Challenges of Closing Large Fly Ash Ponds

John Seymour¹, Steve Macrowski¹, Pedro J Amaya²

¹Geosyntec Consultants, 134 N LaSalle Street – Suite 300, Chicago, IL 60602; ²Civil Engineering and Geotechnical Services, American Electric Power, 1 Riverside Plaza – 22nd Floor, Columbus, OH 43215.

KEYWORDS: Pond Closure, Fly Ash, Acid Mine Drainage, High Hazard Dam, NPDES Permit Compliance.

ABSTRACT

Closure of a 120 hectare (300 acre) fly ash disposal pond contained by a high hazard dam in a former coal mining area presents significant challenges. The fly ash pond was created by construction of a 40-m high earthen dam in an existing stream valley and then sluicing of fly ash into the pond. Approximately 40 hectares (100 acres) of the fly ash was covered with a 3 m layer of sandstone and shale “blastrock”. The remaining area is open water up to 10 m deep. A coal seam was mined for many decades prior to pond construction and acid mine drainage (AMD) lowers the pH of the pond such that buffering is required. Pond closure will involve lowering the surface water; dewatering the surface of the fly ash; re-grading the fly ash and adding contouring fill; constructing an engineered final cover; lowering the dam; installing permanent stormwater management controls; constructing a new overflow spillway and discharge channel. Significant engineering challenges include managing settlements due to consolidation of the fly ash and contouring fill; interim and post-closure stability; management of fly ash consolidation water, cover infiltration water, and groundwater; management of stormwater throughout construction; coordination of AMD mitigation with closure construction; identifying economical borrow sources to meet the considerable construction volume requirements; and sequencing of the dam lowering. Throughout the closure construction, NPDES permit requirements must be achieved.

The engineering, regulatory and constructability challenges of the closure and how the project team managed them are summarized in this paper.

1. PROJECT DESCRIPTION

The 120 hectare coal fly ash reservoir (FAR) is located in southern Ohio. Fly ash was sluiced into the FAR from the mid-1970s to mid-1990s and the ash is approximately 30 m deep, maximum. The FAR closure is being designed to include a cover system that meets the requirements of regulations proposed by the U.S. Environmental Protection Agency (EPA) in 2010 under the Resource, Conservation and Recovery Act (RCRA) Subtitle D for solid waste (U.S. EPA, 2010). Current key site features are shown on Figure 1. An aerial photo is shown on Photo 1.
Figure 1: Existing Site Features

Photo 1: Fly Ash Pond Aerial View
The FAR is considered a “valley fill”. The valley has relatively steep side slopes from stream incision into the native bedrock. The base of the FAR is comprised of native residual soils and fluvium overlying bedrock. The average hydraulic conductivity of the bottom of the FAR is on the order of $5 \times 10^{-7}$ cm/sec. The elevation difference between the water level in the FAR and the top of surrounding ridge lines is on the order of 75 m. The water in the FAR is retained by a 40-m high earthen materials fly ash dam (FAD) that is constructed with a low permeability clay core with a random fill upstream slope armored with rip rap and a downstream slope consisting of random fill and coal combustion bottom ash infiltration layer under a vegetative cover.

The side slopes surrounding the FAR have been altered by coal mining around the perimeter of the valley creating near vertical rock faces called “highwalls” that are 5 to 30 m high. Photo 2 shows a typical highwall. Contour, auger and room and pillar mining methods were utilized to extract the coal. At the base of the highwalls are mine spoil benches from disposal of spoil during historic mining of a 1.2 m+/- thick coal seam. Acid mine drainage (AMD) is prevalent in select areas of the perimeter of the FAR with significantly higher flows near the locations of drift openings and mine mouths. AMD entering the FAR has pH as low as 2.8 and the FAR requires treatment by the addition of sodium hydroxide upstream of the outfall to be within the National Pollutant Discharge Elimination System (NPDES) permit limits of 6 to 9.

The surface water drainage area of the FAR is approximately 345 hectares (1.3 square miles). The water behind the dam is discharged through a vertical tower decant structure leading into a 1.3-m diameter, 240-m long discharge pipe leading into a
stream. Photo 3 shows the decant structure. The discharge flow has been a relatively consistent 4.5 million liters per day (1 million gallons per day, or 1.5 cuft/sec) since the cessation of fly ash sluicing in the early 1990s.

The engineering, regulatory and constructability challenges of the closure and the process to overcome them are presented in the following sections.

2. COMPLIANCE WITH NPDES PERMIT CRITERIA DURING CONSTRUCTION

a. NPDES Permit Criteria

The existing NPDES permit has several important discharge criteria:

- **Total suspended solids (TSS).** The TSS permit has discharge criteria of 100 mg/L maximum with a 30 mg/L average. Meeting these criteria will be a major challenge during construction because of the need to move approximately 1,200,000 m$^3$ of fly ash and fill to build up the ash surface (“contour filling”) to the elevations that provide the required 3% minimum cover slopes to promote drainage off of the cover. For comparison, a typical earth moving construction site has stormwater runoff containing TSS at 600 mg/L. Consequently, meeting a 100 mg/L standard during construction would be very difficult. Two methods of contour filing were considered: (i) hydraulic dredging, and (ii) pond unwatering and mass excavation. The later method was selected after input from a major contractor who had previous experience placing contouring/covering fill at the FAR. Movement of this amount of fly ash material, which is highly erodible, when the pond water level has been significantly lowered, can create significant TSS loading into the NPDES outfall.

- **pH.** The pH of the discharge is to be within a range of 6 to 9. Meeting these criteria will be difficult because comparatively very little water will remain in the FAR during construction to retain/buffer the stormwater and the existing caustic treatment unit will be removed which would leave AMD untreated.

- **Whole Effluent Toxicity (WET).** The discharge has a limit of 1.0 acute toxic units for Fathead Minnow (*Pimephales promelas*) and water flea (*Ceriodaphnia dubia*). Historical testing of untreated water indicates that the untreated discharge fails the WET criterion. The WET criterion was
met after the caustic treatment unit was installed in the central area of the pond and buffered water is allowed to mix and flocculants settle in a relatively large pond of 25 hectares (60 acres) immediately upstream of the dam. However, the caustic treatment unit and the water level in this relatively large pond will be lowered thereby reducing the surface area and depth during construction and reducing the ability to treat the water prior to discharge.

b. NPDES Compliance Approach

The water management to maintain NPDES compliance is as follows:

- Install AMD treatment cells outside of the perimeter of the future cover prior to construction to buffer the AMD prior to draining into the construction work area and later onto the new cover system.
- Close the FAR in six “phases” to limit the amount of fly ash disturbance that may result in re-suspending particles in the water stream and to minimize the build up of pore pressure in the fly ash during the push out of the contouring fill over the expose surface that may lead to internal instability of fly ash slopes and associated re-suspension of fly ash particles in the water stream.
- Begin closure in the upstream reaches of the three main tributary valleys to provide final cover and stabilization of fly ash while leaving a relatively long distance prior to the NPDES outfall to allow room for temporary TSS treatment using best management practices (BMPs).
- Install BMPs within each phase to control the amount of TSS that could be mobilized. The BMPs were designed to manage the 2-year, 24-hour storm event, consistent with a construction project.
- Provide a mobile pH “backup” treatment unit during construction with caustic applied in a temporary channel upstream of the last phase of construction (Phase F).
- Retain a treatment pond in Phase F immediately upstream of the dam designed to provide for settling of TSS and treatment floc during construction.
- Should all of the above treatments still not provide NPDES permit compliance during major storm events, the vertical tower decant structure will be designed to shut down discharge to retain all stormwater runoff until adequate settling can be maintained.

The key components of the treatment approach are shown on the construction site plan in Figure 2.

The construction period has been estimated to be approximately four years. During this time period, there may be significant storm events where the individual treatment technologies will be stressed. Therefore, using multiple
treatment technologies provides prudent redundancy to meet the owner’s objective of not exceeding NPDES criteria.

3. ACID MINE DRAINAGE MANAGEMENT

AMD lowers the pH of the existing FAR causing the need for buffering treatment. An investigation of the sources of the AMD was completed to obtain mine locations, chemistry, flow rates and topography characteristics to design treatment systems close to the AMD sources thereby reducing or eliminating the need for caustic treatment in the FAR during construction. Photo 4 shows typical AMD seepage emanating from the mine spoils near the base of a highwall. At this time, the goal is to have AMD treatment systems functioning during closure of the FAR. However, an additional goal would be to provide alternate treatment of AMD before construction and permanently. To this end, the owner is also engaged in a research partnership with The Ohio State University and other interested parties to explore the use of CCR’s in the reclamation of high walls and AMD treatment.

The coal seam that had been previously mined was found essentially all around the perimeter of the FAR as evidenced by the presence of highwalls. The trace of the highwalls is approximately 14,000 m long around the FAR basin. Further, the perimeter of the site area is remote and rugged and without electricity or access roads.
Therefore, construction of AMD treatment cells all around the perimeter would require construction of an extensive road system to access the AMD sources to build treatment cells.

Consequently, it was decided to focus initial treatment efforts in areas of high AMD flow rates before construction and have a backup mobile pH treatment unit in the FAR during construction. If necessary, additional AMD treatment cells could be added during or after construction to buffer the water to achieve a pH between 6 and 9. Also, during and after construction there would be suitable access to the perimeter of the FAR.

Extensive AMD treatment experience has indicated that mines that utilize deep mining methods (room and pillar and auger mining) generate significantly more AMD than surface (or “contour”) mining methods. Ohio Department of Natural Resources (ODNR) records were obtained and the former deep mine locations were superimposed on site topographic maps to provide locations of deep mines.

A field reconnaissance was conducted after a significant period of no rainfall to identify areas of “base flow” of AMD that would be present even when there was a lack of rainfall runoff. The base flow was located in well-developed gulleys and ditches in several areas on the minespoil benches that identified the locations of the majority (based on flow rate) of the AMD sources.

Weirs were installed in four existing, natural AMD ditches to measure base flow rates and chemistry. The weirs created backwater pools that were sampled monthly for three months to gain chemistry characteristics. The backwater pools were instrumented with pressure transducers to measure the height of water over the weirs over a three month period to calculate flow rates. These data were used to design the initial AMD treatment units.

One significant area that had high AMD base flow was identified at the perimeter of deep mines under the ridge between the center and southern drainage tributaries. The AMD treatment units were designed to be around this ridge along the mine spoil benches as shown on Figure 2.

The treatment technologies considered are essentially passive systems requiring minimal operation and maintenance, making them appropriate for a remote area. The treatment technologies include the following:
- Vertical flow ponds (VFPs). VFPs are the primary, long term AMD treatment technology. They receive AMD from collection channels constructed along the highwalls. The VFPs are located on the outside edges of existing mine spoil benches. The VFPs receive AMD which provides contact to a 1.3-m thick limestone aggregate bed in the VFP. The amount of limestone is calculated using software developed cooperatively by the Pennsylvania Department of Environmental Protection, the West Virginia Department of Environmental Protection and the U.S. Office of Surface Mining Reclamation and Enforcement which utilizes the AMD chemical makeup and flow rates from the field investigation. The water is retained in the VFP for a minimum of 72 hours and released using a valve operated by a timer. The timed valve is powered by electricity stored in batteries generated by a solar cell. The treated AMD is released relatively rapidly through a 0.25 m diameter pipe located at the base of the limestone aggregate bed. The rapid release helps to flush particulates from the VFP to avoid fouling from sediments. The rapid release also reduces the amount of “armoring” of the limestone from precipitates that reduce the treatment capacity of the limestone. The discharge is temporarily retained in a smaller settling pond to collect sediments prior to discharge. The final discharge is directed through an aggregate flow spreader downslope from mine spoil bench and into the FAR area as sheet flow. The VFP is designed to last for 20 years.

- Open limestone channels (OLCs). The primary purpose of the OLCs is to direct AMD into downstream treatment cells. Limestone armoring of the channels provides additional buffering of AMD and helps to remove the acidity and metals. The site investigation identified that there were existing drainage ditches on the mine spoil benches that could be enhanced with little additional excavation. Further, based on flow measurements at the weirs, the existing drainage ditches were located near highwalls and the surface water drainage areas were relatively small and the flow increases from precipitation were relatively small. Consequently, the design flow capacity of the OLCs was relatively small.

The conceptual design of the AMD treatment systems is shown on Figure 3.
Alternatively, the owner is also considering the use of stabilized FGD from the plant to use as the medium to treat AMD as it seeps out of the high wall seams and openings. The technical applicability of this proposed passive system is being researched at The Ohio State University as part of a collaborative effort between The Ohio State University, the Ohio Coal Development Office, American Electric Power, and several other partners interested in addressing AMD (Wolfe, et al. 2012) Figure 4 below, contains a schematic representation of the proposed passive treatment system.
4. POND WATER LEVEL LOWERING

Lowering of the pond water level will be completed using the existing decant structure until the end of closure construction. At this time, it is planned to lower the inlet of the structure to lower the pond level. However, the fly ash level in the pond is high in the middle which creates a three meter difference in water level between an upper pool and a lower pool near the FAD. Consequently, ditches are planned to be constructed to lower the water level in the upper pond to allow for excavation of the high fly ash and placement in the unwatered upper pool.

5. FLY ASH DEWATERING

Dewatering of fly ash is necessary to provide construction equipment access and to reduce the water content to facilitate handling/hauling. Dewatering is challenging because of its relatively low hydraulic conductivity (~1 x 10^-5 cm/sec). Well points have been found to be effective only for relatively small fly ash ponds (EPRI, 1985) in a pond with fly ash hydraulic conductivity of 5 x 10^-4 cm/sec. For larger ponds and ponds with lower fly ash hydraulic conductivity like the FAR, well points would not be cost effective.
The dewatering methods are expected to be completed using several methods:

- Construction of a series of shallow (1 to 3 m deep) trenches to drain the upper levels of the fly ash.
- Mixing of wet fly ash in place with dry materials such as mine spoil or excavated bedrock from the perimeter of the FAR. This would lower the overall water content and facilitate contour filling and compaction.
- Draining of fly ash through double handling by excavating wet ash and stockpiling it to allow it to drain to facilitate subsequent hauling and placement.

Dewatering methods will not be specified in the design; they will be selected by the contractor in discussions with the owner’s engineer to account for the volume as well as the quality of the water removed from the site.

6. SAFETY CONSIDERATIONS

Accidents, near misses and even fatalities have been reported by many pond operators/owners. Understanding and elimination of these failures will be increasingly important as more fly ash ponds are closed. The following is a summary of failures that are related to operations at the surface of the waste within a pond that did not cause a release of fly:

**Southern Ohio FAR:** A soil cover was being placed over an FAR by pushing out a thick lift of sandy/silty rock over the shallow fly ash surface and into the water of an FAR using a dozer. The fly ash surface had a shallow slope that extended out into the FAR. The soil cover failed in tension causing the downslope soil “crust” to slide into the FAR. A dozer was operating on the crust and was lost into the pond. The failure was relatively slow and the operator was able to walk and swim to shore. The dozer was found in a depth of about three meters of water and was recovered.

**West Virginia Coal Slurry Pond.** The perimeter dam of an operating coal slurry pond was being raised in order to raise the pond level. Coal slurry ponds contain the dust and fine grained waste byproducts of coal mining and the waste is similar to fly ash in that it is very soft and fine grained. The method of raising the dam was to push out earth from the crest of the existing dam causing displacement of the underlying waste. The waste below the earth fill apparently failed. As the waste failed the moving waste and overlying soil fill swept a dozer and two trucks out into the pond. The dozer operator became trapped in the dozer and perished while two other personnel escaped injury. This accident occurred in November 2012 and is the cause is currently being investigated.

**Indiana Fly Ash Pond.** A perimeter embankment ash pond separated the primary pond from a secondary settlement pond. The primary pond was situated at a higher elevation than the secondary pond. The embankment failed, allowing surface water in the
primary pond to flood and overtop the secondary pond resulting in a discharge to an adjacent river. No injuries or fatalities were recorded during the incident.

Kentucky Fly Ash Pond. A fatal accident also occurred while removing fly ash from an ash pond in Kentucky. An excavator was operating on the exposed fly ash surface approximately 60 m from the edge of the pond. The pond water level had earlier been lowered approximately 6 m to expose the ash for removal. However, the exposed surface of the fly ash slid over the underlying soft, apparently saturated ash carrying the excavator and its operator more than 60 m and into the pond. The fly ash and water engulfed the cab and the operator could not escape and perished.

Several power utilities have reported to at least one of the authors of this paper that it is common for operators of dozers and haul trucks and personnel to sink and get stuck in wet fly ash. A “trial and error” method is used to develop a competent working grade to haul fly ash into or out of the pond. It is expected that with more pond closures there can be more accidents.

Figure 5 presents several waste failure modes applicable to fly ash ponds.

![Fly Ash Failure Modes](image_url)
7. GROUNDWATER INFLUENCE

The regulations proposed by U.S. EPA include the common solid waste management approach that the cover of the landfill must have a hydraulic conductivity that is lower than the bottom liner or natural subsoils but no greater than \(1 \times 10^{-5}\) cm/sec and no greater than \(1 \times 10^{-7}\) cm/sec where a bottom liner is present. This approach was developed many decades ago and has been incorporated into the landfill regulations of the U.S. The purpose of this requirement is to prevent the “bathtub” effect, which is when surface water infiltrates through the cover at a faster rate than it is able to drain through the bottom and leachate accumulates on top of the bottom liner and eventually rises to a level where it seeps out laterally through the cover causing exposures at the ground surface and in surface water runoff.

In the case of pond closures, the bottoms of the ponds are often native soils because when the ponds were constructed they did not fall into the purview of landfill regulations and homogeneous liners were not required. Therefore, where bottom liners consist of native materials of randomly varying hydraulic conductivity, it may be difficult to have a cover that has a homogeneous hydraulic conductivity that is lower than that of the bottom native materials.

The bathtub effect may occur because in the case of a valley fill pond there is groundwater in the surrounding and underlying geologic materials. While the pond is operating, the groundwater hydraulic gradients are directed out of the pond because of the increased water level in the pond. However, as the pond water level is lowered, the gradients are reversed and can flow into the waste in the former “pond”.

If the groundwater conditions are such that the hydraulic gradients are reversed after closure from outward to inward, the long term groundwater flow regime must be examined to identify the maximum likely water levels inside the newly covered “pond” that water could rise after closure. If this water level is potentially high enough, there can be uplift pressures under the cover that should be addressed. Further, the groundwater level inside the closed pond may eventually rise up high enough to interfere with the vegetative cover by saturating the roots of the vegetation and decreasing the ability of the vegetation to survive.

One solution to the rising groundwater level condition is to construct a subsurface drain under the cover to drain the groundwater laterally to a discharge location. However, the drained groundwater is likely to be considered leachate because it will have been in contact with the waste and may require an NPDES permit and possibly treatment prior to discharge.

Figure 6 presents a schematic of how the groundwater gradients can influence the final cover system.
8. TRAFFICABILITY OF FLY ASH SURFACE DURING CONSTRUCTION

Operating equipment on top of a fly ash pond can be challenging because it is a very soft subgrade. Typically, the ash is placed up to a couple of feet above the water level and a crust is formed. This crust may support pickup trucks and is deceptively stable because the fly ash at and below the level of saturation is very soft and often has standard penetration tests (SPT) N results of 0 to 3. If the surface is trafficked repeatedly it can be easily and deeply rutted. If heavy equipment is operated on the surface, the vibrations can cause localized liquefaction and collapsing of the fly ash mass internal structure resulting in the rapid sinking of the equipment.

To combat the pitfalls of operating on fly ash surfaces, construction of “floating roads” over the exposed/unwatered fly ash surface has proven to be effective. The most successful method of working on the fly ash pond is to first place a geogrid or geosynthetic fabric (collectively “geotextiles”) on the surface and use a dozer to push soil out over the geotextile creating the floating road.

Another successful method is to build the floating road out of backfill without the underlying geotextile but the amount of backfill is significantly more than when a geotextile is used.

The method of surface stabilization will be left up to the contractor.

Figure 7 presents these two types of surface stabilization.
9. CONTOURING FILL

The amount of contouring fill to reach the subgrade level below the cover can be substantial. For a valley fill FAR, the final cover has to be sloped from the upstream end to the downstream discharge location at a minimum slope along the final flow line. If the length of the final cover surface water flow line is long, there can be a large elevation change along the flow line. Even when building a relatively flat 3% cover slope with a 0.75% surface water flow line slope, the elevation difference between the downstream discharge and upstream edge of the cover is 20 m.

The FAR has a high point in the middle composed of exposed ash and a “rock knob” ridge that divides the FAR into a lower pond and several upper ponds as shown on Figure 1. The depth of water in the upper pond is on the order of five meters deep and the water surface is about three meters higher than the lower pond. To achieve a final cover flow line that works to balance cut and fill, the high point will be cut and that material will be used as fill for the low areas.

A sensitivity study was conducted to examine an optimal flow line. The study varied the elevation of the cover to calculate the change in cut and fill. All cover shapes were similar with a 3% cover slope in general leading into central drainage ways for each tributary valley sloped at 0.75%. The alignment of the central drainage way was superimposed over the approximate alignment of the original stream valley flow lines. The central drainage way was extended upslope into the three major drainage tributary valleys.

Figure 7: Surface Stabilization using a “Floating Road” on Fly Ash
The first cover level surface was taken to avoid significant excavation of fly ash or soil fill that had been previously placed in the FAR. This approach was examined because in the initial phases of the project it was not known how the TSS and pH discharge criteria could be achieved if there was significant excavation and disturbance of the fly ash.

The second cover level surface was selected that could be constructed using the lowest reasonable downstream elevation of the top of ash at the FAD as the “starting point”. The second cover level resulted in excavation of the high area that divides the upper and lower pools and placement of fill in the upper pool. This approach was examined to reduce the amount of contouring fill recognizing that the NPDES criteria would be met using additional technologies/approaches.

Figure 8 presents the two cross sections examined.

The fill volume of the first cover level surface was 12,600,000 m$^3$ with negligible cut. For the second cover level surface, the cut was 1,900,000 m$^3$ and the fill was 3,200,000 m$^3$.

The second cover level surface concept was selected because the first cover level surface had too much earth/waste moving. It was recognized that the concept design would be adjusted to reduce the cut/fill imbalance and that imbalance was reduced. However, it proved to be extremely difficult and impractical to lower the second surface to provide a cut/fill balance because any further lowering of the cover along the dam would have required significant dewatering of the fly ash in the lower pond area which was judged to have too many unknowns and therefore too high of a financial and schedule risk to attempt.
10. SETTLEMENT AND COMPENSATION GRADING

The design included a long term final cover slope of 2% and central drainage way slope of 0.5%. To meet these slopes, the design required the cover to be constructed with a 3% cover slope and a 0.75% central drainage way slope to accommodate for some post construction differential settlement. These slopes are relatively flat and consequently, it would not take much differential settlement to not meet the slope criteria after construction.

The cover system will be a uniform thickness placed over the contouring fill. Therefore, there will be negligible differential settlement caused by the cover system. However, the amount of contouring fill will range from zero to ten meters thick over the fly ash and significant differential settlement is possible. Management of the placement of contouring fill will be required to reduce differential settlement.

The approach to manage differential settlement included the following elements:

- The central drainage way was aligned to be coincident with the original stream valley. Therefore the final cover elevation contours would somewhat “mirror” the original stream valley elevations. With this “mirror” approach, the differences between the thicknesses of waste would be less and differential settlement would be less. Further, the differential settlement would increase moving from the edge of the FAR where the fly ash thickness is minimal toward the central drainage way where the fly ash thickness is maximal making it more likely that the 3% slope could increase instead of decrease.

- The current plan is to allow the construction of the final cover system only after the excess pore pressure induced in the fly ash as a result of placing the contouring fill. This approach recognizes the settlement characteristics of fly ash. Fly ash settlement occurs relatively quickly because pore pressures are dissipated quickly. Fly ash does not undergo secondary consolidation, which can take months or years to be complete, which is a clay soil characteristic. Because the contouring fill will occur over very large areas it will be placed relatively slowly allowing pore pressures to dissipate. Therefore, much of the settlement will have occurred prior to construction of the cover system.

11. SLOPE STABILITY

Slope stability at the FAR would not be expected to pose a problem because the final slopes are very shallow. However, there will be interim conditions during construction that were examined because of the sensitivity of slope stability at fly ash ponds and landfills.

- There may be a potential for instability of temporary trenches cut into the fly ash during closure construction to convey water parallel to the central drainage way
while the cover in the central drainage way is constructed. These slopes were designed as part of the engineering effort.

- A containment berm for the lateral expansion of a CCR landfill will be constructed over a portion of the FAR. The stability of the containment berm over the temporary and final slopes of the FAR cover was examined for this future condition.

12. DAM LOWERING

One project goal is to lower the FAD to the maximum extent practicable to reduce its hazard classification. However, the ODNR stated that after closure of the FAR the fly ash will still be considered a “liquefiable” material and the FAD will retain a dam classification based upon the final height of the dam and the volume of the saturated material present behind it. The volume of saturated material is to be determined on the basis of the elevation of the phreatic level predominant within the closed facility.

The closure of the impoundment and the lowering of the FAD will require approval of the ODNR because the proposed work will modify the current facility. Among the modifications proposed for the dam and its appurtenances will be the elimination of the decant outfall structure to be replaced by a conventional spillway channel to pass the design storm’s run off flow. The current FAR does not have an emergency spillway, relying instead on the FAD’s storage capacity to retain the probable maximum flood (PMF) because of the storage capacity behind the FAD in the FAR. The FAR must continue to be able to manage/retain the PMF throughout the closure construction period. After the FAR closure and FAD lowering, the new spillway must manage the 100-year, 24-hour storm.

The current plan is to keep the decant outfall structure and the FAD in place until the final phase of FAR closure. During the final phase, the FAD will be lowered and the spillway will be constructed while the decant structure is available to handle the 100-year, 24-hour storm.

The materials removed from the FAD will be reused on site in cover construction or stockpiled for later use for a later construction phase of the adjacent CCR landfill. The crest of the FAD is currently at el. 224.4 m, MSL and the top of final cover adjacent to the FAD will be approximately el. 204 m, MSL providing material with reuse potential. Reuse materials will include random fill, rip rap, bottom ash and clay.

13. BORROW SOURCES

Borrow sources for contouring fill, low permeability clay, vegetative support cover and subsurface drainage layer were examined. The following summarizes how the borrow needs will be met:
Contouring Fill. Contouring fill will come from fly ash and blastrock excavated from the middle of the FAR and from minespoil and shale and sandstone located immediately outside of the perimeter of the FAR.

Low Permeability Clay. Low permeability clay, also called the “infiltration layer” in the U.S. EPA proposed regulations, will come from minespoil and the FAD. The maximum hydraulic conductivity of the infiltration layer needs to be $5 \times 10^{-7}$ cm/sec to be less than the bottom of the FAR. The final cover layer adjacent to the FAD will be approximately el. 204 m, MSL. The FAD will be lowered to el. 204 m, MSL making the clay core available for the infiltration layer.

Vegetative Support Cover. Vegetative support cover will come primarily from the random fill from the lowering of the FAD and from minespoil. An investigation of the minespoil was planned to assess whether the mineralogy would support vegetation because of the possibility of having pyrite (iron sulfides) and other coal mining constituents that would not support vegetation or that could leach out minerals that could cause a need for ongoing monitoring. However, there had been a mine reclamation project that regraded minespoil and was vegetated. An inspection of the area was conducted and the vegetation was thriving and there was no evidence (staining, lack of vegetation). Therefore, it was judged that minespoil would be suitable for vegetative support cover.

Subsurface Drain. The subsurface drain that will be located near the upstream side of the FAD will come from bottom ash currently in the FAD. The bottom ash in the FAD is functioning both as a chimney drain and as fill material and has a hydraulic conductivity of approximately $1 \times 10^{-2}$ cm/sec. The lowering of the FAD will provide ample volume for the subsurface drainage layer.

14. TIME TO COMPLETE CLOSURE

The proposed closure will require the placement of 3.0 million cubic meters of material to achieve the desired grade elevations. The time to complete closure construction is estimated to take approximately four years. Thus, the overall rate of material placement is approximately 750,000 cubic meters per year. This time period was developed with the input of a major contractor that has experience at the FAR placing blastrock material to cover exposed fly ash. The estimate was based primarily on the amount of materials that have to be moved and placed.

However, a risk to the project in the concluding construction phasing is the control of TSS in the outlet flow. TSS control is difficult during construction because the area of construction is too large to manage TSS using commonly accepted stormwater BMPs. This may be especially true during major rainfall events. Therefore, the current plan is to close the FAR in six phases and allow the contractor to work with the owner and Engineer to increase or decrease the size of the phases after the contractor is selected.
15. CONCLUSIONS

Closure of large fly ash (or CCR) ponds is not as simple as it may appear at first glance. This pond had significant technical challenges that had to be evaluated and solved to provide a project with a reasonable level of risk that allows financial and schedule planning. The significant project issues were resolved with the collaboration among the owner, operators, construction specialists/contractors and engineers all working towards a common goal.

16. ACKNOWLEDGEMENTS

This paper could not have been written without the work completed by the project personnel to investigate and solve problems. The Geosyntec project personnel include Paul Sabatini, Ph.D., P.E., Matthew Bardol, P.E., Dan Bodine, P.E., Chriso Petropoulou, Ph.D., P.E., Bruce Sass, Ph.D., John Esser, P.G., P.E., James Couch, Hydrogeologist, and Steve Macrowski. The American Electric Power project personnel include Pedro Amaya, P.E., Guy Cerimele, Dana Sheets, Doug Workman, Shah Baig and Kent Adkins.

17. REFERENCES

EPRI, Dewatering to Stabilize Fly Ash Disposal Ponds, EPRI CS-3863, May 1985
