An Innovative Cover System Ideally Suited to Coal Ash Impoundment Closure

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CONFERENCE: 2015 World of Coal Ash – (www.worldofcoalash.org)

KEYWORDS: CCR, CCP, closure, impoundment, landfill, cover, solar, fly ash, basin, pond, settlement, renewable energy, carbon footprint reduction

BACKGROUND

Recent regulatory developments at both the state and federal level have elevated the topic of Coal Combustion Residual (CCR) disposal to national prominence in the United States. Specifically, the Federal EPA issued a pre-publication of a final rule on the disposal of CCRs from electric utilities on December 19th, 2014.¹ Previous to this, the state of North Carolina passed the Coal Ash Management Act of 2014.² North Carolina’s legislation established some of the strictest requirements associated with the disposal and management of coal ash anywhere in the U.S.

The result of both the Federal EPA rules and North Carolina’s legislation is that CCR disposal will soon likely experience a transformation not unlike that which occurred within the solid waste industry in the early 1990s when the EPA amended the Resource Conservation and Recovery Act (RCRA). Specifically, there are literally thousands of acres of existing CCR landfills and impoundments that will need to achieve final closure consistent with Subtitle D. The technical requirements associated with closure in compliance with RCRA Subtitle D can be found in the Code of Federal Regulations (CFR), Title 40, Chapter 1, Part 258, Subpart F, Section 258.60 - Closure Criteria-

“(a) Owners or operators of all landfill units must install a final cover system that is designed to minimize infiltration and erosion. The final cover system must be designed and constructed to:

(1) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than 1 x 10⁻³ cm/sec, whichever is less, and

(2) Minimize infiltration through the closed landfill by the use of an infiltration layer that contains a minimum 18-inches of earthen material, and

(3) Minimize erosion of the final cover by the use of an erosion layer that contains a minimum 6-inches of earthen material that is capable of sustaining native plant growth.

(b) The Director of an approved State may approve an alternative final cover design that includes:

(1) An infiltration layer that achieves an equivalent reduction in infiltration as the infiltration layer specified in paragraphs (a)(1) and (a)(2) of this section, and

(2) An erosion layer that provides equivalent protection from wind and water erosion as the erosion layer specified in paragraph (a)(3) of this section.”
The volume of existing CCRs, in both impoundments and landfills, represents a staggering volume that will need to be closed, in some cases on very aggressive schedules. There are over 735 active CCR surface impoundments, with an average size of roughly 50 acres (20 ha) and 310 active CCR landfills, with an average size of approximately 120 acres (49 ha).³

In addition, new disposal facilities will need to be constructed, managed and ultimately closed in accordance with Subtitle D as well. This volume also represents a significant storage requirement. For example, in 2012 alone, there was approximately 110 million tons (100 million metric tons) of CCRs produced in the U.S. With roughly 40% of that being recycled through beneficial reuse activities, that leaves over 60 million tons (54.4 million metric tons) of CCRs being produced annually that require disposal in compliance with the new regulations.⁴

The reality is, our demands for energy outstrip, by great measure, the supply available to us from non-coal power generation sources. This will not change anytime soon, either here in the U.S., or globally. We must accept that coal ash will be produced, in large quantities, into the foreseeable future; and until beneficial reuse practices recycle 100% of the CCRs produced annually, so, too, will the need for safe storage of that ash.

LIMITATIONS OF TRADITIONAL SOIL COVERS ON CCR DISPOSAL FACILITIES

In most areas of the U.S., the traditional practice of constructing a final closure cap in accordance with Subtitle D typically involves placing 24” (600 mm) of soil and vegetative cover above the drainage layer and 40 mil (1.02 mm) thick geomembrane. Several challenges present themselves in taking this approach to CCR impoundments and/or landfills. Some of these challenges include:

- Soil Deficits – Many CCR facilities simply did not anticipate having to cover their coal ash with 24” (600 mm) of soil. As such, they have no soil stockpile allocated for this purpose. At a 30% consolidation rate, approximately 4,200 yd³ (3,200 m³) of soil would be necessary to cover a single acre of CCR impoundment or landfill.

- Safety and Nuisance – Transporting 4,200 yd³ (3,200 m³) of soil would involve approximately 280 truck trips, based upon a 15 yd³ (11.5 m³) truck, from a soil source to the CCR facility per acre. At an average size of 50 acres per impoundment and 120 acres per landfill, that represents 14,000 truck trips per impoundment and 33,600 truck trips per landfill.

- Geotechnical Instability – A consolidated traditional soil cover would add approximately 180 lbs/ft² (881 kg/m²) to the surface of a CCR impoundment or landfill. In instances where geotechnical stability of the waste pile is marginal, this additional loading can introduce the requirement for further mitigation to stabilize the bearing capacity of the impoundment or landfill.
• Project Schedule Limitations – The recent EPA rules include aggressive timelines for closure of certain CCR impoundments and landfills. Depending upon state-level implementation and enforcement, the amount of sites requiring closure could easily overwhelm the existing infrastructure for design, construction and regulatory oversight and permitting. This could result in the unfortunate consequence of compliance-seeking owners and operators missing critical deadlines due to “bottlenecking” of available resources.

• Water Quality Protection – Considering the average size of CCR impoundments and landfills, opportunity exists for significant sediment pollution through erosion that is often an inherent part of traditional soil covers. Figure 1 below shows a photograph of conditions on a prescriptive soil cover on a landfill site.

![Figure 1 - Slope on an actual prescriptive cover on a landfill in the Southeast U.S.](image)

• Burdensome Maintenance – Establishing adequate vegetation to ensure long-term erosion control can entail significant watering, re-grading, re-shaping and re-seeding activities. Once vegetation is successfully established, it requires ongoing, regular maintenance. In addition, the new EPA rules introduce a restriction on keeping vegetation maintained to a maximum height of 6” (150 mm). This individual requirement alone will significantly increase the maintenance burden.

• Land Destruction and Waste – Given the soil requirement associated with a traditional earthen cover, the amount of fill dirt needed to cover the tens of thousands of acres of CCR impoundments and landfills will likely require the destruction of thousands of acres of undisturbed land for the purpose of borrow soil excavation.
An innovative solution for final closure of CCR impoundments and landfills that is fully compliant with the requirements of Subtitle D of RCRA has been developed that offers meaningful advantages specific to CCR disposal challenges. The system, which can be categorized generically as an Engineered Synthetic Turf Cover System (ESTCS), is comprised of three distinct components - a 50 mil (1.27 mm) structural geomembrane with a high-friction interface and integrated drainage layer; engineered synthetic turf cover layer, and a sand infill system. A cross-section of this innovative technology is shown below in Figure 2.

![Cross Section of an ESTCS](image)

The individual components of the ESTCS and their respective functions are shown in bullet-point form below:

- 50 mil (1.27 mm) structural geomembrane –
  - Impermeable layer w/high friction-interface with subgrade.
  - Integrated drainage layer for efficient removal of water
- Engineered Synthetic Turf –
  - Anchoring of Sand Infill
  - Aesthetics

- ~1/2" (13 mm) Sand Infill –
  - Ballast of the system (~6 lbs per Sq Ft (29.3 kg/m²))
  - UV Shielding of turf substrate
  - Drainage

To date, an ESTCS has received approval for and been installed on over twenty (20) landfills in sixteen (16) states across the United States. Figure 3 below shows a site with an ESTCS installed on a typical 3:1 side slope.

Figure 3 – An ESTCS installed on a landfill in the U.S.
A performance-based summary of an ESTCS and Prescriptive Subtitle D Soil Cover is included in Table 1 (shown below). Based on this summary, the ESTCS exceeds the performance requirements of EPA’s Subtitle D Regulation.

Table 1 – Performance-based Summary of an ESTCS and Prescriptive Soil Cover

<table>
<thead>
<tr>
<th>Engineered Synthetic Turf Cover System (ESTCS)</th>
<th>Subtitle D - Prescriptive Cover System</th>
<th>ESTCS Performance Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthetic Turf with Sand Infill Surface Protection Layer</td>
<td>0.5-ft (150 mm) thick Vegetative, Surface Protection Layer</td>
<td>ESTCS Synthetic Turf Protection Layer will require significantly less maintenance of the final cover. It will provide for easier surface water management, better erosion control, and “clear” (no turbidity) runoff. It also has a 100+ year functional longevity with proper maintenance.</td>
</tr>
<tr>
<td>Integrated Drainage Layer in the Geomembrane</td>
<td>1.5-ft (450 mm) thick Infiltration Layer</td>
<td>The ESTCS drainage layer has higher transmissivity and lower water head than a traditional soil cover drainage layer. On account of the lower head, there is less driving force for water to infiltrate through the cover system.</td>
</tr>
<tr>
<td>50-mil (1.27 mm) Structural Geomembrane</td>
<td>40-mil (1.02 mm) Geomembrane</td>
<td>The ESTCS structural geomembrane is thicker and stronger. It will provide less punctures / holes, lower permeability, and less infiltration.</td>
</tr>
<tr>
<td>Low-Permeability Soil Layer not needed due to elimination of hydraulic head (1/2” versus 24” (13 mm versus 600 mm))</td>
<td>2-ft (600 mm) thick Low-Permeability Soil Layer</td>
<td>A low-permeability layer is not technically required beneath the ESTCS due to the elimination of hydraulic head that exists in the 24” (600 mm) traditional cover system.</td>
</tr>
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THE BENEFITS OF AN ESTCS FOR CCR IMPOUNDMENT AND LANDFILL CLOSURES

The ESTCS provides unique and specific benefits that address the limitations of a traditional soil cover in CCR closure applications. These include:

Soil Savings – The ESTCS eliminates, on average, approximately 4,200 YD³ (3,200 M³) of soil per acre ordinarily required for a prescriptive 24” (600 mm) soil and vegetative cover. Depending upon site-specific soil availability, the economical advantages of eliminating this soil layer can be quite significant.
Improved Safety – Through elimination of the 24” (600 mm) soil and vegetative cover layer, along with the related excavation, transporting and deploying activities, the ESTCS can significantly increase the overall safety of the closure site and surrounding community by simply reducing overall equipment hours and vehicle miles. In addition, the removal of the thousands of trucks from local roads can cultivate tremendous goodwill with the community stakeholders.

Increased Geotechnical Stability – The ESTCS can increase the geotechnical stability of the CCR closure through the elimination of the traditional soil and vegetative cover, subsequently reducing the static load surcharge on the impoundment or landfill by approximately 180 lbs/ft² (881 kg/m²). This load reduction can reduce the dewatering needed to stabilize a CCR impoundment for final closure, which in turn can shorten the construction schedule.

Accelerated Project Schedule – The ESTCS provides multiple benefits that can serve to reduce the overall construction schedule by approximately 50%. This reduction is realized through the standardization of construction drawing details, reduced site surveying, as well as the elimination of all activities associated with transporting, placing and grading approximately 4,200 yd³ (3,200 m³) of soil per acre.

Water Quality Enhancement – The ESTCS has been demonstrated to reduce site runoff turbidity by up to 97%. By effectively controlling erosion at the source, downstream storm water quality can be improved to ensure that Nephelometric Turbidity Unit (NTU) levels remain well-below regulatory requirements with minimum treatment infrastructure. An ESTCS was installed on a landfill in the Southeast U.S. in November 2013. The landfill is monitoring the storm water quality from two distinct areas by collecting and analyzing run-off samples. One area is where the ESTCS system is installed, and the other area is where an interim soil and vegetated cover was installed. Both of these areas are approximately 5 acres in size and have similar drainage characteristics. During a 24-hour one-inch rain event, storm water was sampled from both of these two areas. A picture of the storm water samples is shown in Figure 4, and analytical results of the samples are included in Table 3. The storm water runoff from the ESTCS area was of significantly higher quality than from the soil cover area. For example, the turbidity of the storm water from the ESTCS cover area was 11 NTU, and the turbidity from the soil cover area was 371 NTU. This represents an approximate 97% reduction in turbidity with the ESTCS versus the soil and vegetative cover.
Table 3 – Analytical Results from Storm Water Samples at Southeast U.S. Landfill

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Area with Soil Cover</th>
<th>Area with ESTCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity (NTU)</td>
<td>371</td>
<td>11</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>349</td>
<td>&lt;4</td>
</tr>
<tr>
<td>pH</td>
<td>6.5</td>
<td>7.3</td>
</tr>
<tr>
<td>TOC (mg/L)</td>
<td>174</td>
<td>1</td>
</tr>
<tr>
<td>TRI (mg/L)</td>
<td>16</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Maintenance Cost Savings – Total overall maintenance costs are typically reduced by approximately 90% with the ESTCS when compared with the traditional prescriptive cover system. This can amount to savings of well over $1,000/Acre/Year ($2,470/Hectare/Year) for a traditional MSW or Industrial Waste Landfill. Given the average CCR landfill is 120 acres (49 ha) and the average CCR impoundment is 50 acres (20 ha), this could amount to average savings of over $120,000 per year per landfill and $50,000 per year per impoundment. These savings are realized through the elimination of all activities associated with promoting vegetative establishment as well as the maintenance activities (i.e. mowing) once vegetation is achieved. It is reasonable to expect the savings to be greater for CCR impoundments and landfills due to the 6” (150 mm) maximum height requirement as put forth by the Federal EPA. MSW and Industrial landfill sites that have documented maintenance activities associated with an ESTCS system typically allow their vegetation to grow much taller than 6” (150 mm) and usually only mow their vegetation 4 times per year on average. This would suggest their costs are lower, due to this less frequent mowing, than may be realized at CCR facilities.

Land Preservation and Conservation – The significant soil requirements associated with a traditional soil and vegetative cover system necessitates the unfortunate destruction of undisturbed land. There simply is not enough soil available in existing borrow sources to satisfy the technical requirements of this traditional system. The ESTCS effectively eliminates much of this land destruction by replacing this soil layer with the structural geomembrane, engineered synthetic turf and approximate 1/2” (13 mm) of sand infill.

Carbon Footprint Reduction – Compared to a prescriptive Subtitle D cover system, the ESTCS offers a carbon footprint reduction of approximately 80%. Most of this reduction is achieved through the elimination of the prescriptive cover. The calculations that demonstrate this can be seen in Figure 5 below-

![Figure 5 – Carbon Footprint Analysis, Prescriptive Soil Cover vs ESTCS](image-url)
Renewable Energy Opportunities – The ESTCS provides an ideal substrate for Solar photovoltaic (PV) arrays, creating the opportunity for future renewable energy production on what is otherwise “dead” space. The ESTCS eliminates bare spots. Dust from vegetative covers, especially bare spots from shading, can reduce generation. In addition, maintenance activities necessary for vegetative covers create repetitive opportunities for damaging the PV panels. The ESTCS effectively eliminates this maintenance, and along with it the associated damage and subsequent repair costs. Near-zero site maintenance for solar, including reduced dust accumulation, ultimately reduces operating costs and helps maintain greater electrical power generation. Figure 6 below shows an example of a Solar PV Array on an ESTCS.

![Image of Solar Photovoltaic (PV) Array on an ESTCS](image)

**Figure 6 – Solar Photovoltaic (PV) Array on an ESTCS**

**SUMMARY**

CCR closure regulations present significant challenges to coal-fired power plant operators and owners. While most of these challenges can be categorized as economical, environmental, logistical or technical in nature, it’s important to recognize the additional challenge of managing public perception successfully. Coal ash is currently, and will likely remain, a volatile topic in the court of public opinion.

The ESTCS has been demonstrated to deliver superior performance with respect to the challenges faced in CCR closure projects. This performance is realized in the following ways: technically, in the form of increased final cover performance and geotechnical stability; economically, through cost savings on importing soil as well as maintenance of the final cover; logistically, by accelerating the overall construction schedule and
eliminating thousands of hours of equipment both onsite and within the surrounding community; and environmentally, through improved water quality.

The ESTCS can also bring significant additional benefit in the form of valuable public perception by those who choose to utilize it effectively; by communicating the advantages of a reduced carbon footprint, the opportunities for renewable energy utilization, and perhaps most significantly, the preservation of undisturbed lands.

REFERENCES

[1] United States Environmental Protection Agency Website  
http://www2.epa.gov/coalash/coal-ash-rule#rulehistory

[2] North Carolina General Assembly Website  

