Best Practices During Closure

Kathryn Nash¹, Marcella Funderburg, P.E.², Ryan Kamp³

¹Waste Management National Services, Inc., 508 East 5th Street, Chattanooga, TN 37403; ²Waste Management National Services, Inc., 1000 Chinaberry Drive, Bossier City, LA 71111; ³Chesapeake Containment Systems, Inc., 2690-D Salisbury Highway, Statesville, NC 28677

Abstract
Driven by political, environmental, and financial requirements, closure of ash facilities through either clean closure or closure in place has become the industry norm. In this presentation, we will review lessons learned and best practices during closure projects. Topics presented include the development of grading plans, ash dewatering/drying, moisture content during transport/placement, selection and storage of geosynthetics, installation of geosynthetics, stormwater management, support area requirements, loadout methods, transportation options, and off-site disposal. We will explore the operational and efficiency challenges encountered and methods for mitigation. The information presented is intended to provide for a more informed decision-making process when planning and implementing closure projects.

Keywords
best management practices, closure, ash, CCR, geosynthetics, transportation, placement, contact water, stormwater, rail trucking, mobilization, drying, conditioning

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INTRODUCTION

Coal combustion residuals (CCR) generated in the United States are one of the largest industrial waste streams, with disposal occurring at over 310 active on-site landfills and over 735 active on-site surface impoundments.¹ Many of these facilities are in the closure process, in the planning stages of closure, or will be closed in the future for compliance with the Federal CCR Rule or for other environmental, financial, or capacity reasons. There are many aspects necessary to implementing a successful closure project. Planning upfront to address safety and environmental concerns, identify required engineering services, define quality requirements, determine required equipment and materials, establish dewatering requirements, and select the project approach are key to meeting project schedules and budgets. The following lessons learned for several key closure activities are based upon execution of various closure projects, including both closure in place and closure by removal.

PROJECT PLANS

Prior to mobilizing personnel and equipment to the site, a number of project plans should be developed to document the execution strategy and communicate it to all the team members. These plans should also clearly define roles and responsibilities for all team members. To ensure consensus, plans should be reviewed by the client and must be finalized before mobilization begins. These plans should clearly communicate to the client the assumptions and proposed approach to establish expectations at the beginning of the project. Recommended plans include:

- **Work Plan** to address mobilization requirements, erosion and sediment control approach, proposed haul roads/laydown areas, and the overall anticipated sequence of work, and the proposed baseline schedule.

- **Health and Safety Plan (HASP)** to identify the high-risk activities and mitigation measures in addition to detailing client specific safety requirements.

- **Environmental Compliance Plan (ECP)** and related plans (i.e., Fugitive Dust Control Plan, Erosion and Sediment Control (ESC) Plan/Stormwater Pollution Prevention Plan (SWPPP), and Spill Prevention, Control, and Countermeasures (SPCC) Plan) detail site-specific environmental concerns and protective measures and practices to be implemented to protect the surrounding environment, and identification of any protected areas and species.

- **Transportation Plan** to define both the on-site and off-site proposed transportation routes for material movement in addition to the procedures that will be followed when transporting CCR.

Development of these plans provides all parties the opportunity to review, comment on and discuss the assumptions and project approach. Additionally, potential conflicts can be addressed early on making it easier to mitigate and avoid delays and/or unexpected costs.
MOBILIZATION

Mobilization of heavy equipment, site support trailers, and fuel tanks is typically the first area with risk of a safety or environmental event. Below are some lessons learned for mobilization that help minimize these risks:

- **Equipment Inspection.** Inspect equipment prior to arrival or off-load – If possible, inspect the equipment prior to arriving onsite which allows for any identified issues to be repaired before delivery. This also minimizes the risk of a fluid leak/spill. If this isn’t possible, inspection upon arrival to the site also provides similar benefits. Verify that the equipment was loaded properly and did not shift during transport to minimize the risk of an incident while unloading. Figure 1 shows an inspection occurring prior to off-loading.

- **Delivery Plan.** Creating a simplified plan to communicate the delivery procedures to the hauling company will streamline mobilization and minimize site interruptions. At a minimum, the plan should provide the site address, specific delivery point, contact information for on-site team, hours deliveries are accepted, required personal protective equipment (PPE), a map of the site with road names, and expected wait time (i.e., duration the drivers can expect to be onsite). Any site-specific instructions for operating on-site should be included in this plan. The use of delivery plans is especially helpful for sites in remote locations, resulting in a safe and efficient mobilization.

DEWATERING

For closure projects that include CCR excavation, impoundments will typically require some level of dewatering to ensure safe working conditions. Dewatering should be performed as early as possible to remove free water and pore water, providing a stable surface for heavy equipment. Many former impoundments can be deceiving, with years of inactivity allowing heavy grass, reeds, or trees to grow. The vegetated nature provides a false sense of security in that portions appear to be dry and stable but may be adjacent significant soft spots. Given ash’s ability to hold and release water, it can change from a semi-solid state to a liquid state rapidly. This liquification process is only enhanced by movement and vibration of equipment. Without early dewatering to ensure dry ash in the impoundment, excavation poses a significant risk as most impoundments are deep enough to completely engulf personnel and equipment.

Dewatering can either be performed via a series of rim ditches, drainage ditches, and sumps, and/or use of a well point dewatering system. For impoundments where the
groundwater table intersects the basin, dewatering measures should be focused on lowering the phreatic surface and preventing flow of groundwater into the excavation. Best practices include temporarily lowering the phreatic surface to an elevation several feet below the bottom of the planned excavation. For ponded impoundments, free water must also be pumped from the surface prior to installation of the dewatering system. In addition to providing safe conditions for subsequent excavation, early dewatering can facilitate achieving lower CCR moisture content, making it easier to condition the material prior to loading, transport, and placement in a landfill.

Another significant planning aspect of dewatering operations is discharge requirements and permitted outfalls. Active facilities may include a permitted outfall for use in discharging water from dewatering which is generally the most advantageous arrangement for the contractor. Other facilities may be “zero discharge” facilities, in which case project planning must include engineering support to permit a new discharge. Another option may be to work with the client in identifying re-use applications at the facility. Regardless of the discharge arrangement, the dewatering operation needs to consider the limitations of treatment systems and discharge. Dewatering operations must be designed with a flow rate that can be supported by downstream systems.
BORROW MATERIALS

Whether for in-place closure, on-site landfill construction, or backfill in CCR excavations, use of an on-site borrow source can result in significant costs savings. If a borrow source is not available at the facility, electric utilities should consider purchase of adjacent property for use as a borrow source for upcoming closure projects, if possible. If on-site borrow materials are to be used, especially for landfill construction, the source should ideally be identified during the design phase of the project. Once a potential source is identified, soil borings must be collected to verify the material meets the specifications and ensure there is enough suitable material available to complete the project. The engineer should also identify whether or not screening of the material would be required prior to placement, since this can result in additional costs and extend the project duration. Additionally, the contractor should work with the utility to identify a location for temporary stockpiling of material adjacent to the work area so that placement activities are not limited by borrow excavation and transport activities. Another best practice is to identify an alternate source in the event that on-site borrow the material does not meet specifications or there is not enough suitable material available.

When use of an on-site borrow source is not available or must be supplemented with purchased material, contractors should identify multiple off-site borrow sources. This is especially important when a significant volume of fill material must be imported for a project. Testing of the material in accordance with the specifications should be performed early on and results provided to the engineer for approval. Depending upon the location and availability of trucks, the contractor should evaluate just-in-time delivery versus establishing a temporary on-site stockpile. While stockpiling will require additional maintenance (i.e., vegetative cover, dust control, runoff controls) and double handling of the material, it can prevent delays if the backfill supplier is experiencing delays on their end (e.g., not enough trucks, inclement weather, long commute, high-demand, and issues meeting specifications). Having multiple sources of material can help to alleviate these delays.

FIGURE 3. BORROW MATERIAL TEMPORARY STOCKPILE
GEOSYNTHETICS

For closure and containment applications, there are four main types of materials:

- **Geosynthetic Clay Liners (GCL)** that are used as a secondary liquid barrier to the primary geomembrane
- **Geomembranes** that are used as a liquid and or gas barrier
- **Geocomposites** that are used for drainage
- **Geotextiles** that are used for reinforcement, cushion, filtration, and separation.

The exact combination of geosynthetic materials for a project can be specified from multiple sources such as the design Engineer, Installation Contractor or Owner. The reason certain materials are selected can vary greatly, but typically is driven by State/Federal regulations, site geology, location and the waste being capped/contained.

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<th>FIGURE 4. TYPES OF GEOSYNTHETICS</th>
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<td>GEOSYNTHETIC CLAY LINER</td>
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**PROCUREMENT AND PRE-INSTALLATION TESTING**

Once project material types are determined, the installation contractor selects a manufacturer to produce those materials. The two main concerns when determining what manufacturer(s) to use are quality and availability. The manufacturer must have a history of successfully producing the material type(s) that are specified for the project. Manufacturers are experiencing long lead times due to high demand. Therefore, ensuring a manufacturer can deliver on time is critical to ensuring schedule milestones can be met.

After materials are produced, the materials must be conformance tested to ensure the actual materials produced meet the project specifications. An accredited, independent laboratory will conduct the testing in accordance with the project specifications. Conformance testing is typically overseen by the construction quality assurance (CQA) firm, but occasionally by the installation contractor who procured the material.
**Material Delivery and Storage**

Once all project materials are tested and approved by the certifying Engineer, deliveries can be scheduled. Prior to releasing shipments, a laydown or storage yard must be constructed onsite to store geosynthetic materials. Laydown yards must be flat, firm and free draining. Typically, materials are delivered to site via a van or flatbed trailer. Extreme care and caution must be used while unloading freight from trucks. Material unloaded onsite must be handled in a way as to not create unnecessary damage and stacked in the laydown yard in a manner acceptable by the manufacturer. During the receiving process it is necessary to inventory the material to ensure that the received material is the correct material required for the project. Some materials may be weather sensitive and require water proof tarps placed overtop to protect the material from moisture and UV damage.

**Figure 5. Geosynthetic Off-Loading and Storage**

**Installation**

There are three main components to installation: deployment, seaming and quality control. Deployment can be accomplished by rolling the material out by hand, using heavy equipment to roll out the material or using equipment to pull the material into place. Final adjustments to overlap is performed by geosynthetic installation laborers. Seaming of materials is a critical step to ensuring a homogeneous, leak free project. The seaming method is determined by the type of material being installed but generally speaking, most materials are seamed together by fusion or extrusion welding, sewing, adhesive or mechanical.
attachment. The final step in the installation process is quality control. All welded materials are tested using non-destructive and destructive test methods. Every phase of installation must be documented and submitted to the client at the end of the project. A typical end of project closeout submittal consists of an as-built survey, quality control forms, subgrade acceptance forms, compliance letters, project photos and warranties.

**CONDITIONING OF CCR PRIOR TO LANDFILL PLACEMENT**

CCR material excavated from impoundments will typically require some conditioning to remove moisture once the excavation reaches the water table. At this depth, CCR can have a moisture content of approximately 35% to as high as 50%. As discussed previously, dewatering the impoundment early to remove surface water and/or pore water can assist in reducing the moisture content prior to excavation and reduce time associated with ash conditioning. There are various methods to condition CCR to lower the moisture content as discussed below:

- **Blend with Drier Material.** Ideally, the project will have a source of drier material (e.g., ash stack) that can be used to lower the moisture content of the wetter material. This will require sequencing the project so that the drier material is still available on-site once the high moisture content material is encountered. Blending can be performed either within the impoundment or at a temporary stockpile, ideally adjacent to the material loadout area. On- or off-road trucks will be needed to transport material to the blending area and a dozer with disc should be used to mix the dry and wet material together.

- **Windrowing.** When dry material is not available, windrowing to lower moisture content is a good option. However, windrowing requires a large, dedicated area to manage CCR and sustained dry, windy, and sunny weather to facilitate moisture reduction. In addition to trucks to transport the material and an excavator or loader to reload the conditioned CCR, windrowing requires a dozer with disc to form and turn the windrows. The size of the area and amount of equipment needed will be dependent upon the daily volume of material that must be excavated and transported to the landfill to meet the project schedule. Typically, this will require at least 2 to 4 hectares (5 to 10 acres).

- **Turning Stockpiled Material.** When space is limited, instead of windrowing high moisture content CCR, it can be stockpiled and routinely turned to lower the moisture content. Typically, the wet material is stockpiled behind the excavator removing the CCR. It is left in place to drain for the day and then an excavator turns the stockpiled material to facilitate additional drying. Turning of stockpiled material is not as efficient at lowering the moisture content as windrowing and it may be difficult to
achieve optimum moisture content without using an additional method to condition the material.

- **Addition of Lime Kiln Dust (LKD).** In situations where the project is under time constraints, there is limited area to condition excavated CCR, drier CCR is not available, and/or weather conditions are consistently unfavorable for drying, addition of LKD or similar reagents can be used to stabilize the material. The amount of LKD necessary to properly condition the CCR will vary depending upon the CCR’s moisture content. Application of LKD can range from 3 to 9% by weight to achieve the desired moisture content. Typically, an excavator is used to add and mix the LKD followed by a dozer to complete the mixing. LKD must be stored in a dry place to prevent exposure to water prior to use. Use of LKD also requires protective measures to prevent worker exposure to LKD via dusting such as: use of water trucks, misters, keeping personnel in enclosed cabs, and limiting ground personnel. Ground personnel near LKD offloading and mixing operations should be required to wear additional personnel protective equipment (PPE) to prevent exposure.

**LOADING OPERATIONS**

Impoundments requiring clean closure (i.e., excavation and disposal in a landfill or beneficial use), will require loading of on- or off-site trucks to transport material to the designated landfill. When loading is required, identifying loading requirements and establishing an efficient material loadout area are key to project success. Ideally the loadout area will be placed at the edge of the impoundment, to allow for stockpiling material within the basin, avoiding the requirement for construction of a storage area meeting the CCR rule (i.e., placement on an impervious base such as asphalt, concrete, or a geomembrane with leachate and run-off collection, and walls or wind barriers\(^1\)). This loadout configuration also allows trucks to be loaded outside the basin which minimizes tracking of CCR.

**FIGURE 8. MATERIAL LOADOUT AREA**

When designing the loadout area, the contractor should also consider the number of loadout stations that will be required to meet the production rates. Additionally, there should be a clear path for the drivers to take, with clear indications where to stop, and
how to proceed once loading is complete. Use of hand-held radios or CB radios for communication between the operators and drivers is ideal to ensure an efficient operation. For high production projects, the loadout area will need to take into account staging requirements for trucks waiting to be loaded.

Loading operations can be performed with either a loader or an excavator. The use of bucket scales can aid in loading operations. Using a loader typically requires less bucket loads to fill the truck. However, visibility and reach can sometimes be an issue. When using loaders, the loader will ideally be set on top of a ramp or an elevated area next to the trucks to aid with visibility. Given the larger volumes, loaders are ideal for filling rail cars when using railroads for transportation to an off-site landfill. Typically, excavators work well for loading trucks since they can sit higher to make it easier to see the truck bed.

**FIGURE 9. LOADING EQUIPMENT**

| RAIL CAR LOADING WITH CAT 988 LOADER | TRUCK LOADING WITH CAT 336 EXCAVATORS |

Typically, projects requiring off-site transportation will require a truck/wheel wash and truck scale. When required, the truck/wheel wash and truck scale are ideally placed near the loadout area which allows trucks to travel through them prior to leaving the site. It is essential that placement of these items takes into account the truck turn radiiuses but will ideally minimize turning or truck repositioning in order to streamline the process. The loadout area should also incorporate a turnaround or weight adjustment station after the truck scales for trucks that are overweight or significantly underweight.

**OFF-SITE TRANSPORTATION**

While transportation activities typically do not take place at the electric utility, the contractor must consider several logistical elements during the project planning process. Pre-planning, collaboration, and routine communications between the utility, contractor, and transporter is key to align goals and expectations to transport CCR efficiently and safely.
The primary method for off-site transportation is by truck since many electric utilities and the designated landfill do not have access to railroad or barge facilities. Truck transport can either be self-performed or subcontracted. When subcontracting it is critical for high-production projects that an agreement is made to have a certain number of trucks dedicated to the project. Therefore, it may be necessary to subcontract the transportation with multiple vendors to ensure production rates are met. An alternative option is to self-perform transportation. However, there are several factors to take into consideration when self-performing.

On-road trucks can have traditional end-dump trailers or side-dump trailers. End-dumps are more readily available, but pose a potential off-site release risk if the beds are not sealed correctly. Side dumps are not as common, but provide better containment for CCR. Key considerations when trucking CCR off-site include:

- **Department of Transportation (DOT) Compliance.** When determining manpower requirements to meet the estimated production rates, it is important to take into consideration DOT’s restrictions for driver hours. In some cases, a second shift may be required in order to maintain compliance and production. Additionally, the contractor should have a back-up plan for traffic delays that could cause a driver to exceed DOT hours.

- **Routes.** Identifying both a primary and secondary route to avoid major traffic delays or roadway construction. Route planning should consider such features as city pass throughs, school zones, signaled intersections, right versus left turns, and permissive versus protected movements in addition to distance. It should be noted that the optimal routes are not always the most direct.

- **Tracking.** Use of tracking features in on-road trucks is a best practice that has proven invaluable for CCR projects. The use of DriveCAM or similar technology provides video evidence of potential accidents. The technology is triggered by unsafe driving events such as hard braking, bumps, etc. Speed monitoring and route performance through the use of GPS systems also provides alerts for braking, hard driving, speeding, and route geography violations. Both features have proven beneficial in reducing liability associated with accidents and citizen complaints.

- **Storage and Maintenance.** High production projects will require a significant number of trucks to be loaded on a daily basis. In some cases, loaded trucks may not have
ample time to make it to the landfill prior to closure and may not be able to be staged overnight at the project site. In these instances, it may be necessary to identify an off-site yard to stage and maintain trucks. In addition, when identifying storage requirements, contractors should take into consideration truck maintenance requirements since a certain percentage (i.e., 5% to 10%) of trucks will require maintenance and not be available each day.

- **Fueling.** Determine when and where trucks will be refueled to avoid production delays. Ideally, the truck yard will have a fuel tank on-site to allow for fueling at the end or beginning of each day.

- **Inclement Weather.** In the event of inclement weather, it may be necessary to temporarily stage trucks until weather conditions improve. Safe locations should be identified along the primary and secondary routes, both in-bound and out-bound, where drivers can pull off and wait out the weather.

- **Truck Breakdown, Spill, or Accident While En Route.** At the beginning of the project, the contractor should identify the procedures that will be followed in the event of a truck breakdown or accident. Items to be considered include offloading the material into a new truck, spill response, and towing of the truck to a safe location for repairs. As part of project planning, potential spill response contractors and towing companies should be identified and contacted to verify their ability to respond.

**RAIL**

When rail is available near the electric utility site and at the disposal facility, it can be a cost saving option for impoundments with a large volume of material. However, there are several factors that need to be taken into consideration when evaluating and planning for rail transport operations:

- **Track Repairs and Extension.** Often rail tracks at closed electric utilities are no longer in use and will require repairs before rail operations can begin. Additionally, there will need to be enough track available to hold at least two trains as well as to stage rail cars needing repairs or load adjustment. This will allow the locomotive to bring in one train empty and then pull out the loaded train. In some cases, the railroad company will only allow their locomotives to pull trains; therefore, once an unloaded train comes in, the locomotive needs to have a third line that will allow it to move to the front of the loaded train.

- **Railroad Coordination.** Early coordination with the railroad is necessary to clearly identify roles, responsibilities, coordination requirements, mainline track schedules, availability for pickup, and to set expectations, especially in the case where multiple railroad companies will be required to transfer material from the electric utility site to the disposal facility. When two or more rail lines are necessary, rail transport becomes even more complicated since the train exchange will need to be closely coordinated between the railroads to avoid shipment delays. Procedures need to be established for the following conditions: prior to transporting a train, if a loaded rail
car is rejected, a loaded rail car must be cut loose during transport, inspection requirements, and tracking of rail cars. Production and schedule consistency is key to allow the railroad to plan crews, schedule moves, and have train engines available. For smaller production projects, the railroad company may elect to not dedicate engines to the project. In these situations, maintaining a consistent schedule becomes even more critical to maintain production. Upfront communication will allow the process to operate more efficiently.

- **Material Loadout Area.** As with truck loading operations, a material loadout area will need to be established to temporarily stockpile and load rail cars. Since the rail line is often not immediately adjacent to the impoundment, the stockpile area will need to be constructed to meet the CCR pile storage standards set by the CCR rule (i.e., placement on an impervious base such as asphalt, concrete, or a geomembrane with leachate and run-off collection, and walls or wind barriers). Typically, the loadout area will be sequenced as follows:
  - Empty rail car inspection and liner installation, if liners are used
  - Rail car loading
  - Rail car inspection and cleaning, if required
  - Rail car scaling
  - Liner closure or cover placement

Work on top of rail cars (e.g., liner installation) will typically trigger additional fall protection requirements. Therefore, installation of a fall protection system may be necessary to close liners or install covers.

- **Equipment.** A loader or an excavator can be used to load the rail cars. In some cases, it may be beneficial to use a conveyor system to eliminate the need for a temporary CCR storage area. A rail scale will be necessary to weigh loaded rail cars to ensure they are not overloaded. In addition, a railcar movers (e.g., Trackmobile) will be needed to move cars around the track. Additionally, the contractor should
ensure the receiving landfill has the equipment necessary to offload received rail cars and remove excess CCR prior to shipment of empty rail cars back to the site.

**BARGE**

Like rail, transporting CCR by barge to an off-site disposal facility can result in cost savings depending on the existing facilities available at the site. An additional advantage of barge transport is that it is not impacted by vehicle traffic, rail complications, and can transport more volume per load (i.e., anywhere from 725 metric tons [800 tons] up to 5,443 metric tons [6,000 tons]). A 5,443 metric ton (6,000-ton) barge can be unloaded and released within 24 hours.

As with, rail a separate material loadout area will need to be constructed that provides temporary storage of CCR in accordance with the requirements of the CCR rule. The shipping and receiving site do not necessarily need to be located on the waterway. Loadout and/or unloading stations can be constructed away from the site. Loading equipment can include a loader, excavator with clamshell bucket, or conveyor system. Additionally, upon arrival at the receiving dock, additional equipment will be necessary to offload the barge and then transport the CCR to the receiving landfill. Contractors should coordinate with the barge company early on to discuss roles, responsibilities, coordination requirements, travel routes to include locks, draft in the waterway and at the loading/unloading facilities, barge schedules, availability for pickup, delivery times, freezing conditions, and set expectations. Barge transport is a viable alternative to transport large quantities of CCR, provided the proper facilities are in place.

**References**