrane attributable to the unprocessed cover soil or subgrade protrusions was visible.

Photograph 14. Geotextile and geomembrane damaged by excavator while exhuming compacted cover soil.

A few days later an area of Subarea F was re-exhumed by hand shoveling so that the geotextile patch on Subarea F could be surveyed.

7.0 2016 Conclusions
Based on the test pad construction and 2016 evaluation, the following conclusions were made:

1. Proof-rolling resulted in a smooth subgrade with depressions of less than 0.5 in (1.3 cm); therefore, a specification of subgrade depressions not more than 0.5 in (1.3 cm) is achievable.

2. When 12 in (30.5 cm) or 18 in (46 cm) of final cover soil (processed or unprocessed) was placed and compacted on a 3H:1V slope with four passes of a LGP dozer with ground pressure less than 5 psi (34.5 kPa), subgrade protrusions of 1 in (2.5 cm) did not puncture the 50 mil (1.25 mm) HDPE IDS geomembrane; therefore, the test passed the requirements for final cover placement.
3. When unprocessed final cover soil containing particles up to approximately 9 in (23 cm) in maximum dimension was spread on a 3H:1V slope and compacted to a minimum 85% SPMDD, the 8 oz/yd² (271 g/m²) nonwoven IDS geotextile was not noticeably damaged and the 50 mil (1.25 mm) HDPE IDS geomembrane was not punctured; therefore, this test passed project requirements for final cover placement.

4. On the bench, where 1 cm (2.5 cm) angular protrusions were placed on the subgrade and 3 ft (0.9 m) of unprocessed final cover soil containing rocks up to 9 in (23 cm) in maximum dimension were placed over the IDS geotextile and IDS geomembrane, and trafficked with 100 passes of a loaded 45-ton (40.8 t) truck, the 8 oz/yd² (271 g/m²) nonwoven IDS geotextile was not noticeably damaged and the 50 mil (1.25 mm) HDPE IDS geomembrane was not punctured; therefore, this test passed project requirements for final cover placement on trafficked benches.

8.0 2016 Recommendations
Based on the test pad construction observations, the recommendations include the following:

1. Project specifications may allow maximum 1 in (2.5 cm) protrusions (but not sharp objects), based on the findings of the test pad, as approved by the quality assurance engineer.

2. The specifications for Final Cover Soil, may state “Final cover soil shall be a soil matrix which shall not have rocks exceeding 9 in (23 cm) in any dimension.”

3. Allow maximum equipment ground pressure to 5 psi (34.5 kPa) during placement of either the 12 in (30.5 cm) or 18 in (46 cm) thickness of final cover soil. Also, after a 3 ft (0.9 m) thickness of cover soil has been placed on the bench, 45-ton (40.8 t) loaded trucks with maximum 65 psi (448 kPa) tire pressure may be allowed on the bench for access and final cover construction.

9.0 Regulatory Approval
The final cover specifications (based on the test pad evaluations), the test pad report, and the design report for the landfill final cover system were submitted to WVDEP in December 2016 and approved by WVDEP.

10.0 2018 Test Pad Evaluation
Although it was originally expected the test pad areas would be included in the final cap, it was later decided it would be more cost-effective to remove the test pad than attempt seaming new surrounding geomembrane to the existing test pad. This provided an opportunity to exhume and view larger areas of geosynthetics, and to view the underside of the geomembrane nearly 2 years after test pad construction. Since carefully exhuming the soil and geosynthetics was an added expense to the project, the client asked that only limited areas be carefully exhumed; the remainder of the test pad would be removed less carefully. The areas that were exhumed to allow examination of the geomembrane underside are shown on Figure 5.
Areas carefully exhumed in 2018 included locations where rocks had been previously placed above and below the geosynthetics, and where geotextile was patched from the 2016 partial exhuming. Survey equipment was used to locate the areas, and to estimate the excavation depth to prevent the excavator from puncturing the geosynthetics.

10.1 Subarea B Excavation
The soil cover for Subarea B was approximately 18 in (46 cm) thick; therefore, soil was excavated using an Komatsu excavator with a 2 ft (0.6 m) barred bucket to a depth of approximately 1.2 ft (37 cm), as determined by the survey equipment, then hand shoveled in a small area to locate the geotextile (Photographs 15 and 16). Once the geotextile became visible, the excavator carefully excavated nearly all the way to the geotextile. The cover soil had occasional large rocks, but was predominantly soil, and large rocks were generally not in contact with the geotextile.

The soil just above the geotextile was removed by hand with shovels, and the geotextile was swept. The 2018 Subarea B excavation was approximately 7 ft (2.1 m) by 6.5 ft (2.0 m), which was significantly larger than the 2016 geotextile patch. The area where the large rock had been placed over the geotextile during test pad construction and then replaced during the 2016 exhumation was located. The underlying geotextile showed no sign of damage. The geotextile was cut along the edges of the excavation and removed (Photograph 17).

Photograph 15. Barred excavator bucket excavating Subarea B.
Photograph 16. Hand-shoveling cover soil near geotextile, Subarea B.

Photograph 17. Removing geotextile in Subarea B.
With the geotextile removed, the geomembrane was examined. Bumps on the geomembrane clearly indicated where stones had been placed on the subgrade prior to geomembrane installation. No signs of damage were identified.

The geomembrane was then cut along the edges of the excavation, removed, and flipped over. A grid of holes from the geomembrane bottom spikes was readily apparent in the subgrade, as was a scattering of No. 57 aggregate and one medium-sized stone (Photograph 18), which accounted for the depressions in the geomembrane. The medium-sized subgrade stone had subrounded corners (Photograph 19). The No. 57 stones were angular but were pushed about halfway into the subgrade (Photograph 20). The underside of the geomembrane had obvious depressions where it had been over the subgrade stones, but there was no sign of geomembrane damage, or obvious scratches (Photograph 21).
Photograph 19. Subgrade protrusion rock in Subarea B.

Photograph 20. Closeup of Subarea B No. 57 aggregate on subgrade after geomembrane was exhumed.
10.2 Subarea F Excavation

The exhumation of Subarea F proceeded in a similar manner. The goal at this location was to examine the geosynthetics in the path of the tires where the loaded haul truck had made 100 passes in 2016. The Subarea F excavation was 6.7 ft (2.0 m) by 11.5 ft (3.5 m). Again, the area was excavated part way down with the excavator, then the general depth of geotextile was located by hand shoveling. Note that the location of the 2016 geotextile patch in Subarea F (Figure 5) had previously been exhumed and recovered with soil twice in 2016. Two large rocks, including the rock shown on Photograph 22, were found close to, but not directly on, the geotextile. When the excavator was removing soil close to the geotextile, the excavator operator could “feel” additional large rocks. The cover soil was again predominately soil but had more large rocks than the cover material at the Subarea B excavation. The exposed geotextile appeared to have been previously cut to examine the underlying geomembrane, as would be expected from the 2016 test pad study, but the geotextile in the area over the subgrade rocks also had two small tears that had not been recorded during the 2016 exhumation. The remaining area of geotextile showed no sign of damage.

After the top surface of the geotextile was examined, the geotextile was cut along the perimeter of the excavation and removed.

Impressions of the subgrade stones were easily visible on the exhumed geomembrane. One corner of the largest impression had two small ruptures that had not been recorded during the 2016 exhumation. The remaining geomembrane showed no damage.
The geomembrane was cut along the edge of the excavation and removed. The impressions of the underlying No. 57 aggregate and one larger rock were easily visible on the underside of the geomembrane (Photographs 23 and 24). The two ruptures completely penetrated the geomembrane (Photographs 24 and 25), but there was no other detected damage to the geomembrane, not even scratches.

Closer examination of the geomembrane ruptures indicated they may have been cut from the topside, as evidenced by slight scratching and burring along the topside of the geomembrane. Also, the geotextile tears were similar to the geomembrane ruptures (Photograph 26) indicating that both geosynthetics may have been manually but accidentally damaged during the exhumation. The mud stains on the underside of that portion geotextile appeared to be a mirror image of the mud stains on the top of the geomembrane, indicating that area of geotextile overlaid that area of geomembrane. The rock beneath the ruptured geomembrane protruded more than 1 in (2.5 cm) (Photograph 27), exceeding specification allowance.

Photograph 22. Large rock on Subarea F geotextile [6 in (15.2 cm) ruler].
Photograph 23. Subarea F - Impressions of No. 57 stone on underside of geomembrane.

Photograph 24. Subarea F - Impression of large rock on underside of geomembrane
Photograph 25. Subarea F – Two adjacent ruptures in underside of geomembrane.

Photograph 26. Subarea F - Top of ruptured geomembrane alongside geotextile tear.
Photograph 27. The sharp rock from beneath the ruptured geomembrane in Subarea F protruded more than 1 in (2.5 cm).

10.3 Subarea D Excavation

Exhumation of an additional portion of the test pad bench was performed and observed. Geotextile and geomembrane over a subgrade protrusion were removed and examined. Although a significant subgrade protrusion was found, no geomembrane or geotextile damage was observed (Photographs 28 and 29).

Photograph 28. Subarea D soil cover excavated to geotextile in July 2018.
Photograph 29. Rock under geomembrane, no visible physical damage observed. July 2018.

11.0 2018 Conclusions and Recommendations

The following conclusions were made based on 2018 field activities:

- Subgrade protrusions from scattered No. 57 aggregate did not damage the geomembrane on the slope or on the bench.
- A subrounded stone protruding approximately 1 in (2.5 cm) did not damage the geomembrane on the slope.
- Super Gripnet® spikes were well imbedded into the subgrade side slope.
- It is inconclusive whether the ruptures in the bench geomembrane were caused by the angular subgrade rock or was from damage caused by twice removing the overlying materials; however, the subgrade rock beneath the ruptures protruded more than 1 in (2.5 cm).
- Although there were angular rocks as large as 9 in (23 cm) in dimension in the cover soil, they generally were not in contact with the geotextile because they were suspended in a soil matrix. They did not damage the exhumed geotextile.

The following recommendations were made based on 2016 and 2018 field activities:

- Subgrade stones comparable to No. 57 aggregate and subrounded rocks protruding up to 1 in (2.5 cm) are not expected to damage the geomembrane on the slopes under design specification conditions.
- Subgrade stones comparable to No. 57 aggregate are not expected to damage the geomembrane on the benches under design specification conditions.
12.0 Overall Conclusions/Limitations

The construction of test pads in general accordance with GRI GS11 may be used to demonstrate that typical stone/protrusion size requirements may be modified to allow for less conservative requirements for the construction of final cover systems. For the soils and rock types present at the subject site, subgrade protrusions up to 1 in (2.5 cm) were acceptable and rocks up to 9 in (23 cm) in the cover soils were also acceptable. The use of test pads to evaluate site-specific soils and liner configuration can provide significant cost savings by reducing screening and hand picking of rocks from subsoils and cover soils. The method should be employed on a case-by-case basis as results may vary depending on the subgrade material, geosynthetic materials, soil type and borrow sources. In addition, a robust construction quality assurance and construction quality control program is of the utmost importance so that full-scale construction is consistent with the methods and criteria used for the test pad construction.