CCR Impoundment Dewatering Pilot Case Study

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Abstract

Coal Combustion Residual (CCR) surface impoundment (ash pond) closures may require ash dewatering. Though dewatering means and methods are well developed, understood, and practiced in the construction/design industry at large, there is less ash pond closure industry dewatering experience. Understanding the site-specific ash pond characteristics is critical to closure construction success and influences construction safety, design, sequencing, schedule, and cost. The authors recently collaborated on an ash pond dewatering pilot program supporting the closure design of a 1960’s era ash pond over 250 acres in area with saturated ash on the order of 40 to 50 feet deep. The proposed ash pond closure approach was consolidation and closure in place, requiring dewatering and removing ash from select areas within the ash pond footprint. The pilot program was designed and implemented to evaluate three dewatering methods at two locations. The dewatering methods included well points, deep wells, and pit/trench pumping. One test area was located in the vicinity of the sluice line discharge into the ash pond, while the other was located closer to the outlet structure. The authors summarize the dewatering pilot layout, installation, implementation, and results and present observations, lessons learned, design considerations, and suggestions for dewatering pilots. This discussion stands to benefit owners, contractors, engineers, and regulators through promoting understanding of ash pond dewatering characteristics and presenting data useful in larger-scale dewatering design as well as groundwater modeling efforts.

Introduction

Coal Combustion Residual (CCR) surface impoundments (ash ponds) typically require some amount of ash dewatering with closure construction. The USEPA CCR Rules 40 CFR Part 257 published in the Federal Register April 17, 2015, effective October 19, 2015 regulate CCR as a non-hazardous waste under Subtitle D of the Resource Conservation and Recovery Act (RCRA) and require many CCR surface impoundments to close within certain timeframes. As many Owners and Operators have expended significant effort in planning and developing feasibility studies and cost models for closing CCR surface impoundments using varied approaches, determining the most effective method for dewatering existing coal ash ponds for closure poses many challenges in meeting regulatory deadlines and performance expectations. While
dewatering means and methods are well developed and commonly practiced in other construction/design industry projects, there is less experience available to draw upon for CCR ash pond closures specifically. Since understanding the site-specific ash pond hydrogeological characteristics is critical to closure construction success, Wood Environment & Infrastructure Solutions, Inc. (Wood) and Moretrench teamed for a recent ash pond dewatering pilot test at a confidential site to test these means and methods and site specific response.

**Background**

The subject of the dewatering pilot test was a 270+ acre unlined CCR ash pond constructed in the early 1960s. The ash pond contains over 24 million cubic yards of ash including a dry ash stack extending approximately 100 feet above the top of dike elevations.

A hybrid closure approach was selected for this closing this ash pond that includes closure by removal in some areas around the perimeter of the ash pond and consolidating the CCR into a smaller footprint to be closed in place. The closure by removal areas will be backfilled with compacted soil to develop grades for stormwater management. The closure by removal area is approximately 73 acres resulting in a total closure in place area of approximately 197 acres. The consolidated ash stack (closure in place area) side slopes will be graded to a maximum of four horizontal to one vertical (4H:1V) slopes with 20-foot wide terraces prior to construction of the final cover system. For the top level of the ash stack 5% minimum slopes were used and graded to drain toward two proposed stormwater ponds located along the perimeter for discharge to surface waters.

Wood estimated that approximately 2 million cubic yards must be dewatered for excavation, stacking, hauling and placement for the ash consolidation. Excavation depths from 30 to 80 feet with saturated ash thicknesses on the order of 30 to 40 feet are required to support this consolidation and closure plan, which will require a significant amount of ash dewatering.

Wood characterized site geotechnical, geologic, and hydrogeological conditions by conducting microgravity surveys, drilling/sampling with standard penetration testing (SPT) and rock coring, advancing cone penetrometer test (CPT) soundings, installing piezometers, slug testing, and laboratory testing between May 2017 and August 2018. A total of 34 geotechnical borings were advanced at the site during this time for site characterization activities. These borings including SPTs at each location, rock coring at 20 of the 34 locations, and CPTs at 8 locations. Seismic CPT (ASTM D-5778) measures tip resistance, sleeve friction, and pore pressure every centimeter, and is used to correlate to a range of engineering properties and to approximate material types. The frequency of the test measurements allows for stratification to be observed to a greater degree than SPT. CPT pore-pressure dissipation tests, which can be related to hydraulic conductivity, were performed at 7 locations within the ash. CPTs within the ash provided an early glimpse of the distribution of more permeable strata within the pond. The CPTs can differentiate between finer and coarser strata, but pore pressure dissipation tests are of limited effectiveness with higher permeability strata. In-situ pumping from representative devices was determined to be a reliable way to evaluate the permeability of the strata and their ability to deliver water to various types of dewatering devices.
The ash impoundment contains a mixture of fly ash and bottom ash. At the location of the two pumping tests, the ash was predominantly fly ash. One stratum of more granular ash, less than five feet thick at a depth of 35 feet, was identified by split spoon sampling nearby the West Test Area, further from the plant discharge. This may be evidence that significant reworking of the ash has occurred over time. Gypsum was also encountered on the surface at the eastern end of the ash pond as well as in some of the borings, as gypsum storage/disposal has occurred in the ash pond. The native soils surrounding the ash impoundment consist of clay overlying shallow bedrock.

**Project Goals**

The dewatering pilot was proposed to evaluate dewatering effectiveness of the identified techniques by field testing to obtain site-specific dewatering information. The dewatering pilot data would be incorporated into the ash pond closure design package and supporting documents with the intent to improve site safety, cost estimating, scheduling, and project planning and execution. Identification of two major key elements: 1. Site-specific ash dewatering characteristics and 2. Effective dewatering methodologies would facilitate accomplishing the overall project goal by achieving the following:

1. Understanding site-specific ash conditions, dewatering methodology, and monitoring for safe access and excavation with instrumentation and telemetry
2. Refining groundwater modeling with ash characteristics to estimate the phreatic water surface for slope stability during closure and post-closure
3. Including closure design elements to enhance dewatering and water collection for slope stability
4. Reducing uncertainties for developing control cost estimates for dewatering, ash excavation and handling, and instrumentation systems
5. Planning construction sequencing for saturated and unsaturated ash excavation and handling, dewatering system installation and operations and planning temporary lined water storage ponds for water treatment through an owner-supplied treatment system

A goal of the dewatering pilot test was also to verify results of previous site characterization investigations and to identify characteristics or variability that could affect interstitial water removal.
Test Locations

The dewatering pilot test program was designed and implemented to evaluate three most probable means of dewatering the ash during ash pond closure. The methods tested included:

- Shallow wellpoints
- Deep wells
- Pit/trench pumping with wet stacking and decanting observations

Each of these three methods was evaluated at two separate areas of the ash pond: one area was located closer to the sluice line discharge into the pond (East Test Area), and the other was located in the vicinity of the process water flow path closer to the outlet structure (West Test Area). The East Test Area was located in the vicinity of future CCR excavation along the ash pond dike adjacent to a river. The West Test Area was located at the western edge of the ash stack in an area slated for CCR excavation and closure-by-removal. The East and West Areas were approximately 4000 feet apart and separated by the ash stack. The testing was expected to gather important information on dewatering method feasibility to support CCR excavation in those important areas.

Test Installation

At each test location a single line of fifteen wellpoints were installed for testing in addition to a single deep well. Five observation wells were installed perpendicular to the line of pumping wellpoints. The layout of the wellpoints, deep well and observation wells are shown in Figures 1 and 2. The wellpoints and observation wells were installed by duplex, cased drilling methods using a 6-inch casing advanced using clean water as drilling fluid. All the wellpoints were installed to a depth of 25 feet. Four of the five observation wells at each site were installed to a depth of 25 feet; one observation well was installed deeper. All wellpoints were constructed with 2-inch diameter PVC slotted screen and select filter pack. The wellpoints were developed by over pumping with a self-priming centrifugal pump. The deep wells were installed through the full depth of the ash. The deep wells were installed by duplex, cased drilling methods using a 9⅝-inch outer casing also advanced using clean water as a drilling fluid. Within each casing, a 4-inch diameter PVC well was constructed with 40 feet of slotted screen and select graded filter sand. The deep wells were developed by air lifting.

For both deep well and wellpoint tests, pressure transducers with data loggers were programmed and installed in each of the observation well piezometers to continuously measure and record water level readings, every two minutes, during the dewatering pilot test and for 48-hours post-test. In addition, water levels were recorded manually at one- to two-hour intervals throughout the testing. Some of the pressure transducer data showed oscillations in water levels which are likely related to diurnal temperature changes. These oscillations due to temperature change could not be corrected; therefore, data obtained from the transducers was deemed to be less reliable although some of the transducer data did not show this hydraulic head oscillation and matched the manual observations.
Test Performance

Deep Well Pumping Test

A constant rate deep well pump test was performed in each test location. Wellpoints and observation wells installed near the deep well were utilized as observation points during each test. The average pumping rates during the East and West Test Area deep well tests were 21.2 and 5.2 gallons per minute (gpm) respectively. The saturated ash thicknesses in the East and West areas were estimated to be approximately 40 and 36 feet respectively.

Wellpoint Pumping Test

A constant rate wellpoint pump test was performed in each test location. The East and West Test Area wellpoint pump tests average pumping rates were 5.2 and 12.2 gpm respectively.

Pit/Trench Pumping Test

Initially, an excavator was used to dig sump pits. However, shortly after pumping commenced, the ash began sloughing and the pits could not be maintained open deep enough to maintain a continuous flow. Additional care was exercised during this test phase due to the unstable nature of the sidewalls of the excavation through wet ash. Concurrent with this test, the excavated stacked wet ash was carefully observed for moisture content and angle of repose that will be valuable for construction planning.

A vacuum excavator was subsequently used to dig sump pits at both sites. The pumps evacuated the sump pits almost immediately and there was not enough recharge into either pit to sustain any appreciable flow.

An additional test was performed in the West Test Area using an existing dredging dewatering trench with approximate dimensions of 20 feet wide by 8 feet deep by up to 1500 feet long. A pump was set approximately 25 feet from the West Test Area observation wells. This test behaved similarly to the pit tests; the water in the trench was pumped down quickly and there was not enough recharge to sustain a consistent flow.

Results and Discussion

Deep Well and Wellpoint Pumping Tests

The deep well tests lend themselves to the calculation of aquifer parameters such as transmissivity, hydraulic conductivity and radius of influence. The Cooper-Jacob method of analysis was used to calculate these parameters with both drawdown vs time and drawdown vs distance data. A line of “best fit” is matched to the data to calculate the aquifer parameters. As with any pump test, there are a number of deviations from the theoretical or ideal conditions.

The calculated hydraulic conductivities from the East Test deep well test time-drawdown data varied from 82 to 190 gallons per day per square foot (gpd/ft²) and averaged 128 gpd/ft². The calculated hydraulic conductivities from the West Test Area deep well test time-drawdown data varied from 123 to 174 gpd/ft² and averaged 156 gpd/ft². In general, the time drawdown plots indicated continuing drawdown at the end of the pump test, with no leveling off or equilibrium.
This would be expected in a situation where recharge is limited, such as pumping from the interior of a clay lined pond.

The Cooper-Jacob distance–drawdown plot is considered to be the single most reliable representation of the aquifer response and characteristics from a pumping test [Powers, et. al., 2007]. The distance–drawdown plot is essentially a straight line representation of the cone of depression created by pumping a single well. The distance-drawdown plots from the East and West Test Areas at maximum pumping time are shown in Figures 3 and 4.

Four of the five data points from the East Test Area fall very close to the line of best fit, which indicates fairly consistent ground conditions within the area of the test instruments. It should be noted that the one data point which falls markedly below the line of best fit is the single deep observation well (EPZ-3). This suggests that there is some coarser ash below the 25 ft depth of the other observation wells. The calculated hydraulic conductivity from the East Test Area distance-drawdown plot at maximum time of 9600 minutes was 95 gpd/ft². The radius of influence projected at 9700 minutes was 850 feet.

All five data points from the West Test Area distance-drawdown plot fall essentially on the line of best fit, including the furthest wellpoint which was installed to a deeper 46 foot depth. The resulting data points again suggests fairly consistent conditions through the West Test Area as well. The calculated hydraulic conductivity from the West Test Area distance-drawdown plot at maximum time of 8590 minutes was 174 gpd/ft². The radius of influence projected was greater than 10,000 feet, which would be indicative of a barrier boundary.

Aquifer parameters such as transmissivity and hydraulic conductivity cannot be calculated from the wellpoint tests as they are essentially multiple well tests, and do not lend themselves to similar analysis methods. The system yield data and the drawdown observations in the perpendicular piezometers are, however, quite valuable. Figure 5 is a distance versus drawdown plot of the perpendicularly oriented observation wells. Note that the deep observation well (EPZ-3) in the East Test Area experienced less drawdown than adjacent piezometers, as would be expected if this deeper observation well penetrated a coarse stratum below the depth of the pumping wellpoints. The large projected radius of influence from the West Test Area also reflects the barrier boundary, similar to the deep well test.

In the writers’ experience, the calculated ash hydraulic conductivity values are all considered to be quite close and reasonable based on experience performing dewatering in numerous coal ash impoundments. The hydraulic conductivity will be utilized in a detailed site groundwater model, and the yield per device will be used to estimate the total number of devices necessary to drain the various stages of the pond excavation. The difference in yield between the string of shallow wellpoints and the one deep well at the East Test Area suggest that there are deep, coarser strata that can be effectively tapped and pumped with deep well dewatering devices. It should also be noted that this was not foreseen with the geotechnical investigation at this location. This result supports the effectiveness for performing a dewatering pilot pumping test.

**Pit/Trench Pumping Tests**

The data collected during the sump pit tests could not be analyzed using either the Cooper Jacob time-drawdown or distance-drawdown method as the ash aquifer was not able to be
stressed sufficiently to cause a noticeable reaction in the observation wells. Relative to the
wellpoint and the deep well pumping performed, rim ditching and sumping is clearly the slowest
acting method, that it could not practically be evaluated with a pilot study. It should be noted
that the rim ditching and sumping test clearly showed the potential for ash instability inherent
with this approach. Instability was observed above the water level as well as below the water
level.

Groundwater Model Refinements

Wood developed groundwater models to evaluate ash pond groundwater levels during
sequences of ash pond closure construction and post-closure. Wood used the results of the
dewatering pilot testing to evaluate the groundwater flow model input parameters by
calibrating the model to pilot-testing observed drawdowns. To obtain the needed resolution of
the observation wells which are approximately 10 ft apart, Wood developed a Telescopic Mesh
Refinement (TMR) model (ESI, 2011) from our original model for this site which simulated post–
sluicing conditions. A sub-grid was created from the post-sluicing model extending 1,000 feet
east and west and north and south from the test well for both the East and West Test Areas. This
distance is greater than the maximum reasonable radius of influence estimated from the East
Test Area data (which is 850 feet). An initial grid spacing of 4 feet was used in construction of
the TMR models. This grid spacing was reduced to 2 feet in the areas of the pumped wells,
piezometers, and wellpoints. A constant head boundary was used along the perimeter of the
TMR model using the heads from end of the period (1 year) of the post-sluicing model. The last
set of observed drawdowns (manual data only) during the pumping period for the wellpoints
and piezometers were used as calibration targets.

Hydraulic conductivity and specific yield parameters were varied to match the observed
drawdowns using the reported average pumping rate for each test. The model tended to match
the drawdowns when using a specific yield near 0.2 or slightly greater although the model was
not very sensitive to this parameter. The model was most sensitive to varying values of hydraulic
conductivity with values closer to 6 ft/day yielding the best results for both areas. The calibration
at the West Test Area is slightly better. The model was used to estimate the anticipated volumes
of water which may be produced during the dewatering processes and possible configurations
of deep wells and wellpoints. All of these estimates were informed by observations developed
from the pilot study (e.g., observed drawdowns and the attainable flow rates from wellpoints or
deep wells).
Conclusions

The most effective method of dewatering can only be determined taking into consideration all of the elements of the ash pond closure process. It is not simply a matter of dewatering system installation and operation cost and yield of each type of system. In general, wellpoints may appear to be the most effective in drawing water out of the ash, and may require the least amount of surface preparation for access; however, they have limited effectiveness at depth, are limited by the available suction lift of a vacuum system and will present the greatest physical interference to earthwork operations. Deep wells may be very effective at all depths within a pond where relatively coarse ash strata are present. These wells may be spaced hundreds of feet apart, and will require a safe working platform for any drilled-in installation. Rim ditches and sumps are the lowest cost dewatering approach; however, drainage from the ash will occur much slower, and often resulting in the phreatic surface close to the working surface. Rim ditching and sumping demands experienced contractors due to the unstable nature of the materials.

The general conclusions from this pilot study are as follows:

1) Deep wells can be effective at this site. Their yield may vary between 5 and 20 gpm depending on the absence/presence of any coarser strata.

2) Wellpoints are also effective at this site, but where there may be deep coarser strata underlying the wellpoint system in some areas; those strata will more or less remain untapped. The wellpoints are expected to be effective when excavations approach the pond bottom or coarser strata where such depths can be reached with this method.

3) Rim ditches and sumps may be a viable method in shallower areas based on the Contractor’s approach to the work, however, the drainage time may be significantly prolonged.
References


Confidential Site-Specific Reports of Geotechnical Findings prepared by Amec Foster Wheeler, 2016, and by Wood Environment and Infrastructure Solutions, Inc., 2018.


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Δδ = 0.43 ft/log-cycle
T = 6,279.4 gpd/ft
K = 174.4 gpd/ft²
Figure 5 Wellpoint Tests Distance vs. Drawdown Plot